march 1961

the institute of radio engineers

Proceedings of the IRE

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INTERNATIONAL CONVENTION

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Typical Miniature Audios

RC-25 Case
61/64 x 1-13/32 x 1-9/16
1.5 oz.

Type No	Application	MIL Type	Pri. Imp. Ohms	Sec. Imp. Ohms	Unbal. DC in Pri. MA	Response 2 db (Cyc.)	Max. level dbm
H-1	Mike, pickup, line to grid	TF4RX10YY	50, 200CT, 500CT	50,000	0	50-10,000	+ 5
H-2	Mike to grid	TF4RX11YY	82	135,000	50	250-8,000	+18
H-5	Single plate to P.P. grids	TF4RX15YY	15,000	95,000 CT	0	50-10,000	+ 5
H-6	Single plate to P.P. grids, DC in Pri.	TF4RX15YY	15,000	95,000 split	4	200-10,000	+11
H-7	Single or P.P. plates to line	TF4RX13YY	20,000 CT	150/600	4	200-10,000	+21
H-8	Mixing and matching	TF4RX16YY	150/600	600 CT	0	50-10,000	+ 8
H-14	Transistor Interstage	TF4RX13YY	10K/2.5K, Split	4K/1K split	4	100-10,000	+20
H-15	Transistor to line	TF4RX13YY	1,500 CT	500/125 split	8	100-10,000	+20

Typical Compact Audios

RC-50 Case
1-5/8 x 1-5/8 x 2-5/16
8 oz.

Type No.	Application	MIL Type	Pri. Imp. Ohms	Sec. Imp. Ohms	Unbal. DC in Pri. MA	Response ± 2 db (Cyc.)	Max. level dbm
H-20	Single plate to 2 grids, can also be used for P.P. plates	TF4RX15YY	15,000 split	80,000 split	0	30-20,000	+12
H-21	Single plate to P.P. grids, DC in Pri.	TF4RX15YY	15,000	80,000 split	8	100-20,000	+23
H-22	Single plate to multiple line	TF4RX13YY	15,000	50/200, 125/500	8	50-20,000	+23
H-23	P.P. plates to multiple line	TF4RX13YY	30,000 split	50/200, 125/500	8 BAL.	30-20,000	+19
H-24	Reactor	TF4RX20YY	450 Hys.-0 DC, 250 Hys.-5 Ma. DC, 6000 ohms 65 Hys.-10 Ma. DC, 1500 ohms				
H-25	Mixing or transistors to line	TF4RX17YY	500 CT	500/125 split	20	40-10,000	+30

Typical Subminiature Audios

SM Case
1/2 x 11/16 x 29/32
.8 oz.

Type No	Application	MIL Type	Pri. Imp. Ohms	Sec. Imp. Ohms	Unbal. DC in Pri. MA	Response ± 2 db (Cyc.)	Max. level dbm
H-31	Single plate to 1 grid, 3:1	TF4RX15YY	10,000	90,000	0	300-10,000	+13
H-32	Single plate to line	TF4RX13YY	10,000	200	3	300-10,000	+13
H-33	Single plate to low imp.	TF4RX13YY	30,000	50	1	300-10,000	+15
H-35	Reactor	TF4RX20YY	100 Henries-0 DC, 50 Henries-1 Ma. DC, 4,400 ohms.				
H-36	Transistor Interstage	TF4RX15YY	25,000 (DCR800)	1,000 (DCR110)	.5	300-10,000	+10
H-39	Transistor Interstage	TF4RX13YY	10,000 CT (DCR600)	2,000 CT	2	300-10,000	+15
H-40A	Transistor output	TF4RX17YY	500 CT (DCR26)	600 CT	10	300-10,000	+15

Typical Power Transformers

Pri: 115V 50/60 Cyc.
*Choke/Cond. inp.

Type No.	HV Sec. CT	DC MA*	Military Rating Fil. Secs.	DC MA*	Industrial Rating Fil. Secs.	Case
H-80	450	120	6.3V,2A	**130**	**6.3V,2.5A.**	FA
H-81	500/550	65/55	6.3V,3A-5V,2A	**75/65**	**6.3V,3A.-5V,2A.**	HA
H-82	540/600	110/65	6.3V,4A.-5V,2A.	**180/100**	**6.3V,4A.-5V,2A.**	JB
H-84	700/750	170/110	6.3V,5A.-6.3V,1A.,5V-3A.	**210/150**	**6.3V,6A.-6.3V,1.5A.-5V,4A.**	KA
H-89	850/1050	320/280	6.3V,8A.-6.3V,4A.,5V-6A.	**400/320**	**6.3V,8A.-6.3V,4A.-3V,6A.**	OA

Typical Filament Transformers

Pri: 105/115/210/220V
except H-130 (115) and
H-131 (115/220) 50/60 Cyc.

Type No.	Sec. Volts	Amps.	Test Volts	Case	Type No.	Sec. Volts	Amps.	Test Volts	Case
H-121	2.5	10(12)	10 KV	JB	H-131	6.3 CT	2(2.5)	2500	FB
H-122	2.5	20(26)	10 KV	KB	H-132	6.3 CT 6.3 CT	6(7) 6(7)	2500	JA
H-125	5	10(12)	10 KV	KB	H-133	6.3 CT	7(8)	2500	HB
H-130	6.3 CT	.6(.75)	1500	AJ	H-134	6.3 CT	10(12)	2500	HA

Typical Filter Reactors

Type No.	MIL Type	Ind. Hys.	@ MA DC	Ind. Hys.	@ MA DC	Ind. Hys.	@ MA DC	Ind. Hys.	@ MA DC	Res. Ohms	Max. DCV Ch. Input	Test V. RMS	Case
H-71	TF1RX04FB	20	40	18.5	50	15.5	60	10	70	350	500	2500	FB
H-73	TF1RX04HB	11	100	9.5	125	7.5	150	5.5	175	150	700	2500	HB
H-75	TF1RX04KB	11	200	10	230	8.5	250	6.5	**300**	90	700	2500	KB
H-77	TF1RX04MB	10	300	9	350	**8**	**390**	**6.5**	**435**	60	2000	5500	MB
H-79	TF1RX04YY	7	800	6.5	900	6	1000	5.5	**1250**	20	3000	9000	7x7x8

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VOLUME 49, NUMBER 2

March, 1961

published monthly by The Institute of Radio Engineers, Inc.

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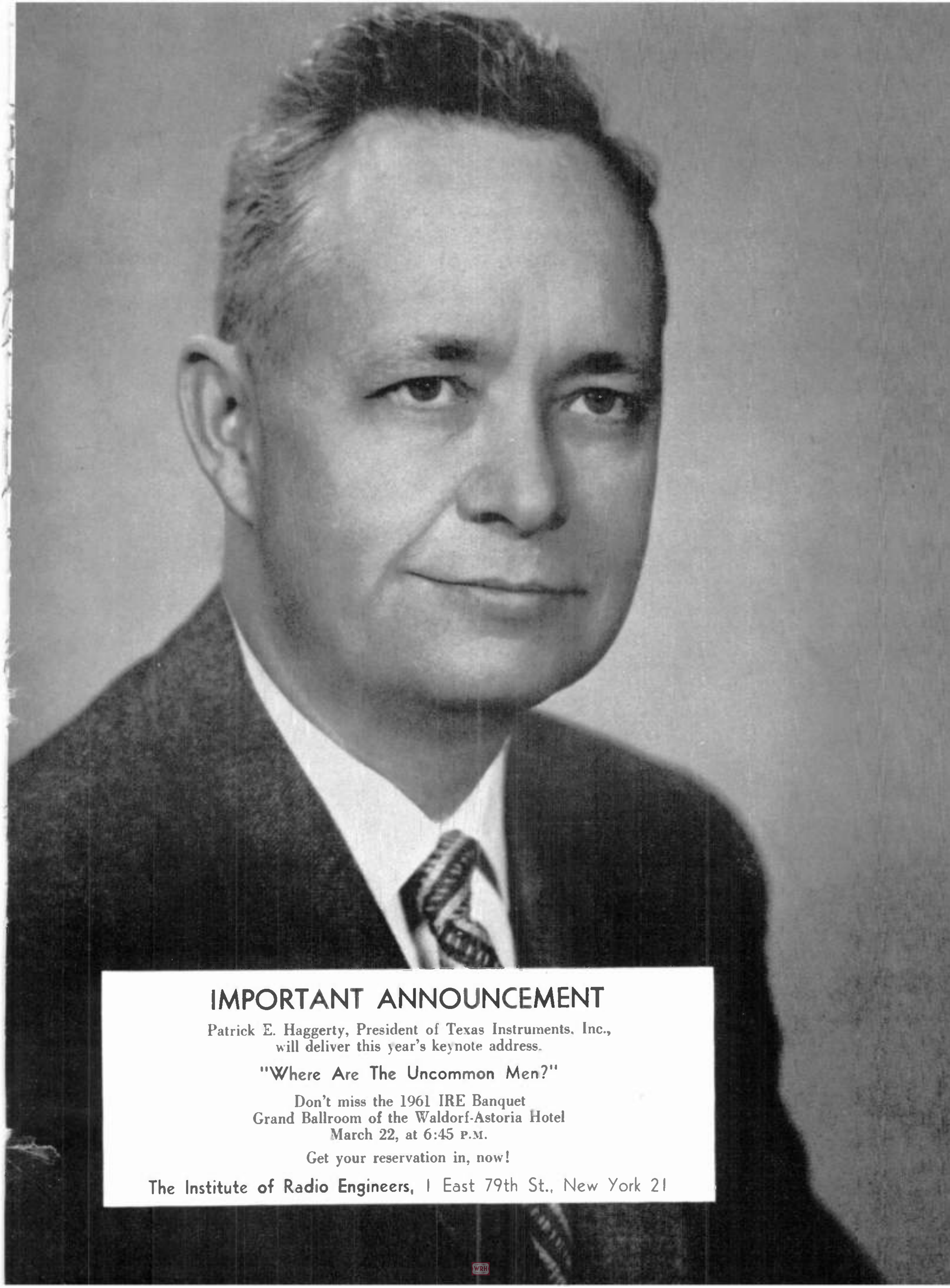
MARCH

PROCEEDINGS OF THE IRE, published monthly by The Institute of Radio Engineers, Inc., at 1 East 79th Street, New York 21, N. Y. Manuscripts should be submitted in triplicate to the Editorial Department. Correspondence column items should not exceed four double-spaced pages (illustrations count as one-half page each). Responsibility for contents of papers published rests upon the authors, and not the IRE or its members. All republication rights, including translations, are reserved by the IRE and granted only on request. Abstracting is permitted with mention of source.

Thirty days advance notice is required for change of address. Price per copy: members of the Institute of Radio Engineers, one additional copy $1.25; non-members $2.25. Yearly subscription price: to members $9.00, one additional subscription $13.50; to non-members in United States, Canada, and U. S. Possessions $18.00; to non-members in foreign countries $19.00. Second-class postage paid at Menasha, Wisconsin, under the act of March 3, 1879. Acceptance for mailing at a special rate of postage is provided for in the act of Febuary 28, 1925, embodied in Paragraph 4, Section 412, P. L. and R., authorized October 26, 1927. Printed in U.S.A.


IMPORTANT ANNOUNCEMENT
Patrick E. Haggerty, President of Texas Instruments, Inc., will deliver this year's keynote address.
"Where Are The Uncommon Men?"
Don't miss the 1961 IRE Banquet
Grand Ballroom of the Waldorf-Astoria Hotel
March 22, at 6:45 P.M.
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AIL and the Compagnie Générale de Télégraphie Sans Fil (CSF) have jointly designed and placed in operation an experimental swept-frequency tropospheric scatter link to determine how tropospheric scatter loss varies with time and frequency. Jack Greene, the Section Head in our Department of Applied Electronics who was responsible for this program, discusses below one interesting aspect of the experimental data collected on this link.

TROPOSPHERIC SCATTER LINK EFFICIENCY AS A SIMULTANEOUS FUNCTION OF TIME AND FREQUENCY*

Signals received over a tropospheric scatter link are subject to severe fluctuations in amplitude because of variations in net path loss. This loss has a rapidly varying component, due to air turbulence, and a slowly varying component, due to changes in weather conditions. To overcome the undesired signal attenuation imposed by the rapid variations in path loss, space diversity reception is ordinarily used. Here, two or more receiving antennas are physically separated so that the resulting variations in path loss at each antenna are uncorrelated. Then, by properly combining the outputs of the antennas, the probability of obtaining a combined output signal that has suffered little fading improves steadily as the number of antennas is increased. Although such systems are effective, they are also costly. Based on some experimental data we have collected on a swept-frequency tropospheric scatter link, it appears that similar high quality reception may also be obtained with a single receiving antenna if the carrier frequency is correctly varied from time to time.

The experimental tropospheric scatter link,[1] which is established in France, has a transmitter frequency that can be swept in a triangular manner at a 10-cps sweep rate over all or any portion of the 3100 to 3600 Mc frequency band. The average transmitted power in this band is 250 watts. A superheterodyne receiver, with a local-oscillator sweep synchronized with the transmitter sweep, measures the amplitude of received signals as a simultaneous function of frequency and time. The resolution bandwidth of the receiver is 0.3 Mc. Signal levels as low as −110 dbm can be tracked and, after a severe fade, the receiver will typically reacquire the signal within a few milliseconds after it rises above this level. The transmitting and receiving antennas are two identical 25 foot parabolic reflectors located 190 miles apart.

During a single sweep period, the received signal amplitude exhibits random fluctuations with about 10 to 15 maxima over a 180 Mc band and up to 40 db differences from maximum to minimum. Figure 1 is a photograph of a frequency-time-intensity presentation in which the received signal level is used to intensify the display and the time axis is generated by moving a film past successive frequency sweeps. In this figure, the signal amplitude has been quantized so that the white areas represent regions in the frequency-time plane where the signal level exceeds a preset threshold. As expected, the white areas become smaller as the threshold level is increased, but an analysis of many records indicates that the correlation between the mean frequency extent and the mean time duration of these areas (1 Mc of frequency extent is equivalent to 0.1 second of time duration) remains substantially constant.[2] In Figure 2, these quantities have been plotted as a function of threshold level.

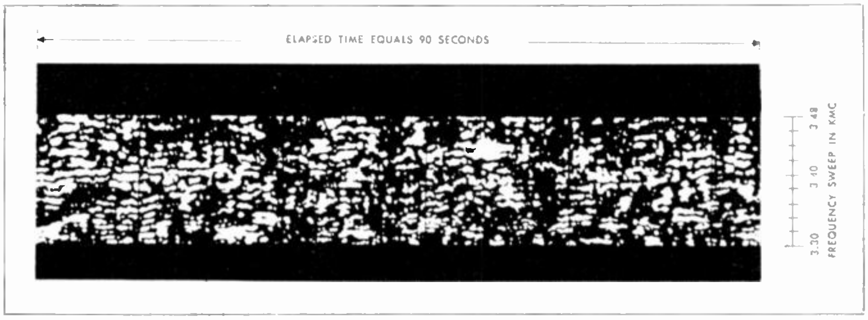

Figure 1—FTI Display Photograph

Figure 1 indicates that there are many optimum transmission bands within the swept range at any instant, and the possibility arises of using these optimum bands to reduce path loss fluctuations. The idea here is to locate the signal spectrum in a preferred (white) band and when the path loss in this band suddenly increases, to shift the signal spectrum to a nearby preferred band. As indicated in Figure 2, an optimum band for such a system is one having a frequency extent only wide enough to pass the desired signal spectrum, since the narrower this extent the lower the path loss. Figure 2 also indicates that an optimum band must be sought more often as the signal bandwidth decreases.

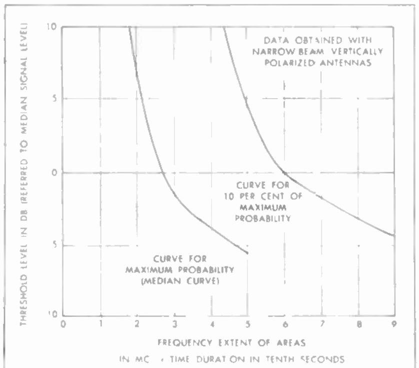

Figure 2—Frequency Extent and Time Duration of Areas vs. Threshold Level

In a practical system of this type, a closed loop is required between the transmitting and receiving ends so that information on the optimum frequency(s) can be relayed periodically to the transmitter. Some thought has been given to this problem and it appears that a simple, effective loop can readily be established. Using such a system in applications where a reasonably large search band can be tolerated, rather dramatic improvements seem quite feasible. For example, with a 50 Mc search band, a signal could be sent over the link with a reliability that would require at least 3 additional receiving antennas in a conventional space diversity system.

Further experimental work is in progress. In particular, CSF personnel are now investigating received signal level as a simultaneous function of frequency, time, and antenna pointing angle.

REFERENCES

1. W. E. Landauer, "Experimental Swept-Frequency Tropospheric Scatter Link," IRE Trans. on Antennas and Propagation, vol. AP-8, p. 423-428, July 1960.
2. J. C. Greene, "Final Report On Time-Frequency Variation of Tropospheric Scatter Propagation," AIL Report 4231-2, August 1960.

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* The work reported here was performed under Contract DA-36-039-sc-73276 with the U. S. Army Signal Research and Development Laboratory, Ft. Monmouth, New Jersey.

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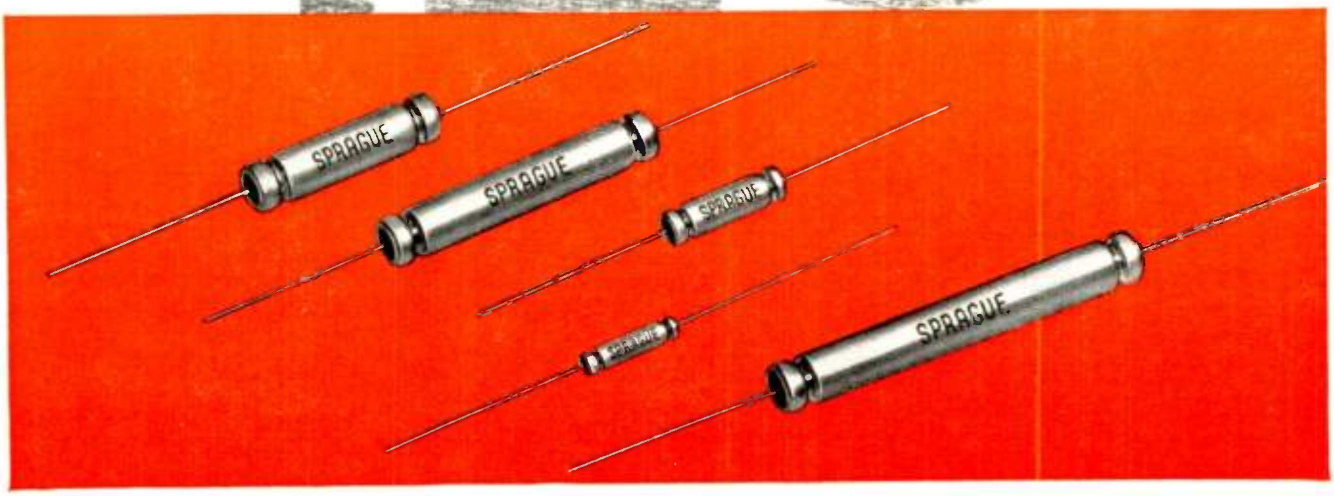

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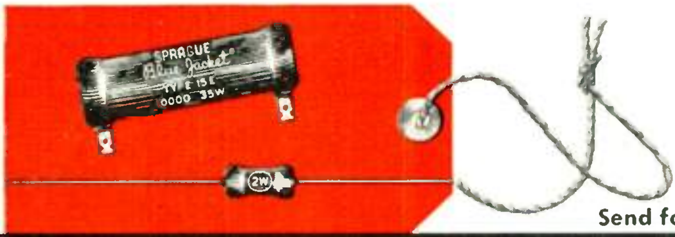

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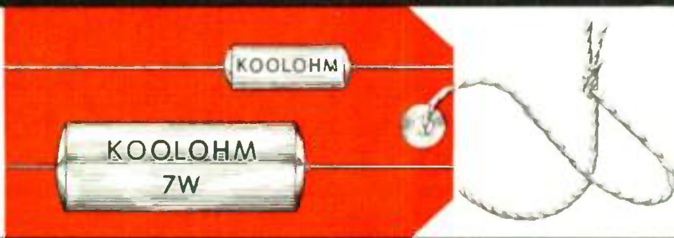

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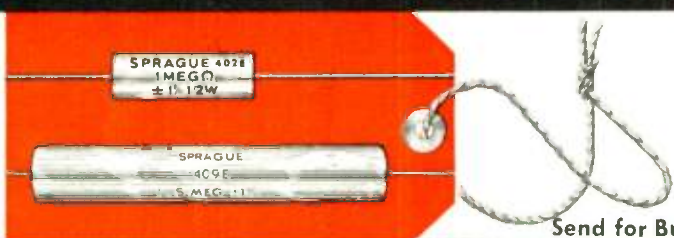

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Meetings with Exhibits

● As a service both to Members and the industry, we will endeavor to record in this column each month those meetings of IRE, its sections and professional groups which include exhibits.

March 20-23, 1961

International Radio and Electronics Show and IRE International Convention, Waldorf-Astoria Hotel and New York Coliseum, New York, N.Y.

Exhibits: Mr. William C. Copp, Institute of Radio Engineers, 72 West 45th Street, New York 36, N.Y.

April 12-13, 1961

15th Annual Spring Technical Conference—"Electronic Data Processing," Hotel Alms, Cincinnati, Ohio.

Exhibits: Mr. J. R. Ebbeler, 7030 Ellen Ave., Cincinnati 39, Ohio.

April 19-21, 1961

SWIRECO, South West IRE Conference & Electronics Show, Dallas Memorial Auditorium and Baker Hotel, Dallas, Tex.

Exhibits: Mr. B. Williams, Texas Instruments, Inc., 6000 Lemmon Ave., Dallas 9, Tex.

April 26-28, 1961

Seventh Region Technical Conference and Trade Show, Westward Ho Hotel, Phoenix, Ariz.

Exhibits: Mr. G. T. Royden, 912 W. Linger Lane, Phoenix, Ariz.

May 8-10, 1961

National Aerospace Electronics Conference (NAECON), Miami & Dayton-Biltmore Hotels, Dayton, Ohio.

Exhibits: Mr. Robert J. Stein, 136 W. Second St., Rm. 202, Dayton 2, Ohio.

May 9-11, 1961

Western Joint Computer Conference, Ambassador Hotel, Los Angeles, Calif.

Exhibits: John H. Whitlock Associates, 253 Waples Mills Road, Oakton, Va.

May 22-24, 1961

Fifth National Global Communications Symposium (GLOBECOM V), Sherman Hotel, Chicago, Ill.

Exhibits: Mr. Fred Hilton, Motorola, Inc., 4501 W. Augusta Blvd., Chicago, Ill.

May 22-24, 1961

National Telemetering Conference, Sheraton Towers Hotel, Chicago, Ill.

Exhibits: Mr. Frank Finch, 795 Gladys Ave., Long Beach 4, Calif.

June 6-8, 1961

Armed Forces Communications & Electronics Show, Sheraton Park and Shoreham Hotels, Washington, D.C.

Exhibits: Mr. William C. Copp, 72 W. 45th St., New York 36, N.Y.

(Continued on page 10A)

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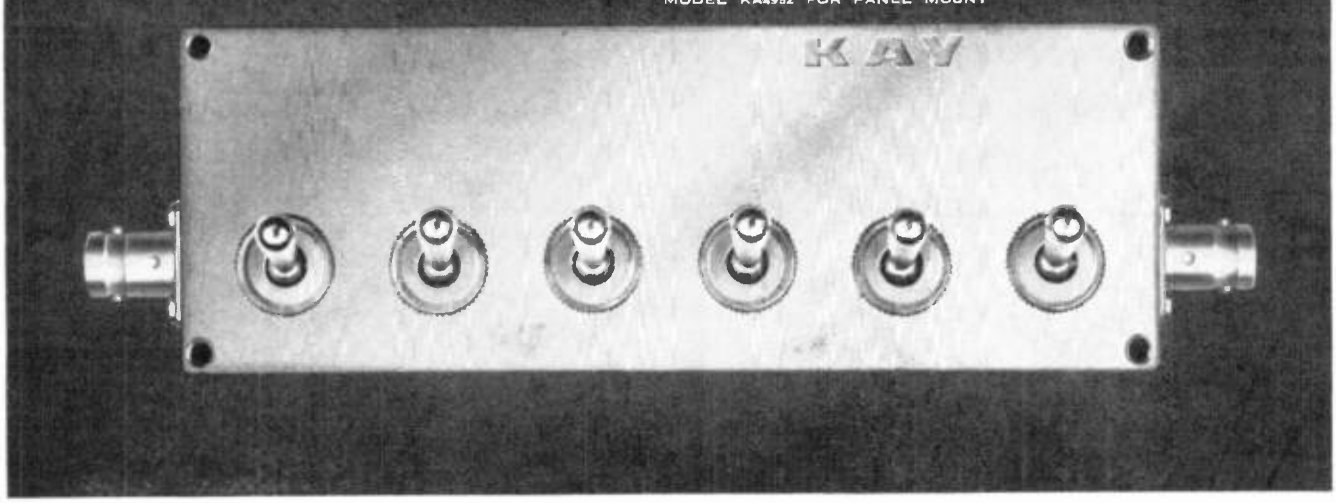

Meetings with Exhibits

(Continued from page 8A)

June 13-14, 1961
Fifth National Conference on Product Engineering & Production, Philadelphia, Pa.
Exhibits: Mr. Paul J. Riley, Radio Corp. of America, Building 10-6, Camden 2, N.J.

June 19-20, 1961
Second National Conference on Broadcast and Television Receivers, O'Hare's Inn, Des Plaines, Ill.
Exhibits: Mr. Ray Lee, Philco Corp., 6957 West North Ave., Oak Park, Ill.

June 26-28, 1961
Fifth National Convention on Military Electronics, Shoreham Hotel, Washington, D.C.
Exhibits: Mr. L. David Whitelock, 6514 Greentree Road, Bethesda 14, Md.

July 16-21, 1961
Fourth International Conference on Medical Electronics & Fourteenth Conference on Electrical Techniques in Medicine & Biology, Waldorf-Astoria Hotel, New York, N.Y.
Exhibits: Mr. Lewis Winner, 152 W. 42nd St., New York 36, N.Y.

August 22-25, 1961
Western Electronic Show and Convention (WESCON), Cow Palace and Fairmont Hotel, San Francisco, Calif.
Exhibits: Mr. Don Larson, WESCON, 701 Welch Road, Palo Alto, Calif.

September 6-8, 1961
National Symposium on Space Electronics & Telemetry, Albuquerque, N.M.
Exhibits: Mr. V. V. Myers, 2912 Texas N.E., Albuquerque, N.M.

October 2-4, 1961
Seventh National Communications Symposium, Hotel Utica & Utica Municipal Auditorium, Utica, N.Y.
Exhibits: Mr. R. E. Bischoff, 19 Westminster Road, Utica, N.Y.

October 2-4, 1961
IRE Canadian Convention, Automotive Building, Exhibition Park, Toronto, Canada.
Exhibits: Business Manager, IRE Canadian Convention, 1819 Yonge St., Toronto 7, Ontario, Canada.

Note on Professional Group Meetings: Some of the Professional Groups conduct meetings at which there are exhibits. Working committeemen on these groups are asked to send advance data to this column for publicity information. You may address these notices to the Advertising Department and of course listings are free to IRE Professional Groups.

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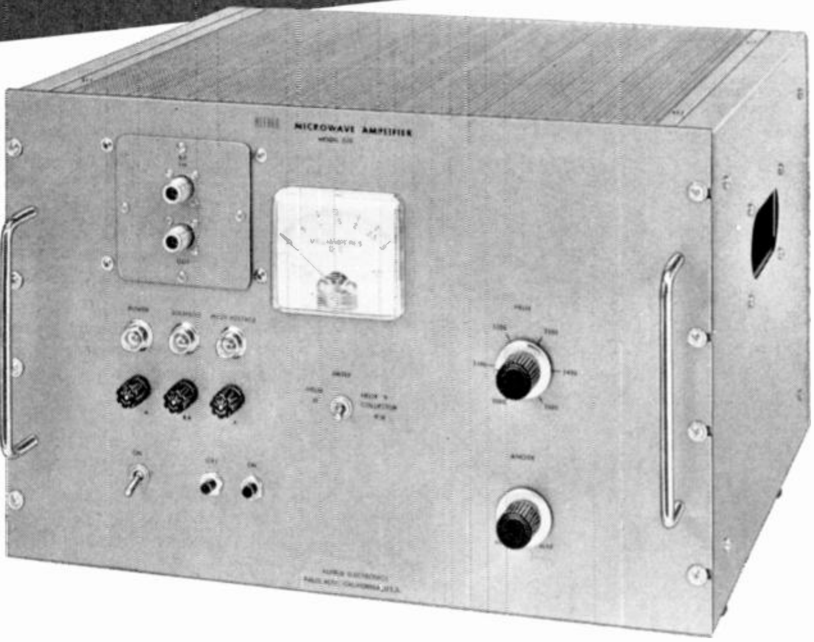

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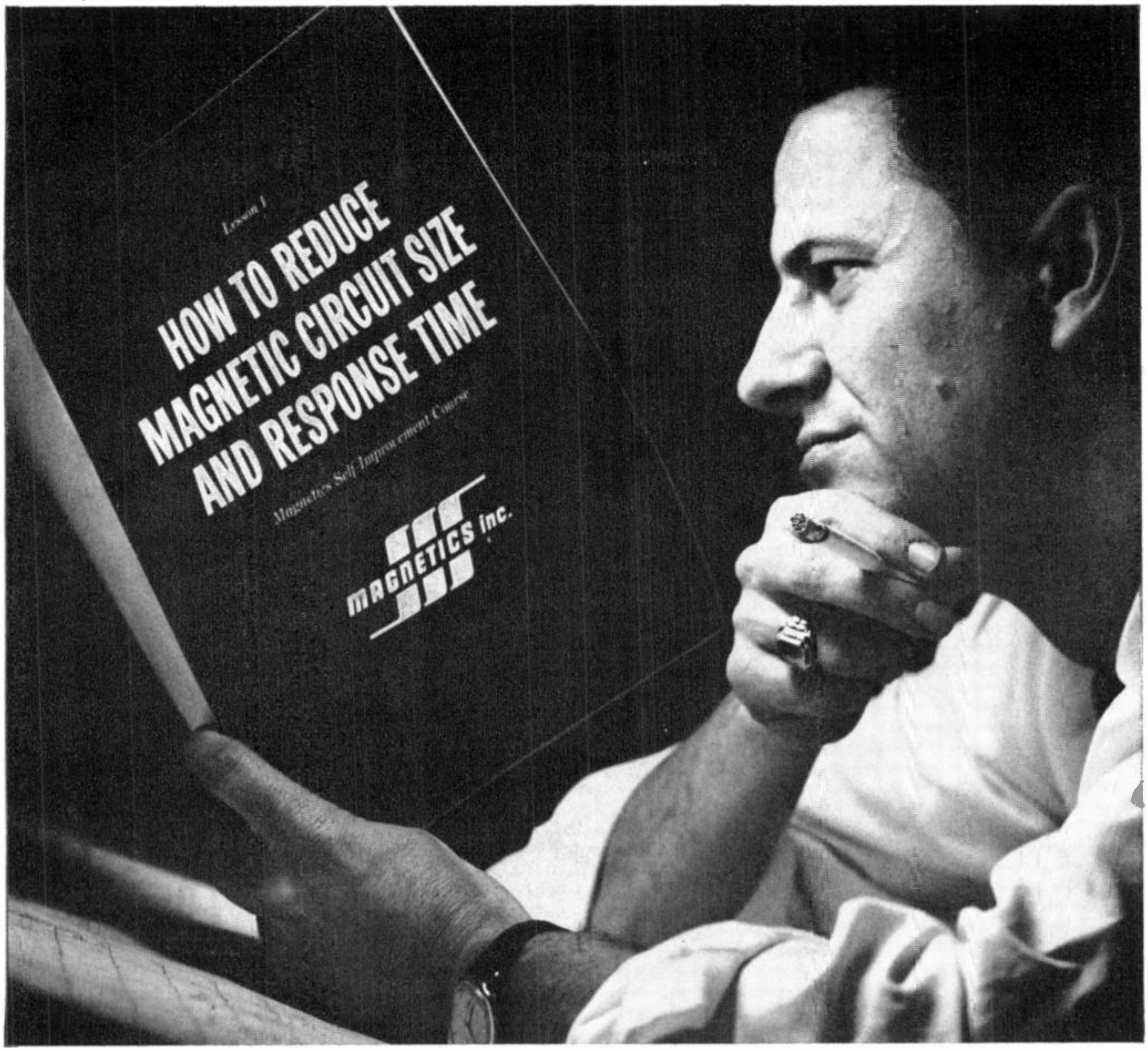

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Current IRE Statistics

(As of January 31, 1960)
Membership—88,479
Sections*—110
Subsections*—28
Professional Groups*—28
Professional Group Chapters—276
Student Branches†—198

* See this issue for a list.
† See October, 1960 issue for a list.

Calendar of Coming Events and Authors' Deadlines*

1961

Symp. on Engrg. Aspects of Magnetohydrodynamics, Univ. of Pa., University Park, Mar. 9–10.

IRE Int'l. Conv., N. Y. Coliseum and Waldorf-Astoria Hotel, New York, N. Y., Mar. 20–23.

2nd Int'l. Conf. on Quantum Electronics, Berkeley, Calif., Mar. 23–25.

PIB Int'l. Symp. on Electromagnetics and Fluid Dynamics of Gaseous Plasma, N. Y., N. Y., April 4–6.

Symp. on Information and Decision Processes, Purdue Univ., Lafayette, Ind., Apr. 12–13.

15th Ann. Spring Tech. Conf., Hotel Alms, Cincinnati, Ohio, Apr. 12–13.

SWIRECO, Dallas, Tex., April 19–21.

7th Region Tech. Conf. & Trade Show, Westward Ho Hotel, Phoenix, Ariz., April 26–28.

URSI-IRE Spring Mtg., Georgetown Univ., Washington, D. C., May 1–4. (DL*: Mar. 1, Commission Chmn., c/o K. S. Kelleher, 1200 Duke St., Alexandria, Va.)

Electronic Comp. Conf., Jack Tar Hotel, San Francisco, Calif., May 2–4.

2nd Nat'l. Symp. on Human Factors in Electronics, Marriott Twin-Bridges Motor Hotel, Arlington, Va., May 4–5.

Workshop in Graph Theory, University of Illinois, Urbana, May 6.

5th Midwest Symp. on Circuit Theory, Allerton Park & Urbana Campus, Univ. of Ill., Urbana, May 8–9.

NAECON, Miami & Biltmore Hotels, Dayton O., May 8–10. (DL*: Abstracts, Jan. 1; Papers, March 7, A. J. Wilde, 4136 Lotz Rd., Dayton 29, Ohio.)

Western Joint Computer Conf., Ambassador Hotel, Los Angeles, Calif., May 9–11.

Microwave Theory and Tech. Nat'l. Symp., Sheraton Park Hotel, Washington, D. C., May 15–17.

* DL = Deadline for submitting abstracts.

(*Continued on page 15A*)

Purdue University Will Sponsor Symposium

Norbert Wiener will head a group of speakers at the Third Symposium on Information and Decision Processes at Purdue University on April 12–13, 1961. Others joining Dr. Wiener on the program will include Richard Bellman of the Rand Corporation, discoverer of the new tool of dynamic programming; T. C. Koopmans, one of the founders of linear programming; Howard Raiffa, co-author with R. D. Luce of the recent book, "Games and Decisions"; L. J. Savage of the University of Michigan, best known for his book, "The Foundations of Statistics."

The two previous symposia have been well attended by representatives of electronic industries, defense industries, the armed services and the universities. Out of these events came the recent book, "Information and Decision Processes," edited by R. E. Machol, chairman of the forthcoming symposium, and published by McGraw-Hill Book Company, Inc. The program on April 12–13 will bring together a new group of eight speakers presenting a sampling of the approaches being taken by some of the most brilliant men in the field to the use of mathematics in the making of optimal decisions in exceedingly complex situations in various branches of engineering and the sciences.

According to Dr. Machol, the program will be of particular interest to those concerned with information theory, decision theory and mathematical statistics as well as those interested in operations research, systems engineering and related fields. He anticipates that members of the audience will have some familiarity with the calculus and with the elements of probability theory, and says that a greater degree of mathematical sophistication will aid in understanding some of the talks.

Complete information on the symposium may be had by addressing Dr. R. E. Machol, School of Electrical Engineering, Purdue University, Lafayette, Ind.

The list of speakers and their subjects follows:

Richard Bellman, Mathematician, the Rand Corporation, "Theory of Dynamic Programming."

T. C. Koopmans, Cowles Foundation for Research in Economics at Yale University, currently visiting at Harvard University, "Axioms for Persistent Preference."

Bradford Dunham, International Business Machines Corporation, "Exploratory Mathematics by Machine."

Norbert Wiener, Institute Professor and Professor of Mathematics, Emeritus, Massachusetts Institute of Technology, "Mathematics of Self-Organizing Systems."

Kai-Lai Chung, Professor of Mathematics, Syracuse University, "The Ergodic Theorem of Information Theory."

Sigeiti Moriguti, Professor, Faculty of Engineering, University of Tokyo, currently visiting at Columbia University, "Further Results in the Theory of Numerical Convergence."

L. J. Savage, Professor of Mathematics, University of Michigan, "Bayesian Statistics."

Howard Raiffa, Professor of Business Administration, Harvard University, "Some Techniques for the Application of Bayes Decision Theory."

P. F. Chenea, Head of the School of Mechanical Engineering, Purdue University, will address a banquet meeting.

NEC Announces Conference Dates

The National Electronics Conference has announced the dates of its 1961 and 1962 meetings. The 1961 Conference will be held at the International Amphitheatre on October 9–11. In 1962 the Annual Conference will be held at Chicago's new lake-front exposition hall, McCormick Place, on October 8–10.

NEC is now in the process of negotiating agreements for the 1963 and 1964 Conferences.

Call for Papers

1961 Western Electronic Show and Convention (WESCON)

August 22–25, 1961

Cow Palace, San Francisco, Calif.

The 1961 Western Electronic Show and Convention now issues a call for papers for its 1961 meeting which is to be held August 22–25 at the Cow Palace in San Francisco, Calif.

Prospective authors are required to submit 100- to 200-word abstracts and 500- to 1000-word detailed summaries of their papers by May 1, 1961, in order to be considered for inclusion in the program. They will be notified by June 1, 1961, of acceptance or rejection of their papers.

Submissions should be sent to: E. W. Herold, c/o WESCON's Northern California Office, 701 Welch Road, Palo Alto, Calif.

PGHFE Plans Spring Meeting

The Second National Symposium on Human Factors in Electronics will be held May 4–5, 1961, at the Marriott-Twin Bridges Motor Hotel in Arlington, Va. This annual meeting is sponsored by the Professional Group on Human Factors in Electronics of the IRE.

E. S. Krendel, Head of the Engineering Psychology Branch of the Franklin Institute Laboratories, Philadelphia, Pa., is Chairman of the Symposium. H. P. Birmingham, Head, Human Engineering Development Section, U. S. Naval Research Laboratory, Washington, D. C., is in charge of local arrangements for the meeting.

Attendance at the First National Symposium, held at Bell Telephone Laboratories, Inc., in New York, N. Y., March 24–25, 1960, totaled about 150.

The special field of interest of the Professional Group on Human Factors in Electronics is "the development and application of human factors and knowledge germane to the design of electronic equipment." R. R. Riesz, Technical Staff, Bell Telephone Laboratories, Inc., Murray Hill, N. J., is Chairman of the PGHFE.

Seventh Region To Hold Annual Conference

The Phoenix Section of the IRE announces its plans to hold the annual Seventh Region Technical Conference for 1961 in Phoenix, Ariz. The conference will be held on April 26–28; headquarters will be at the Hotel Westward Ho. This technical conference is sponsored by the Seventh Region of the IRE.

Special emphasis will be placed on technical papers dealing with the problems of increased use of the electromagnetic spectrum and industrial process control. However, the program will be diversified enough to be of interest to representatives of both military and industrial activities.

As with previous Seventh Region Technical Conferences, an interesting exhibit by electronic manufacturers is planned. The varied program is rounded out by a full schedule of women's activities.

The Phoenix Section is pleased to announce that the National IRE Board of Directors will hold a meeting in Phoenix concurrent with the Conference.

For further information, contact: G. Roydon, Conference Chairman, 912 Linger Lane, Phoenix, Ariz.

Conference on Quantum Electronics To Be Held in California

The Second International Conference on Quantum Electronics will be held in Berkeley, Calif., March 23–25, 1961. Emphasis will be placed on basic theory, progress, and new research efforts in the field. Topics will include methods for the generation of millimeter and shorter waves, coherent sources and amplifiers (high frequency masers, iraser, lasers), and fundamental studies of materials and techniques suitable for the higher frequencies. The conference is sponsored by the Office of Naval Research.

Attendance will be limited to those active in research. For further information, contact: Prof. J. R. Singer, Chairman, Second International Conference on Quantum Electronics, Department of Electrical Engineering, University of California, Berkeley 4, Calif.

Dr. Lloyd V. Berkner, President of the IRE, addressed the members of the New York Section of the IRE at the Section's Fellow Awards Dinner held January 11, 1961, at the Barbizon-Plaza Hotel. Dr. Berkner delivered a talk on "The Professional Responsibilities of the IRE."

Calendar of Coming Events and Authors' Deadlines*

(Continued from page 14A)

GLOBECOM V, Sherman Hotel, Chicago, Ill., May 22–24.

Nat'l. Telemetering Conf., Chicago, Ill., May 22–24.

Electro-Optical Devices Symp., Los Angeles, Calif., May.

3rd Nat'l. Symp. on Radio Frequency Interference, Washington, D. C., June 12–13.

5th Nat'l. Symp. on Product Engrg. and Production, Philadelphia, Pa., June 14–15.

2nd Nat'l. Conf. on Broadcast and Television Receivers, O'Hare Inn, Des Plaines, Ill., June 19–20. (DL*: Feb. 15, N. Frihardt, Motorola Inc., 4545 W. Augusta Blvd., Chicago, Ill.)

MIL-E-CON 1961, Shoreham Hotel, Washington, D. C., June 26–28. (DL*: Feb. 1, 1961, H. Davis, SAFRD, The Pentagon, Washington 25, D. C.)

JACC, Univ. of Colorado, Boulder, June 28–30.

4th Int'l. Conf. On Medical Electronics & 14th Conf. on Elec. Techniques in Medicine & Biology, Waldorf-Astoria Hotel, N. Y., N. Y., July 16–21. (DL*: April 1, 1961, H. P. Schwan, Moore School of E.E., Philadelphia 4, Pa.)

WESCON, San Francisco, Calif., Aug. 22–25. (DL*: May 1, E. W. Herold, WESCON North Calif. Office, 701 Welch Rd., Palo Alto, Calif.)

3rd Int'l. Conf. on Analog Computation, Belgrade, Sept. 4–9.

1961 Symp. on Transmission & Processing of Information, M.I.T., Cambridge, Mass., Sept. 6–8. (DL*: Abstracts, Jan. 1, 1961; Papers, April 1, 1961, P. Elias, M.I.T., Cambridge, Mass.)

1961 Nat'l. Symp. on Space Electronics and Telemetry, Albuquerque, N. M., Sept. 6–8.

Joint Nuclear Instrumentation Symp., North Carolina State College, Raleigh, N. C., Sept. 6–8.

9th Ann. Engrg. Management Conf., New York, N. Y., Sept. 14–16.

10th Ann. Industrial Electronics Symp., Boston, Mass., Sept. 20–21.

7th Nat'l. Communications Symp., Utica, N. Y., Oct. 2–4.

IRE Canadian Electronics Conf., Automotive Bldg., Toronto, Canada, Oct. 2–4.

IRE Canadian Conv., Exhibition Park, Toronto, Can., Oct. 4–6.

Nat'l. Electronics Conf., Chicago, Ill., Oct. 9–11.

5th Nat'l. Symp. on Engrg. Writing and Speech, Kellogg Ctr. for Continuing Education, Michigan State Univ., East Lansing, Oct. 16–17.

East Coast Conf. on Aeronautical & Navigational Electronics, Lord Baltimore Hotel, Baltimore, Md., Oct. 23–25.

Elec. Tech. in Medicine & Biology Conf., Univ. of Nebraska, Lincoln, Oct. 26–27.

Radio Fall Mtg., Hotel Syracuse, Syracuse, N. Y., Oct. 30–31.

NEREM, Boston, Mass., Nov. 14–16.

MAECON, Kansas City, Mo., Nov. 14–16.

* DL = Deadline for submitting abstracts.

NYU Hosts Conference on Reliability Problems

The Electronics Division of the American Society for Quality Control and the Section on Engineering and Physical Sciences of the American Statistical Association are sponsoring a conference on "Mathematics and Statistics for Reliability Problems," to be held at New York University, New York, N. Y., on March 27 28, 1961. The program is being planned to be of especial value to people involved in technical aspects of reliability.

Several sessions are being provided for the presentation of contributed papers. Those who feel that they have ideas or experiences of interest are invited to submit, as soon as possible, one-hundred-word abstracts of papers to the program chairman: W. A. Glenn, Research Triangle Inst., P.O. Box 490, Durham, N. C. Contributed papers should be limited to fifteen minutes presentation time.

Call for Papers

Special Issue of Proceedings of the IRE on Plasmas

It is planned to publish a special issue of the Proceedings of the IRE in the field of gaseous plasmas, during the Fall of 1961. The undersigned has been asked to coordinate this issue and endeavor to obtain outstanding papers in the field for incorporation. Tentatively, it has been decided to look for papers in the following areas:

A. Broad survey papers
B. Original work on
   1) Fundamental processes
   2) Plasma applications to communication, *i.e.*, ionosphere effects, missile re-entry effects, propagation and nonreciprocal transmission through plasmas in magnetic fields, etc.
   3) Plasmas for electric power generation, *i.e.*, MHD and thermionic energy conversion
   4) Plasmas for controlled thermonuclear fusion, including magnetic and electromagnetic containment, and radio-frequency heating
   5) Plasmas for generation of free radicals, new chemical combinations, high-temperature jets, including r-f plasma generation
   6) Low density plasma explorations such as the magnetically contained Penning ionization-gauge type of discharge, ion pumps, etc.
   7) Generation and amplification of oscillations in a plasma, including negative resistance effects, and electron beam excitation
   8) Diagnostic procedures

If you have done any work *or know of any work by others* which ought to be considered for this special issue, please write the undersigned with a brief description, or suggested titles. In order to meet the desired publication schedule, manuscripts should be available by approximately June 1, 1961. Three copies of the paper, including one set of reproducible illustrations, and a photograph and biography of each author should be submitted to the undersigned. Inquiries may also be directed to Mr. E. K. Gannett, Managing Editor, Proceedings of the IRE, The Institute of Radio Engineers, One East 79th Street, New York 21, N. Y.

E. W. Herold
Editor, IRE Plasmas Issue
Varian Associates
611 Hansen Way
Palo Alto, Calif.

7th Annual Radar Symposium Scheduled for Spring

Since 1955, annual radar symposia have been held at the University of Michigan, Ann Arbor, in recognition of the fact that if radar techniques, devices, and applications are to be improved, technical information must be widely disseminated among scientists and engineers working in the field of radar.

With the support of Project MICHIGAN and under sponsorship of the Army, Navy, and Air Force, the Radar Laboratory of the University of Michigan's Institute of Science and Technology will conduct the Seventh Annual Radar Symposium in Ann Arbor, May 31–June 2, 1961. Project MICHIGAN, which engages in research and development for the U. S. Army Combat Surveillance Agency, is carried on by the Institute under Department of the Army Contract DA-36-039 SC-78801, administered by the U. S. Army Signal Corps.

Single general sessions are planned for each morning and afternoon. The papers will pertain to areas of radar research such as the following:

Components and Techniques—antennas, circuitry, power supplies, plumbing, phase shifters, microminiaturization.

Propagation Phenomena—effects in space, aurora problems, weather effects, scatter propagation, high-power effects.

Engineering Applications—inertialess scanning, synthetic antennas, moving-target indication, coherent and master oscillator-power amplifier technologies, terrain avoidance, navigation and guidance, passive radar, high-power methodology, countermeasures, missile and satellite tracking, satellite installations.

New Data and Their Organization—millimeter waves, pulse and frequency analysis, noise, target returns, frontiers and resources of radar performance.

Security clearance through *SECRET* and certification of a need to know will be required.

An announcement detailing security and registration procedures and providing information on housing accommodations will be mailed in March, 1961. Prospective attendees who wish to have their names entered on the mailing list are asked to submit a request by letter or postcard to: Coordinator, Seventh Annual Radar Symposium, Institute of Science and Technology, P.O. Box 618, Ann Arbor, Mich. Special information can be obtained by telephoning H. A. Amble at NOrmandy 3-1511, Ext. 324W, Ann Arbor.

Tenth Annual SSB Dinner

The SSB Amateur Radio Association will sponsor the Tenth Annual SSB Dinner and Hamfest on Tuesday, March 21, 1961, at the Hotel Statler-Hilton, New York, N. Y. All amateurs and their friends are invited. Held during the week of the IRE International Convention, this dinner attracts many outstanding radio amateurs and communications men from all parts of the world. Emphasis will be placed on a large social gathering featuring good food, good fellowship and professional entertainment. There will be no formal speeches.

Equipment displays open at 10 A.M. and the dinner starts at 7:30 P.M. William B. Williams, noted radio personality, will be master of ceremonies. Tickets purchased in advance are $10 each and $11 at the door.

Checks for reservations should be sent to: SSBARA, c/o M. Le Vine, WA2BLH, 33 Allen Rd., Rockville Centre, L. I., N. Y.

MIT Announces Summer Session On Radar Astronomy

A one-week course on Radar Astronomy will be given in the MIT Summer Session from Monday, August 14 through Friday, August 18. The course will include discussions of the physics of the upper atmosphere and extended solar atmosphere, recent advances in the high-powered radar art and recent results in the exploration by radar of the upper atmosphere, the moon and the nearest planets. The lectures will be given by staff members of the Massachusetts Institute of Technology, Lincoln Laboratory, and the Research Laboratory for Electronics, assisted by guest lecturers from other universities. The program will be under the general direction of Drs. J. V. Harrington and J. V. Evans of the Radio Physics Division of the MIT Lincoln Laboratory.

RQC Symposium Issues Call For Papers

The Eighth National Symposium on Reliability and Quality Control, which will be held in the Statler Hilton Hotel, Washington, D. C., January 9–11, 1962, now issues a call for papers.

The time table of the Program Committee is as follows:

May 15, 1961—deadline for submission of title of paper and abstract of not more than 800 words. The letters and spaces in the title for the program must not exceed 50. Submit brief biographical sketches of the author and/or authors, suitable for publication in the PROCEEDINGS. For papers with more than one author, please indicate a single author for the presentation. *Ten copies* of the abstract and biographies should be sent to: E. F. Jahr, IBM Corp., Dept. 351, Owego, N. Y.

June 30, 1961—Authors notified of paper acceptance or rejection.

October 6, 1961—Complete papers submitted to the Program Committee for publication in the Symposium Proceedings.

All papers must be new and not presented prior to the Symposium at a national society meeting. Papers presented at local meetings are acceptable.

John F. Byrne (*right*), Vice President for North America of the IRE, talks with John H. Rubel, Acting Director of the Office of Research and Engineering for the Department of Defense, during the December 9, 1960 meeting of the Los Angeles Section of the IRE. The meeting was held in the Biltmore Hotel, Los Angeles, Calif., and Mr. Rubel spoke on "Technical Decision Making in the Defense Department."

International Conference on Analog Computation to Be Held in Belgrade

The Third International Conference on Analog Computation will take place in Belgrade, Yugoslavia, on September 4–9, 1961. This Conference, organized by the International Association for Analog Computation and the Yugoslav National Committee for ETAN, will be divided into four sections:

1) Theoretical considerations,
2) Analog computing equipment,
3) Application of analog methods and devices, and
4) Connection between analog and digital techniques.

The first section will deal with general and specific theoretical problems concerning the principles of analog computation, the characteristics of computing equipment and the solution of various problems by analog methods.

The second section will be devoted to practical achievements and experiences in the design and realization of various analog computers and computing elements.

The third section will deal with the application of analog computing devices for simulation, computation and analysis in industry, science and engineering.

The fourth section will consider the relationship between analog and digital techniques, their common aspects and interferences.

Apart from the scientific program, a special entertainment program for the participants of the conference and their families will also be arranged.

An exhibition of analog computing equipment and components will be organized during the conference in conjunction with the International Fair of Technical Achievements, which is held every autumn in Belgrade.

The conference may be attended by all persons interested either as individuals or as elected representatives of scientific institutions or companies.

Each person taking part in the conference is entitled to read a paper which must deal with questions concerning analog computation or related branches.

All correspondence relating to the Third International Conference on Analog Computation should be addressed to: Yugoslav Committee for ETAN, Terazije 23/VII, Belgrade, Yugoslavia.

Companies wishing to participate in the exhibition of analog computing equipment are requested to contact the Organizing Committee of the Conference, who will be pleased to provide them with full information concerning terms and conditions of participation.

Air Force MARS Announces Schedule

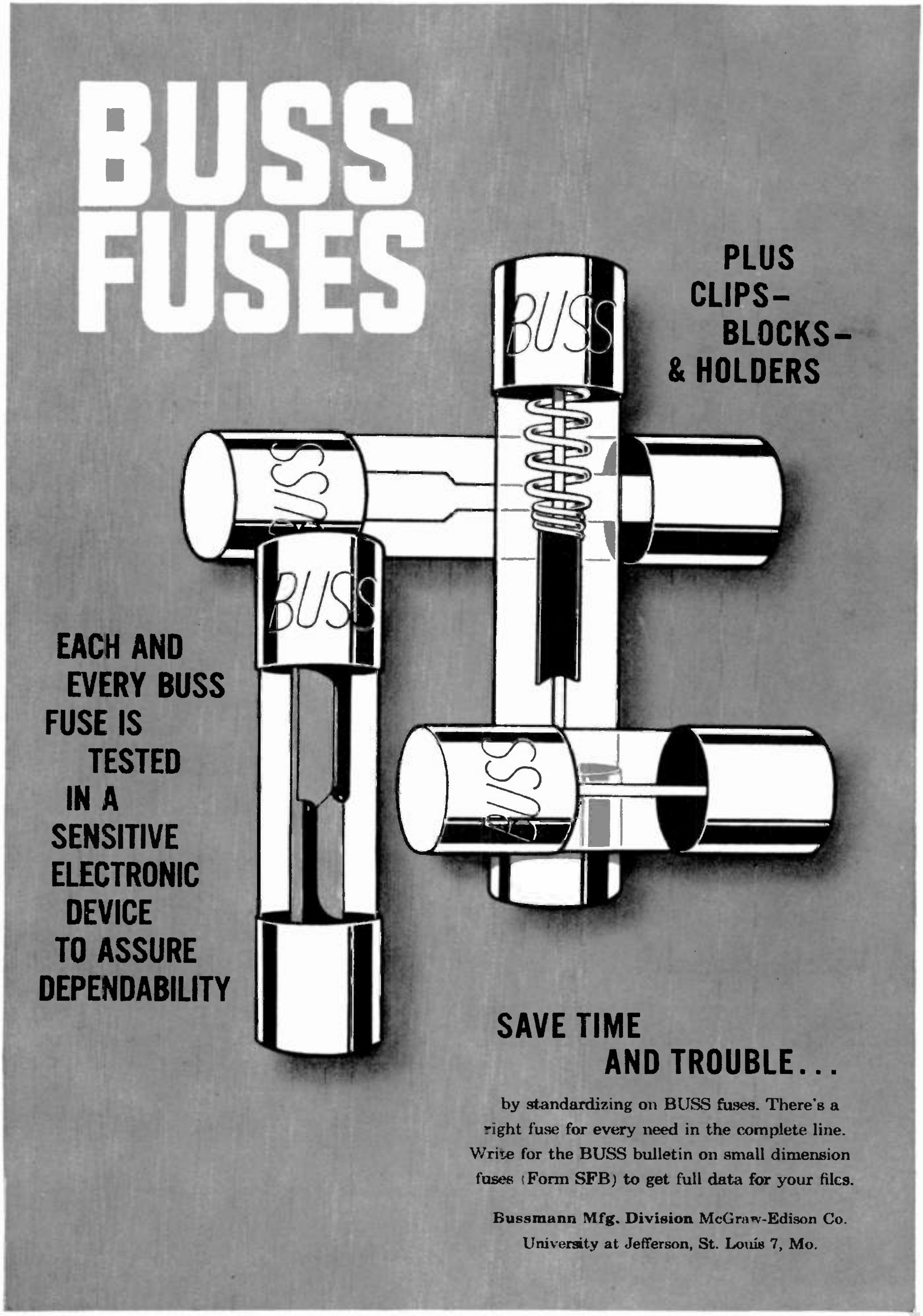
The schedule of broadcasts of the Air Force MARS Eastern Technical Net, operating Sundays from 2 to 4 P.M. EDT, on 3295, 7540, and 15,715 kc, has been announced as follows:

March 19—"Thermionic Power Generation," Dr. J. W. Coltman, Associate Director, Westinghouse Research Laboratories. The basic mechanisms involved in the direct generation of electric power by thermionic means will be reviewed. Factors which set limits to the efficiency and life of such devices will be identified and discussed. The practicality of the thermionic converter will be estimated.

March 26—"Thermonuclear Power," Dr. W. S. Emmerich, Advsiory Physicist, Westinghouse Research Laboratories. The energy produced by the sun and the stars is derived from thermonuclear fusion. The duplication of this process under less than controlled conditions has been demonstrated by the explosion of the hydrogen bomb, but corresponding attempts to obtain power in the laboratory are at a very early stage of development. When these problems reach solution, the immense quantities of deuterium in the waters of the oceans will become available for power production and the fuel problems of the world will have been solved.

April 2—"Single Sideband Circuit Considerations," R. Gunderson, Editor, Braille Technical Press. Modern circuitry and design performance parameters in a step-by-step analysis of sideband equipment will be discussed.

April 9—"Some Aspects of Radio Receiver Design," F. Roberts, Chief Engineer, National Radio Company, Inc. The increasing requirements for sensitivity, selectivity, improved signal-to-noise ratios and special features in radio receiving equipment provide exceptional challenges to the designer. Modern advances and new developments will be described.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Symposium on Electromagnetics and Fluid Dynamics of Gaseous Plasma

April 4–6, 1961, Polytechnic Institute of Brooklyn, Engineering Societies Building, New York, N. Y.

The eleventh international symposium organized by the Polytechnic Institute of Brooklyn, Brooklyn, N. Y., will be held on April 4–6, 1961, in the Auditorium of the Engineering Societies Building, 33 W. 39 St., New York, N. Y. This year the symposium has been organized by the Department of Aerospace Engineering and the Microwave Research Institute in cooperation with the Professional Groups on Electron Devices, Microwave Theory and Techniques, and Nuclear Science of the IRE and the Institute of the Aerospace Sciences. The support of the Air Force Office of Scientific Research, the Office of Naval Research and the U. S. Army Signal Corps permits this series to be held without any charge for admission or registration.

The following advance program may be supplemented by some foreign contributions which are still to be confirmed:

Tuesday Morning, April 4

Opening Session

"Is Aerodynamics Breaking an Ionic Barrier?" *A. Busemann, NASA, Langley Res. Lab.*

"Linear Wave Propagation in Plasmas," *I. B. Bernstein, Princeton University.*

Tuesday Afternoon

Microscopic and Macroscopic Theory

"Microscopic and Macroscopic Models in Plasma Physics," *H. Grad, New York University.*

"Concerning a Continuum Theory of the Electrodynamics and Dynamics of Moving Media," *S. Goldstein, Harvard University.*

"On the Application of Two-Particle Distribution Functions," *J. M. Burgers, University of Maryland.*

"Stability Analysis of Plasmas by a Modified Hydromagnetic Theory," *O. Buneman, Stanford University.*

Wednesday Morning, April 5

Wave Phenomena

"The Effect of Collisions on Two-Stream Instabilities of Plasmas," *D. A. Tidman, University of Maryland.*

"Radiation from Electric Charges in Compressible Plasmas, Part I—Uniformly Moving Charge; Part II—Oscillating Dipole," *M. Abele, A. Hessel and J. Shmoys, Polytechnic Institute of Brooklyn.*

"Interaction of Microwaves in Gaseous Plasmas Immersed in Magnetic Fields," *L. Goldstein, University of Illinois.*

"Investigation into the Problem of Optimum Additional Heating of a Hypersonic Plasma Stream by Means of Oscillating Electromagnetic Fields," *D. H. Middendorf and G. M. Palmer, Purdue University.*

"Power and Energy Relations in Bi-directional Waveguides," *P. Chorney, Massachusetts Institute of Technology.*

Wednesday Afternoon

Comparison of Theory and Experiment

"Interaction Between Magnetic Fields and Moving Plasmas," *W. H. Bostick, Stevens Institute of Technology.*

"Theory of Experiment on the Contribution of Space Charge to the Acceleration of Plasmas," *R. V. Hess, J. Burlock and J. R. Sevier, NASA, Langley Res. Lab.*

"Preliminary Experiments on MHD Effects in Slightly Ionized Gases," *G. W. Sutton, General Electric Company.*

"Plasma Studies in a Shock Tube," *J. W. Daiber and H. S. Glick, Cornell Aeronautical Lab., Inc.*

"Magnetically-Driven Shock Waves," *J. D. Cole and C. Greifinger, California Institute of Technology and the Rand Corporation.*

Thursday Morning, April 6

Shocks and Flows

"Paradoxes Associated with Alfven Flow," *W. Sears, Cornell University.*

"Ionization in Crossed Electric and Magnetic Fields," *S. A. Colgate, Lawrence Radiation Lab.*

"Problems in MFD Turbulence," *L. Napolitano, University of Naples.*

"Oblique Shock Waves in Steady Two-Dimensional Hydromagnetic Flow," *J. Bazer, New York University, and W. B. Ericson, Grumman Aircraft Engineering Corporation.*

"Electromagnetic Diffusion into a Cylindrical Plasma Column," *J. Neuringer, L. Kraus, and H. Malamud, Republic Aviation Corporation.*

"Plasma Dynamics of Rapidly Moving Bodies in Terrestrial Atmosphere," *K. P. Chopra, Polytechnic Institute of Brooklyn.*

Thursday Afternoon

Panel Discussion

In keeping with tradition, the symposium will endeavor to serve the twofold purpose of providing both a review of the present state of research in the plasma field and a forum for discussion of recent outstanding advances of interest to engineers, mathematicians, and physicists involved in plasma research. The program will conclude with a critical summary of the symposium presentations.

Abstracts of all papers, a detailed program and registration forms are available from: Symposium Committee, Polytechnic Institute of Brooklyn, 55 Johnson St., Brooklyn 1, N. Y.

Thirteenth Annual SWIRECO

Dallas Memorial Auditorium, Dallas, Tex., April 19–21, 1961

Dallas Memorial Auditorium, Dallas, Tex., will be the scene of the Thirteenth Annual SWIRECO, April 19–21, 1961.

Dr. Lloyd V. Berkner, president of the IRE and president of the Graduate Re-Research Center, Inc., Dallas, will be guest speaker at a special conference session Thursday afternoon, April 20. He was formerly president of Associated Universities, Inc., New York, N. Y. He managed the Brookhaven National Laboratory, Upton, L. I., N. Y., under contract with the Atomic Energy Commission, and developed the National Radio Astronomy Observatory, Green Bank, W. Va., under contract with the National Science Foundation.

The technical program will consist of twelve key sessions, according to technical program chairman Orville Becklund of Texas Instruments, Inc., in addition to a panel on engineering education Friday morning, April 21, which will be moderated by Dr. W. W. Hagerty, Dean of the College of Engineering, University of Texas, and presentation of student papers from colleges and universities throughout the Southwest. The top three student papers will be presented for the conference on Thursday, April 20.

More than 2,500 paid registrations have already been received for SWIRECO, and over eighty exhibitors will display new products and electronic equipment, according to B. M. Williams, exhibits chairman, also of Texas Instruments, Inc.

A "Showtime Dinner Dance" will be held in the Baker Hotel, and a complete program for IRE wives is planned by ladies' activities chairman, Mrs. Earl Lipscomb and her com-

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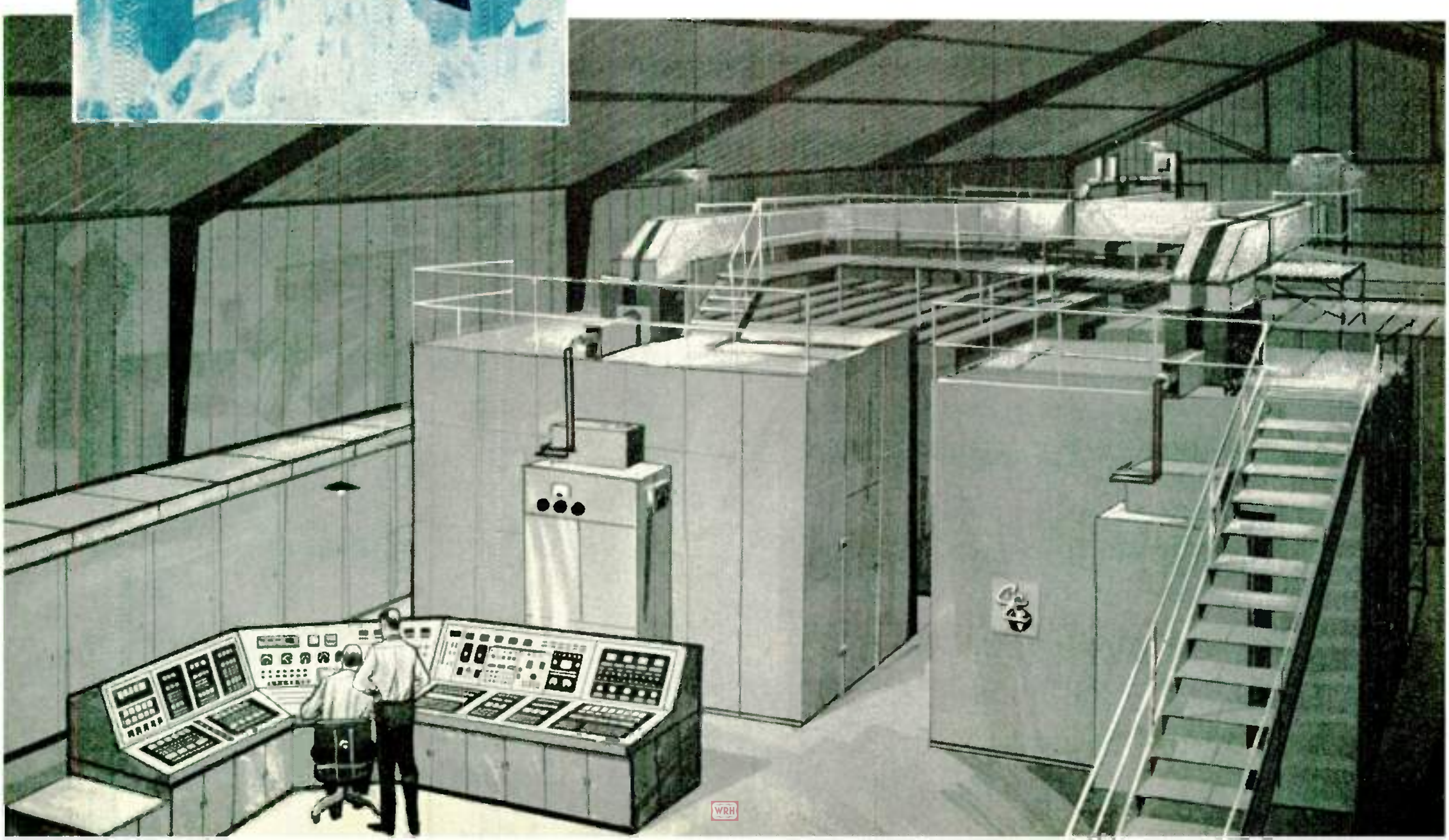


mittee and will consist of sightseeing, fashion and theatrical events.

Registration information is available from F. J. Fogarty, Vought Electronics Div. Chance Vought Corp., P. O. Box 5907, Dallas. General chairman is R. W. Olson of Texas Instruments, Inc.

The tentative program is scheduled as follows:

Wednesday Afternoon, April 19
Session 1—Computer Design

"Design Philosophies of and Problems Encountered in the Design of a Very High Speed Digital Computer," *L. J. Donohoe, Texas Instruments, Inc., Houston, Tex.*

"The Utilization of Switching Algebra to Obtain Analog Computing Circuits for Simulation of Nonlinear Phenomena," *L. E. Heizer, Convair, Fort Worth, Tex.*

"Limiting Factors in Future High Speed Magnetic Computer Memories," *M. M. Stern and H. A. Ullman, Sylvania Electric Products, Inc., Needham, Mass.*

"Transient Response of the Forward Biased Diffused P-N Junction," *H. K. Cooper, Pacific Semiconductors, Inc., Lawndale, Calif.*

Session 2—Semiconductor Design

"An Analysis of Heat Dissipation Problems and Junction Temperature Behavior in Transistors," *G. Kornfuehrer, Texas Instruments, Inc., Dallas, Tex.*

"Thermal Stability of Transistor Stages," *J. A. Walston, Texas Instruments, Inc., Dallas, Tex.*

"Experimental Dependence of Tunneling Probability on Depletion Layer Width in the GaAs Tunnel Diode," *J. C. Day, J. P. Mize, and W. A. Stone, Texas Instruments, Inc., Dallas, Tex.*

Session 3—Microminiature Devices and Digital Design

Moderator: *R. D. Alberts, Wright Air Development Div., Wright-Patterson Air Force Base, Dayton, Ohio.*

"A Microcircuitry AGC Preamplifier," *W. C. Cantwell, Varo Manufacturing Co., Inc., Garland, Tex.*

"Analog Multiplication in a Monolithic Semiconductor Block," *H. C. Lin, C. E. Benjamin, P. W. Smith, and B. Aronson, Westinghouse Research Labs., Pittsburgh, Pa.*

"A Precision Digital Frequency Generator for High Frequency Communication Systems," *M. E. Peterson and W. L. Shockley, Collins Radio Co., Dallas, Tex.*

"High Speed Decade Circuits for Long Counter Chains," *M. E. Peterson and W. L. Shockley, Collins Radio Co., Dallas, Tex.*

"Safety Supervision of Remote-Fired Burners with Transistorized Digital Switching Controls," *D. R. Whitson, Texas Instruments, Inc., Dallas, Tex.*

"Digital Circuit Module Design," *E. P. Fitzgerald, Chance Vought Electronics Div., Dallas, Tex.*

Session 4—Bionics and Medical Electronics

Moderator: *Maj. J. E. Steele, M.D., Wright Air Development Div., Wright-Patterson Air Force Base, Dayton, Ohio.*

"Multi-Valued Logic Devices for Simulating Threshold Neurons," *R. S. Ledley and D. R. Boyle, National Biomedical Research Foundation, Silver Spring, Md.*

"A Stimulation System for Medical Research," *F. W. Wenninger, Jr., and J. E. Tompkins, Frontier Labs., Stillwater, Okla.*

"A Transistorized Radio Frequency Coupled Cardiac Pacemaker," *D. M. Hickman, L. A. Geddes, H. E. Hoff, M. Hinds, A. G. Moore, C. K. Francis, and T. Engen, Baylor University College of Medicine, Houston, Tex*

"A Mobile Physiological Telemetering System for Monitoring FAA Control Tower Operators," *M. Oviatt, FAA, Oklahoma City, Okla.; J. Russell, Dallas, Tex.; W. Greatbatch, Taber Instrument Corp., North Tonawanda, N. Y.*

"The Monitoring of Physiological Parameters in Space Flight," *W. Greatbatch, Taber Instrument Corp., North Tonawanda, N. Y.*

Thursday Morning, April 20
Session 5—Computers

"A Simple Electromechanical Harmonic Analyzer," *H. D. Schwetman and J. H. Cooper, Baylor University, Waco, Tex.*

"Solution of Polynomials by Use of an Electromechanical Synthesizer," *H. D. Schwetman, C. Burmeister, and D. Arrington, Baylor University, Waco, Tex.*

"Increasing the Self-Checking Ability of a Real Time Digital Computer," *W. A. Mulle, RCA, Moorestown, N. J.*

"Differential Analyzer-Type Output from a Compiler-Programmed Digital Computer," *L. L. Howard, Southern Methodist University, Dallas, Tex.*

Session 6—Magnetic Devices

"Magnetic Core Tests for Pulsed Operation of 30-Nanosecond Pulse Width," *G. A. Reeser, University of California, Livermore.*

"Preparation of Single-Crystal Garnets," *L. L. Abernethy, T. H. Ramsey, Jr., and E. L. Johnson, Texas Instruments, Inc., Dallas, Tex.*

"Microwave Application of Single-Crystal Garnets," C. G. McCormick and G. H. Theiss, Texas Instruments, Inc., Dallas, Tex.

"Helium Magnetometer," *B. List, Texas Instruments, Inc., Dallas, Tex.*

Session 7—Equipment Design

"A Dual Output Quartz Crystal Filter and Its Use with a Phase Detector," *D. M. Lauderdale, University of Texas, Austin.*

"A Versatile Phonograph Preamplifier-Equalizer," *H. Fristoe, Oklahoma State University, Stillwater.*

"A TRF Television Receiver," *M. Zimmerman, Electron Corp., Dallas, Tex.*

"Using Circuit Design Tolerances to Optimize Reliability and Cost," *F. K. Heiden and A. L. Stewart, Chance Vought Electronics Div., Dallas, Tex.*

"A High Power Variable Transformation Balun," *J. T. Coleman, RCA, Moorestown, N. J.*

Session 8—Circuit Theory

"Digital Computer Calculation of the Operation of Nonlinear Devices with Energy Storage Elements," *T. H. Puckett and P. R. Hinrichs, University of Oklahoma, Norman.*

"Linearity and the Equipment Designer," *D. Burnett, Stromberg-Carlson Co., San Diego, Calif.*

"Quiescent Stabilization of the Transistor as an Amplifier," *H. T. Fristoe, Oklahoma State University, Stillwater.*

"Design of a Series Tuned Negative Resistance Amplifier," *J. C. Paul, Oklahoma State University, Stillwater.*

Friday Afternoon, April 21
Session 9—Communications and Telemetry

"A Transistorized Phase-Locked Receiver for Receiving VLF Time and Frequency Standard Broadcasts," *O. J. Baltzer, Textron Corp., Austin, Tex.*

"Engineering Trade-Offs for Mercury Capsule Communications," *W. Benner, McDonnell Aircraft Corp., St. Louis, Mo.*

"UHF Multi-Polarized Antenna," *C. T. Wadlington and T. R. Fouts, Vought Electronics Div., Dallas, Tex.*

"Communication System Using Thermoelectric Generators and Gas Fired Tower Lights," *F. V. Long, Texas Eastern Transmission Corp., Shreveport, La.*

Session 10—Systems

Moderator: *J. F. Reagan, Chance Vought Aircraft Inc., Dallas, Tex.*

"A Study of Airborne Radar-Beacon Traffic," *S. Neshyba, Arlington State College, Arlington, Tex., and R. R. Coffman, Convair, Fort Worth, Tex.*

"Reliability Analysis and Prediction Independent of Distribution," *J. S. Donaldson, Chance Vought Electronics Div., Dallas, Tex.*

"The Computer Simulation of a Colonial Socio-Economic Society," *W. D. Howard, General Motors Corp., Warren, Mich.*

"A Digital Range Tracking System," *D. Nepveax, General Electric Co., Ithaca, N. Y.*

Session 11—Geophysics

"Investigations of a Possible Electrodynamic Process in the Formation of Tornadoes," *E. M. Wilkins, Temco Electronics and Missiles Co., Dallas, Tex.*

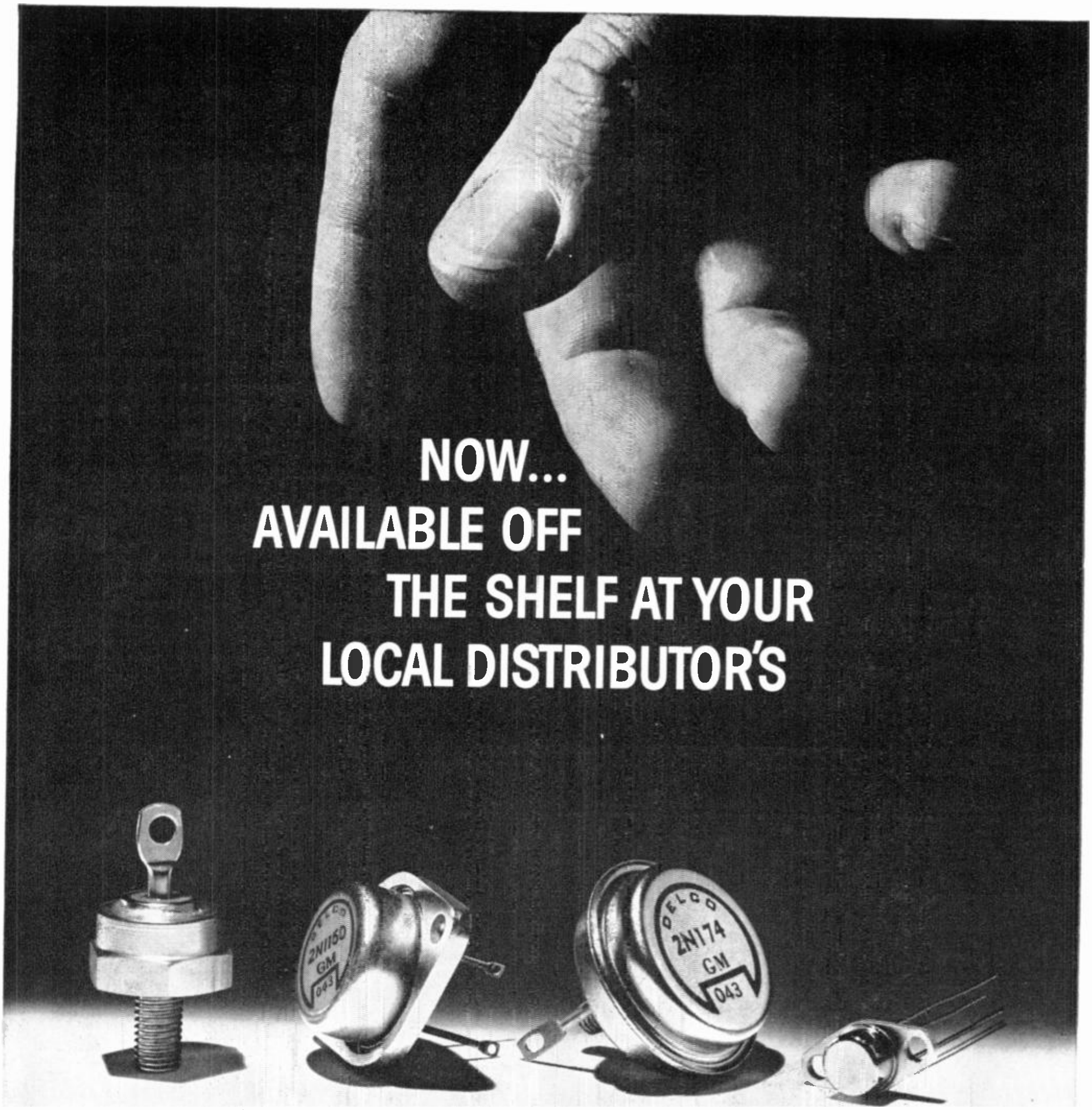
"Measurement and Analysis of Magnetotelluric Signals," *H. W. Smith and F. X. Bostick, University of Texas, Austin.*

"The Effects of Ionizing Radiations on Man in Space," *K. E. Richter, Temco Electronics and Missiles Co., Dallas, Tex.*

Session 12—Industrial Electronics

"The Industrial Electronic Distributor," *R. W. Snipes, Engineering Supply Co., Dallas, Tex.*

"A Concept of Distribution in the Industrial Electronics Industry," *D. D. Coleman, Ampex Magnetic Tape Products, Dallas, Tex.*



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Aerospace & Navigational Electronics (G-11)—E. A. Post, Radio Systems Lab., Stanford Res. Inst., Menlo Park, Calif.; H. R. Mimno, Cruft Lab., Harvard Univ., Cambridge 38, Mass.

Antennas & Propagation (G-3)—E. C. Jordan, E. E. Dept., Univ. of Illinois, Urbana, Ill.; S. A. Bowhill, Pennsylvania State Univ., University Park, Pa.

Audio (G-1)—H. S. Knowles, Knowles Electronics, 9400 Belmont Ave., Franklin Park, Ill.; M. Camras, Armour Res. Found., Tech. Ctr., Chicago 16, Ill.

Automatic Control (G-23)—J. M. Salzer, Ramo-Wooldridge, 5500 El Segunda, Hawthorne, Calif.; G. S. Axelby, Westinghouse Air Arm Div., Friendship Airport, Baltimore 3, Md.

Bio-Medical Electronics (G-18)—H. P. Schwan, Univ. of Pennsylvania, Moore School of E. E., Philadelphia 4, Pa.; L. B. Lusted, Dept. of Radiology, Univ. of Rochester, Rochester 20, N. Y.

Broadcast & Television Receivers (G-8)—R. R. Thalner, Sylvania Home Electronics, 700 Ellicott St., Batavia, N. Y.; C. W. Sall, RCA, Princeton, N. J.

Broadcasting (G-2)—G. E. Hagerty, Westinghouse Elec. Corp., 122 E. 42 St., Suite 2100, N. Y. 17, N. Y.; W. L. Hughes, E.E. Dept., Iowa State College, Ames, Iowa.

Circuit Theory (G-4)—S. Darlington, Bell Telephone Labs., Murray Hill, N. J.; M. E. Van Valkenburg, Dept. of E.E., Univ. of Illinois, Urbana, Ill.

Communications Systems (G-19)—C. L. Engleman, Engleman & Co., Inc., 2480 16th St., N.W., Washington 9, D. C.; W. B. Jones, Jr., School of E. E., Georgia Inst. Tech., Atlanta 13, Ga.

Component Parts (G-21)—F. E. Wenger, Headquarters ARDC, Andrews AFB, Washington 25, D. C.; G. Shapiro, Engineering Electronics Sec., Div. 1.6, NBS, Connecticut Ave. and Van Ness St., Washington 25, D. C.

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Electron Devices (G-15)—A. K. Wing, Jr., ITT Labs., 500 Washington Ave., Nutley 10, N. J.; E. L. Steele, Hughes Prods., Inc., 500 Superior Ave., M.S. A 2308, Newport Beach, Calif.

Electronic Computers (G-16)—A. A. Cohen, Remington Rand Univac, St. Paul 16, Minn.; H. E. Tompkins, E. E. Dept., Univ. of New Mexico, Albuquerque, N. M.

Engineering Management (G-14)—H. M. O'Bryan, Sylvania Elec. Products, 730 3rd Ave., N. Y. 17, N. Y.; A. H. Rubenstein, Dept. of Indus. Engrg., Northwestern Univ., Evanston, Ill.

Engineering Writing and Speech (G-16)—J. M. Kinn, Jr., *IBM Journal*, 17th Floor, 545 Madison Ave., N. Y., N. Y.; H. B. Michaelson, IBM Res. Center, Box 218, Yorktown Heights, N. Y.

Human Factors in Electronics (G-28)—R. R. Riesz, Bell Te ephone Labs., Murray Hill, N. J.; J. I. Elkind, Bolt, Beranek and Newman, Inc., 50 Moulton St., Cambridge, Mass.

Industrial Electronics (G-13)—J. E. Eiselein, RCA Victor Div., Camden, N. J.; R. W. Bull, Coleman Instruments, Inc., 42 Madison St., Maywood, Ill.

Information Theory (G-12)—P. E. Green, Jr., Lincoln Lab., M.I.T., Lexington, Mass.; A Kohlenberg, Melpar Inc., 11 Galen St., Watertown, Mass.

Instrumentation (G-9)—C. W. Little, C-Stellerator Assoc., Box 451, Princeton, N. J.; G. B. Hoadley, Dept. of E.E., North Carolina State College, Raleigh, N. C.

Microwave Theory and Techniques (G-17)—K. Tomiyasu, General Engrg. Lab., General Electric Co., Bldg. 37, Schenectady, N. Y.; D. D. King, Electronic Comm., Inc., 1830 York Rd., Timonium, Md.

Military Electronics (G-24)—E. G. Witting, R&D Dept., U. S. Army, Pentagon, Washington 25, D. C.; D. R. Rhodes, Radiation Inc., Box 6904, Orlando, Fla.

Nuclear Science (G-5)—L. Costrell, Nucleonic Inst. Sec., NBS, Washington 25, D. C.; R. F Shea, Dig Power Plant Engrg., Knolls Atomic Power Lab., General Electric Co., Schenectady, N. Y.

Product Engineering and Production (G-22)—W. D. Novak, General Precision Lab., 63 Bedford Rd., Pleasantville, N. Y.; D. B. Ehrenpreis, 325 Spring St., New York, N. Y.

Radio Frequency Interference (G-27)—R M. Showers, Moore School of E.E., 200 S. 33 St., Philadelphia 4, Pa.; O. P. Schreiber, Technical Wire Prods., Inc., 48 Brown Ave., Springfield, N. J.

Reliability and Quality Control (G-7)—P. K. McElroy, General Radio Co., 22 Baker Ave., West Concord, Mass.; W. X. Lamb, Jr., 22124 Dumetz Rd., Woodland Hills, Calif.

Space Electronics and Telemetry (G-10)—R. V. Werner, Cubic Corp., 5575 Kearney Villa Rd., San Diego 11, Calif.; F. T. Sinnott, Mail Zone 549-30, Convair-Astronautics, San Diego 12, Calif.

Ultrasonics Engineering (G-20)—D. L. Arenberg, Arenberg Ultrasonic Lab., Inc., 94 Green St., Jamaica Plain 30, Mass.; O. E. Mattiat, Res. Div., Acoustica Associates Inc., 415 E. Montecito St., Santa Barbara, Calif.

Vehicular Communications (G-6)—R. P. Gifford, General Electric Co., Rm. 206, Mountain View Rd., Lynchburg, Va.; W. G. Chaney AT&T Co., 195 Broadway, N. Y 7, N. Y.

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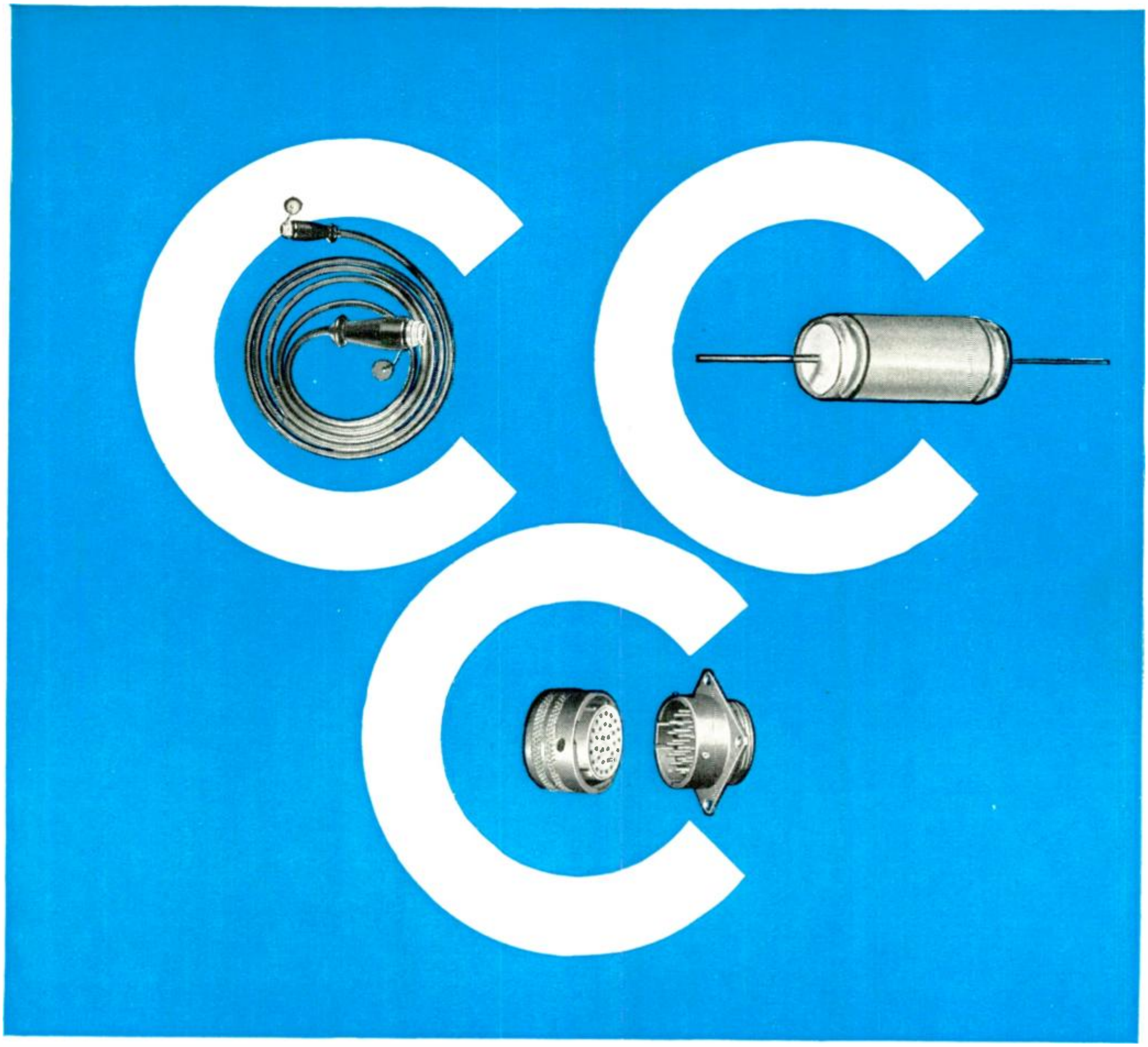

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Rio de Janeiro—J. A. Wiltgen, Caixa Postal 450, Rio de Janeiro, D.F., Brazil; Secretary to be advised.

AN ACHIEVEMENT IN DEFENSE ELECTRONICS

HIPAR Proves Effective In Hercules Anti-Missile Test

This new General Electric *High Power Acquisition Radar* (HIPAR) more than triples the detection capability of the U. S. Army's Nike-Hercules System. Produced for Western Electric, Nike-Hercules System Prime Contractor, this General Electric radar provides high resolution target data at long range and high altitudes on bomber and fighter aircraft, air-launched missiles and tactical ballistic missiles. The effectiveness of this Improved System was demonstrated at the White Sands Missile Range on June 3, 1960, with the successful intercept and destruction of a Corporal Missile, and in August and September, 1960, when target Nike-Hercules Missiles were destroyed by their defending counterparts at altitudes to almost 100,000 feet and closing speeds near Mach 7. 176-06

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Las Cruces-White Sands Proving Ground (6)—H. Coleman, Box 1238, Las Cruces, N. M.; Secretary to be advised.

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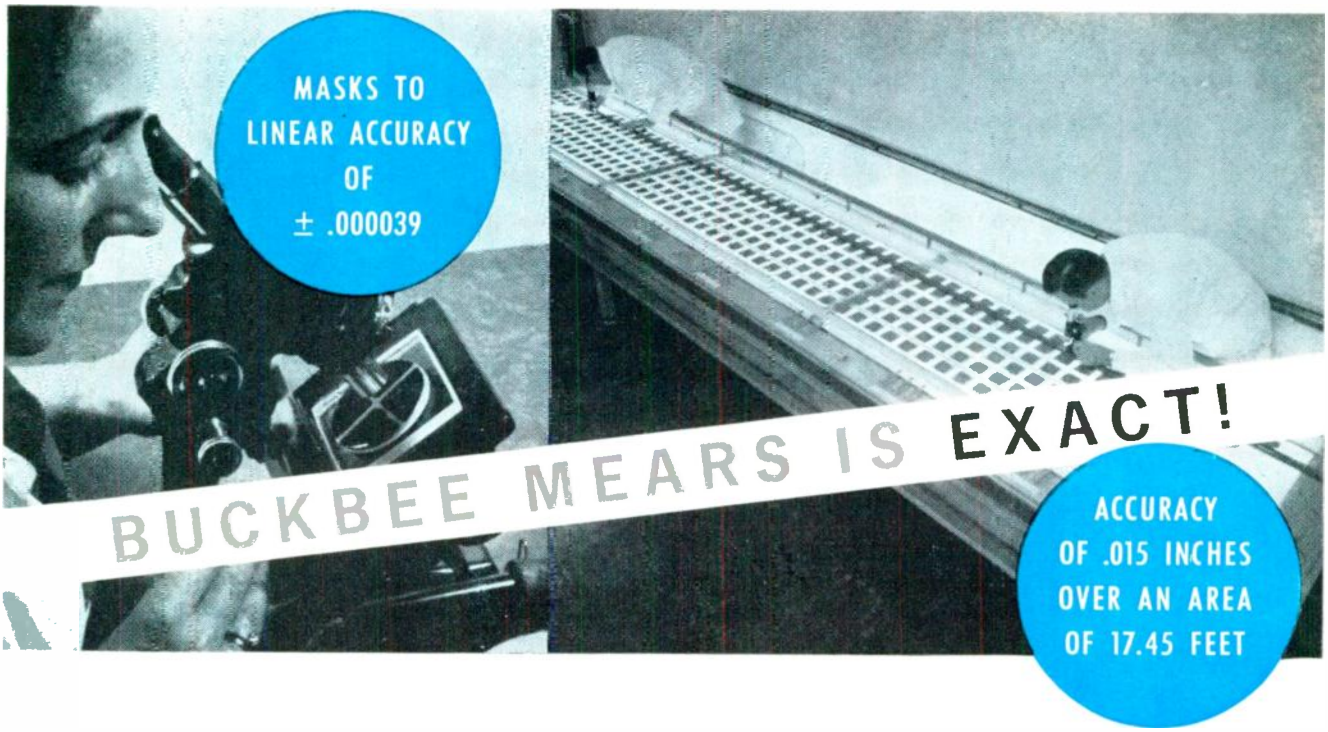

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Industrial Engineering Notes*

Governmental and Legislative

A vigorous increase in activity in three scientific and technological areas of vital concern to the electronics industry—space communications, instrumentation, and radio astronomy—was recommended in the first report of President-elect Kennedy's Ad Hoc Committee on Space.

The report cited the "important contributions to our civilian efforts and our economy" of such applications of space technology as satellite communications and broadcasting; satellite navigation and geodesy; meteorological reconnaissance; and satellite mapping.

It advocated immediate initiation of a research program in advanced instrumentation. "Problems of automation, processing, and transmission of information must be tackled by competent and imaginative research teams," the report declared.

In the field of astronomy, the Committee's report forecast a "major breakthrough in the development of radio telescopes. By means of radio telescopes we can now 'see' not only the stars, but also the great masses of gas between the stars; we can detect the high-energy electrons produced by cosmic accelerators located thousands or millions of light years away from the earth."

The nine-man Ad Hoc Committee is headed by Dr. Jerome B. Weisner, Director of the Electronics Research Laboratory at the Massachusetts Institute of Technology. Dr. Weisner has been named Special Assistant for Science and Technology to President-elect Kennedy.

The Weisner report, highly critical of present space efforts, made these recommendations:

1) Make the Space Council an effective agency for managing the national space program.

2) Establish a single responsibility within the military establishments for managing the military portion of the space program.

3) Provide a vigorous, imaginative, and technically competent top management for the National Aeronautics and Space Administration.

4) Review the national space program and redefine the objectives in view of the experience gained during the past two years. Particular attention should be given the booster program, manned space flight, the military uses of space, and the application of space technology to the civilian activities of the country.

5) Establish the organizational machinery within the government to administer an industry-government civilian space program.

On the non-military applications of space technology and an industry-government space program, the Ad Hoc Committee said many civilian uses for satellites emerged as the technical feasibility and reliability of man-made satellites were demonstrated. It made the following observations on the direction future civilian space programs should take:

"Industrial and governmental communications satellites appear practical and economically sound. Communication satellites will provide high quality and inexpensive telephone and general communication service between most parts of the earth. A by-product of a communication satellite will almost surely be an international television relay system linking all the nations of the world. On a longer time scale it should be feasible to provide radio and television broadcasting service via satellite-mounted transmitters. Such systems would give the quality broadcast reception now only available in and near urban areas to most of the inhabitants of the earth.

"Satellites containing reliable beacons can be used to provide improved means of navigation for aircraft and ships at sea and can greatly advance the field of geodetics.

"Proper use of the information gathered by meterological satellites should greatly increase our understanding of meteorology. With more knowledge of meteorology and with world-wide data frequently available from the satellites, longer-range and more reliable weather predictions should be possible. These projects, dreams a decade ago, bridge areas of technical speciality in which this nation is unexcelled. The United States has the most advanced communication system in the world, with a vast scientific and technological base supporting the communication industry. We are preeminent in the development of our electronic skills in radio, television, telephone and telegraphy. This entire industrial-scientific base is available to apply its art through satellite systems to the civilian needs of the world.

"The exploitation of a new area of industrial opportunity for civilian use is normally left by our government to private enterprise. However, in the case of these important space systems, the development investment required is so large that it is beyond the financial resources of even our largest private industry. Furthermore, the use of commercial space vehicles will require physical support of government installations as well as financial support.

"All of the civilian satellite projects listed here will have direct or indirect military usefulness as well. Furthermore, com-

(Continued on page 32A)

* The data on which these NOTES are based were selected by permission from *Weekly Report* issues of January 3, 9, and 16, 1961, published by the Electronic Industries Association, whose helpfulness is gratefully acknowledged.

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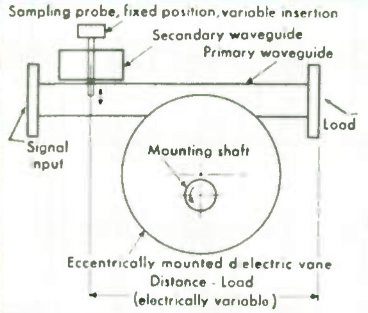
FXR G105A SLOTTED SECTION



Frequency Range: 140-220 KMC/sec

Novel technique (see drawing) incorporates a fixed position probe and an adjustable phase shifter to sweep VSWR pattern past the probe.

Recommended accessories:
FXR G208A Detector Mount and Crystal

FXR also has available the most complete line of mm waveguide components for use in the 18 KMC to 90 KMC region.

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Series 208 Detector Mount can be used with replaceable crystal, bolometer, or thermistor cartridges
Recommended accessories:
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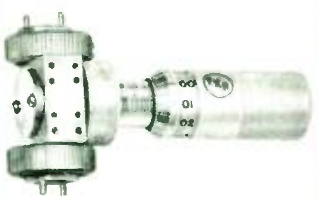

FXR G412A FREQUENCY METER

Frequency Range: 140-220 KMC/sec

Micrometer dial, calibration chart supplied provides an accuracy of ±0.5%. Specific point accuracy ±0.2%.

Self-calibrating by using successive resonances

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FREQUENCY RANGE IN KMC/SEC	90.-140.		140.-220.	
SLOTTED SECTIONS	F105A	$1400	G105A	$1400
ATTENUATORS—Precision Calibrated	F163A	$ 975	G163A	$ 975
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CRYSTAL DETECTOR CARTRIDGE	Z224S	$ 150	Z224S	$ 150
HARMONIC GENERATOR	F781A	$ 475	G781A	$ 475
HARMONIC GENERATOR CARTRIDGE	Z225S	$ 150	Z225S	$ 150
BOLOMETER CARTRIDGE	Z230S	$ 150	Z230S	$ 150
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WAVEGUIDE BENDS—90° E-plane 90° H-plane	F623A F624A	$ 275 $ 275	G623A G624A	$ 275 $ 275
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RA. 1-9000
TWX: NY 43745

PRECISION MICROWAVE EQUIPMENT • HIGH-POWER PULSE MODULATORS • HIGH-VOLTAGE POWER SUPPLIES • ELECTRONIC TEST EQUIPMENT

Industrial Engineering Notes

(*Continued from page 30A*)

munication and navigation systems of the type envisaged would be extremely useful in implementing an inspection system which might accompany a disarmament agreement. For these reasons projects of the type proposed might well be undertaken in cooperation with the military services.

"We recommend a vigorous program to exploit the potentialities of practical space systems. The government, through NASA or the Department of Defense, should make available the required facilities as well as any extraordinary financial support to make the undertakings successful.

"Organizational machinery is needed within the executive branch of the government to carry out this civilian space program."

The Federal Communications Commission has broadened its study of long-range frequency needs for space communications by adding a new issue regarding earth terminal sites in sparsely populated areas.

The FCC said it needs information on whether protected areas might be established and held in reserve for future earth terminals for civil communication systems via space relays. If such a concept were adopted, the Commission said, "it might be advisable to prohibit, for example, the use of certain frequency bands between 1215 Mc and 10,000 Mc within 'X' miles of a given site for any use other than space communication."

Deadline for initial comments in the proceeding remains March 1.

A year-end statement by Federal Communications Commission Chairman Frederick W. Ford re-emphasized the Commission's intent to press for legislation requiring the manufacture of all-channel television receivers only.

In reviewing "one of the most eventful and significant" years for the FCC, Chairman Ford also highlighted the increasing popularity of FM, the surge of interest in educational TV, channel splitting to provide for more safety and special radio services, and the Commission's actions in frequency allocations. Mr. Ford also predicted a decision soon on an application for experimental subscription TV broadcasts in Hartford, Conn.

The Federal Communications Commission has acquired space in New York City's Empire State Building for a high-power television station to be used for two years of tests of UHF transmission and reception.

The Commission leased space on the building's 80th floor at a cost of $93,600 a year for antenna and floor space. The new station joins seven commercial stations which broadcast from the building.

It was disclosed that contract negotiations are under way for construction of the station. The $2-million project is financed with funds appropriated during the last session of Congress.

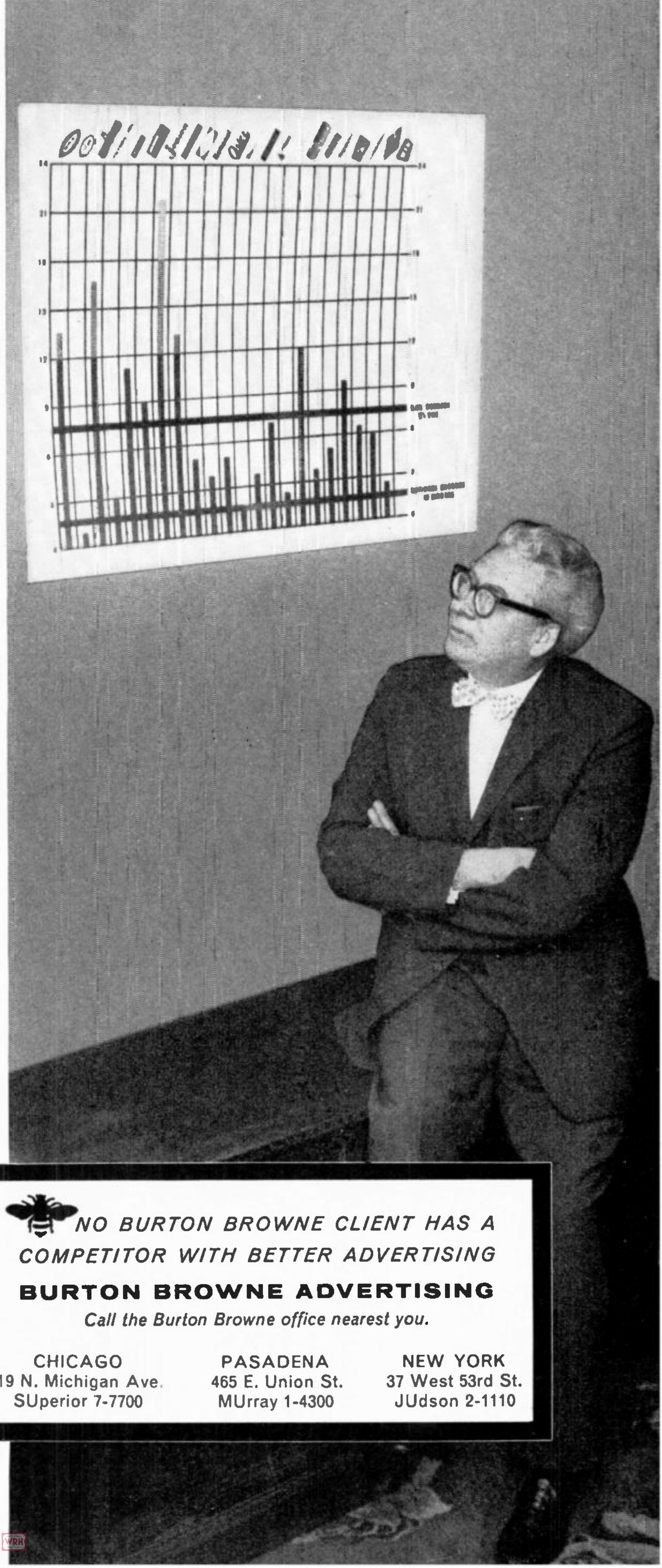
The Federal Communications Com-

(*Continued on page 34A*)

PROFILES OF INDUSTRY

BURTON BROWNE ADVERTISING

A REFRESHING EXCEPTION WHERE CLIENTS STAY PUT



Mr. Burton Browne studies the agency's "client loyalty" chart.

In the advertising business the average client-agency relationship lasts about eighteen months. Not so with Burton Browne Advertising. This Chicago/New York agency points proudly to a record of account stability that few can match. *Eight and one-half years* is the current average, and it's growing steadily higher.

One may well ask why BBA is so exceptional in the advertising scramble. The answer is interesting. First and always foremost, *creativity* is prized. The agency is made up of a few highly talented individuals who pool their considerable abilities to create ads that catch the reader's eye . . . and make him think. The traditional *originality* of the agency's work has earned some of the most coveted national advertising awards.

The other part of this success recipe is *client loyalty.* BBA tends to be a bit choosy about their clients. They want—and get—companies that appreciate their many services and are prepared to work intimately with them in solving merchandising problems both routine and unusual. This close cooperation leads to mutual trust and admiration which is responsible for relationships of long standing. The longer the association, the more expert the agency becomes in selling the client's product.

Burton Browne Advertising is a business . . . run as a business . . . with plans to stay in business. Just as client stability is basic, so is financial stability. No agency has a higher credit rating. They never miss a discount. It's just good business that way.

The 9 outstanding electronic accounts on the following pages are among the clients who benefit from the unique services of Burton Browne Advertising.

NO BURTON BROWNE CLIENT HAS A COMPETITOR WITH BETTER ADVERTISING

BURTON BROWNE ADVERTISING

Call the Burton Browne office nearest you.

CHICAGO	PASADENA	NEW YORK
619 N. Michigan Ave.	465 E. Union St.	37 West 53rd St.
SUperior 7-7700	MUrray 1-4300	JUdson 2-1110

Industrial Engineering Notes

(Continued from page 32A)

mission has authorized the International Telephone and Telegraph Laboratories to operate an experimental station to bounce signals off the moon and passive earth satellites for basic research and study of the space communications theory.

The authorization, which is for one year, specifies operation on 2120 Mc or 2299.5 Mc until July 1, after which only the 2299.5 Mc frequency is to be used. The second frequency is in a band allocated for space research by the Geneva 1959 radio regulations; the first is in a band allocated for use by common carrier fixed, international control and operational fixed stations.

The station, to be located in Nutley, N. J., will use input power of 10 Kw to a 40-foot steerable antenna for directing narrow-band transmissions into space. The reflected signals will be received by the same station.

The Commission asked ITT Laboratories, a division of the International Telephone and Telegraph Corp., to supply data resulting from the research on the conditions under which Earth transmitting terminals can operate without causing harmful interference to microwave fixed service stations.

ITT Labs was also reminded that no determinations have been made either nationally or internationally as to what portions of the radio spectrum ultimately may become available for use by operational space communications systems.

The new Chairman of the Federal Communications Commission will be Newton H. Minow, a youthful Illinois lawyer, President-elect Kennedy disclosed.

Mr. Minow, 34, a partner in Adlai E. Stevenson's law firm, served as administrative assistant to Mr. Stevenson when he was Governor of Illinois.

The appointee will replace Frederick W. Ford as Commission Chairman. Mr. Ford will remain a Commission member, filling the post of Charles H. King, who was appointed last summer by President Eisenhower but not confirmed by the Senate.

Engineering

The electronic equipment reliability handbook used by the U. S. Air Force's ground electronic equipment research and development center at Rome, N. Y., has been made available to industry.

Rome Air Development Center (RADC) is the central agency responsible for all research and development related to Air Force ground electronic equipment.

The handbook, called the "RADC Notebook," contains specifications prepared by RADC covering both development and production models of electronic equipment and describes the Center's technique for predicting reliability of ground electronic equipment on a quantitative basis. The Notebook also discusses problems in organizing a reliability program and provides suggestions as well as case histories showing how the RADC reliability program can be implemented into an existing industrial operation.

Separate sections in the handbook are devoted to reliability information services at RADC, Air Force specifications, the role of management in reliability programs, the mathematics of reliability and reliability prediction, and testing for reliability. The Notebook also discusses maintaining reliability in production, data feedback in the reliability program, and reliability factors in environment, components, and in mechanical, electrical and electronic design.

The publication is "RADC Reliability Notebook," October, 1959, 275 pages. (Order PB 161 894 from the Office of Technical Services, Department of Commerce, Washington 25, D. C., $4.)

Military and Space

The National Aeronautics and Space Administration has revised its schedule for space exploration during the next decade, it was disclosed in a summary of NASA's activities released by outgoing Administrator T. Keith Glennan.

The new schedule shows the following major space activities:

1961—First sub-orbital, then full orbital flights around the Earth by an astronaut; launching of a SATURN S-1 first stage booster carrying a cluster of eight engines capable of 1.5 million pounds of thrust; an ATLAS CENTAUR launching.

1962—Landing of an instrument payload on the moon, using a RANGER vehicle; another payload to Venus or Mars; and launching of the first NIMBUS weather satellite.

1963—Orbiting of the first real time communications satellite; launching of the SATURN in a two-stage configuration and a test of a three-stage version; soft-landing of instruments on the moon.

1964—First flight test of an orbiting solar observatory; survey of Mars and Venus by unmanned satellites; qualification of a 200,000-pound thrust liquid hydrogen-liquid oxygen rocket engine for the SATURN.

1965—Flight qualification tests of a 1.5 million-pound thrust, single-chamber engine; tests of the first APOLLO prototype capsule.

1966–1967—Tests of the first three-stage SATURN and a nuclear-thermal rocket; landing of unmanned, mobile instruments on the moon.

1968–1970—Unmanned VOYAGER satellites launched into orbit around Venus or Mars; Earth and lunar orbits by the APOLLO.

"Sometime after 1970"—Landing of a man on the moon.

PROFILES OF INDUSTRY

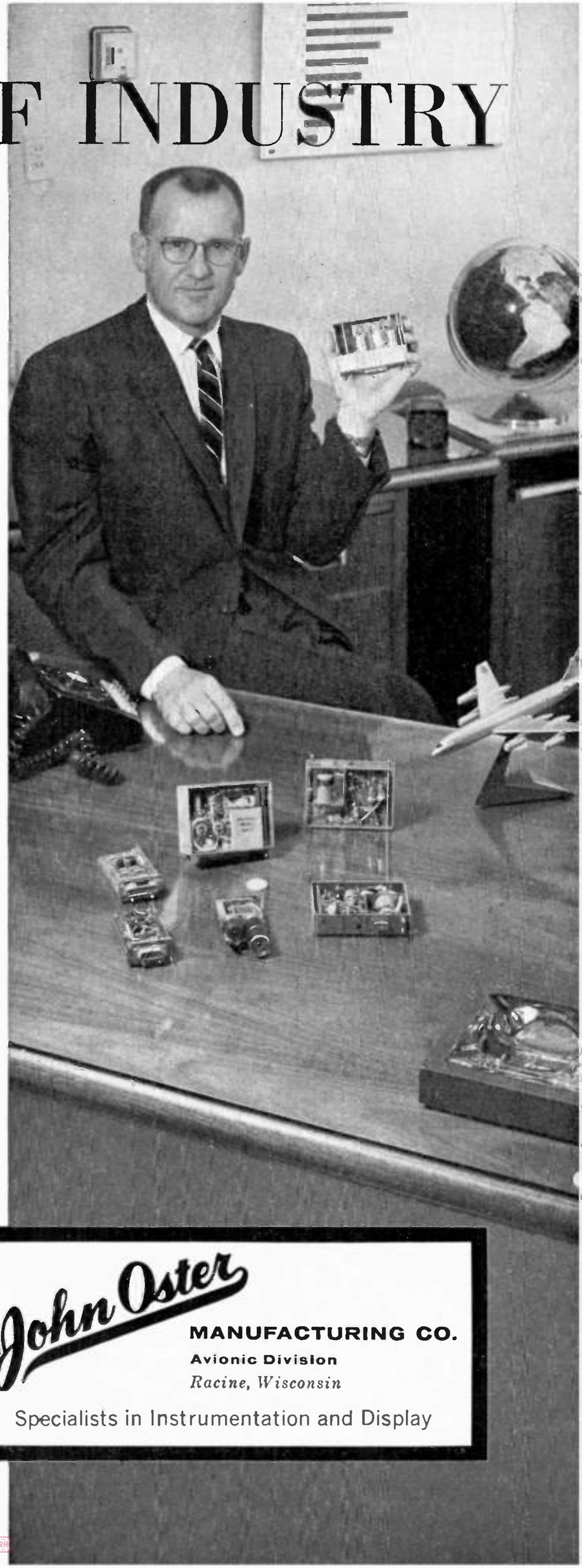
1

JOHN OSTER MANUFACTURING COMPANY

Avionic Division

APPLYING BUILDING BLOCK THEORY, THIS COMPANY SAVES SPACE, WEIGHT AND MAINTENANCE WITH VERSATILE MIL SPEC AVIONIC MODULES.

Mr. Robert Oster, Executive Vice President, is shown with typical building block basic units—compact, transistorized, hermetically sealed.



Oster engineers have followed suggestions of space conscious electronic design engineers in creating systems employing these densely packaged black boxes, with −55°C to +105°C temperature range and −1000 feet to +80,000 feet altitude tolerance. Humidity, salt atmosphere, fungus growth, sand and dust requirements meet MIL-E-5272, opening up a new area in compact design.

Basic units available are:

- Type 9805-19—Synchronizer
- Type 9616-08—Demodulator
- Type 9616-07—Synchronizer Amplifier
- Type 9616-16—4-Channel Isolation Amplifier
- Type 9616-09—Servo Actuator Amplifier
- Type 9616-15—Relay Amplifier
- Type 9616-06—Summing Amplifier (Dual)

Basic units can be modified easily or completely redesigned to your specific requirements. On-the-spot advice and design services are available from technically experienced engineers in the eastern and western offices as well as from the home office. In the east, phone HUnter 7-9030 at 310 Northern Boulevard, Great Neck, Long Island, New York, and in the west, phone EXmont 1-5742 or UPton 0-1194 at 5333 South Sepulveda Boulevard, Culver City, California.

Other products handled include servos, synchros, resolvers, motor tachs, DC motors, computers, indicators, servo mechanisms and servo torque units.

IRE Booth 1330-1332

John Oster
MANUFACTURING CO.
Avionic Division
Racine, Wisconsin
Specialists in Instrumentation and Display

Professional Group Meetings

Aerospace and Navigational Electronics Communications Systems

Florida West Coast—December 14

"Value Engineering," A. A. Hoffman, General Electric Co., Johnson City, New York.

Antennas and Propagation Microwave Theory and Techniques

Washington D. C.—December 6

"Microwave Measurement Techniques," Dr. E. K. Damon (Substituting for Dr. T. Tice), Ohio State University, Columbus.

Washington, D. C.—October 25

"Reflectors as Antennas," R. L. Mattingly, Bell Telephone Labs., Whippany, N. J. (This was the second of a series of five lectures on Antenna Theory and Techniques.)

Washington, D. C.—October 11

"Fundamentals of Antennas," Dr. H. Jasik, Jasik Labs., Westbury, L. I., N. Y (This was the first of a series of five lectures on Antenna Theory and Techniques.)

Audio

San Francisco—December 7

"FM/FM Multiplex Stereo Broadcasting" (Panel Discussion), Moderator: R. S. MacCollister, KPFA Berkeley, KPFK Los Angeles; Panelists: E. David, KDFC-FM San Francisco; A. Isberg, University of California; E. Goldsmith, KPFA-FM Berkeley.

Automatic Control

Baltimore—December 8

"Application of Automatic Controls to the Field of Medicine," Dr. S. Talbot, Johns Hopkins University School of Medicine, Baltimore, Md.

Baltimore—November 10

"Application of Linearized Analysis Techniques to Servo Control Systems," W. L. Kinney, Cook Research Lab., Morton Grove, Ill.

Los Angeles—December 13

"Guidance and Control Aspects of the Ranger Program," R. Morris, Jet Propulsion Lab., Pasadena, Calif.

Automatic Control/Electronic Computers/Space Electronics and Telemetry

Philadelphia—December 8

"Magnetic Orientation Control of Spin Stabilized Satellites," W. Manger, RCA.

Bio-Medical Electronics

Houston—December 8

"Current Trends in Speech Synthesis," Dr. J. Bangs, Houston Speech and Hearing Clinic, Houston, Tex.

Portland—November 17

"Mathematical Models and the Use of Analog Techniques in Neurophysiologic Problems," Dr. G. Austin, Professor and Head of Division Univ. of Oregon Medical School, Portland.

Portland—October 27

"Measurement of Ionic Transport by Voltage Clamp Technique," Dr. J. M. Brookhart, Univ. of Oregon Medical School, Portland; L. Dillard, Tektronix, Inc., Portland.

Portland—September 29

"Measurement of Oxygen and Carbon Dioxide Tension in Fluids," Dr. B. Ross, Univ. of Oregon Medical School, Portland.

"Electronic Readout Systems for the Clark Oxygen Electrode," J. Dahnke, Univ. of Oregon Medical School, Portland.

San Francisco—November 16

"The Photoreceptor as a Transducer," Dr. D. Kennedy, Stanford University.

Washington, D. C.—November 14

"Instrumentation in Bio-Medical Research," G. C. Riggle, National Institutes of Health.

Broadcasting

Cleveland—December 15

"Field Test Results of FM Multiplex Systems," A. P. Walker, National Association of Broadcasters, Washington, D. C.

Cleveland—November 17

"Transistorized Audio Equipment for Radio-TV Stations," A. C. Angus, General Electric Co., Syracuse, N. Y.

Florida West Coast—November 22

"Radio Equipment and Communications in Air Traffic Control," Capt. Hertel, 1928th AACF Squadron, MacDill AFB.

Circuit Theory

Los Angeles—December 14

"How Not to Use Circuit Theory in Network Design," R. D. Middlebrook, California Institute of Technology, Pasadena.

"The Value of Network Theory in Active Filter Design," I. M. Horowitz, Hughes Res. Labs., Malibu, Calif.

Component Parts

Dayton—November 3

"An Integrated Binary Adder," M. E. Szekely, RCA Labs., Princeton, N. J.

Philadelphia—November 22

"Ad Hoc Study Group on Parts Specification Management for Reliability," P. S. Darnell, Bell Telephone Labs., Whippany, N. J.

Electron Devices

Boston—December 8

"Recent Advances in Infra-Red," M. Block, Block Associates, Cambridge, Mass.

San Francisco—December 7

"Recent Developments in Esaki Diodes and Their Applications," G. C. Dacey, Bell Telephone Labs., Murray Hill.

(Continued on page 38A)

PROFILES OF INDUSTRY

2

CTS CORPORATION

9 NEW PRODUCTS KEEP UP WITH SURGING ELECTRONIC GROWTH

Mr. B. S. Turner, President, is shown with new controls for the military, industrial and commercial fields.

Space Age Hi Temp Military Control. ½" dia. variable resistor with infinite resolution and better stability and higher reliability than carbonaceous type units. Uses new CTS-developed hi temp metal-ceramic resistance element.

"Double Use" MIL-R-94B Style RV6 Variable Resistor. Unique carbon-ceramic element helps *one* control do *two* jobs: 1) Surpass MIL-R-94B Style RV6 stability under military environmental conditions, and 2) Provide full ¾ watt power rating @ 70°C with derating to zero at 150°C on most values for higher load and temperature applications.

Trimmer Potentiometer with Extremely Stable MIL-Type carbon element. Available with 25 turn lead screw with clutch stops or 18 turn lead screw with fixed stops.

Compact Vernier Variable Resistor. 12½ to 1 reduction. Ball bearing rotation.

Miniature Compact ⅝" Control. Available with standard bushing or economical ear mounting. Special thin model available for portable pocket transistorized radios.

Higher Reliability Micro-Miniature Composition Control. $\frac{9}{32}$" dia. For miniature transistor hearing aids, miniature radios, telephone equipment and industrial applications requiring tiny size and exceptional reliability.

Highly Uniform Rugged Rotary Switches, TROLEX Series. Exceptionally high uniform reliability is achieved by an entirely new manufacturing concept.

Compact Side-by-Side Printed Circuit Ceramic Base Control. ⅓ the size of previous units. Self-supporting snap-in 2 or 3-section variable and fixed resistor network for printed circuit applications.

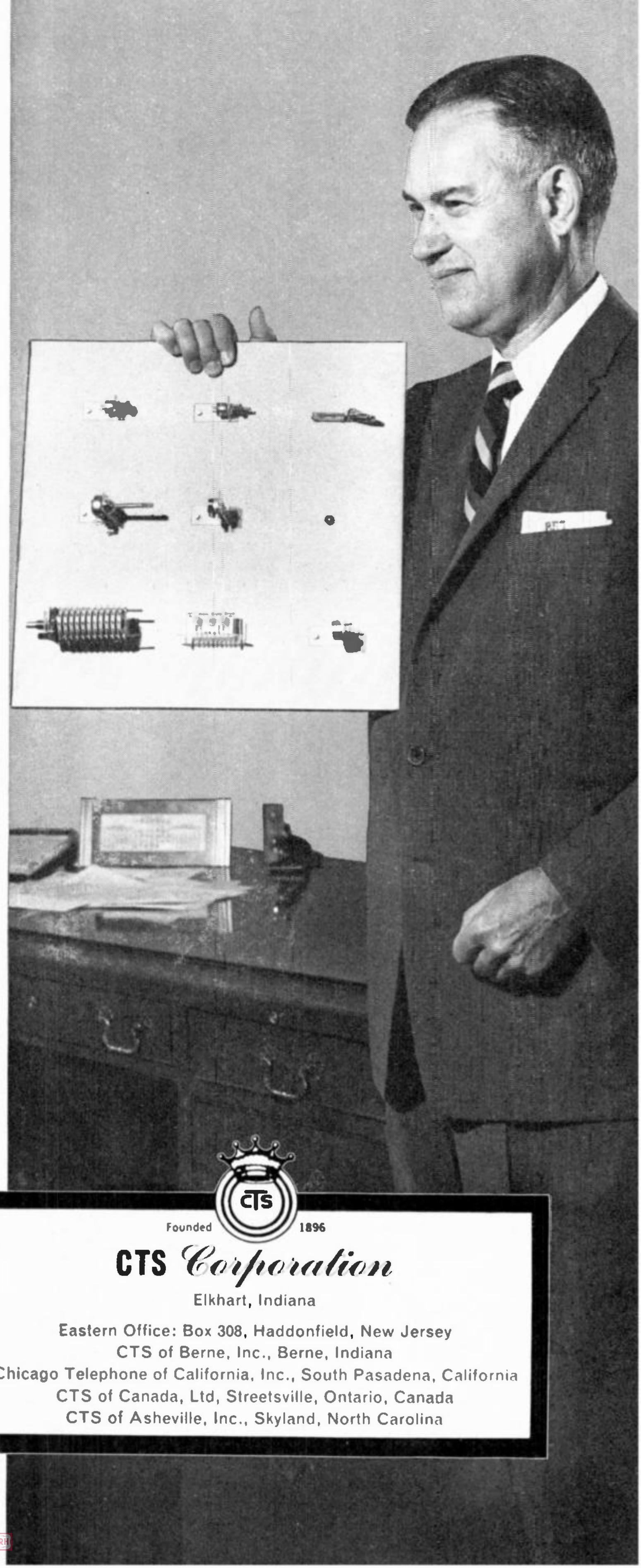
Low Cost Miniature Trimmer Pot. ¾" dia. preset wirewound ½—5000 ohms resistance range variable resistor. Exceptional reliability due to several unique design features.

CTS was founded in 1896. Today, 5 CTS factories have an aggregate area exceeding 500,000 sq. ft. for manufacturing variable resistors, allied switches and other electronic components. With wholly owned manufacturing plants in two countries and foreign licensees, CTS products are used on every continent.

Extensive research and development helps maintain the firm's world-wide reputation for quality products. A team of scientists, engineers and technicians use precision modern facilities to keep CTS products ahead of industry requirements.

CTS engineers are available to help solve your component problems.

IRE Booth 1400



Professional Group Meetings

(Continued from page 36A)

Electron Devices Microwave Theory and Techniques

San Francisco—December 7

"Recent Developments in Esaki Diodes and Their Applications," G. C. Dacey Bell Telephone Labs., Murray Hill, N. J.

San Francisco—November 30

"Low-Noise Traveling Wave Tubes," D. Watkins, Watkins-Johnson Co., Palo Alto, Calif.

"Low-Noise Parametric Amplifiers, Masers, Photon Counters and other Low-Noise Devices," G. Wade, Raytheon, Los Angeles, Calif.

Electronic Computers

Binghamton—November 21

"Engineering Via Digital Computers," R. A. Armstrong, IBM, Oswego, N. Y.

Dayton—December 8

"The Texas Instrument Approach to Semi-Conductor Networks," C. H. Phipps and H. G. Cragon, Texas Instruments Co., Dallas.

Dayton—October 13

"Micro Circuit Techniques for Computer Application," R. G. Counihan, IBM, Kingston, N. Y.

Detroit—November 28

"Modeling Techniques for Digital Computers," R. Legault, Institute of Science & Technology, Univ. of Michigan, Ann Arbor.

Demonstration of the IBM 709 at the IST.

Fort Worth—December 6

"State-of-the-Art and Future Trends in Semi-Conductor Technology," M. E. Jones, Texas Instruments, Dallas.

Fort Worth—November 15

"Useful Parameters and Basic Circuits (Semi-Conductor Series)," W. T. Jones, Texas Instruments, Dallas.

Philadelphia—December 15

"Application of Tunnel Diodes to Digital Circuits," E. A. Fisch, General Electric Co.

San Francisco—December 13

"Random Access Ferrite Store," F. F. Stucki, Lockheed MSD, Palo Alto, Calif.

Engineering Management

Dayton—November 10

"The Navy's Program Evaluation and Review Technique (PERT)," Capt. K. M. Tebo, USN.

San Francisco—November 17

"Game Played with Computer," B. Lefkowitz, Dr. C. Perry, SRI, Menlo Park, Calif.

Engineering Writing and Speech

Philadelphia—November 30

"Documentation Needs from the Viewpoint of Military and Industrial Management," J. A. Vaughan, RCA, Moorestown, N. J.

"Same—with Emphasis on Military Aspects," S. M. Jacoby, AF Eastern Contract Management Div., Philadelphia, Pa.

Philadelphia—September 28

"Articles for Publication," S. P. Kaprielyan, Aircraft & Missiles; J. McLean, Electronic News; S. Weber, Electronics.

Microwave Theory and Techniques

Baltimore—November 21

"Spectrum Utility in Space Communications," C. T. McCoy, Philco Corp.

Military Electronics

Dayton—December 1

"Military Aspects of an Advanced Instrument Landing Technique," F. H. Battle, Jr., Airborne Instruments Lab., Mineola, L. I.

Dayton—October 20

"USAF Calibration Program," R. Bailey, Dayton Air Force Dept.

Dayton—September 15

"Abilities of Disabled," H. Viscardi, Jr., Abilities Inc., Albertson, L. I.

Nuclear Science

Atlanta (Oak Ridge)—December 15

"Microwave Measurement Techniques," L. Fisher, Polytechnic Research and Development Co.

Product Engineering and Production

Philadelphia—December 7

"Maintainable Electronic Equipment Design," R. Swengel, AMP Inc., Harrisburg, Pa.

"Practicability of Throw Away Maintenance," H. F. Tryon, US Army Signal Corp., Fort Monmouth, N. J.

Radio Frequency Interference

Fort Worth—November 29

"Oscillators and R. F. Circuitry," V. L. Brown, Texas Instruments, Dallas.

Fort Worth—November 22

"Power Converters, Regulators, and DC Amplifiers," O. J. Cooper, Texas Instruments, Dallas.

San Francisco—November 15

Nomination of Candidates for Office.

Reliability and Quality Control

Metropolitan New York—December 5

"A Measure of Reliability and Information Quality in Redundant Systems," S. A. Rosenthal, American Bosch Arma Corp., Garden City, N. Y.; H. Jaffe and M. D. Katz, Sperry Gyroscope Co., Great Neck L. I., N. Y.

Space Electronics and Telemetry

Philadelphia—December 8

"Magnetic-Orientation Control of Spin Stabilized Satellites," Dr. W. Manger, RCA Astro Electronics Div., Heightstown, N. J.

PROFILES OF INDUSTRY

4

SYNTRONIC INSTRUMENTS, INC.

Yoke Specialists

Dr. Henry Marcy, President, illustrates the versatility of Syntronic's yoke design, one of the reasons why major C.R. tube manufacturers recommend Syntronic Yokes. Other factors are:

1 Exceptional manufacturing uniformity. Achieved by unique pepperpot tube testing—the most comprehensive method known for precise measurement of spot uniformity . . . to attain extremely accurate focusing. For technical details, request ELECTRONIC INDUSTRIES reprint # 6-57 from Syntronic.

2 Syntronic yoke procedure originated the industry standard for specification correlation between yoke, c.r. tube and circuitry. For a helpful, time-saving checklist covering all physical and electrical yoke parameters and their determining conditions, request ELECTRONICS reprint # 12-59 from Syntronic. Thorough correlation enables Syntronic to *guarantee* accepted specifications.

3 Just about *any* type of yoke you can dream up can be designed and built by Syntronic Yoke Specialists. The industry's greatest range of winding machines can produce an infinite variety of coils.

4 The industry's broadest yoke line . . . already tooled for quantity production. Or yokes can be custom designed to your precise requirement.

Call your nearest Syntronic Rep today.

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N. J. UNion 4-9577

PHILADELPHIA AREA:
Massey Associates • Phone: MOhawk 4-4200

WASH.-BALT. AREA:
Massey Associates • Phone: APpleton 7-1023

INDIANAPOLIS:
Joe Murphy • Phone: VIctor 6-0359

LOS ANGELES:
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IRE Booth 2711

syntronic
INSTRUMENTS, INC.
100 Industrial Road, Addison, Illinois
Phone: KIngswood 3-6444
YOKE SPECIALISTS

Membership

(*Continued from page 40A*)

Davis, R. G., Dallas, Tex.
Day, R. L., Los Angeles, Calif.
Demskey, S., Havertown, Pa.
Desposito, S. F., New York, N. Y.
Diesel, T. J., Palo Alto, Calif.
Dodson, E. E., Baltimore, Md.
Donnellan, S. J., Jr., Glen Cove, L. I., N. Y.
Dorsam, T. J., Jr., Philadelphia, Pa.
Dougherty, M. W., New York, N. Y.
Dow, J. J., Corona, Calif.
Drugan, J. R., Sun Valley, Calif.
Edman, P., Poughkeepsie, N. Y.
Edwards, W. B., Jr., Richardson, Tex.
Eikenberg, A. F., Baltimore, Md.
Eisner, G., Woodland Hills, Calif.
Elder, F. L., Oklahoma City, Okla.
Elliott, G. M., St. James, Man., Canada
Emero, R. F., Reading, Mass.
Escude, J. C., Newton, Mass.
Evans, A. L., Baltimore, Md.
Feijoo, J. A., Sherman Oaks, Calif.
Feldmeier, J. R., Philadelphia, Pa.
Ferry, B. A., Redstone Arsenal, Ala.
Fiala, H. E., Los Angeles, Calif.
Fishbein, S., Washington, D. C.
Fleischer, A. A., Goletta, Calif.
Fox, H. M., Haddonfield, N. J.
Franks, R. K., Annapolis, Md.
Freeman, P. H., Great Neck, L. I., N. Y.
French, E., San Gabriel, Calif.
Gibson, H. B., Elizabeth, N. J.
Gill, D. J., Mobile, Ala.
Giorgio, F., Midvale, Utah
Glassey, R. W., Whitesboro, N. Y.
Glen, G. E., Falls Church, Va.
Golmis, T. L., Whittier, Calif.
Gomez, A. D., San Diego, Calif.
Gonick, J. G., Kensington, Md.
Greenberg, L., Los Angeles, Calif.
Griffith, W. F., Utica, N. Y.
Haidemenakis, E. D., New Brunswick, N. J.
Halacy, D. S., Jr., Glendale, Ariz.
Hale, L. F., Mobile, Ala.
Halford, J. R., Redstone Arsenal, Ala.
Hawley, E. B., Framingham, Mass.
Heckert, G. P., San Francisco, Calif.
Helme, G. H., Baltimore, Md.
Hetrick, E. H., Fremont, Ohio
Hieber, J. C., Jr., Dewitt, N. Y.
Higgins, W. T., Alexandria, Va.
Hladky, W., Chatham, N. J.
Howden, P. F., Arcadia, Calif.
Hughes, W. L., North Syracuse, N. Y.
Hunter, I. R., Silver Spring, Md.
Illig, F. J., East Aurora, N. Y.
Jackson, R. W., Jr., Warren AFB, Wyo.
Janci, S. J., Franklin Park, Ill.
Jennings, J. J., Jr., Chicago, Ill.
Jensen, J. A., West Vancouver, B. C., Canada
Johnson, L. V., Las Vegas, Nev.
Johnson, R. H., Jr., Dover, N. J.
Jolicoeur, R. A., Southboro, Mass.
Jones, D. L., Kensington, Md.
Jones, H. E., Needham Heights, Mass.
Kamens, B. H., Thomaston, Conn.
Kenneally, W. J., Baltimore, Md.
Kimmel, M. J., Pasadena, Calif.
Knapp, G. H., St. Petersburg, Fla.
Knuijt, M. J., Wauwatosa, Wis.
Kolondra, F., West Orange, N. J.
Kruschke, E. A., Amery, Wis.
Lamb, K. D., Orange, Calif.
Lambert, A. G., Mountain View, Calif.
Layton, F. W., Mesa, Ariz.
Lepanto, P. J., Arlington, Va.
Lintner, P. D., Oswego, Ore.
Little, R. I., Idaho Falls, Idaho
Lock, M. K., Mobile, Ala.
Long, V. L., Beaverton, Ore.
Lowe, E. H., Jr., Memphis, Tenn.
Lynch, G. J., Albuquerque, N. M.
Lyons, F. T., Syracuse, N. Y.
MacFadyen, J. C., Newton, Pa.
Mahan, R. E., West Sacramento, Calif.
Mainieri, A. J., Rosario, FCNGBM, Argentina
Maino, L. T., Jr., Fort Huachuca, Ariz.
Maisel, L., Hicksville, L. I., N. Y.
Matzke, A. F., Minneapolis, Minn.
Mayfield, G. L., Jr., Albuquerque, N. M.
Maywald, D. W., Des Plaines, Ill.
McCormick, C. G., Dallas, Tex.
McMurray, W. D., Cary, N. C.
McReynolds, E. B., Jr., San Jose, Calif.
Meinelt, K. H., Phoenix, Ariz.
Melville, J. T., New York, N. Y.
Menkes, A. B., New York, N. Y.
Meth, I. M., New York, N. Y.
Mingione, J. A., Downingtown, Pa.
Moneno, W. J., E. Syracuse, N. Y.
Morgan, A. A., Seattle, Wash.
Mullin, B. M., Arlington, Va.
Mullo, M. P., Worcester, Mass.
Najita, K., Honolulu, Hawaii
Najork, J., Northbrook, Ill.
Nakahara, T., Osaka, Japan
Niccolini, M. E., Arlington, Va.
Norvell, B. E., Pelham Manor, N. Y.
Odell, H. A., Kirkuk, Iraq
O'Donnell, V. C., Little Falls, N. J.
Okino, H., Winston-Salem, N. C.
Olsen, V. O., Northridge, Calif.
O'Neill, J. J., Commack, L. I., N. Y.
Parfrey, W. M. J., Herts., England
Paris, D. C., Hyde Park, Mass.
Parrott, E. A., Wokingham, Berkshire, England
Patton, F. K., Los Altos, Calif.
Pera, C. A., Lima-Peru, S. A.
Peterson, A. E., Jr., Whippany, N. J.
Petty, G. W., Redwood City, Calif.
Pittler, G. M., Syracuse, N. Y.
Pratt, P. D., Tacoma, Wash.
Ranzi, I., Rome, Italy
Rawlings, J. H., Fullerton, Calif.
Recine, T. D., Rochester, N. Y.
Reed, W. L., Norfolk, Mass.
Reid, R. A., Jr., Williamstown, Mass.
Reifer, J. C., Oshkosh, Wis.
Rhinehart, N. G., Altadena, Calif.
Robinson, S. C., New Albany, Ind.
Rohel, G. Z., Chicago, Ill.
Rosenberg, A. C., Bethesda, Md.
Rosenblatt, A., New York, N. Y.
Saklem, S. J., Altadena, Calif.
Sander, K. F., Cambridge, England
Sanker, B., Silver Spring, Md.
Sauber, C. R., San Diego, Calif.
Schaefer, R. A., Timonium, Md.
Schafer, D. C., Fayetteville, N. Y.
Scherrer, I., Neuchatel, Switzerland
Schwan, A., Jr., Lynchburg, Va.
Shapiro, A. L., Philadelphia, Pa.
Shrader, D. J., Salem, Mass.
Skillman, W. A., Linthicum Heights, Md.
Smithpeter, C. H., Otis AFB, Mass.
Snider, J. B., Boulder, Colo.
Spitze, J. M., Berkeley, Calif.
Steele, F. H., Huntsville, Ala.
Strasilla, U. J., Framingham, Mass.
Stump, G. C., Jr., Cupertino, Calif.
Sugaya, H., Eindhoven, Holland
Suhler, S. A., Houston, Tex.
Sullivan, M. M., Wilmington, Mass.
Sutton, A. J., Cold Spring, N. Y.
Stomberg, D. H., Lake Stevens, Wash.
Taggart, J., Laurel, Md.
Taylor, J. W., Fullerton, Calif.
Teklits, F. A., Warminster, Pa.
Tharp, R. R., Houston, Tex.
Thielen, J. W., Santa Cruz, Calif.
Thomas, L. C., Camden, N. J.
Thompson, C. J., Riverside, Calif.
Tritter, L., Malden, Mass.
Turner, J. G., Encino, Calif.
Urquhart, E. H., Houston, Tex.
Valstar, J. E., Garden Grove, Calif.
van der Esch, P. B., Syracuse, N. Y.
Vanslette, R. A., Medfield, Mass.
Venier, G. O., Ottawa, Ont., Canada
Wald, H., Astoria, L. I., N. Y.
Walder, J., Baltimore, Md.
Walker, W. J., Dallas, Tex.
Watts, J. A., Moorestown, N. J.
Weber, D. W., Alamogordo, N. M.
Weinberg, S. B., Yonkers, N. Y.
Welsh, D. R., Teterboro, N. J.
Wheeler, L. A., Anaheim, Calif.
Wiener, L., Rego Park, N. Y.
Wilburn, C. D., Montreal, Que., Canada
Wilson, J. L., Dorval, Que., Canada
Wolf, G. L., Hazel Crest, Ill.
Woodruff, H. E., Middletown, R. I.
Woods, R. H., Cleveland Heights, Ohio
Work, C. F., Manhattan Beach, Calif.
Wyatt, T. F., Jr., Lantana, Fla.
Yoshida, T., Yokohama, Japan
Young, L. S., Los Angeles, Calif.
Zames, I. I., New York, N. Y.
Zanella, V. J., Federal Way, Wash.
Zielony, M. A., Haddonfield, N. J.
Ziemendorf, E. F., Niagara Falls, N. Y.
Zuch, H. W., Fort Worth, Tex.

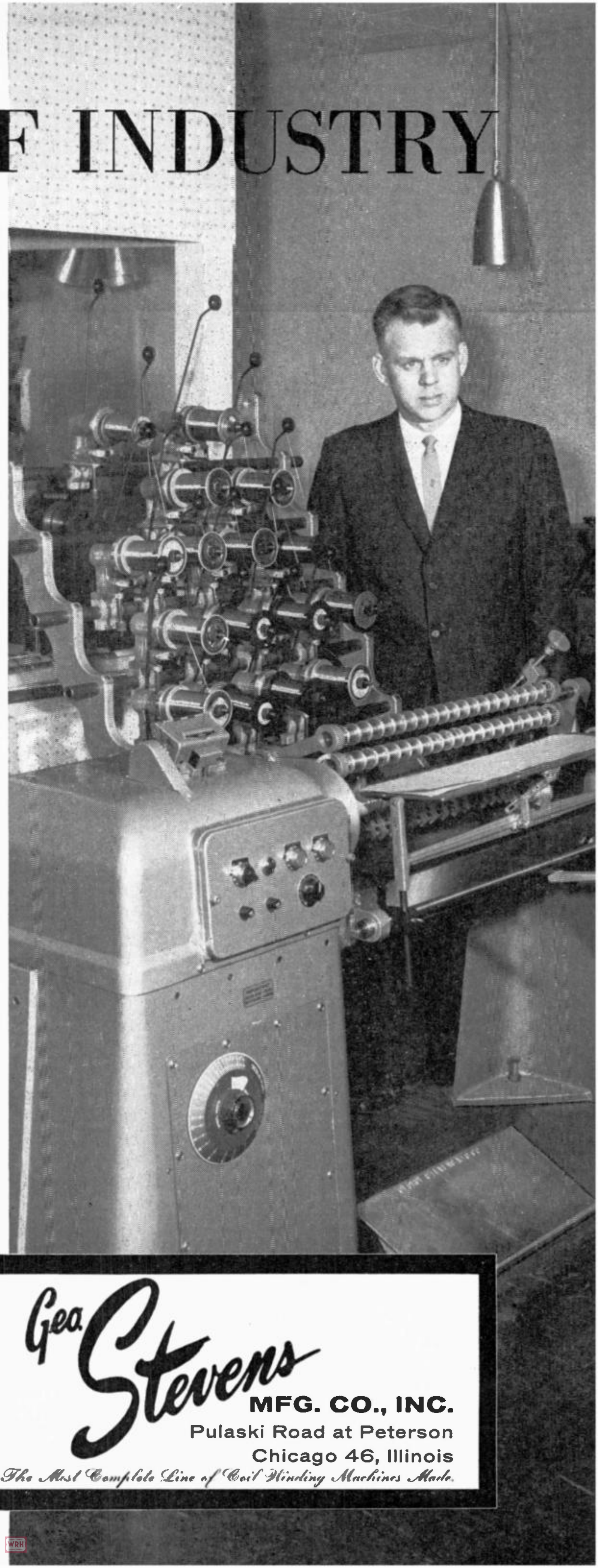
Admission to Associate

Adair, B. N., Dallas, Tex.
Atherton, D. L., Toronto, Ont., Canada

(*Continued on page 46A*)

PROFILES OF INDUSTRY

5



GEO. STEVENS MFG. CO., INC.

Mr. Jack Stevens, Vice President, displays the Stevens' Model 405-AM, Gearless Multiple Transformer Coil Winding Machine for long production runs.

Since 1939 Geo. Stevens has been the preferred supplier of coil winding machines to the electrical and electronic industries. Many of the firm's machines, built in 1939, are still performing production coil winding jobs today.

Geo. Stevens has the most complete line of coil winding machines and accessories available. For years, the Stevens catalogs have been considered the industry's buyer's guide.

72 basic machines, from which numerous modifications are made to accommodate customer's exact requirements, are currently listed as "stock" machines in Catalog No. 62 and Catalog No. 61 HD. In addition, Stevens maintains a complete engineering staff to design special machines to wind any type of coil. Many manufacturers have enjoyed substantial competitive advantage through confidential collaboration with Stevens engineers.

Stevens has machines capable of winding wire as heavy as No. 2 A.W.G. through No. 56 A.W.G. in fine wire applications.

A series of automatic and semi-automatic machines are being developed. Stevens spends a considerable sum for Research and Development to keep their machines ahead of industry requirements. These machines, never before thought possible, will permit one operator to assume the role of supervisor over several machines. Time savings is just one more Stevens plus.

You will find the answer to your coil winding machine needs in the modern Geo. Stevens plant. Visitors from all over the world have come to the Stevens plant and seen the most complete line of coil winding machines made. Virtually every firm in the world which winds coils uses one or more Geo. Stevens machines.

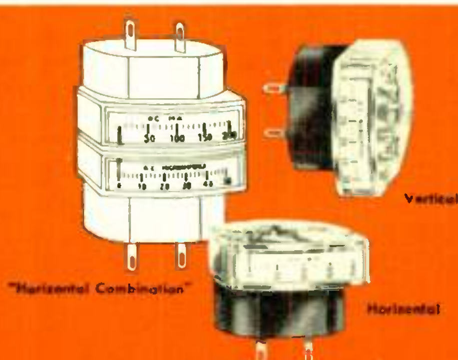
IRE Booth 4218-20

Geo. Stevens
MFG. CO., INC.
Pulaski Road at Peterson
Chicago 46, Illinois
The Most Complete Line of Coil Winding Machines Made.

LINE FULLY MEETS YOUR NEEDS

The name TRIPLETT has been on instruments of our manufacture for more than 55 years, and is regarded as a symbol of customer satisfaction to industrials and distributors in all parts of the world. Our instruments can be built to customer specifications or provided from our large stocks of standard ranges in hundreds of sizes and types. We also carry in stock many semi-finished movements which can be converted readily to special customer needs.

Rectangular Flush Mounting (4½")
Model: DC 420, AC 430, RF 440



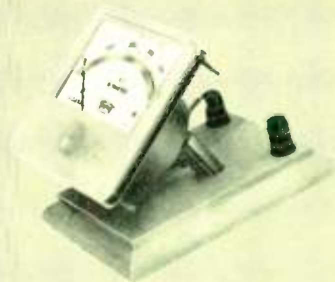
Miniature Edgewise Panel Meters —Model 120

Model 327-U Unimeter 3¼" Assembled

Model 354 Relay

Tilting Case Portable
Model: 325 (DC), 335 (AC)

Model 420-U Unimeter 4½"
with mirror scale



Model 234 Unimeter Stand

Round Flush Mounting (3½")
Model: DC 321-PL, AC 331-PL, RF 341-PL

Rectangular Flush Mounting (7 1/16")
Model: DC 726, AC 736, RF 744

Model 420 VU Meter
Type A Scale

6" Molded Case 4.7" Scale Portables
Model: 625 (DC), 635 (AC)

Membership

(Continued from page 42A)

Atkinson, D. A., Bradford, Pa.
Auger, M. E., Jr., Schenectady, N. Y.
Barello, G. P. U., Milan, Italy
Basler, J. A., East Greenwich, R. I.
Binachi, G., Rome, Italy
Birns, M. L., Pleasantville, N. Y.
Blanchet, R., Montreal, Que., Canada
Boggett, D. M. E., Grimsby, Lincs, England
Camden, J. E., Los Angeles, Calif.
Carlson, E. L., Hudson, N. H.
Chen, Y-B., Rochester, N. Y.
Chorney, G. L., Chicago, Ill.
Christie, R., Edmonton, Alberta, Canada
Conroy, J. R., Colorado Springs, Colo.
Cook, J. W., Rowayton, Conn.
Curran, J. D., Biloxi, Miss.
Curry, W. H., Jr., Sheboygan, Wis.
d'Afflito, G. A., Naples, Italy
DeMartino, A. J., Plainview, L. I., N. Y.
Doolan, F. E., Toronto, Ont., Canada
Ford, C. J., York, Pa.
Fullbright, H. J., III, Atlanta, Ga.
Gray, H. J., Beverly Hills, Calif.
Hananel, M. D., Istanbul, Turkey
Harleman, T. W., Vandalia, Ohio
Harris, G. J., Metairie, La.
Harrison, R. J., St. Boniface, Man., Canada
Honour, J. H., Jr., Paterson, N. J.
Ide, M., Tokyo, Japan
Jaytanie, J. M., Sherburne, N. Y.
Johannessen, K. M., Glendora, Calif.
Johnson, R. W., Milwaukee, Wis.
Jones, W. L., Ellerson, Va.
Joshi, S. B., Poona City, Maharashtra, India
Khouri, D. E., Waltham, Mass.
Kuhn, J., Kitchener, Ont., Canada
Lawrence, W. R., APO 23, New York, N. Y.
Lumb, J. P., Vancouver, B. C., Canada
MacLafferty, W. C., Walla Walla, Wash.
Mallon, J. A., Ludlow, Mass.
Martin, D., New York, N. Y.
McCartney, M. A., Rolling Hills, Calif.
McKnight, B., Philadelphia, Pa.
McSweeney, W. R., Williamsville, N. Y.
Montgomery, R. L., Rock Springs, Wyo.
Moskowitz, L. S., Winston-Salem, N. C.
Mullane, J. T., Richmond Hill, L. I., N. Y.
Naeher, W. F., Arlington Heights, Ill.
Nagle, C. L., Omaha, Nebr.
Navis, R. W., Flushing, L. I., N. Y.
Noren, R. G., Detroit, Mich.
Nowell, J. H., St. Boniface, Man., Canada
Paintner, J. P., Phoenix, Ariz.
Paleshnuik, J. A., Winnipeg, Man., Canada
Parker, R., Buffalo, N. Y.
Patterson, R. J., Palmyra, N. J.
Rauzino, V. C., Philadelphia, Pa.
Riccardi, J. A., Oklahoma City, Okla.
Robben, J. D., Belmont, Calif.
Schneider, M., Pennsauken, N. J.
Schwartz, A., White Plains, N. Y.
Sexton, D. W., San Diego, Calif.
Sheets, C. E., Los Angeles, Calif.
Siedare, R. J., Chicago, Ill.
Simmers, R. C., Harrisburg, Pa.
Smith, W. A., Hasbrouck Heights, N. J.
Sparks, M. M., Silver Spring, Md.
Terada, T., Oura-gun, Gunma-ken, Japan
Thalls, W., Arlington Heights, Ill.
Verhovnik, V. J., Toronto, Ont., Canada
Vick, E., Jr., Colonia, N. J.
Vittitow, R. K., Owensboro, Ky.
Voight, C. L., Chicago, Ill.
Wahren, P., Roslags Nasby, Sweden
Welch, P. L., Twin Falls, Idaho
Welch, W., Arlington, Va.
Wiley, C. M., Chicago, Ill.
Worban, R. A., Chicago, Ill.
Young, R., Los Angeles, Calif.

NEWS New Products

New Digital Computer System To Process Exhibit Interests of 80,000 Engineers at Largest Electronic Industry Convention

New York, N. Y.—When 80,000 electronics engineers and executives convene at the N. Y. Coliseum and Waldorf Astoria this March for The IRE Convention and Show they will participate in the first use of "Lead-Master," a new digital computer system for conveying specific attendee interests, and names, back to each participating exhibitor at trade and public conventions. It is expected to start a trend toward saving a great deal of time and headaches for attendees and exhibitors alike at such gatherings.

Sales leads through the "Lead-Master" electronic convention process come out of the High Speed Printer at 1500 lines per minute. Each pre-gummed, perforated label contains the personal information of an individual who visited a particular booth. The cost to that booth's exhibitor for this lead is about 3¢. Data Patterns, Incorporated, New York business system specialists, developed the process which will be used for the first time at this year's IRE Convention and Show for 80,000 electronics engineers.

Almost 1,000 exhibitors and 30 IRE technical meetings will be monitored during the Show period, March 20–23, according to Data Patterns, Incorporated, New York business system specialists who developed "Lead-Master."

The Institute of Radio Engineers, the largest technical organization of its kind in the country, expects heretofore unattainable attendee benefits to accrue at this year's convention. Engineers will be able to "leave" their names instantly at any booth without writing it, have literature sent direct to their offices without carrying it, and in the process save at least 25% of the time now consumed in waiting in groups at booths of interest to fill out query cards. Exhibitors need no special equipment in their booths, save a pencil,

(Continued on page 48A)

and they also collect nothing.

The entire registration tabulation procedure is assumed by Data Patterns, Incorporated in the "Lead-Master" process. Special coded "Lead-Master" pocket cards are distributed to all attendees and special Booth Signs to all participating exhibitors.

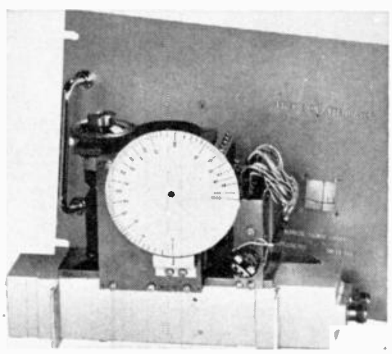
The names of those visiting any given booth are provided, at end of Show, as "sales leads" to each exhibitor, back at his plant, in the form of pre-gummed, perforated labels at a cost of about 3¢ per lead, ready for mailing or field follow-up.

In addition, the answers to product preference and industry questions from all attendees are provided both the exhibitors and the Exhibit Manager, who also receives a complete, alphabetical attendance record as the Show closes. A daily alphabetical list including each individual's name, firm and hotel will also be provided the Exhibit Manager for posting in the Coliseum as an aid to attendees in locating friends and customers from out of town. This information is over and above the over 2,000,000 lead labels the firm expects to process for IRE exhibitors.

Special visitor traffic analyses useful to researchers and of interest to sales, marketing and management executives will soon be published by Data Patterns, Incorporated as a by-product of attendance records at the Show. Additional trade and public exhibitions to be processed will continuously add to these heretofore unavailable findings. Exhibit Managers in Chicago, Boston, Atlantic City, Washington and Philadelphia in addition to New York have indicated plans to offer their exhibitors "Lead-Master" as an integral part of their show "Package" starting in 1961.

The firm is utilizing the Burroughs 220 computer in addition to other off-line equipments, including a 1500 line per minute high speed printer, to process "Lead-Master." A hand-picked task force of economists, mathematicians, programmers and operators drew upon their own convention experience and trade questionnaires to produce "Lead-Master."

C-Band Attenuator



These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your IRE affiliation.

A new direct reading 0–100 db C-Band attenuator has been approved by **Transco Products, Inc.**, 12210 Nebraska Ave., Los Angeles 25, Calif. The unit has coaxial type N connectors and is motor actuated from 0 to 100 db in less than 50 seconds. Attenuation is accomplished by inserting 2 glass cards transversely into waveguide. The direct reading dial is accurate to 0.1 db or ±1% of dial reading at calibration frequency. Actuation is accomplished by means of a two way switch with spring return to a neutral position and/or switch selection of 5 preset positions between 0 and 100 db. VSWR is under 1.5 from 5.0 to 5.8 kmc (under 1.1 at one frequency), insertion loss is 1.0 db maximum. The 19 inch rack-mountable panel shown is optional. Another option offers waveguide flanges instead of coaxial connectors. For details write to the firm.

Klystron Power Supply

Sperry Microwave Electronics Co., Div. of Sperry Rand Corp., Clearwater, Fla., announces the availability of a new 700 volt klystron power supply, Microline Model 62A3. This unit was designed for the large majority of klystrons requiring beam voltages not exceeding 700 volts. Specifications include:

The beam is continuously adjustable from −200 to −700 volts, 0 to 70 ma, ±1 volt line regulation, with 5 mv maximum ripple.

Reflector: 0 to 1000 volts, 0.1% regulation, with 5 mv maximum ripple.

Filament: 6.3 volts ac, 0–2 amperes.

Metering: Panel meter has 2% accuracy, switched between voltage and current on beam. Reflector voltage is read directly from multi-turn dial.

Modulation: 0 to 150 volts, pp, all waveforms, Sawtooth: 40 to 400 cps, Square wave: 200 to 2000 cps, Sine wave: line frequency, External modulation: direct, External modulation amplified.

Power requirements are 105 to 125 volts, 50 to 60 cps, approximately 220 watts. Size is approximately 8×12×16 inches. Weight is 32 pounds. Price is $550.

AMP Names Maslin Product Sales Manager

Al Maslin has been appointed product sales manager for the AMPin-cert printed circuit edge connector line being manufactured by **AMP Incorporated,** Harrisburg, Pa.

The firm announced the Maslin appointment shortly after a corporate decision to make printed circuit connectors a distinct and separate product division, in line with the increasing usage of printed circuitry in the modern electronic equipment concept.

Maslin, who had been a district sales engineer for AMP on the West Coast, will be transferred to the firm's home offices in Harrisburg, Pa. Maslin has become familiar with numerous aviation and avionics firms located throughout the Far West, during his six years of experience in that section of the nation as a sales representative.

(Continued on page 50A)

NEWS New Products

(Continued from page 46A)

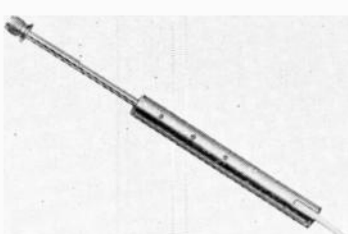
New Plant for Delta Semiconductors

J. G. Hammerslag, president of **Delta Semiconductors, Inc.,** announced the first step in an expansion program, with the opening of their new plant in Newport Beach, Calif. Delta makes a line of glass silicon computer switching and all purpose diodes.

The research and development staff, headed by Gordon A. Nielsen, has developed completely new processing equipment that is said to provide faster and more efficient production. One of the major problems facing semiconductor manufacturers is a relatively low rate of yield of diodes with acceptable parameters. Hammerslag states that this newly developed machinery coupled with in-production reliability checks have provided his firm with substantially higher yield rates of acceptable parameter diodes.

Linear Motion Potentiometers

A new series of ½ inch diameter linear motion potentiometers for servo control systems and instrumentation transducers in aircraft and missile applications is being offered by **Markite Corp.,** 155 Waverly Place, New York 14, N. Y. The precision units are said to be applicable in designs with inherent space limitations and high performance, continuous-duty requirements.



In these potentiometers the resistive element embodies a solid raised track of conductive plastic integrally co-molded,

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your IRE affiliation.

together with terminals and taps, to an insulator base of phenolic resin of matched thermal expansion coefficient. The conductive plastic track can be provided with a wide range of electrical resistivities. The potentiometers are also characterized by low electrical noise and an ability to resist vibration as well as shock loading in excess of 100g without malfunction.

The series, currently covering catalog Types 3239 and 3209, is designed to fill MIL environmental specifications. These potentiometers offer independent linearities of ±0.5% or better, and are available with element resistances ranging from 1K to 20K ohms. Type 3239 has a shaft stroke length of 1.587", and Type 3209, a shaft stroke length of 0.600". Other stroke lengths can be provided to meet special requirements. Shaft and ½ inch diameter cylindrical case are fabricated of stainless steel, and overall case lengths are 4.694 and 2.226 inches respectively. They are designed to withstand as much as 1000v rms without dielectric failure.

Glass Insulating Paper

A series of new applications are demonstrating the ability of Tissuglas—to solve unusual electrical, thermal, and electronic problems.

Tissuglas, an all-glass insulating paper, is a product of **American Machine & Foundry Co., Amflex Products Dept.,** Springdale, Conn. It is available in thicknesses as low as 0.0006 of an inch, and is uniform in texture and electrical resistance.

The newest application is as a base for electroluminescent lamps. These lamps are flexible panels as thin as $\frac{1}{16}$ of an inch. The resulting lamps are said to be the brightest, clearest and most uniformly textured light of any electroluminescent panels on the market today.

Another application is in the manufacture of bonded strain gages. Tissuglas, in this application, is used as a saturating base. In this use, its ability to pick up resins in uniform thicknesses (a function of its patented floc-free matting) gives the gages uniform resistance and high temperature stability.

Tissuglas is also finding a new market as a component for printed circuit materials. In this application, the material is laminated with a very thin copper foil. As an example, the one mil Tissuglas together with the ¾ mil copper produce the thinnest and most flexible printed circuit material now available.

Tissuglas is a sheet of matter submicron glass fibers made on a specially adapted paper making machine. Its properties as an insulating material are: melting temperature above 1,200°F; thicknesses from ultra-thin (0.0006 inch) to 0.012 inch; pore sizes from 8 to 90 microns; and a dielectric of 370 to 2,370 volts. Produced in any width up to 38" and in continuous rolls.

Fifteen-Inch Infrared Window

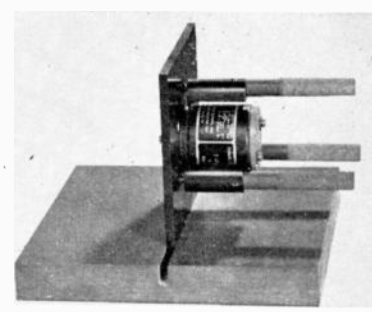
A fifteen-inch infrared window used in detection systems for missile guidance and space surveillance, has been produced by **Hughes Aircraft Co.,** scientists at Newport Beach, Calif.

The window, a solid casting of germanium 15 inches in diameter and half an inch thick, will expand the view area of infrared sensors which have been limited in lateral angle of vision by smaller viewing devices.

Although it is no more transparent to the human eye than a chunk of solid lead, it is optically clear for an "eye" that sees at infrared wavelengths.

Using a unique CUP (casting for ultra purity) technique, Hughes scientists have succeeded in producing windows of an optical purity of one foreign atom in ten billion.

Heatsink Fixture for Servo Component Testing



Angler Industries, Metuchen, N. J., announces a new series of fixtures used to hold servo type components under test. They feature accurately standardized thermal characteristics, and extremely fast acting, high thermal resistance rota-way holding clamps. Test units such as synchros, resolvers, motors, generators, potentiometers, and so forth, can be tested with close repeatability of thermally affected parameters. Device is designed to withstand extremely adverse environ-

(Continued on page 52A)

PRODUCES MORE AND DELIVERS FASTER FAMOUS AMPHENOL COAXIAL CABLE AND WIRE

As a new decentralized division of Amphenol-Borg Electronics Corporation, R F PRODUCTS now has responsibility for the engineering, manufacture and marketing of Amphenol Coaxial Cable and Wire. To the electronics industry—and to you—this means more and faster deliveries from factory inventory of the world's largest selection of approved, high quality RG type cable.

R F PRODUCTS also means the consolidation of three great names in radio-frequency components—Amphenol Coaxial Connectors and Cable, IPC Coaxial Connectors, and DK Coaxial Switches. The integration of these related component lines makes possible the engineering-in-depth needed to stay abreast of your demands in this exacting field.

Whether you require sub-miniature coaxial cable, high-temperature flexible cable, large special-purpose multi-conductor cable—or any of hundreds of other varieties—you'll find that R F PRODUCTS offers a comprehensive, single-source supply.

IRE Show: Booth 2501-03

A DIVISION OF AMPHENOL-BORG ELECTRONICS CORPORATION

AMPHENOL **R F PRODUCTS** ipc DK

DANBURY, CONNECTICUT • Pioneer 3-9272

NEWS New Products

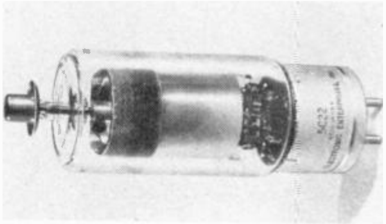
These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your IRE affiliation.

(Continued from page 50A)

mental conditions for use in type and qualification testing of components.

Suitable for units size 5 through 19. Price is $57.50 with one week delivery FOB Metuchen.

Hydrogen Thyratrons



Electronic Enterprises, Inc., 65 Seventh Ave., Newark, N. J., manufacturers of gas and mercury vapor rectifiers, vacuum rectifiers, grid controlled rectifiers, triodes and hydrogen thyratrons, announces that it has added to its line and is currently manufacturing a hydrogen thyratron tube, Type 5C22/HT415. This tube, which is capable of producing pulse outputs in excess of 2.0 megawatts at an average power level of 1.6 kilowatts, was designed primarily as a radar pulse modulator. The new hydrogen thyratron tube features high peak voltage and high current ratings, high repetition rate, short deionization time and low time jitter.

Section Meetings

AKRON

"Fundamentals of Infra-Red," J. P. Ovrebo, Avco. 12/6/60.

ALAMOGORDO-HOLLOMAN

"Application of Statistics to Engineering & Production," H. C. Carver, Univ. of Mich. 11/29/60

ALBUQUERQUE-LOS ALAMOS

"Problems of Controlled Fusion," Jack Katzenstein, Univ. of N. Mex. 10/11/60.

Technical meeting. 11/17/60.

Annual Christmas Dance. 12/3/60.

BALTIMORE

"What We Learned with Satellites," J. P. Hagen, NASA. 12/5/60.

"Maryland Civil Defense Program," Sherley Ewing, Md. Civil Defense Agency; "Communications for Civil Defense," Cecil Harrison, Md. Civil Defense Agency. 1/9/61.

BAY OF QUINTE

Tour of Aluminum Co. 12/7/60.

BEAUMONT-PORT ARTHUR

"Automation Equipment for Oil Terminal Facilities," R. L. McDaniel, Sun Oil Co. 1/10/61.

BENELUX

Inter-Society Meeting on Radioastronomy. 12/16/60.

BINGHAMTON

Plant Tour of IBM & 1401—Chain Printer. 1/16/61.

BUENOS AIRES

"Radioastronomy," Enrique Gaviola. 6/2/60.

"Electromagnetic Properties of Interplanetary Space," J. G. Roederer. 6/23/60.

"Solutions to One Problem of Nuclear Electronics," Alberto Jech. 6/30/60.

"Masers," J. F. Westerkamp. 7/7/60.

"The Study of Semiconductors," Andrea Levialdi. 7/21/60.

"Output Measurements of a Luminiscent Phosphor," Norberto Majlis, Hector A. Arduino. 8/11/60.

"Filters Calculation by Means of the Transference Method," J. M. Barcala. 8/18/60.

"Electromagnetic Waves and Their Applications—Infrared," Jose Porto. 9/1/60.

Visit to Establishment Siemens Argentina S. A. 9/15/60.

"The Microwaves Spectrometer of the Facultad de Ciencias Exactas," J. A. Trench, J. C. Lerman. 9/22/60.

"Spectroscopy—General Consideration (in Optics and in Radiofrequencies)," H. A. Farach. 9/29/60.

"Progresses in Radar in the Last 15 Years," C. A. Burundarena. 10/6/60.

"Physics of the Low Temperatures," J. M. Goldschvartz. 10/13/60.

"Cybernetics and Its Possibilities," J. C. Torrent. 10/20/60.

"Education for Engineering," Adolfo Di Marco. 11/7/60.

"Radioastronomy in Communications," Fernandez Guido; "Electronic Computers," L. F. Rocha, 11/8/60.

"Good Sense in High Fidelity," J. F. Duranona; "Television in the Interior of the Country," Marcelo Barbieri. 11/9/60.

"Functional Music Service," C. N. Cuttler. 11/10/60.

"The New International Regulations in Radiocommunications," Juan Autelli. 11/11/60.

BUFFALO-NIAGARA

"Utilization of Oscilloscopes and Test Equipment," R. Lysecki, Tektronix Inc. 12/14/60.

CEDAR RAPIDS

Fifth Conference on communications, entitled, "Tomorrow's Techniques—A Survey." 9/9–9/10/60

"Communications System for Project Mercury Space Capsule," William Benner, McDonnell Aircraft Corp.; Film: "Fields of the Future, Man's Conquest of Sky & Space." 10/19/60.

"Human Survival on the Moon," James Gaume, Martin Aircraft Co. 11/10/60.

"Military Applications of Fuel Cells," S. S. Nielsen, GE Co. 12/14/60.

CENTRAL FLORIDA

"Mistram," F. Radclift, GE Co. 10/20/60.

"Antennas," Laverne Williams. 11/17/60.

Film—Progress Report on Project Mercury, Mr. Satterfield, NASA, PAFB 12/12/60.

CENTRAL PENNSYLVANIA

"Basic Electronic Circuit Operations," Carl Voltz; "Some Physical Phenomena Having Applications in Electronic Miniaturization," J. P. Smith, HRB-Singer Inc. 12/20/60.

CINCINNATI

"Global Communications via Artificial Satellites," H. S. Black, Bell Tele. Labs. 12/20/60.

CLEVELAND

"Transistor Assembly Automation," David DeWitt, IBM. 12/8/60.

DALLAS

"Optical Pumping with Magnetometer & Frequency Standard Applications," Peter Franken, Univ. of Mich. 12/20/60.

DAYTON

"How to Engineer Technical Breakthroughs," N. V. Petrou, Westinghouse Corp. 9/8/60.

"Self Adaptive Flight Control," P. C. Gregory, WADD W-PAFB. 10/6/60.

"Microfilm & TV Progress," W. D. Novak, General Precision Lab. 11/3/60.

"Thermoplastic Recording," Wayne Holden, G.E. Co. 12/1/60.

EGYPT

"Large Screen Projection Television," Ahmed Salah El-Katoury, U.A.R. Broadcasting & TV.; 10/7/60.

"Color Television," M. M. Kishk, U.A.R. Broadcasting & TV.; 11/13/60.

"TV Network in U.A.R.", A. M. Anter, U.A.R. Broadcasting & TV.; 12/1/60.

EMPORIUM

Social meeting. 12/9/60.

FLORIDA WEST COAST

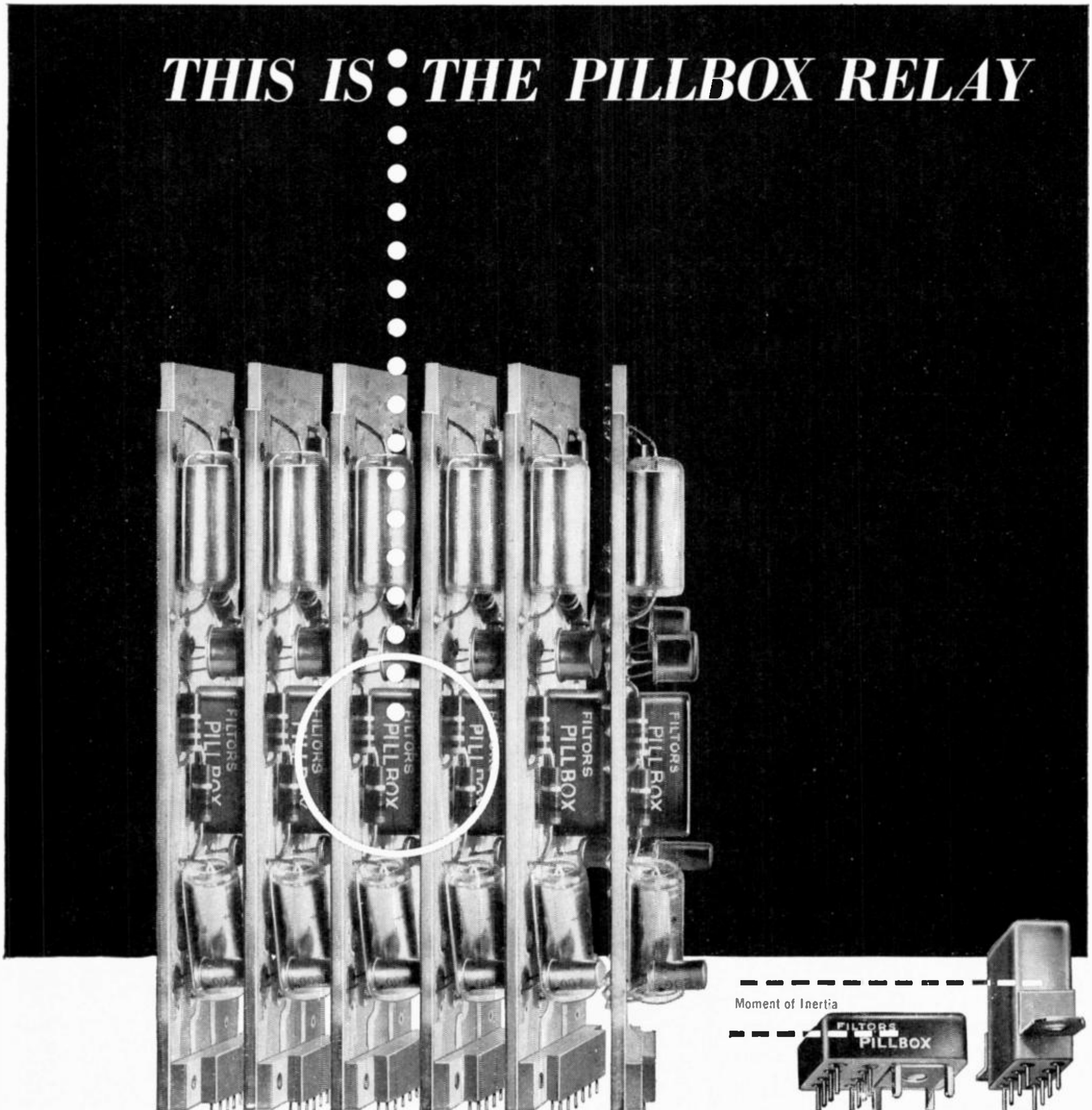
"Value Engineering," A. A. Hoffman, General Electric Co. 12/14/60.

FORT WORTH

Talk on the history of the IRE by Director of Region 6, C. H. Harp. 12/13/60.

"Arc Type Ion Source for Electrostatic Propulsion," R. E. Rinehart, Convair. 1/10/61.

(Continued on page 54A)



New relay silhouette

Standard microminiature silhouette

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The Pillbox houses Filtors' Sensi-Tork rotary relay motor which delivers more torque per milliwatt than any other known crystal-case rotary motor. Higher torque means higher contact pressure per milliwatt and greater reliability under all environmental conditions.

Ambient Temperature Range......................—65 degrees C to 125 degrees C
Dielectric Strength................ 1000 volts rms (750 volts between open contacts)
Contact Arrangements.................................2C (2 pole double throw)
Contact Rating...................Dry circuit, or 2 amperes resistive at 28 volts dc.*
Shock..75 G's, 11 milliseconds
Vibration..................10-55 cps at 0.06-inch amplitude, 55-3000 cps at 20 G's*
Switching Time.....................5 milliseconds maximum at nominal coil voltage

*Higher ratings available

Pillbox relays come in two mounting styles: tab and stud. Style A-1 uses tabs spaced in the standard printed circuit 0.2-inch grid pattern. Style B-1 employs ⅜-inch 4-40 NC-2 studs. The header terminal is supplied in two styles: straight pins and hooks.

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Section Meetings

(Continued from page 52A)

GAINESVILLE

Inspection of facilities at Southern Bell Telephone Bldg.; 12/14/60.

"Impressions on Russia," A. G. Guy, Univ. of Fla.; 1/12/61.

HAMILTON

"Soviet Research in Circuit Theory & Automatic Control," M. E. Van Valkenburg, Univ. of Illinois. 11/21/60.

"The Growth of Recorded Music." E. H. Kinnear, Ampex of Canada Ltd., 12/5/60.

"Fundamentals of Storage Tubes and Uses to Which Such Devices Can Be Put," G. Morton, Canadian Marconi Co., 1/9/61.

HOUSTON

"Potential Advantage of Smearing-Desmearing Filter Techniques in Overcoming Impulse Noise Problems in Data Systems," R. A. Wainwright, Rixon Electronics Inc.; 12/20/60.

INDIANAPOLIS

"Building Block Modules in Digital Systems," A. L. Anderson, Delco Radio Div., GMC.; 12/29/60.

ISRAEL

"Developments in H. F. transistors and their uses," A. Amouchi. Ministry of Def.: 11/23/60.

"The Tunnel Diode & Its Uses in Pulse Techniques," Y. Hazoni, Ministry of Defense. 12/12/60.

KANSAS CITY

"Magnetic Amplifiers," Henry Patton, Aeromag. Inc., 12/13/60.

KITCHENER-WATERLOO

"Pulse Sampling," M. B. Crouch, Tektronix Inc. 12/19/60.

LOS ANGELES

"Technical Decision Making in Defense," J. H. Rubel, Dept. of Defense. 12/9/60.

LUBBOCK

"Your IRE," Charles Harp, Okla. Univ. 12/20/60.

MIAMI

"Tunnel Diodes," D. Akhurst, Univ. of Fla. 10/5/60.

"Applications & Characteristics of Germanium Power Transistors," P. M. LaHue, Minneapolis-Honeywell Regulator Co. 11/2/60.

"Magnetic Amplifier Applications," B. A. Mazzeo, Airpax Electronics Inc. 12/14/60.

MILWAUKEE

"Procedures for Determining Reliability," David Bair, Reliability Engrg. Assocs. 12/15/60.

MOBILE

"Nose Cone Recovery & Retrieving," E. T. Bullock, Cook Technological Center. 12/2/60.

MONTREAL

"Manning & Operation of Microwave Systems in Arctic & Sub-Arctic Areas," B. A. Rorholt, Norwegian Joint Signals Board. 9/26/60.

Tour of T.C.A. Repair Base. 11/23/60.

NEW ORLEANS

"The Semiconductor Network Concept," R. E. Lee, Texas Instruments, Inc.; 12/2/60.

NORTHERN ALBERTA

"Microwave Lenses," G. Bidulock, Alberta Government Telephones. 12/20/60.

NORTHWEST FLORIDA

"Scientific Data Recording Principles," William Craig, Ampex Data Products Co., 12/13/60.

OKLAHOMA CITY

Tour of Aeronautical Center; Joint meeting with Tulsa Section. 11/14/60.

"'X' Bar Switching," R. L. Brown, Western Electric Co.; 12/12/60.

ORLANDO

"Psychophysiological Aspects of Manned Space Flight," J. J. Rosa, AFMTC, PAFB.; 11/16/60.

OTTAWA

"Plasma Physics & the Future," M. P. Bachynski, RCA Victor Co.; 12/1/60.

PHILADELPHIA

"Teaching Machines & Programmed Learning," R. W. Roop, General Atronics Corp.; 1/4/61.

PORTLAND

"Our trip to Europe and Russia," Dr. and Mrs. M. L. Morgan, Electro Scientific Industries. 9/22/60.

"Wave Forms Unlimited," G. E. Evelsizer, Exact Electronics. 10/20/60.

"The Application of Computers to the Design of Communication Distribution Systems," R. W. Amory, Bell Tele. Labs.; 11/10/60.

"Engineering Application of Computers in Several Asian Countries," J. K. Delson, Consulting Engineer. 12/5/60.

PRINCETON

"Electronics in Oceanography," J. B. Hershey, Woods Hole Oceanographic Inst. 11/10/60.

"Scientific Techniques of Criminal Investigation," I. W. Conrad, FBI. 12/8/60.

QUEBEC

"Hyperfrequencies et Optique," Real Tremblay, Laval Univ. 12/13/60.

ROCHESTER

"Electronics Today & Tomorrow," J. D. McLean, Stromberg-Carlson. 12/6/60.

"The Growing Epic of Christmas," Rev. W. P. Jenkins, First Unitarian Church. 12/13/60.

ROME-UTICA

"Radio Frequency Interference Reduction," C. L. Fredrick, Fredrick Res. Corp.; "Radio Frequency Interference," Benjamin Lindeman, RADC, Griffiss AFB. 12/12/60.

SACRAMENTO

"Microwave Fuel to Power an Airborne Platform," Dr. R. L. McFarlan, IRE President. 12/10/60.

ST. LOUIS

"Environment of Manned Space Systems," A. J. Cacioppo, Goodyear Aircraft Corp. 11/10/60.

"The Matric Computer," P. M. Honnell, Washington Univ. 12/6/60.

SALT LAKE CITY

"A Survey of Low-Noise Amplifiers at Microwave & Higher Frequencies," Glen Wade, Raytheon Spencer Lab.: 11/29/60.

"The Inter-Continental Ballistic Missile," D. F. Folland, Sperry Utah Engrg. Lab.; Films: "On Target" & "Photograph Earth." 12/8/60.

"Solid State Traveling Wave Masers," H. E. D. Scovil, Bell Tele. Labs.; "Systems Aspect of Maser Research," E. D. Reed, Bell Tele. Labs. 12/16/60.

SAN ANTONIO-AUSTIN

"The Silicon Unijunction Transistor," C. W. Martin, GEEIA Regional Off., USAF, 10/19/60.

"Development of Ground Station Instrumentation for the Transit Navigation Satellite," G. G. Moore, Univ. of Texas, 11/9/60.

"Stereo Geometry Measurements," P. W. Klipsch, Klipsch and Associates, Inc.; Sponsored by San Antonio Chapter PGA; 12/7/60.

SAN DIEGO

"Deep Sea Operations of the Bathyscaph 'Trieste'," D. C. Jensen, N E L Lab.; 12/7/60.

SEATTLE

"Adaptive Control Systems," R. N. Clark, Univ. of Washington, 9/29/60.

"Brainstorming—a technique for producing ideas," C. H. Clark, Boeing Airplane Co.; 10/27/60.

SHREVEPORT

"M.T.I. Radar," V. J. Holobaugh, F.A.A. Radar Approach Control Center; 1/3/61.

SOUTH CAROLINA

"Quantum Amplifiers, including MASERS, Esaki Diodes and Negative Mass Amplifiers," A. J. MacKinnon, Western Electric Co.; Joint meeting with AIEE; 12/14/60.

TOLEDO

Tour of Enrico Fermi Atomic Power Plant, Monroe, Mich.; 12/15/60.

"The Transistor Story," R. C. Clark, Ohio Bell Telephone Co.; 1/10/61.

TORONTO

"Ultrasonic Cleaning," C. J. McReynolds, Canadian Westinghouse Co., Ltd.; 1/9/61.

TWIN CITIES

"Microphone Design and Application," L. Burroughs, Electrovoice Corp.; Tour of Kay Bank Company studios; 1/11/61.

VANCOUVER

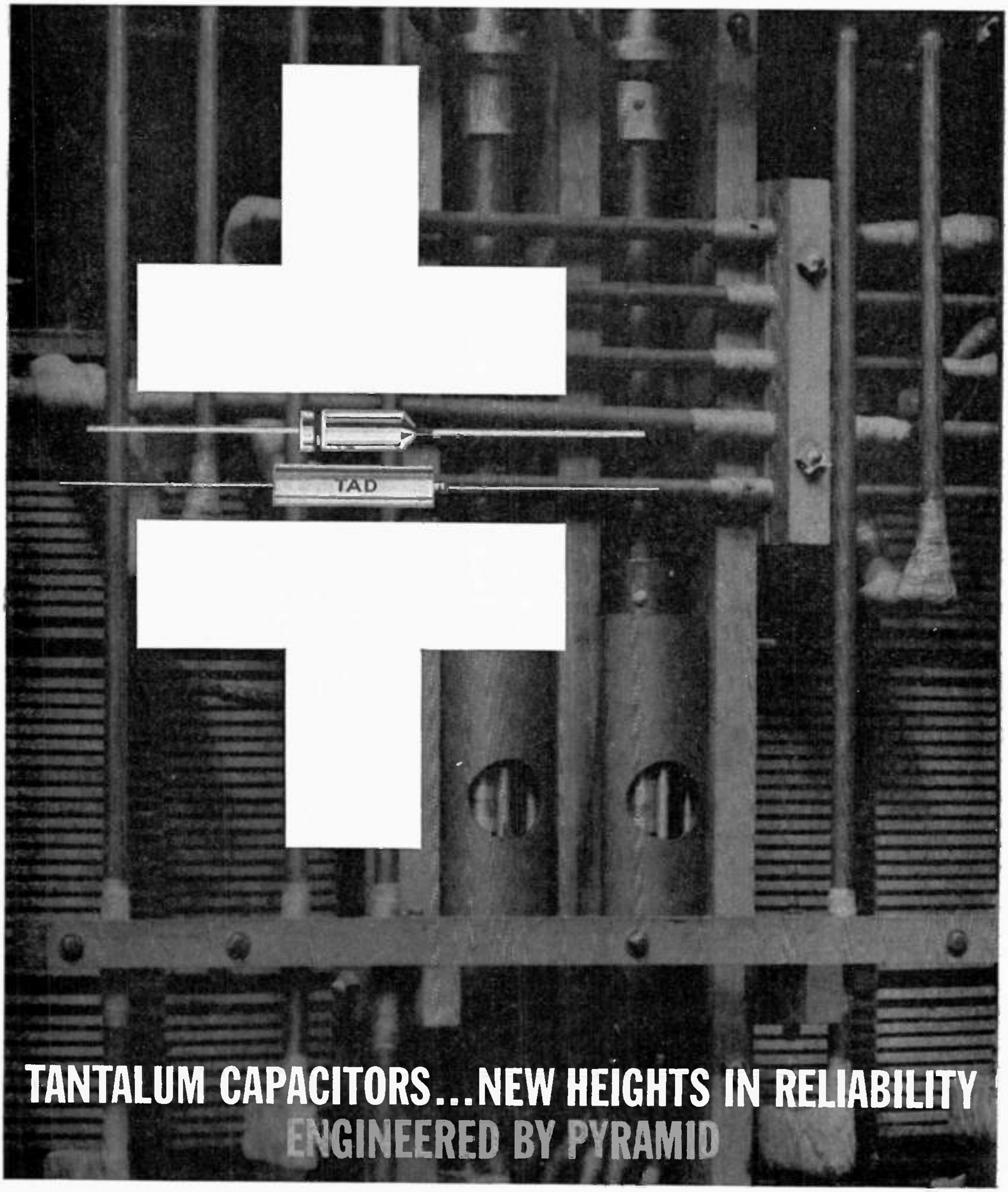
"Direct Distance Dialing," N. N. Harrah, B. C. Telephone Co.; 12/12/60.

VIRGINIA

"Human Servo Response," M. G. Foster, Univ. of Virginia; 12/16/60.

"Molecular Circuitry—A New Concept in Miniaturization," T. E. Dunn, Westinghouse Electric Corp., 1/6/61.

(Continued on page 58A)



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Chapter

1 Tunnel Diode Theory
2 Ratings and Characteristics
3 Amplifiers
4 Oscillators
5 Switches
6 Logic Circuits
7 Test Circuits
8 Bibliography
9 Specifications

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Section Meetings

(Continued from page 54A)

WICHITA

"The Development of an All-Solid-State Microwave Power Source," T. W. Falconer, Texas Instruments; Joint meeting with AIEE; 10/24/60.

"Infrared Detection Systems," D. E. German, Infrared Tech. Gp., Boeing Airplane Co.; 11/29/60.

SUBSECTIONS

EAST BAY

"The LARC Computer, The Fastest Computer in Operation Today," R. Douthitt, Remington-Rand Consultant for I RL; Tour of the LARC; 9/26/60.

"The Stanford 2-mile Electron Linear Accelerator," O. E. Snyder, Stanford Univ.; 12/28/60.

EASTERN NORTH CAROLINA

"Application of an Economic Dispatch Computer to Utility Systems," W. J. Brogdon, Carolina Power & Light Co.; Election of Officers for 1961; 1/13/61.

LANCASTER

"Tiros I—History, Development, and Operation of Satellite and Ground Equipment," J. Keigler, RCA; 11/29/60.

LEHIGH VALLEY

"Statistical Concepts in the Checkout of Missile-Borne Electronic Equipment," N. D. Larky, General Electric at Space Tech. Labs.; 9/28/60.

"Artificial Earth Satellites and the Ionosphere," G. Hame, Ohio State Antenna Lab.; 12/2/60.

"Ballistic Missile Guidance for Weapons and Satellites," D. R. Hagner, Bell Tel. Labs.; Joint meeting with AIEE; 12/9/60.

(Continued on page 62A)

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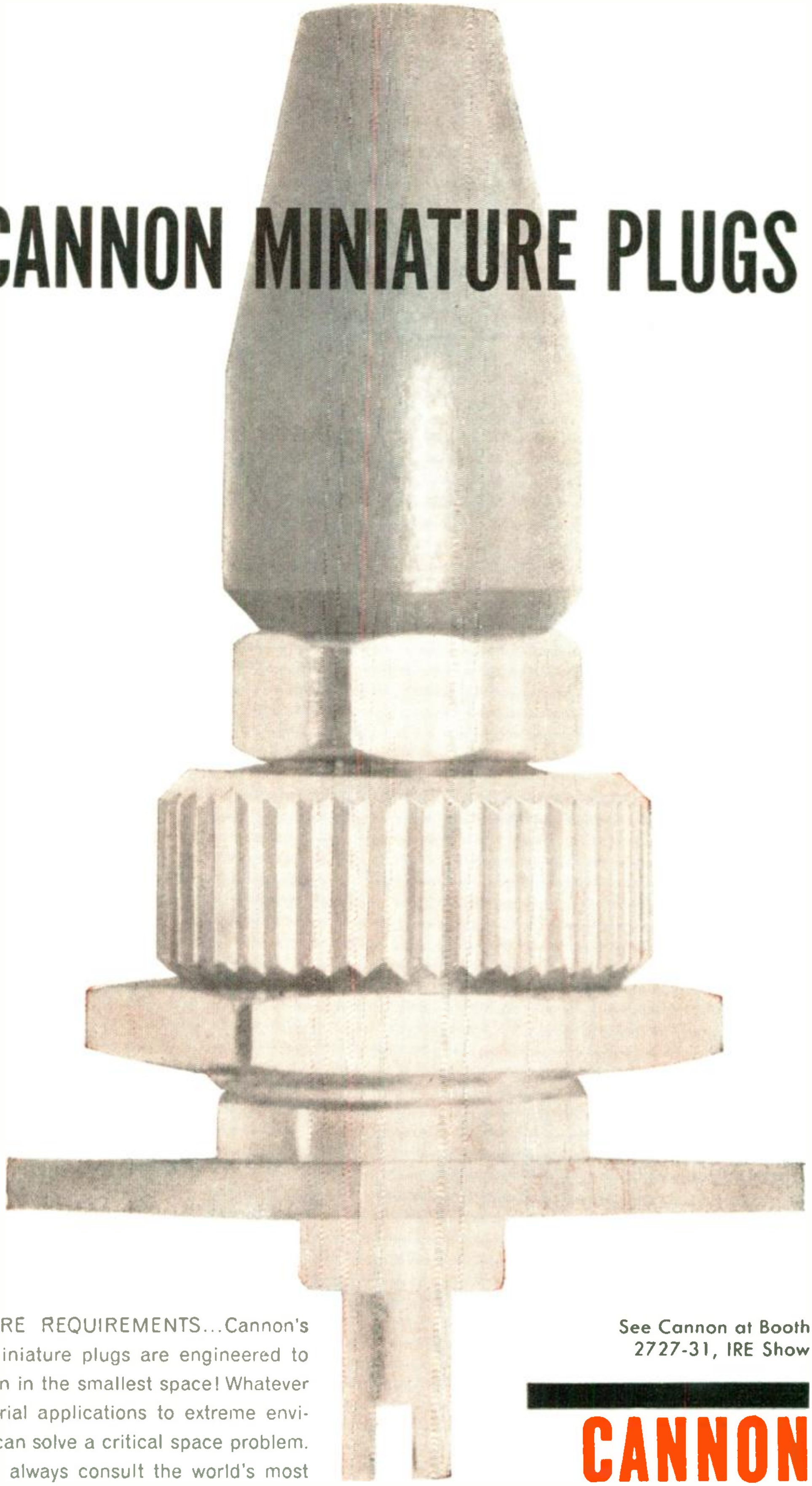

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IRE People

Dr. Richard B. Adler (S'44–A'48–SM'53–F'60), Professor of Electrical Engineering at Massachusetts Institute of Technology, Cambridge, has been named to the Board of Directors of Solid State Materials Corporation of East Natick, Mass., it was announced by J. P. Wenckus, President of Solid State.

R. B. Adler

After receiving the B.S.E.E. degree in 1943 from MIT, Dr. Adler served in the U. S. Naval Reserve as instructor at the MIT Radar School until 1946. At that time he became part-time staff member at the Research Laboratory of Electronics at the Institute; he has been associated with MIT since then in both research and teaching capacities.

His major interests have been in Circuit Theory, Electromagnetic Theory, and Semiconductor Electronics. In 1949 he received the degree of Sc.D. in Electrical Engineering.

From 1951 to 1953, he was leader of the MIT Lincoln Laboratory Solid State and Transistor Group. Since then, he has continued in the same field at the MIT Research Laboratory of Electronics and more recently, with the Energy Conversion Group of the MIT Electronic Systems Laboratory.

Dr. Adler was born in New York, N. Y., on May 9, 1922. He is a member of Sigma Xi and Eta Kappa Nu.

❖

Stuart L. Bailey (A'28–M'36–SM'43–F'43) was elected a vice-president of Atlantic Research Corporation at a meeting of the Board of Directors on December 15, 1960, it has been announced. He has been president of the electronics and communications firm of Jansky & Bailey, Inc., of Washington, D. C., which was acquired by Atlantic Research in September, 1959. He continues as President of the recently-established Jansky & Bailey Division of Atlantic Research.

Mr. Bailey received the degree of Bachelor of Science in Electrical Engineering from the University of Minnesota, Minneapolis, in 1927, and the Master of Science degree from the same institution in 1928. He was a student of C. M. Jansky, Jr., at the University of Minnesota, and the two organized a consulting engineering business in Washington in 1930.

❖

Rubin Blumkin (A'50–M'58) has been appointed Vice President, Engineering, of General Resistance, Inc., manufacturers of wire wound resistors and networks. He has been Chief Engineer since he joined General Resistance in October, 1959.

R. Blumkin

Previously he was with Olympic Radio & Television, Inc., as an Engineering Department Head in charge of production development work. From 1945 to 1952 he was associated with the Federal Telecommunication Laboratories of the International Telephone and Telegraph Corporation as a project engineer.

Mr. Blumkin received the B.S.E.E. degree from the College of the City of New York, N. Y., in 1943 and has done graduate work at the Polytechnic Institute of Brooklyn, Brooklyn, N. Y.

❖

David D. Bulkley (M'56) has been appointed product manager for intercommunication systems in Stromberg-Carlson's Commercial Products Division. Stromberg-Carlson is a division of General Dynamics Corporation.

D. D. Bulkley

He comes to Stromberg-Carlson from the International Telephone and Telegraph Corporation in New York, N. Y., where he spent six years in research and development administration for the company's network of research laboratories located in the United States and Europe. He has been most recently associated with the International Telephone and Telegraph subsidiary, Intelex Systems Incorporated, where for four years he was product line sales manager for imported electronic products.

He has been engaged for more than 16 years in the telecommunication industry, and has written extensively for technical and semi-technical journals. In his new position, he will be responsible for coordination of all intercommunication products manufactured by the Commercial Products Division. These include automatic private internal telephone systems, loudspeaking intercommunicating systems, and manual private telephone systems.

During World War II, Mr. Bulkley served with the U. S. Maritime Service from 1943 to 1946 with rank of Lieutenant

(*Continued on page 66A*)

IRE People

(Continued from page 64A)

(j.g.). He is a member of the Professional Group on Communication Systems, having served as treasurer in 1959–60.

❖

Dr. George Caryotakis (S'50–A'51–M'57) has been appointed Manager of the newly formed High-Power Laboratory of Eitel-McCullough, Inc. He will direct Eimac's research and development activities for amplifier klystrons and other high-power microwave tubes. The High-Power Tube Laboratory is located in Belmont, Calif.

G. Caryotakis

Prior to his recent appointment, he was Senior Project Engineer in Eimac's Power Klystron Division. His work at Eimac has involved high-power, broadband klystron research and development.

He received the Ph.D. and M.S. degrees from Stanford University, Stanford, Calif., and the B.S.E.E. degree from Syracuse University, Syracuse, N. Y. He worked on periodic focusing of traveling-wave tubes while a research associate at Stanford Electronics Laboratories.

Mr. Caryotakis has several patents pending on klystron design and has presented a number of papers on this subject. He is a member of Sigma Xi and Tau Beta Pi.

❖

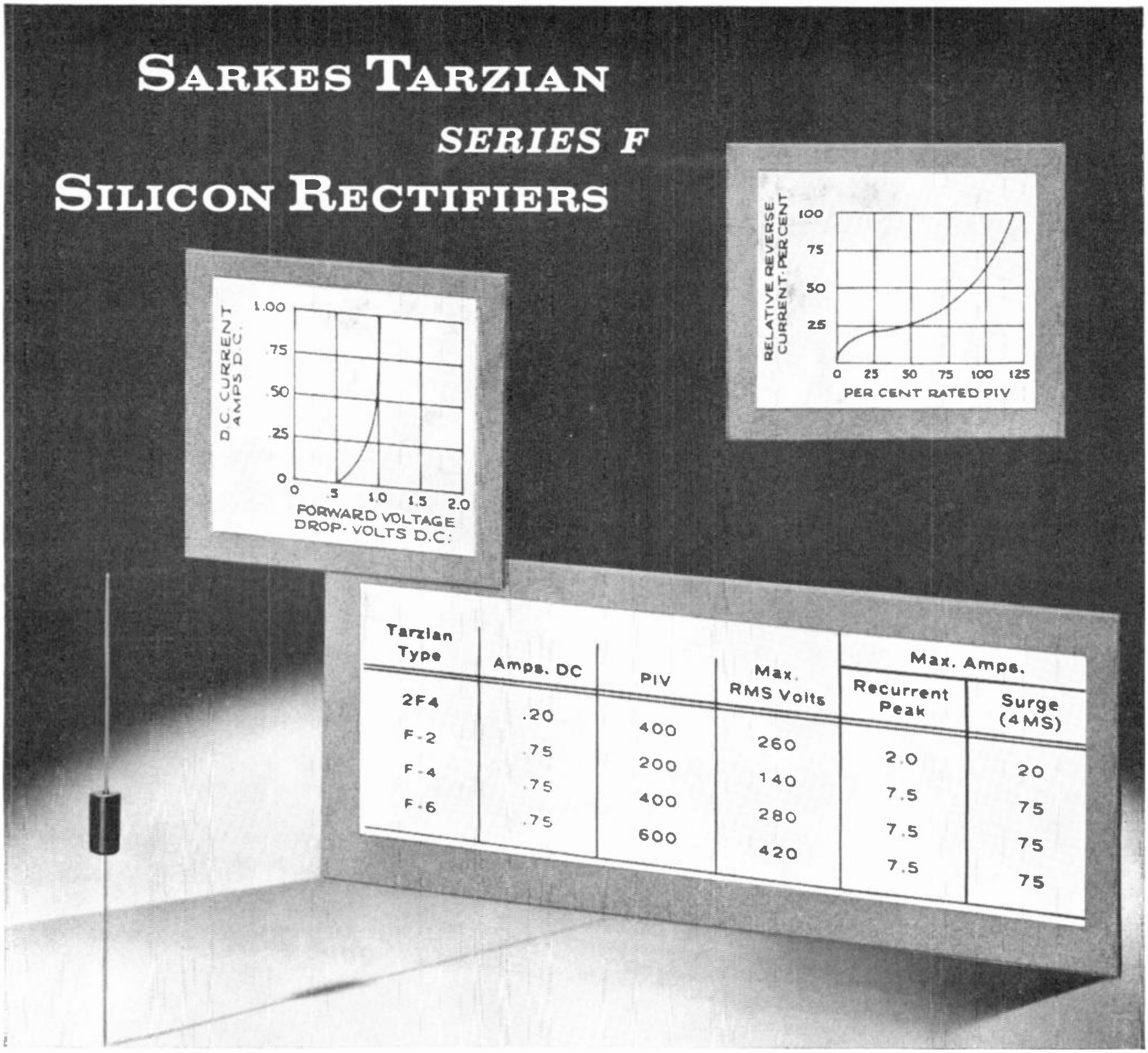
Appointment of **Gilbert B. Devey** (S'45–M'50) as general manager of Vec-Trol Engineering, Inc., of Stamford, Conn., manufacturer of thyratron and silicon controlled rectifier electrical controls, has been announced by D. B. Peck, vice-president—special products of the Sprague Electric Company, parent company of Vectrol.

Mr. Devey will be responsible for the commercial expansion of VecTrol's line of electronic and electrical power control components as furnished to end equipment manufacturers, working closely with **Walter J. Brown** (M'25–SM'43), president and director of engineering of the recently acquired Sprague subsidiary. Mr. Brown will at the same time undertake expansion of VecTrol's custom design program for electronic control users with a greatly increased engineering staff.

Mr. Devey's new responsibilities are in addition to those of his present post as marketing manager of Sprague's Special Products Group, which manufactures digital electronic components, packaged component assemblies, and high temperature magnet wires.

He first came to Sprague in 1953 as a product specialist in the field engineering department, having previously been with the Office of Naval Research in Washing-

(Continued on page 70A)



Tarzian Type	Amps. DC	PIV	Max. RMS Volts	Max. Amps. Recurrent Peak	Max. Amps. Surge (4MS)
2F4	.20	400	260	2.0	20
F-2	.75	200	140	7.5	75
F-4	.75	400	280	7.5	75
F-6	.75	600	420	7.5	75

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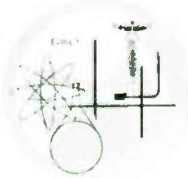

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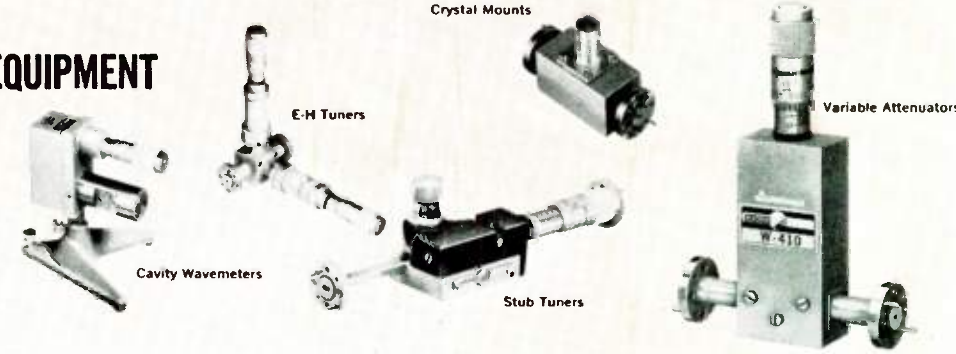

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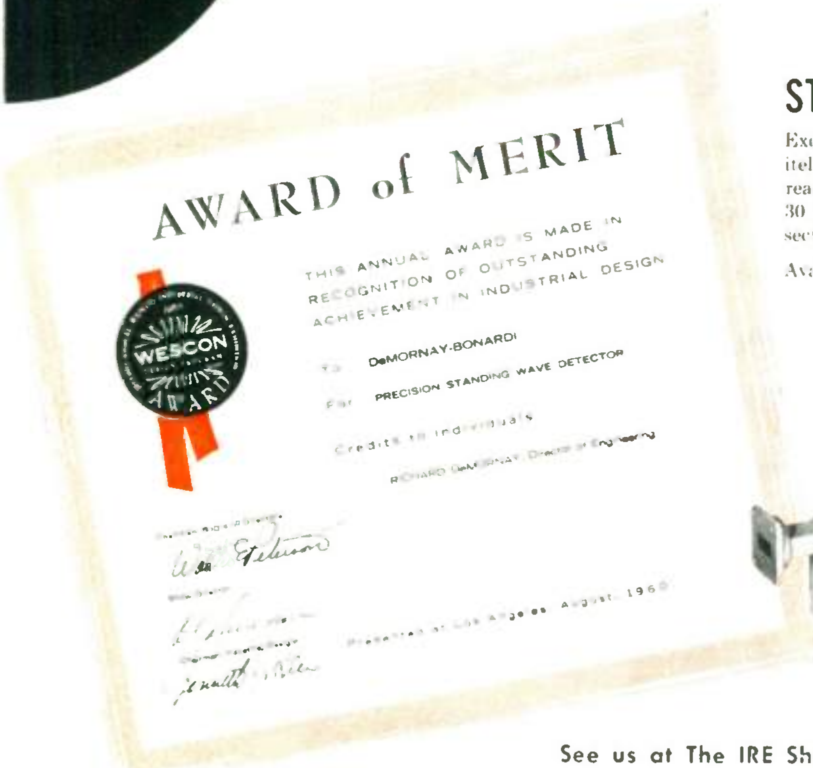

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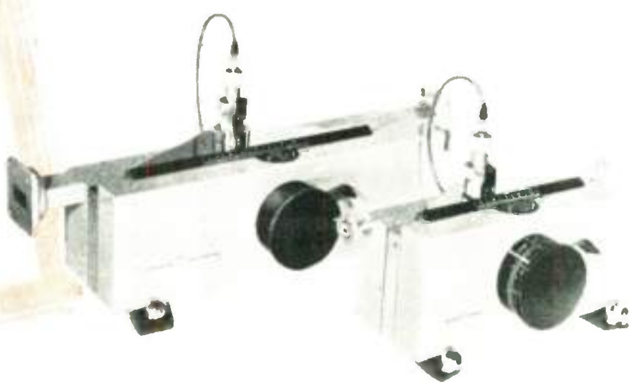

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(Continued from page 66A)

ton, D. C., where he was an electronic scientist engaged in undersea warfare studies. During World War II, he was a lieutenant commander in the United States Navy. He is a graduate of the Massachusetts Institute of Technology, Cambridge, and attended the United States Naval Academy Post-Graduate School specializing in electronic engineering. He was named product manager of the Special Products Division of Sprague when it was founded in 1958, and was later promoted to his present post. He is chairman of the Electronic Industries Association Committee P-9 on Printed and Modular Components.

Mr. Brown, well-known, English-born inventor, prior to joining VecTrol was at various times section leader in radio research at Metropolitan Vickers Electrical Co., Ltd.; chief engineer of the radio set division of Electric and Musical Industries, Ltd.; director of engineering at Philco of Great Britain, Ltd.; and vice-president in charge of production and assistant to the president at The Brush Development Co., Cleveland, Ohio. He has the Bachelor of Science degree from the University of Manchester, England. He presently has 110 patents to his credit, dating back to 1923. He is a fellow of the American Institute of Electrical Engineers, a member of the Institution of Electrical Engineers, London, a registered professional engineer in Connecticut and Ohio, and a chartered electrical engineer in Great Britain.

⁂

Dr. F. Beringer Fank (S'50–A'52–M'56) has been named Manager—Low Power Traveling Wave Tube Engineering at General Electric's electronics plant in Schenectady, N. Y.

F. B. FANK

A native of Glendale, Calif., he joined General Electric in 1951 and is a graduate of the Company's Engineering Training Program. He was with the Company's Electronics Laboratory in Syracuse for two years before joining the Microwave Laboratory, Schenectady, in 1954.

Dr. Fank is a graduate of Stanford University, Stanford, Calif., and received the doctor's degree in electrical engineering there in 1958. He is a member of Sigma Xi.

⁂

(Continued on page 72A)

IRE People

(Continued from page 70A)

Leon D. Findley (M'57) has been appointed manager of the naval tactical data system (NTDS) department at Remington Rand Univac.

L. D. Findley

He was employed by the Midwest Research Institute, Kansas City, Mo., from 1950–60, lastly as head of the systems engineering section. He joined Univac's predecessor company in St. Paul, Engineering Research Associates, in 1948 after receiving the master's degree in electrical engineering from Kansas State University.

A member of the Association for Computing Machinery and the Research Society of America, Mr. Findley is a native of Kiowa, Kans.

He returned to the Univac Military division in October, 1960 as staff consultant to the acting manager of NTDS.

❖

The appointment of **Dr. Lawrence J. Giacoletto** (S'37–A'42–M'44–SM'48–F'58)

(Continued on page 76A)

Specifications for General Magnetics' Sub-Ouncer Line of "MAG MOD" miniaturized MAGNETIC MODULATORS

TYPE NUMBER	IMM 487-4	IMM 495-8	IMM 504-5	IMM 562-1	IMM 561-1	IMM 556-5
Excitation Carrier Voltage and Frequency	115 V @ 400 cps	115 V @ 400 cps	115 V @ 400 cps	2.5 V RMS @ 4 KC	1.0 V RMS @ 10 KC	6 to 10 V RMS @ 35 KC
Control Signal Winding DC Resistance	Winding No. 1 6200 ohms Winding No. 2 7400 ohms	Signal Winding No. 1 550 ohms Signal Winding No. 2 600 ohms	1000 ohms	Signal Winding [illegible] ohms Feedback Winding 160 ohms	200 ohms	5000 ohms
Input Control Signal Range	0 to ±40 μa Each Winding	0 to ±100 μa (Both Sig. Windings in Series)	0 to ±100 μa	0 to ±100 μa 0 to ±1 V Bipolar	0 to ±400 μa	0 to ±400 μa
Amplitude Modulated AC Output Range	3 V RMS @ 400 cps Phase Reversing	0 to 1 V RMS @ 400 cps Phase Reversing	0 to 1.5 V RMS @ 400 cups Phase Reversing	0 to 6 V RMS @ 4000 cps Phase Reversing	0 to 3 V RMS @ 4 KC Phase Reversing	0 to 1.8 V RMS @ 35 KC Phase Reversing
Differential Gain RMS mv AC Out/μa Signal In	100 mv/μa	15 mv/μa	10 mv/μa	200 mv/μa	10 mv/μa	4.2 mv/μa
Null Amplitude (Noise Level) mv RMS	25 mv RMS Maximum	5 mv RMS Maximum	10 mv RMS Maximum	30 mv RMS Maximum	10 mv RMS Maximum	20 mv RMS Maximum
Output Impedance	Approx. 30 K ohms	1600 ohms	1000 ohms	Approx. 70 K ohms	Approx. 40 K ohms	900 ohms Each Output Wind.
External Load (Suggested)	Approx. 20 K ohms	Approx. 10 K ohms	Approx. 5 K ohms	Approx. 100 K ohms	Approx. 100 K ohms	1000 ohms Each Output Wind.
Null Drift (In terms of Input Signal) −65°C to +135°C	Less than ±0.25 μa Over Temp. Range	Less than ±0.25 μa Over Temp. Range	±1 μa Maximum Over Temp. Range	±0.5 μa Maximum Over Temp. Range	±1 μa Over Temp. Range	±2 μa Over Temp. Range
Hysteresis (% of Input Control Signal)	0.5% Maximum	0.5% Maximum	0.5% Maximum	Approx. 0.5%	0.5% Maximum	0.5% Maximum
% Harmonic Distortion In Output AC Modulated Envelope	Approx. 40% (3rd Harmonic)	Approx. 25% (3rd Harmonic)	Approx. 30% (3rd Harmonic)	Approx. 15% (3rd Harmonic)	Less Than 10% (3rd Harmonic)	Approx. 5% (3rd Harmonic)
Overall Dimensions (In Inches)	1¼ x 1⅛ x ¾	¾ x 1 x 1	1 x 1 x 1	1 x 11/16 x ⅞	11/16 x 1 x ⅝	7/16 x 1⅜ x 1¼
Type of Mounting	4-40 Studs or Inserts	4-40 Studs or Inserts	4-40 Studs or Inserts	4-40 Studs or Inserts	2-56 Studs	4-40 Tapped Holes or Studs
Weight In Ounces	Approx. 1.25	Approx. 1	Approx. 1.1	0.75	0.6	1
Response Time (Band Width cps)	0.01 sec. for 15 K Sig. Source Imp. (12 cps Corner Frequency)	20 cps for 10 K Sig. Source Imp. 25 cps for 20 K Sig. Source Imp. (Both Sig. Windings In Series)	5 cps for 1 K Sig. Source Imp. 10 cps for 5 K Sig. Source Imp. 20 cps for 10 K Sig. Source Imp.	70 cps for 10 K Sig. Source Imp. (Time Constant Approx. 2 Milli-Seconds)	Corner Frequency 2 KC for Sig. Source Imp. of Approx. 6 K ohms	Corner Frequency 200 cps for 600 ohm Signal Source Imp or 1000 cps for 5 K Source

Magnetic Multiplying Modulator Model MCM 515-1

The MAGNETIC MULTIPLIER is a miniaturized magnetic modulator specifically designed to deliver an analog output voltage which is the continuous product of two variable input voltages. One of these is an excitation voltage which varies over a pre-determined range; in this case, 0 to 1 VRMS 400 cycles per second. The other signal is a DC current which varies between 0 and ±400 μa. The output voltage is 400 cycles AC, and is always in phase or 180° out of phase with the variable excitation or fixed reference, i.e., in phase when the variable amplitude DC signal is positive, and 180° out of phase when the DC signal is negative. The general schematic is illustrated in Fig. 1. The relationship between variable alternating supply signal voltage E_S, variable direct current control signal E_C, and the alternating load voltage E_L having a sinusoidal wave shape is denoted by the equation—

$$E_L = \text{Constant} \times E_S \times E_C.$$

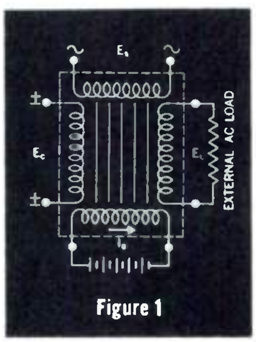

Figure 1

This expression, which defines the fundamental principle of the four quadrant MAGNETIC MULTIPLYING MODULATOR, can be clearly illustrated by linear transfer response curve families as shown at right, in Figure 2-A and Figure 2-B.

Illustrating:

(1) Load voltage E_L as a function of alternating supply signal voltage E_S with control DC signal voltage E_C as a parameter.

(2) Load voltage E_L as a function of control DC signal voltage E_C with alternating supply voltage, E_S as a parameter.

With linearity response curves held to within approximately 1 to 2% of theoretical straight lines, the product accuracy of the fundamental equation will be within 2 to 5% of the theoretical product.

SPECIFICATIONS MODEL MCM 515-1

Variable Excitation Carrier Voltage and Frequency	Variable AC Signal 0 to 1 V RMS 400 cps
Control Signal Winding DC Resistance	DC Signal Winding Resistance 2650 ohms
Input Control Signal Range	Variable DC Signal 0 to ±400 μa
Amplitude Modulated AC Output Range	0 to 0.9 V RMS @ 400 cps Phase Reversing
Null Amplitude (Noise Level) mv RMS at Max. AC Excitation	5 mv RMS
Output Impedance	Approx. 3500 ohms
External Load (Suggested)	Approx. 25 K ohms
Null Drift (In terms of Input Signal) −65°C to +135°C	±2 μa over Temperature Range
Hysteresis (% of Input Control Signal)	0.5% Maximum
% Harmonic Distortion In Output AC Modulated Envelope	Less than 5%
Overall Dimensions (In Inches)	27/32 x 27/32 x 1 3/16
Type of Mounting	4-40 Insert or Stud
Weight	Approx. 1 Ounce

Amplitude Response Curve

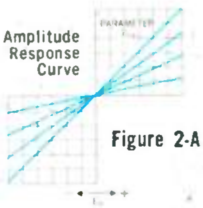

Figure 2-A

Amplitude Response Curve

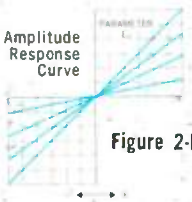

Figure 2-B

Typical "Mag Mod"® Applications—Circuit applications for MAGNETIC MODULATORS include algebraic addition, subtraction, multiplying, raising to a power, controlling amplifier gain, mechanical chopper replacement in DC to fundamental frequency conversion, filtering and low signal level amplification.

Consult General Magnetics—For magnetic amplifier components of proven reliability. These dependable instruments are widely employed in automatic flight systems, fire control, analog computers, guided missiles, nuclear equipment, antennas, gun turrets, commercial power amplifiers and complete control systems. Miniature, subminiature, standard and customized types available.

Call or write for new Brochure 102 on "MAG MOD" Miniaturized Magnetic Modulators and Magnetic Multiplying Modulators. Please address inquiries on company letterhead.

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135 BLOOMFIELD AVENUE, BLOOMFIELD, NEW JERSEY, U. S. A.

WRH

IRE People

(Continued from page 72A)

as a professor in the Department of Electrical Engineering and the Division of Engineering Research within the College of Engineering of Michigan State University, East Lansing, has been announced. It is felt that the addition of Dr. Giacoletto to the university staff will materially strengthen the institution in the broad area of electronics with emphasis on semiconductor devices and electronic properties of materials. It is anticipated that his extensive background and scientific experience will be important factors in developing interdisciplinary graduate research programs.

L. J. GIACOLETTO

Before accepting the academic position, he was for four years the Manager of the Electronics Department of the Ford Motor Company Scientific Laboratory. Prior to holding that position, he had been associated for ten years with the Radio Corporation of America Research Laboratories, where he was first occupied with electron tube research and subsequently with transistor and semiconductor research. In connection with the latter work, he has received world-wide recognition and election to the grade of Fellow in the IRE for the development of a transistor parameter circuit which bears his name and for the first development of a nonlinear semiconductor capacitor with ultra-high-frequency properties which is now being exploited extensively for low-noise microwave parametric amplification. He is also a Fellow of the American Association for the Advancement of Science and a member of the American Physical Society and Sigma Xi.

Dr. Giacoletto did his undergraduate work at Rose Polytechnic Institute, Terre Haute, Ind. He received the M.S. degree in Physics from the State University of Iowa, Iowa City, and the Ph.D. degree from the University of Michigan, Ann Arbor. During World War II he held various positions as a Signal Corps officer with the Signal Corps Engineering Laboratories and was particularly responsible for research and development work on navigational systems, communications and meteorological direction finders, and related apparatus; his present rank is that of Lieutenant Colonel in the U. S. Army Reserve. He has been very active in IRE activities at both the section and national level, and is currently a member of the Editorial Review committee, Executive Committee of the Detroit Section and Executive Committee of the Professional Group on Industrial Electronics. He was the founder of one subsection and has been chairman of three different sections.

In addition to authoring approximately 50 articles in various technical and scientific magazines, he has contributed to two

(Continued on page 80A)

28 Fields of Special Interest-

The 28 Professional Groups are listed below, together with a brief definition of each, the name of

Aerospace and Navigational Electronics

Annual fee: $2.

The application of electronics to operation and traffic control of aircraft and to navigation of all craft.

Mr. E. A. Post, Chairman, Stanford Research Inst., Menlo Park, Calif.

37 Transactions, *6, & *9, and Vol. 2, No. 1-3; Vol. 4, No. 1, 2, 3; Vol. 5, No. 2, 3, 4; Vol. 6, No. 1, 2, 4; Vol. 7, No. 1, 2, 3.

Antennas and Propagation

Annual fee: $4.

Technical advances in antennas and wave propagation theory and the utilization of techniques or products of this field.

Prof. Edward C. Jordan, Chairman, Electrical Engineering Dept., University of Illinois, Urbana, Ill.

33 Transactions, *Vol. AP-2, No. 2; AP-4, No. 4; AP-5, No. 1-4; AP-6, No. 1, 2, 3, 4; AP-7, No. 1, 2, 3, 4; AP-8, No. 1, 2, 3, 4, 5, 6.

Audio

Annual fee: $2.

Technology of communication at audio frequencies and of the audio portion of radio frequency systems, including acoustic terminations, recording and reproduction.

Mr. H-S. Knowles, Chairman, Knowles Electronics, 9400 Belmont Ave., Franklin Park, Ill.

55 Transactions, *Vol. AU-1, No. 6; *Vol. AU-2, No. 4; Vol. AU-3, No. 1, 3, 5; Vol. AU-4, No. 1, 5-6; Vol. AU-5, No. 1, 2, 3, 4, 5, 6; AU-6, No. 1, 2, 3, 4, 5, 6; AU-7, No. 1, 2, 3, 4, 5, 6; AU-8, No. 1, 2, 3, 4, 5.

Automatic Control

Annual fee: $3.

The theory and application of automatic control techniques including feedback control systems.

Mr. John M. Salzer, Chairman, 909 Berkeley St., Santa Monica, Calif.

11 Transactions, PGAC-3-4-5-6, AC-4, No. 1, 2, 3; AC-5, No. 1, 2, 3, 4.

Bio-Medical Electronics

Annual fee: $3.

The use of electronic theory and techniques in problems of medicine and biology.

Dr. Herman P. Schwan, Chairman, University of Pennsylvania, School of Elec. Engrg., Philadelphia 4, Pa.

17 Transactions, 8, 9, 11, 12; ME-6, No. 1, 2, 3, 4; ME-7, No. 2, 3.

Broadcast & Television Receivers

Annual fee: $4.

The design and manufacture of broadcast and television receivers and components and activities related thereto.

Mr. Robert R. Thalner, Chairman, Sylvania Home Electronics, Batavia, N.Y.

27 Transactions, *7, 8; BTR-1, No. 1-3, BTR-2, No. 1-2-3; BTR-3, No. 1-2; BTR-4, No. 2, 3-4; BTR-5, No. 1, 2; BTR-6, No. 1, 2, 3.

Broadcasting

Annual fee: $2.

Broadcast transmission systems engineering, including the design and utilization of broadcast equipment.

Mr. George E. Hagerty, Chairman, Westinghouse, 122 E. 42nd St., New York 17, N.Y.

17 Transactions, No. 10, 11, 12, 13, 14; BC-6, No. 1, 2, 3.

Circuit Theory

Annual fee: $3.

Design and theory of operation of circuits for use in radio and electronic equipment.

Mr. Sidney Darlington, Chairman, Bell Tel. Labs., Murray Hill, N.J.

28 Transactions, CT-4, No. 3-4; CT-5, No. 1, 2, 3, 4; CT-6, No. 1, 2, 3, 4; CT-7, No. 1, 2, 3.

Communications Systems

Annual fee: $2.

Radio and wire telephone, telegraph and facsimile in marine, aeronautical, radio-relay, coaxial cable and fixed station services.

Capt. C. L. Engleman, Chairman, CEIR, Inc., 1200 Jefferson Davis Highway, Arlington, Va.

19 Transactions, CS-5, No. 2, 3; CS-6, No. 1, 2; CS-7, No. 1, 3, 4; CS-8, No. 1, 2, 3.

Component Parts

Annual fee: $3.

The characteristics, limitation, applications, development, performance and reliability of component parts.

Mr. Floyd E. Wenger, Chairman, Headquarters ARDC, Andrews AFB, Washington 25, D.C.

21 Transactions, CP-4, No. 1, 2, 3-4; CP-5, No. 1, 2, 3, 4; CP-6, No. 1, 2, 3, 4; CP-7, No. 1, 2, 3.

Education

Annual fee: $3.

To foster improved relations between the electronic and affiliated industries and schools, colleges, and universities.

Dr. John G. Truxal, Chairman, Dept. of EE, PIB, Brooklyn, N.Y.

12 Transactions, Vol. E-1, No. 3, 4; E-2, No. 1, 2, 3, 4; E-3, No. 1, 2, 3, 4.

Electron Devices

Annual fee: $3.

Electron devices, including particularly electron tubes and solid state devices.

Mr. A. Kyle Wing, Jr., Chairman, Fed. Telecommunication Labs., 500 Washington Ave., Nutley 10, N.J.

30 Transactions, *Vol. ED-1, No. 3-4; ED-3, No. 2-4; ED-4, No. 2-3, 4; ED-5, No. 2, 3, 4; ED-6, No. 1, 3; ED-7, No. 1, 2, 3, 4.

Electronic Computers

Annual fee: $4.

Design and operation of electronic computers.

Dr. A. A. Cohen, Chairman, Remington-Rand Univac, St. Paul 16, Minn.

35 Transactions, EC-6, No. 2, 3; EC-7, No. 1, 2, 3, 4; EC-8, No. 1, 2, 3, 4; EC-9, No. 1, 2, 3.

Engineering Management

Annual fee: $3.

Engineering management and administration as applied to technical, industrial and educational activities in the field of electronics.

Dr. Henry M. O'Bryan, General Tel. & Elec. Lab., 730 3rd Ave., New York 17, N.Y.

19 Transactions, EM-3, No. 2; EM-4, No. 3, 4; EM-5, No. 1-4; EM-6, No. 1, 2, 3; EM-7, No. 1, 2, 3

Engineering Writing and Speech

Annual fee: $2.

The promotion, study, development, and improvement of the techniques of preparation, organization, processing, editing, and delivery of any form of information in the electronic-engineering and related fields by and to individuals and groups by means of direct or derived methods of communication.

John M. Kinn, Jr., Chairman, IBM Journal, 545 Madison Ave., New York, N.Y.

7 Transactions, Vol. EWS-1, No. 2, EWS-2, No. 1, 2, 3; EWS-3, No. 1.

THE INSTITUTE OF RADIO

-IRE's 28 Professional Groups

the group chairman, and publications to date.

* Indicates publications still available

Human Factors in Electronics

Annual fee: $2.

Development and application of human factors and knowledge germane to the design of electronic equipment.

Mr. Robert R. Riesz, Chairman, Bell Tel. Labs, Murray Hill, N.J.

2 Transactions, HFE-1, No. 1, 2.

Industrial Electronics

Annual fee: $3.

Electronics pertaining to control, treatment and measurement, specifically, in industrial processes.

Mr. J. E. Eiselein, Chairman, RCA Victor Div., Camden, N.J.

13 Transactions, *PGIE 3, 5, 6, 7, 8, 9, 10, 11; IE-7, No. 1, 2.

Information Theory

Annual fee: $4.

The theoretical and experimental aspects of information transmission, processing and utilization.

Dr. Paul E. Green, Jr., Chairman, 14 Bradford Rd., Weston 93, Mass.

23 Transactions, PGIT-4, IT-1, No. 3; IT-2, No. 3; IT-3, No. 1, 2, 3, 4; IT-4, No. 1, 2, 3, 4; IT-5, No. 1, 2, 3, 4; IT-6, No. 1, 3, 4.

Instrumentation

Annual fee: $2.

Measurements and instrumentation utilizing electronic techniques.

Mr C. W. Little, Jr., Chairman, C-Stellerator Assoc., Princeton, N.J.

17 Transactions, PGI-4, Vol. 1-6, No. 2, 3, 4: Vol 1-7, No. 1, 2; Vol. 1-8, No. 1, 2; Vol. 1-9, No. 1.

Microwave Theory and Techniques

Annual fee: $3.

Microwave theory, microwave circuitry and techniques, microwave measurements and the generation and amplification of microwaves.

Dr. Kiyo Tomiyasu, Chairman, General Electric Gen. Eng. Lab., Schenectady, N.Y.

33 Transactions, MTT-4, No. 3; MTT-5, No. 3, 4; MTT-6, No. 1, 2, 3, 4; MTT-7, No. 2, 3, 4; MTT-8, No. 1, 2, 3, 4, 5, 6.

Military Electronics

Annual fee: $2.

The electronics sciences, systems, activities and services germane to the requirements of the military. Aids other Professional Groups in liaison with the military.

Dr. Edward G. Witting, Chairman, U. S. Army R & D., Pentagon 25, Washington, D.C.

10 Transactions, MIL-1, No. 1; MIL-2, No. 1; MIL-3, No. 2, 3, 4; MIL-4, No. 2-3, 4.

Nuclear Science

Annual fee: $3.

Application of electronic techniques and devices to the nuclear field.

Mr. Louis Costrell, Chairman, N.B.S., Washington 25, D.C.

18 Transactions, NS-1, No. 1; NS-4, No. 2; NS-5, No. 1, 2, 3; NS-6, No. 1, 2, 3, 4; NS-7, No. 1, 2-3, 4.

Product Engineering & Production

Annual fee: $2.

New advances and materials applications for the improvement of production techniques, including automation techniques.

Mr. W. D. Novak, Chairman, General Precision Labs., Pleasantville, N.Y.

6 Transactions, No. 2-3, 4, 5, 6.

Radio Frequency Interference

Annual fee: $2.

Origin, effect, control and measurement of radio frequency interference.

Professor Ralph M. Showers, Chairman, Moore School of Elec. Eng., 200 S. 33rd St., Philadelphia 4, Pa.

2 Transactions, RFI-1, No. 1, RFI-2, No. 1.

Reliability and Quality Control

Annual fee: $3.

Techniques of determining and controlling the quality of electronic parts and equipment during their manufacture.

Mr. P. K. McElroy, Chairman, General Radio Co., West Concord, Mass.

18 Transactions, *3, 5, 10, 11, 12, 13, 14, 15; RQC-9, No. 1, 2.

Space Electronics and Telemetry

Annual fee: $3.

The control of devices and the measurement and recording of data from a remote point by radio.

Mr. Robert V. Werner, Chairman, 5575 Kearney Road, San Diego 10, Calif.

15 Transactions, TRC-1, No. 2-3; TRC-2, No. 1; TRC-3, No. 2, 3; TRC-4, No. 1; SET-5, No. 1, 2, 3, 4; SET-6, No. 1, 2.

Ultrasonics Engineering

Annual fee: $2.

Ultrasonic measurements and communications, including underwater sound, ultrasonic delay lines, and various chemical and industrial ultrasonic devices.

Mr. David L. Arenberg, Chairman, Arenberg Ultrasonic Lab., Inc., 94 Green St., Jamaica Plains, Mass.

9 Transactions, PGUE, 5, 6, 7; UE-7, No. 1, 2.

Vehicular Communications

Annual fee: $2.

Communications problems in the field of land and mobile radio services, such as public safety, public utilities, railroads, commercial and transportation, etc.

Mr. Richard P. Gifford, Chairman, General Electric Co., Lynchburg, Va.

15 Transactions, 5, 8, 9, 10, 11, 12, 13; Vol. VC-9, No. 1, 2.

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IRE People

(Continued from page 76A)

books and has more than twenty patents. His technical qualifications have been recognized by the inclusion of his name in American Men of Science, Who's Who in Engineering, Who's Who in Science and Industry, National Engineers Register, and National Register of Scientific and Technical Personnel.

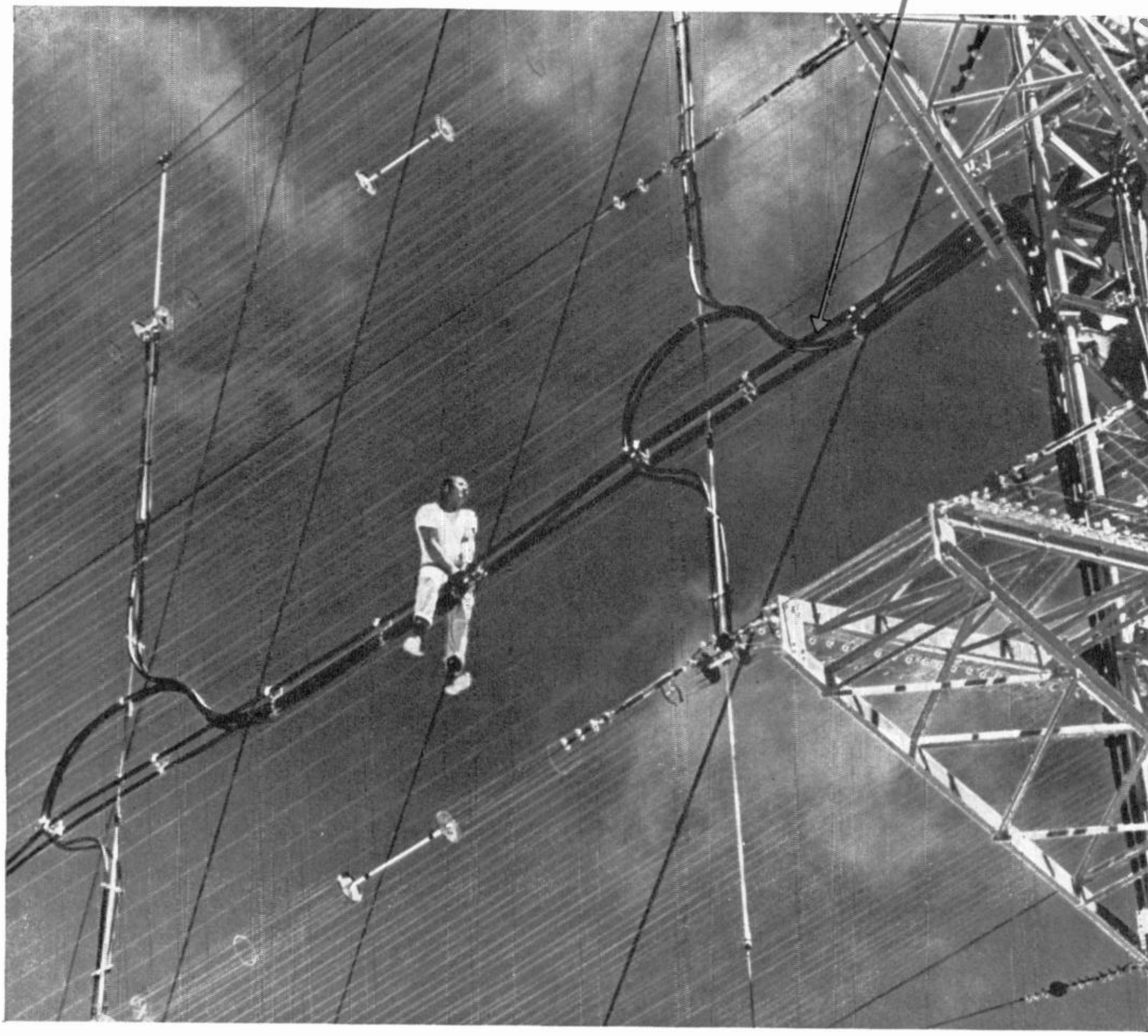
❖

Election of Frank A. Gunther (A'25–M'30–SM'53) as President of Radio Engineering Laboratories, Inc. (REL), communications subsidiary of Dynamics Corporation of America and the country's leading producer of tropospheric scatter radio equipment, was announced January 19, 1961 by DCA. He had been Executive Vice President and General Manager of REL since July, 1959, and his promotion to the presidency, DCA President R. F. Kelley stated, "marks recognition of the role he has played in the continuing growth of REL . . . ."

F. A. Gunther

(Continued on page 84A)

Engineer inspects Styroflex® cable installed on an antenna array at one of Pacific Scatter Communication System stations shown at right.

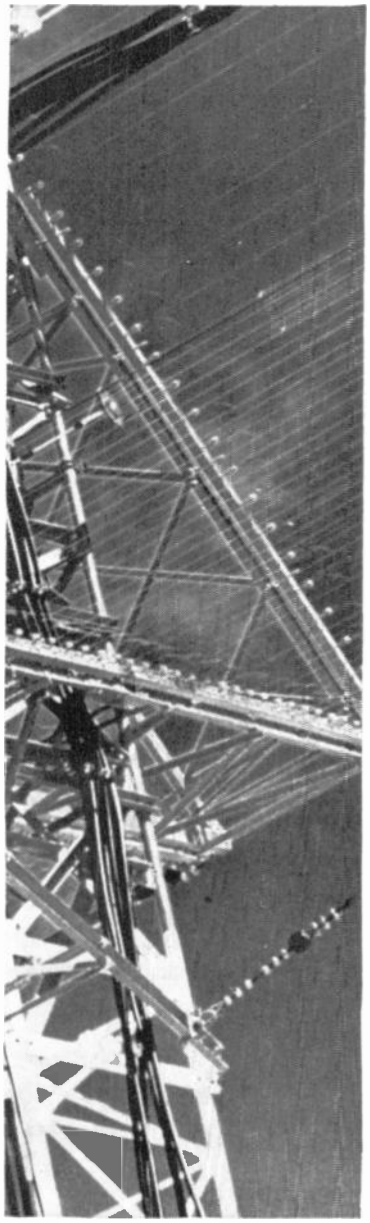


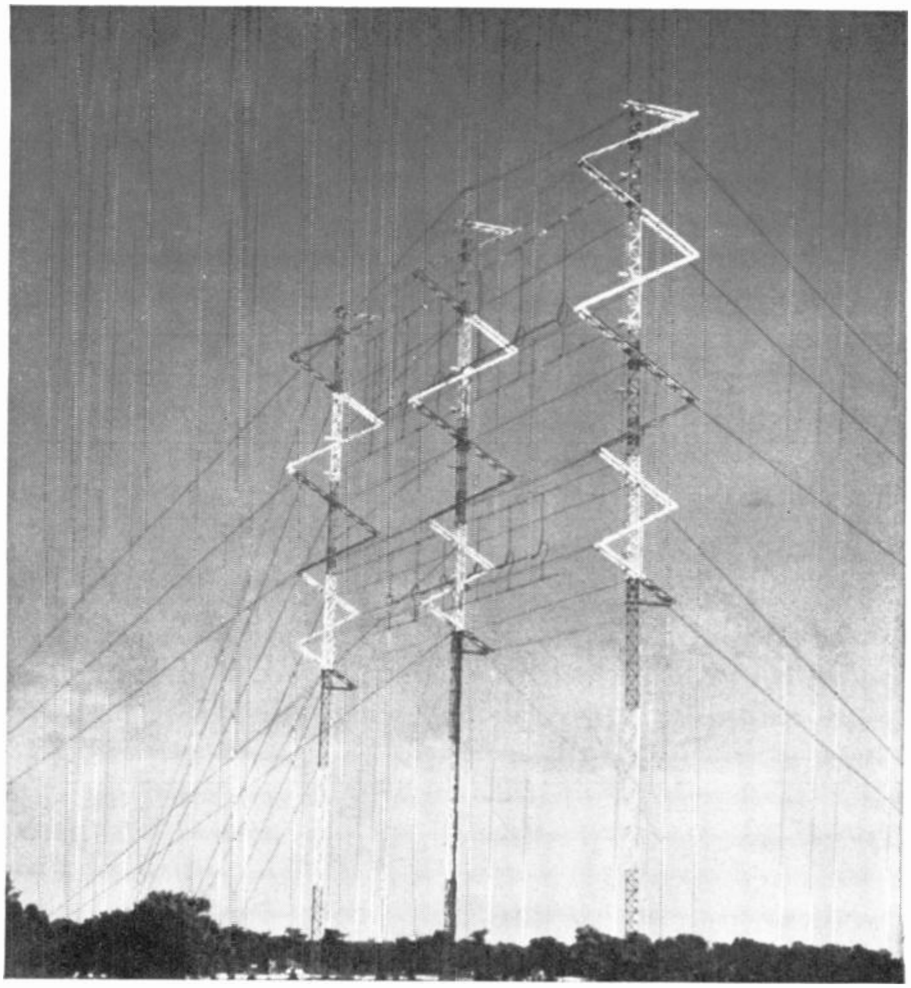
Over 40 miles of Styroflex® Coaxial Cable help assure

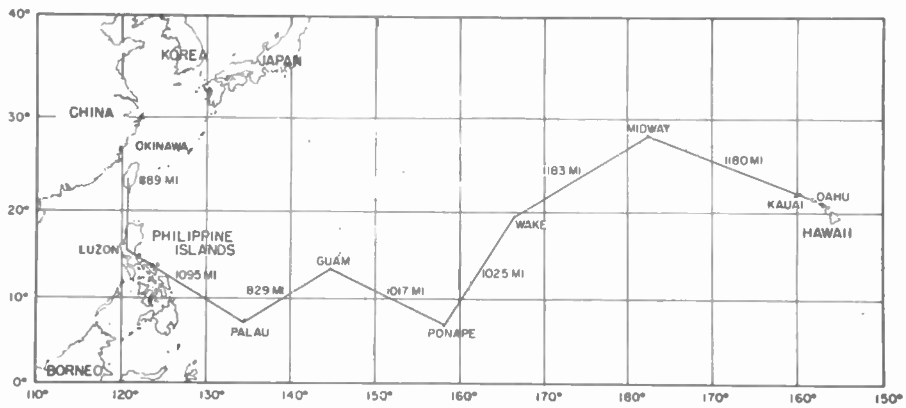
More than 200,000 feet of Styroflex® coaxial cables are in active use as balanced antenna feed lines in the recently completed Pacific Scatter Communication System stretching from the Hawaiian Islands to Okinawa. This trans-Pacific system, one of the largest and most advanced of its kind in the world, uses ionospheric and tropospheric propagation techniques that produce over 99% reliability. An important part of the Strategic Army Communications Network (STARCOM), the system was designed, developed and constructed by Page Communications Engineers, Inc. for the U. S. Army Signal Corps.

Each of the nine stations in the network is equipped with the same major component parts—transmitters, exciters, multiplex terminals and antennas. The cables used in the 200- and 400-foot antenna arrays range from ⅞" jacketed Styroflex® cable to 3⅛" jacketed Styroflex® cable. About 7,000 feet of ½" jacketed Foamflex® cable is also used in the system. The Styroflex® cables were spliced in the field by an inert-gas Heliarc welding process to assure noise-free connections required for successful duplexed antenna operation.

The extremely low inherent noise level and low attenuation of Styroflex®—together with this air-







Pacific Scatter Communication System reliability!

dielectric cable's stable electrical and mechanical properties—especially qualify it for the critical specifications of this STARCOM system. If your system requirements call for a cable with low loss and high reliability, investigate the successful record of Styroflex®!

(Photos courtesy of Page Communications Engineers, Inc.)

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IRE People

(Continued from page 80A)

A 35-year veteran with REL, Mr. Gunther joined the company in 1925, became a vice president in 1929 and has served in virtually every department and capacity. A pioneer in advanced communications engineering, he was instrumental in development of the world's first two-way mobile radio, very high frequency two-way aircraft installation, v.h.f. radio-teletype, FM broadcast equipment, mass-produced FM receivers for professional use, Loran transmitters, and, in recent years, tropospheric scatter equipment.

A contributor to many technical publications, he is a Fellow and Past President of the Radio Club of America, Vice President of the New York Chapter of the Armed Forces Communications and Electronics Association, Honorary Director of the Single Sideband Amateur Association, and member of the Veteran's Wireless Operator's Association and of the Quarter Century Wireless Association. He is a lifelong amateur radio enthusiast operating under the call letters W2ALS.

❖

Dr. Harold V. Hance (S'39–A'41–M'46–SM'57), known for his work in radar and the information sciences, has joined the Systems Research Center of Lockheed Electronics Company, Plainfield, N. J. He will serve as both Associate Director of the Center and as a Senior Scientist.

H. V. Hance

In his scientific capacity, he will be concerned initially with defining problem areas for investigation, and with planning theoretical and experimental research in preparation for the development of new concepts, theories, and processes. Some of the areas with which he will be involved are pattern recognition, information retrieval, and cognitive systems, as well as problems of a more specialized nature in the field of signal processing.

Before joining Lockheed Electronics, he worked in various capacities for nine years at Hughes Aircraft Company in Culver City, Calif. The last position he held at Hughes was Senior Scientist in the Research and Development Laboratories.

During his career, he also worked for the U. S. Naval Air Development Center in Johnsville, Pa., and the U. S. Naval Research Laboratory in Washington, D. C.

He received the Bachelor of Science degree in electrical engineering from the California Institute of Technology, Pasadena. He took graduate work in radio and electronics at Stanford University, Stanford, Calif., and received the Doctor of Science degree in electrical engineering from the Massachusetts Institute of Technology, Cambridge.

(Continued on page 86A)

■ *A production reality based on 20 years of crystal engineering experience...*

Miniature Wide Band-Pass Crystal Filters Delivered In Quantity...To Specification

Filters just recently considered as "state of the art" are now a *production* reality. In addition to its many stock narrow band filters, Midland offers prototype and production quantities of practical Miniature Wide Band Filters in the .5 to 30 mc range. These filters are of exceptional quality.

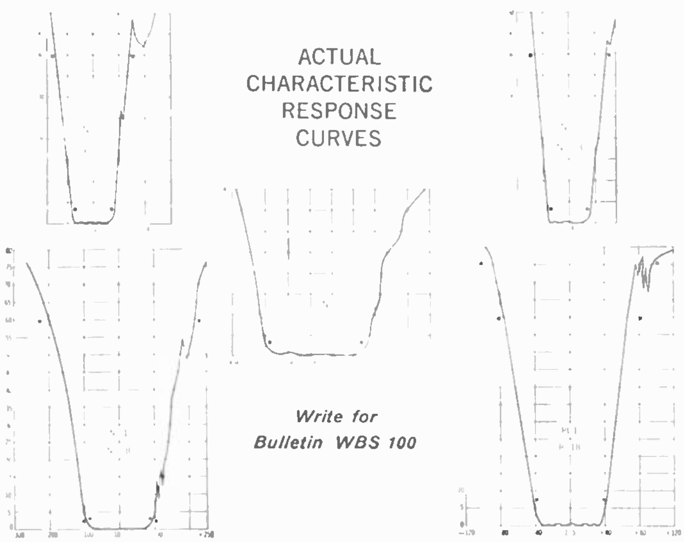
They are essentially free from unwanted spurious modes which have previously limited the realization of many types of wide band filters. Small quantities for engineering evaluation are available *immediately* from stock. Consultation is available at any time to potential filter users.

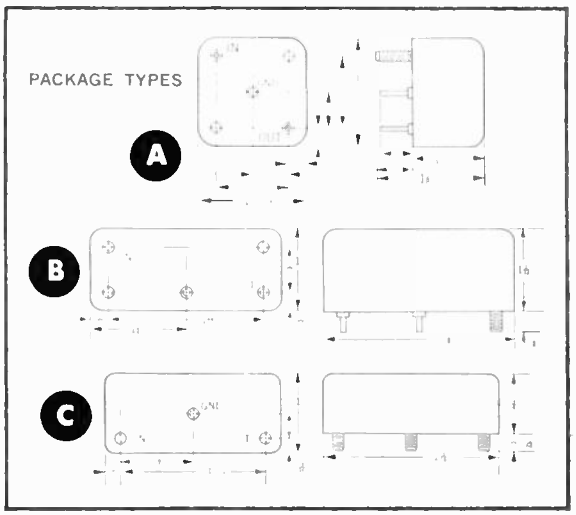
Shown below are specifications for ten of our stock wide band filters, as well as actual characteristic response curves. These filters are actually being delivered to major weapons system manufacturers in quantities — to specification.

THESE ARE NOT LABORATORY CURIOSITIES OR IN PROTOTYPE DEVELOPMENT STAGE

Type	Center Freq.	3db Bandwidth Minimum	40db Bandwidth Max.	60db Bandwidth Max.	75db Bandwidth Max.	Ultimate Discrim. Minimum	Insertion Loss Max.	Impedance ohms	Inband Ripple Max.	Package Type
NJ-1	7.2MC	160KC	300KC			60db	6db	13K	1db	A
NJ-1B	7.2MC	160KC	300KC			60db	6db	13K	.5db	B
NJ-2	7.4MC	160KC	300KC			60db	6db	13K	1db	A
NJ-2B	7.4MC	160KC	300KC			60db	6db	13K	.5db	B
NG-1	5.09MC	160KC	350KC			60db	6db	20K	1db	A
NG-1B	5.09MC	160KC	350KC			60db	6db	20K	1db	B
NB-1	10.7MC	200KC		450KC		75db	12db	50	1db	A
NB-1B	10.7MC	200KC		450KC		85db	8db	50	.5db	B
RL-1	11.5MC	80KC		160KC	200KC	85db	6db	50	.5db	C
RL-1B	11.5MC	80KC		160KC	200KC	90db	5db	50	.5db	B

Operating Temp.: —55 C to +90°C Shock: 100g Vibration: 15g to 2KC Units hermetically sealed





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IRE People

(Continued from page 84A)

From 1955 to 1956, he served on the Committee on Radar Range of the Department of Defense's Ad Hoc Group on AI Radar. In 1957, he was a member of the special summer study project conducted by the National Academy of Sciences for the Air Research and Development Command.

Dr. Hance is a member of Sigma Xi, the Research Society of America, and the IRE's Professional Groups on Information Theory, Circuit Theory, and Electronic Computers.

❖

John H. Haughawout (M'59) has been appointed manager of the computer laboratory's advanced development department at Hughes Aircraft Company's ground systems group, it was recently announced.

Before his new appointment, he served as manager of an advanced Navy computer project. He joined Hughes in 1952. Previously, he had been a circuit design engineer for the General Electric Company.

A 1947 graduate of the University of California, Berkeley, he holds the bachelor of science degree in electrical engineering. He did graduate work at Syracuse University, Syracuse, N. Y., from 1950–1952.

Mr. Haughawout served with the U. S. Navy during World War II.

❖

(Continued on page 88A)

IRE People

(Continued from page 86A)

The appointment of **Charles E. Jacobs Jr.** (A'51–M'52) as project manager of a study program on the feasibility of a field army ballistic missile defense system has been announced by Sylvania, a subsidiary of General Telephone & Electronics Corporation.

A $250,000 contract for the study, to be undertaken at the Waltham Laboratories, has been awarded to Sylvania by the U. S. Army. The Army is seeking a missile system capable of moving with and protecting forces in the field from the threat posed by a variety of ballistic and guided missiles that could be employed by an enemy.

Mr. Jacobs, who joined Sylvania in 1951, carried major responsibility for the design and analysis of acquisition and tracking radars in the PLATO anti-missile system. His most recent assignment has been in the Systems Engineering Laboratory in Waltham as manager of the Signal and Operations Analysis Department.

A native of New York City, he received the bachelor's degree in electrical engineering from Brooklyn Polytechnic Institute, Brooklyn, N. Y., in 1951 and has completed course requirements for a master's degree in electrical engineering at the same institution.

❖

H. Raymond Jacobus (SM'46) joined Eitel-McCullough, Inc., as Manager of the Negative Tube Division on March 1, 1961. He will direct the research, development and manufacturing activities for the production of Eimac power tubes in the negative grid tube field.

H. R. JACOBUS

He brings to Eimac more than 28 years of experience in the electron-tube industry. For the past five years, he has been Manager of the Washington Division of Tung Sol Electric, Inc., at Washington, N. J. Prior to this, he served for many years with the Radio Corporation of America in engineering and production management of electron tubes.

He received the degree in mechanical engineering with a communications major from Stevens Institute of Technology, Hoboken, N. J. He holds two electron-tube patents and has applications pending on several additional patents.

Mr Jacobus is a member of a number of professional groups on engineering management and electron devices. He is the author of many technical papers on electron tubes and their operation.

❖

(Continued on page 90A)

IRE People

(Continued from page 88A)

Henry P. Kalmus (A'39–SM'45–F'56), Associate Director of the Army's Diamond Ordnance Fuze Laboratories, Washington, D. C., was awarded the doctorate degree from the Technical University of Vienna in December, 1960. The subject of his thesis was "Light and Radiation Measuring Instruments with High Sensitivity and Stability."

H. P. KALMUS

He received the Dipl.-Engrg. from the Technical University of Vienna in 1930. After an association of eight years with the Orion Radio Corporation in Europe, he came to the United States and was employed in a professional capacity with the Emerson Radio Corporation, New York, N. Y., and with the Zenith Corporation, Chicago, Ill., prior to joining the staff of the National Bureau of Standards, and subsequently the Diamond Ordnance Fuze Laboratories in 1948.

Dr. Kalmus holds more than twenty-five patents in the field of electronics and has published a great number of scientific

(Continued on page 92A)

FEATURES:

- A new low in noise levels — down to 0.007 μv providing 0.02 μv full scale sensitivity at minimum bandwidth.
- 5 db steps
- Attenuation range of 85 db
- FOUR regular VSWR scales plus one expanded
- All meter scales automatically normalized when switching ranges
- Large 5¾″ meter with 1% linearity
- Continuous gain control over 15 db range
- Continuously variable bandwidth control
- Front panel meter monitors bolometer bias current

SPECIFICATIONS:

Frequency: 1,000 cps; adjustable over a 2% range.

Sensitivity: 0.02 μv at minimum (4 cps) bandwidth. 0.1 μv at maximum (40 cps) bandwidth.

Noise Level: 5db below full scale (0.007 μv at minimum bandwidth).

Amplifier Q: 250 at 4 cps; 25 at 40 cps.

Bandwidth: Continuously variable from 4 to 40 cps.

Calibration: Square Law. Meter reads SWR, db.

Range: 85 db. Input attenuator provides 70 db in 5 db steps. Gain control provides 15 db adjustable. Accuracy ±0.1 db per 10 db. Maximum cumulative error of ±0.2 db at 40 cps bandwidth.

Scale Selector: Expanded, Regular, and Bolometer Current. Meter scale always normalized when switching from scale to scale or from expanded to regular.

Meter Scales: SWR: 1-4; SWR: 1.8-6; SWR: 3.2-10; SWR: 6-15; Expanded SWR: 1-1.3; db: 0-10; Expanded db. 0-2.3.

Input Selector: 220,000 ohms; Crystal; Bolometer. Bias provided for high 8.4 ma bolometer or 4.3 ma low current bolometer. Bias adjustable ±15%. A bolometer protective circuit permits any switching operation or cable connect-disconnect without damage to bolometer.

Output: Jack for 1500 ohm recorder. 1 ma full scale deflection.

Input Connector: BNC Jack.

Power: 115/230 v ±10%, 50-60 cps, 40 watts.

Dimensions: Cabinet: 7¾″ wide, 10½″ high, 11″ deep.

Weight: 14 lbs. net.

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The new portable PRD 277-B Standing Wave Amplifier is designed to meet the present and future needs of microwave test laboratories. Due to its extremely low inherent noise, 0.007 μv, weak signals which once were undetectable by conventional instruments can now be measured. Attenuation in 5 db steps combined with 4 VSWR scales and a large meter permit VSWR measurements to be made with maximum resolution and accuracy.

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IRE People

(Continued from page 90A)

papers and articles. Among the many honors he has received is the Department of Commerce Gold Medal for Exceptional Service, awarded to him in 1954.

❖

Robert O. Kimmel (S'51–A'52–M'56) has been appointed western district sales manager for Hughes Aircraft Company's microwave tube division.

Before joining Hughes, he was the Raytheon Company's western area manager for special microwave devices, especially the ferrite component field. Previously, he was Raytheon's senior west coast sales engineer for microwave tubes. He was also a field engineer for the General Electric Company on high powered radar equipment ultimately specializing in microwave tube equipment compatibility.

Mr. Kimmel is a graduate of the Polytechnic Institute of Brooklyn, Brooklyn, N. Y., and is a member of the American Rocket Society.

❖

Harold B. Law (SM'46–F'52) and **Alfred H. Sommer** (SM'54), scientists of the Radio Corporation of America, have been named Fellows of the Technical Staff, RCA Laboratories, in recognition of their continued outstanding achievement in research, it was recently announced.

The rank of Fellow, Technical Staff, was established by RCA Laboratories in early 1959 to give recognition to continued individual contributions by staff scientists, just as recognition is extended by title and position for contributions made through group administration. It compares with similar use of the title of Fellow by the various professional societies.

Dr. Law was honored for his continued contributions to the advancement of television, particularly in the field of pickup and display tubes for both black-and-white and color-television systems. Dr. Sommer was honored for his continued contributions in the field of electron-emission phenomena relating particularly to special materials as emitters for electron tubes.

Dr. Law, a native of Iowa, was graduated from Kent State University, Kent, Ohio, in 1934, and received the M.S. and Ph.D. degrees in physics at Ohio State University, Columbus. He joined RCA in 1941 as a member of the electronic research staff, specializing in research on television camera pickup tubes. Among his major contributions have been the development, with Drs. A. Rose and P. K. Weimer, of the Image Orthicon camera tube now in standard use for television pickup, and his subsequent development of the method employed in making the phosphor screen of the color television picture tube. For the latter achievement, Dr. Law was awarded the Zworykin Gold Medal of the IRE in 1955. A member of the American Physical Society and Sigma Xi, he holds 25 United States patents on inventions relating principally to television pickup and display tubes.

(Continued on page 95A)

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- Overcome the problem of contact misalignment due to post-mold shrinkage of other plastics.
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DAPON molds easily around metal inserts without corrosion. With DAPON there's virtually no shrinkage or cracking after molding (connector pins remain tight!). The material has extremely low moisture absorption—it maintains high arc resistance even in moist atmospheres.

DAPON diallyl phthalate resin withstands extremes of temperature, vibration and shock. The tolerances of DAPON parts are practically unaffected by long-term operation at temperatures up to 450°F.

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- Low dielectric loss
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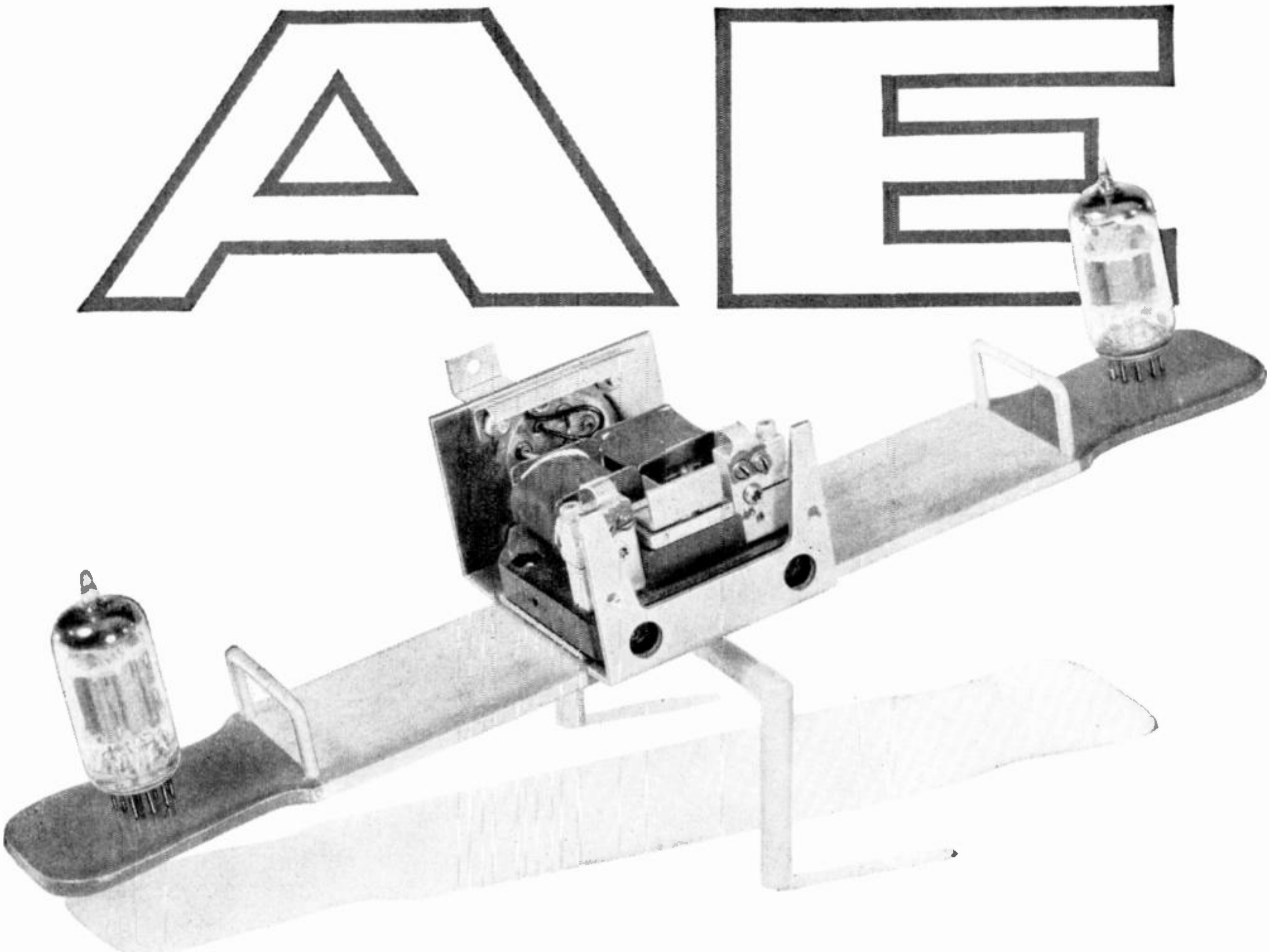
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IRE People

(Continued from page 95A)

The appointment of Dr. Ward C. Low (M'56) as senior staff specialist-development planning for Sylvania Electronic Systems, a division of Sylvania Electric Products Inc., has been announced by Dr. E. G. Schneider, divisional Vice President—Research and Engineering. Sylvania is a subsidiary of General Telephone & Electronics Corporation.

W. C. Low

In his new capacity, Dr. Low will study trends in advanced electronics technology and make recommendations concerning Sylvania Electronic Systems' planning for technological requirements of the future.

He joined Sylvania in 1955 as head of the physics section in the analysis department of the Missile Systems Laboratory, Waltham, Mass. He subsequently moved up to manager of the aerophysics department of the Waltham Laboratories in 1957.

During the past two years, he has been on leave of absence from Sylvania for work with the Advanced Research Projects

(Continued on page 99A)

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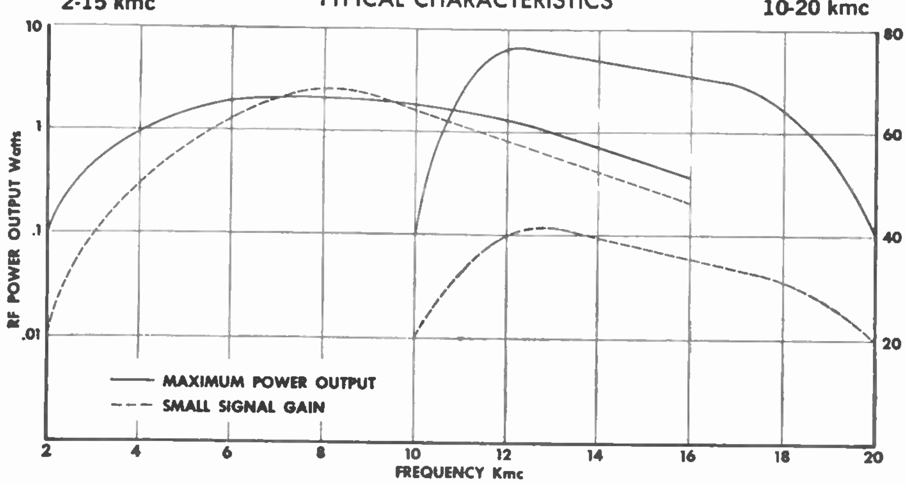

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IRE People

(Continued from page 97A)

Agency of the Department of Defense, where he was in charge of the development of an upper atmosphere physics program for ballistics missile defense. He also conducted a national study on advanced technologies for ballistic missile defense.

Prior to joining Sylvania, he was a research associate at Massachusetts Institute of Technology, Cambridge. He also had served as acting director and project supervisor of the upper atmosphere research program at Boston University, Boston, Mass.

He received the bachelor's degree from the University of Wyoming, Laramie, in 1943 and taught there as a physics instructor prior to U. S. Naval service. He received the doctor's degree in physics from Boston University in 1955.

Dr. Low is a member of the American Physical Society and the American Society for the Advancement of Science.

❖

Dr. Harold Lyons (SM'50–F'58) has joined the staff of Electro-Optical Systems, Inc., as a Vice President, and will manage the Company's newly formed Quantum Electronics Division.

In his new position, he will be responsible for extending present company capabilities in the field of coherent light, with particular emphasis upon development of masers, lasers, and irasers. Applications of these techniques will be to company programs in the fields of homing and guidance, communications, space defense, and other areas utilizing advanced electro-optical techniques.

He was formerly head of the Atomic Physics Department and Senior Scientist at Hughes Research Laboratories, where he was responsible for the organization and direction of that company's program in light amplification by stimulated emission of radiation (laser). He invented the world's first "atomic clock" in 1949 while at the National Bureau of Standards, where he was a physicist and Assistant Chief for Research of the Radio Standards Division.

His background includes the Ph.D. degree in nuclear physics from the University of Michigan, Ann Arbor, in 1939, postdoctoral research at the University of Michigan, and research at Naval Research Laboratory before joining NBS. The recipient of awards by the U. S. Department of Commerce, the Washington Academy of Sciences, and the University of Buffalo for his research and inventions, he was also honored for his invention of the atomic clock by the Franklin Institute in 1959.

Dr. Lyons is recognized as one of the country's foremost authorities in the field of quantum electronics. He has authored over 30 technical articles on subjects such as atomic clocks, relativistic clock satellite experiment, microwave spectroscopy, masers, lasers, and irasers. He is a Fellow of the American Physical Society.

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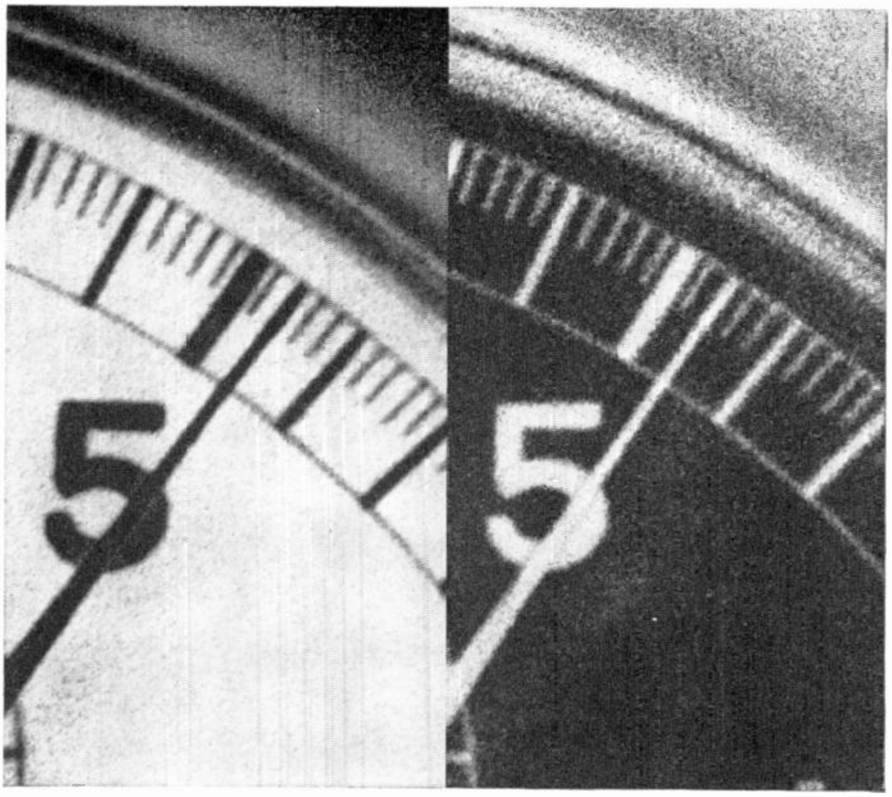

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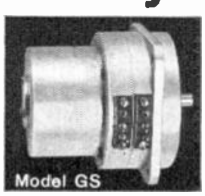

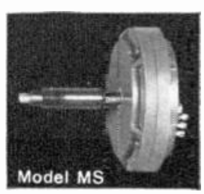

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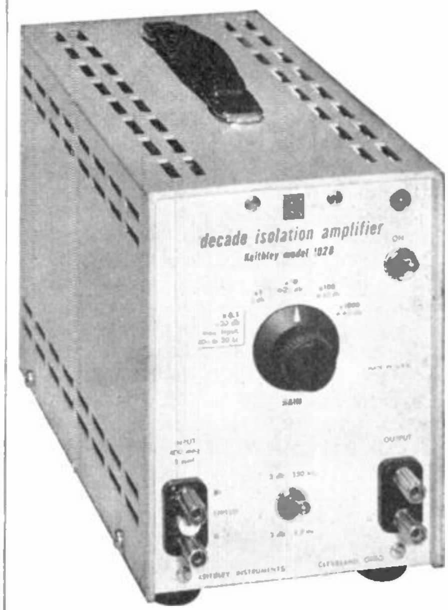

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- **input impedance** of 400 megohms, shunted by 3 $\mu\mu$f.
- **low noise level,** below 10 μv from 10 cps to 150 kc at maximum gain.
- **gain accuracy** of 1% at midband for all gain settings.
- **rise time** of 0.3 μ sec at highest gain.
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IRE People

(Continued from page 99A)

Dr. Harold S. Osborne (A'14–M'29–SM'43–F'45)(L), retired Chief Engineer of the American Telephone and Telegraph Company, has won the prized Edison Medal of the American Institute of Electrical Engineers, N. S. Hibshman, Institute secretary announced recently. The award will be presented at the Institute's Winter General Meeting in New York, N. Y., January 29–February 3, 1961, at the Hotel Statler.


H. S. Osborne

Dr. Osborne, who is a consultant with the International Electrotechnical Committee, was cited "for his contributions to the art of telecommunication and his leadership and vision in extending its application; for his achievements in the coordination of international communication and in national and international standardization; and for his advancement of the engineering profession."

The Edison Medal was founded in 1904 by an organization of associates and friends of Thomas A. Edison, to serve "as

(Continued on page 102A)

IRE People

(*Continued from page 101A*)

an honorable incentive to scientists, engineers, and artisans to maintain by their works the high standard of accomplishment" which had been set by Edison.

The Medal is awarded annually by the American Institute of Electrical Engineers. Among past recipients of the award were George Westinghouse, Alexander Graham Bell, Robert A. Millikan, Alexander Dow and Vannevar Bush.

Born in Fayetteville, N. Y., Dr. Osborne attended the Massachusetts Institute of Technology, Cambridge, where he received the B.S. degree in 1908 and the Eng. D. in 1910. He joined A.T.&T. in 1910 as an engineer in the transmission and protection department. Ten years later, he was appointed transmission engineer, and operating results engineer in 1939. After serving as plant engineer and assistant chief engineer (1940–1943), he was appointed chief engineer in 1943, which position he held until his retirement in 1952.

He has rendered significant service to the government as well. He was special consultant to the Office of the Secretary of War, World War II, and a member of the Telegraph Committee, War Communications Board, World War II. He has also served on the Industry Advisory Council of the Federal Specifications Board, and

(*Continued on page 104A*)

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IRE People

(Continued from page 102A)

the Industry Advisory Committee for Supply Cataloging, Munitions Board.

A past president of the American Institute of Electrical Engineers, he has served on its Board of Directors, and as chairman or member of many committees. He has been a Director of the Research Corporation and Graphite Metallizing Corporation, and is the author of many technical articles. Dr. Osborne also is a fellow of AIEE, the Acoustical Society of America, and American Physical Society, and the American Association for the Advancement of Science.

❖

Dr. Rolf W. Peter (A'47–SM'52–F'58) has resigned the position of Director of the Physical and Chemical Research Laboratory, RCA Laboratories, Princeton, N. J., to become manager of the Electron Devices Division of Watkins-Johnson Co., Palo Alto, Calif. He will take immediate charge of his firm's activities in microwave tubes and other devices.

R. W. Peter

A native of Zurich, Switzerland, Dr. Peter had his academic training at the Swiss Federal Institute of Technology. While completing work there for the Ph.D. degree in the field of microwave network synthesis, he was assistant professor of Radio Engineering and Physics for two years.

He came to this country in 1948 to join RCA Laboratories as a research scientist. Subsequently he became head of Microwave and Gaseous Electronics at the David Sarnoff Research Center.

Appointed to head Physical and Chemical research in 1957, he was responsible for fundamental and applied research in electronic materials and special image and detector devices and for research activity of Laboratories RCA Ltd., in Zurich. He also represented RCA on the Operating Committee of the Industrial Reactor Laboratories at Plainsboro, N. J.

Dr. Peter is a member of the American Physical Society and Sigma Xi. He assisted in organizing the IRE's annual Electron Tube Conference and the Electron Devices Conference and was chairman of the former in 1957. He holds 16 U. S. patents and has several pending in the fields of microwave tubes and circuits, solid-state devices and electronic systems.

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(Continued on page 106A)

IRE People

(Continued from page 105A)

Pierre A. Portmann (M'46) was recently promoted to the office of Assistant Director in the Research and Development Directorate of Page Communications Engineers, Inc., a Northrop Corporation subsidiary. He was formerly Senior Staff Engineer in the R & D Directorate.

P. A. PORTMANN

In his new capacity, he will be responsible for the development of improved digital communication methods by integrating techniques in the field of propagation, coding, information theory, and automatic data processing.

His background in electronics and communications research spans a 20-year period. He came to Page from the Electronics Division of Westinghouse Electric Company, where he conducted research programs for the development of communications system concepts capable of yielding improved reliabilities.

He is the author of published papers on tropospheric propagation, automatic impedance-measuring equipment, and automatic control of microwave networks.

Mr. Portmann holds the B.S. degree in electrical engineering from the Massachusetts Institute of Technology, Cambridge, and the M.S. degree in electrical engineering from the University of Maryland, College Park.

❖

Vernon G. Price (M'52) has been appointed Manager—Filter and R-F Component Engineering at the General Electric Power Tube Department plant in Palo Alto, Calif.

V. G. PRICE

The new engineering subsection was created recently when the Company's Palo Alto Microwave Laboratory was reorganized as a separate product section of the Power Tube Department specializing in traveling-wave tube development and manufacture.

Mr. Price was formerly project engineer in charge of the high power harmonic absorption filter program at the Laboratory.

He joined the General Electric Company in 1955, after three years with the U. S. Navy Electronics Laboratory.

A native of Salt Lake City, he is a graduate of the University of Utah, Salt Lake City, where he received the

(Continued on page 110A)

IRE People

(Continued from page 106A)

bachelor's and master's degrees in electrical engineering. He is a member of the American Association for the Advancement of Science.

❖

Samuel Raber (S'56–M'57) a research development specialist, has joined the engineering staff of Dorne & Margolin, Inc., Westbury, L. I., N. Y., as Section Head of the Circuit Group.

He was formerly associated with Fairchild Astrionics Division as a development specialist in the research division. Working on the Data Link Transmitter for the USD5 Surveillance Drone at Fairchild, he developed a transistorized wide band voltage controlled oscillator in the 5–10 mc region and was engaged in a feasibility study to determine a novel ranging system involving the "near field" radiation of a dipole.

In 1959, he was on the engineering staff of American Bosch Arma Corporation, where he was engaged in the design and development of transistor circuitry for oscillators, digital operations, amplitude stabilized amplifiers, and associated measurement problems. Previously, he had been with the U. S. Naval Ordnance Laboratory, White Oak, Md.

Mr. Raber received the B.S.E.E. degree from Union College, Schenectady, N. Y., in 1950, and the M.S.E.E. degree from the University of Maryland, College Park, in 1957.

❖

William H. Rous (A'49) has been appointed Vice President, International Operations, of the Amphenol-Borg Electronics Corporation, Broadview, Ill. He will be in charge of developing international business wherever there are markets for the company's products. He will also continue to serve as Vice President, Marketing.

W. H. Rous

He joined Amphenol-Borg in 1941 and has served in various important capacities. He is a director of Amphenol-Borg Electronics Corporation; Amphenol-Borg, Ltd. (England); Amphenol Canada, Ltd.; Borg Fabrics, Ltd. (Canada); Clinton Hosiery Ltd. (Canada).

He is a member of the Electronics Industries Association, the American Ordnance Society, the Armed Forces Communications & Electronics Association, and Business International.

❖

Harold W. Schaefer (J'26–A'32) has been appointed vice president-director of engineering for the Consumer Products Division of Philco Corporation.

(Continued on page 112A)

IRE People

(*Continued from page 110A*)

Formerly vice president and general manager for appliance planning and product development, he joined Philco in 1950 and since that time has held posts as vice president and assistant to the director of Research and Engineering as well as vice president and general manager of the Appliance Division.

A native of Chicago, Ill., he studied electrical engineering at Lewis Institute, Lockport, Ill., and physics at the University of Chicago, Chicago, Ill. He became associated with the Majestic Radio Corporation in Chicago as assistant to the president and carried out the development of the first all-electric complete radio receiver through tube development, RF circuits, audio and the acoustical system.

He then joined General Household Utilities Company as assistant to the president, where he worked on the development of the first low pressure refrigerant for refrigerating systems.

He served during World War II at the Carnegie Institute of Washington and at the Applied Physics Laboratory of Johns Hopkins University, Baltimore, Md., where, under the Office of Scientific Research and Development, he was in charge of the engineering and manufacturing of the proximity fuse. The proximity fuse was used by the Army and Navy to explode anti-aircraft shells automatically within effective range of enemy aircraft. He received the Vannevar Bush certificate at the end of the War honoring his work on the fuse.

In 1943, he became associated with the Radio Corporation of America in charge of facilities planning for commercial equipment as well as production of the proximity fuse. He left RCA in 1944 to organize the Westinghouse Home Radio Division as general manager of engineering, manufacturing and product development.

He is responsible for over 50 patents in the air conditioning, electronic and refrigeration fields.

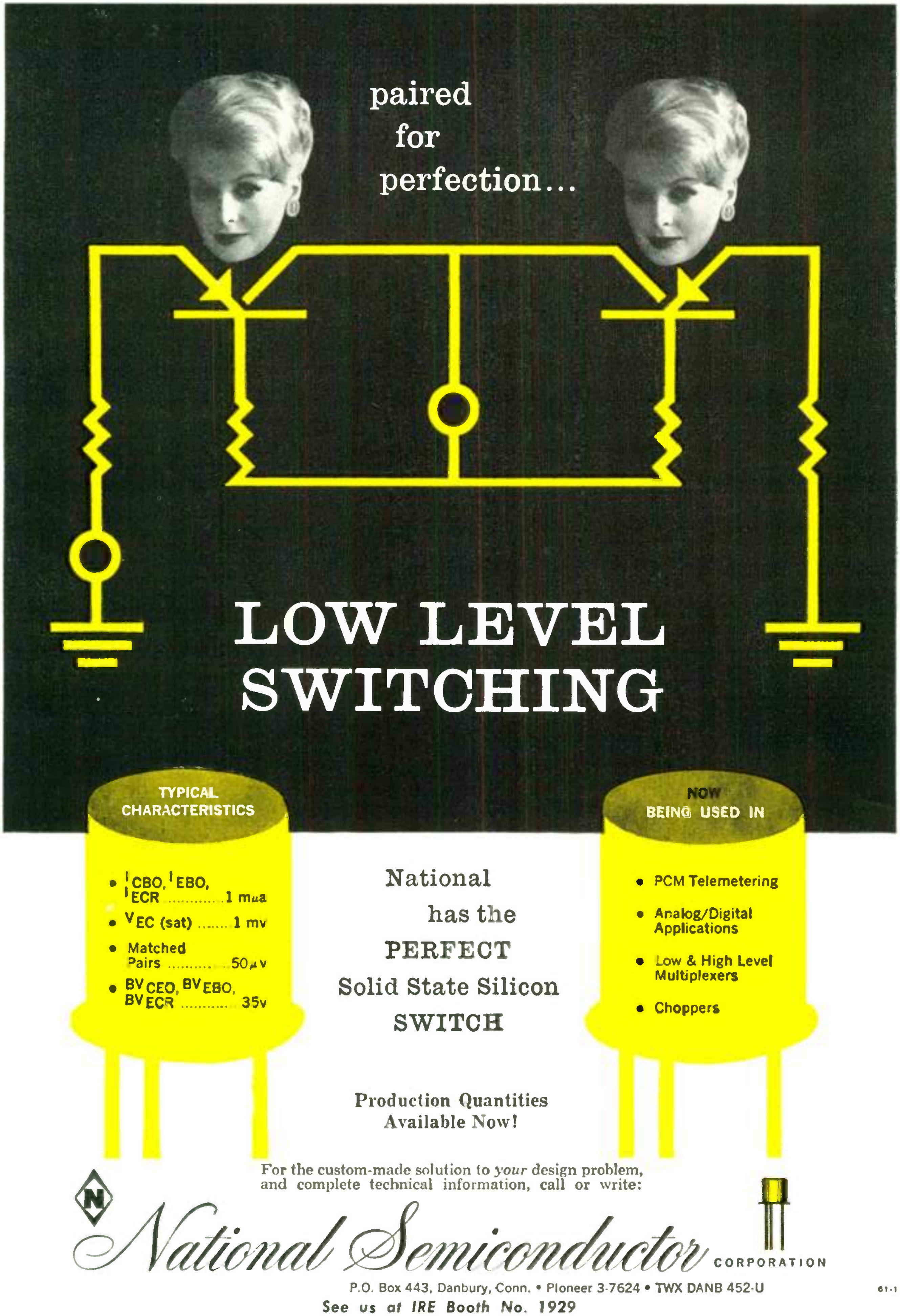
Mr. Schaefer is a member of the board of the National Electrical Manufacturers Association (NEMA), and a member of the Newcomen Society of North America, Franklin Institute, American Association for the Advancement of Science, and the International Society of Bioclimatology and Biometerology. He is a charter member and vice president of the American Institute of Medical Climatology.

❖

Harold R. Terhune (SM'51), manager of standards at ITT Federal Laboratories, Nutley, N. J., has been elected president of the Standards Engineers Society, an international organization of standards executives and engineers.

A Fellow and one of the founders of the Society, he has been active in national and international standardization since 1940, and has served as chief United States

(*Continued on page 114A*)



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IRE People

(Continued from page 112A)

delegate to meetings held in Zurich, Switzerland, and Madrid, Spain.

Mr. Terhune joined the ITT System in 1951 from the Mycalex Tube Socket Corporation where he was vice president. He is a member of the IRE Standards Committee and former chairman of the Symbols Committee. He is also a member of the Montclair Society of Engineers.

❖

The Conductron Corporation, New York, N. Y., announces the appointment of **Keeve M. Siegel** (SM'57) as its President and as Director of its Ann Arbor Division with offices in Ann Arbor, Mich.

K. M. Siegel

He has been Professor of Electrical Engineering at the University of Michigan, Ann Arbor, since January, 1957, and Head of the University's Radiation Laboratory since June, 1957. He will retain the latter position on a part-time basis. Within the past ten years, he has published 40

(Continued on page 116A)

miniature
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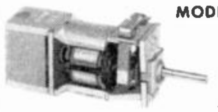
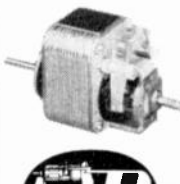
for industrial use



MODEL DC 195
1 11/16" long x 5/8" wide x 57/64" high. Shaft extends 1/2". Weight 1 1/2 oz. 0.0018 horsepower.

- Wide range of quality commercial grade motors wound for 12 volts D.C. Other windings from 3 to 28 volts available for most motors on special order.
- All motors equipped with self-lubricating powdered metal bearings, copper graphite brushes, and double insulated, impregnated windings.
- Integral gearing can be incorporated to customer's specifications in production quantities.
- Data sheets for individual motors available on request.



MODEL DC 105
2 11/16" long x 1 3/4" wide x 2 1/16" high. Shaft extends 7/8" each end. Weight 17 oz. 0.031 horsepower.

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IRE People

(Continued from page 114A)

articles in technical journals and a large number of widely circulated University of Michigan Reports, mostly on problems related to the interaction of electromagnetic waves with various types and shapes of matter. He is a member of the Scientific Advisory Board of the U. S. Air Force and consultant to NASA, the U. S. Army, and to numerous industrial and research organizations. He is on the editorial boards of the Radio Propagation Section of the NBS Journal of Research and of the Journal of Mathematics and Physics. He is a member of Commission VI of URSI and Chairman of Subcommission 6.3.

Professor Siegel is a member of the Professional Group on Antennas and Propagation and its Administrative Committee as well as Associate Editor of its Transactions.

❖

Harold A. Wheeler (A'27–M'28–F'35), has been appointed to the Department of Defense Advisory Group on Radar, according to Dr. H. York, Director of Defense Research and Engineering, Office of the Secretary of Defense. The membership of this group includes representatives from major laboratories and governmental agencies specializing in radar.

(Continued on page 118A)

IRE People

(Continued from page 116A)

Mr. Wheeler, who is a vice-president and director of Hazeltine Corporation, as well as president of Wheeler Laboratories, Inc., has been specializing in the radar field for 20 years. During World War II, he was chief consulting engineer for Hazeltine, which was responsible for the Navy's program of IFF radar. Since the end of the war, he has been directing the work of Wheeler Laboratories, Inc., in the design of microwave circuits and antennas for radar. These have been utilized in guided missile systems for target tracking and for missile guidance. Outstanding examples of this work are the tracking radar for Nike-Hercules, Terrier-Tartar and Nike-Zeus, for guidance of the Titan ICBM and the Thor-Able rockets. The last were used to orbit the Tiros weather satellites and the Star communications reflector satellite.

❖

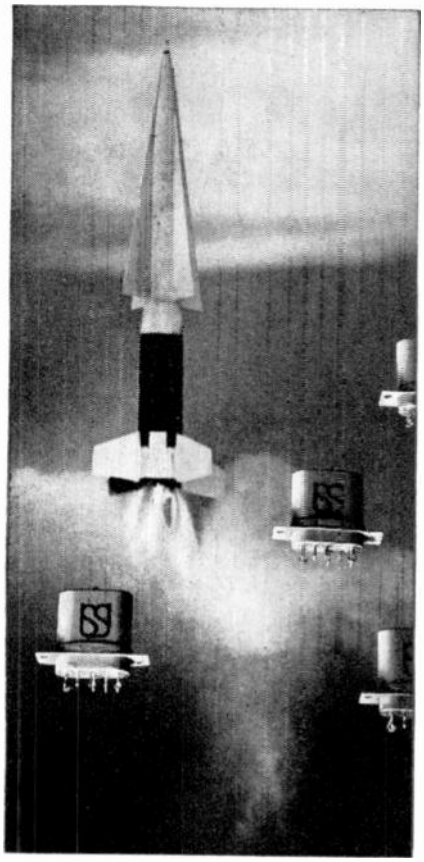
David O. Zopf (S'50–A'53–M'57) has joined the Meteorology/Oceanography Systems Engineering group of Borg-Warner Controls, it was recently announced. The group is based at Santa Barbara, Calif.

He will be responsible for systems engineering required for large meteorological/oceanographic data-gathering networks.

(Continued on page 121A)

VISIT US AT THE IRE SHOW BOOTH NO. 2122-24

RELAY NEWS from Union Switch & Signal



Contact Redundancy in New UNION Crystal Case Relays

The UNION 2-pole double throw General Purpose Crystal Case Relay is designed to consistently meet the requirements of Mil-R-5757D and Mil-R-5757/10. Its essential features . . . from minimum size to optimum reliability . . . permit it to be used in aircraft, guided missiles, shipboard and ground control electronic equipment.

A unique torsion-wire armature suspension system and a rugged all-welded frame construction provide a high level of vibration and shock immunity. Contact redundancy, which assures reliability in dry circuit and higher level contact loads, is provided through the use of bifurcated contacts.

Available with 0.2″ grid-spaced header or "S" type header, with various mountings, terminals, and operating voltages. Write for Bulletin 1064.

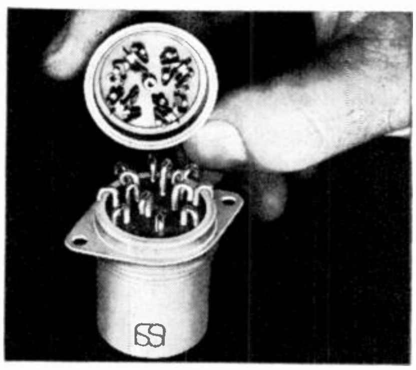
Why UNION Relays Are So Dependable

There's a good reason why our relays are the standard for reliability. For years, we've been building tough, reliable relays for use in airborne and guided missile electronic equipment and similar vital applications where perfect operation under severe environmental conditions is mandatory.

Our engineers created a compact 6-PDT miniature relay with just three major assemblies . . . instead of a fistful of small parts. This was accomplished by using a balanced rotary-type armature that provided a maximum resistance to the severe shock and vibration environment of aircraft and guided missiles. The rotary principle of operation is utilized in all our relays.

We have a reputation for building reliable electronic components and we intend to maintain our tradition for building reliable relays. And we supply these quality relays in quantity. Stocks are now available for prototype requirements in New York, Pittsburgh, Dallas and Los Angeles.

New 4-PDT-10-amp Relay Most Compact Rotary Type Available



This new durable relay is designed to meet the requirements of Mil-R-6106. It's a rugged relay featuring exceptionally sturdy terminals and husky contacts for high current applications. Glass-coated cylindrical contact actuators attached to the rotary armature provide square mating of contact surfaces, thereby assuring longer relay life. The balanced rotary armature provides maximum resistance to severe shock and vibration.

This small 4-PDT-10-Ampere relay is currently available with 115VAC and various DC operating voltages. Various mounting styles are provided. Write for bulletin 1069.

For additional information, write for Bulletin 1017 or call Churchill 2-5000 in Pittsburgh.

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19 STOCK VALUES below

Part No.	Capacitance mmf	Tolerance	Working Volts D.C.
NC-5	5	±15%	50
NC-7.5	7.5	±15%	50
NC-10	10	±15%	50
NC-15	15	±15%	50
NC-22	22	±15%	50
NC-33	33	±15%	50
NC-47	47	±15%	50
NC-68	68	±15%	50
NC-82	82	±15%	50
NC-100	100	±20%	50
NC-250	250	±20%	50
NC-500	500	±20%	50
NC-750	750	±20%	50
NC-1000	1000	±20%	50
NC-1500	1500	±25%	25
NC-2000	2000	±25%	25
NC-3000	3000	±30%	25
NC-4000	4000	±30%	25
NC-01	10000	±30%	10

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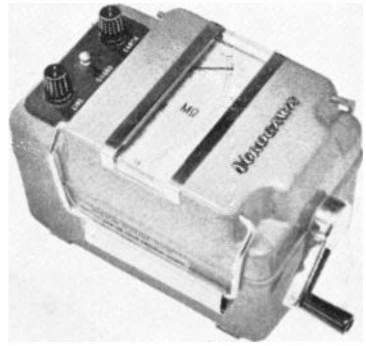

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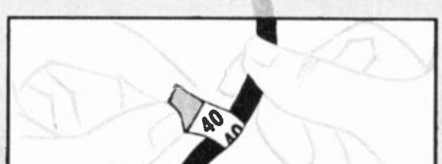

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(Continued from page 118A)

Research and development of advanced meterological and oceanographic instrumentation will also be pursued as required by the demands of systems now under study.

He was formerly with the Aerophysics Corporation and Curtiss-Wright, where he was section head for Guidance and Control of the Electronics Department. Other employment affiliations include Bell Aircraft Corporation, Pt. Mugu, Calif., where he was in charge of missile guidance systems activities, and Boeing Aircraft Company as a member of the physical research staff.

Mr. Zopf holds the B.S., M.S. and E.E. degrees from Stanford University, Stanford, Calif. He is a member of the American Rocket Society and the American Institute of Electrical Engineers.

❖

Dr. Jerome B. Wiesner (S'36–A'40–SM'48–F'52) has been appointed to serve as special assistant to President Kennedy for science and technology. He is Professor of Engineering and Director of the Research Laboratory of Electronics at Massachusetts Institute of Technology, Cambridge. He has been a member of the President's Science Advisory Committee and of the Army Scientific Advisory Committee.

J. B. Wiesner

His research has helped develop the "scatter communications" technique, used for covering greater distances than are possible in line-of-sight communications.

During World War II he was in charge of development of large airborne early-warning radar. At Los Alamos, N. M., he was in charge of an electronic development group and headed planning of instrumentation for the Bikini atom bomb test. Since then his government advisory work has taken him all over the world.

He was born in Detroit, Mich., on May 30, 1915. In 1937 he was graduated from the University of Michigan, Ann Arbor, with the B.S. degree in mathematics and electrical engineering. He received the M.S. degree in 1938 and the Ph.D. degree in 1950 from the same institution.

His first professional job was as chief engineer at the Library of Congress, where he developed the recording and acoustical laboratory. He also did record-preservation work, traveling throughout the country to record folk music. At that time he also became interested in books for the blind. He is now chairman of the technical committee of the American Foundation for the Blind.

Dr. Wiesner is a member of Sigma Xi,

(Continued on page 124A)

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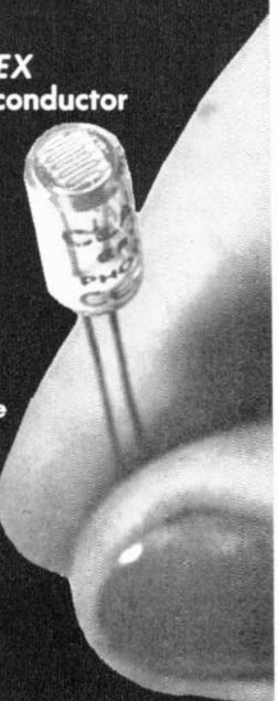

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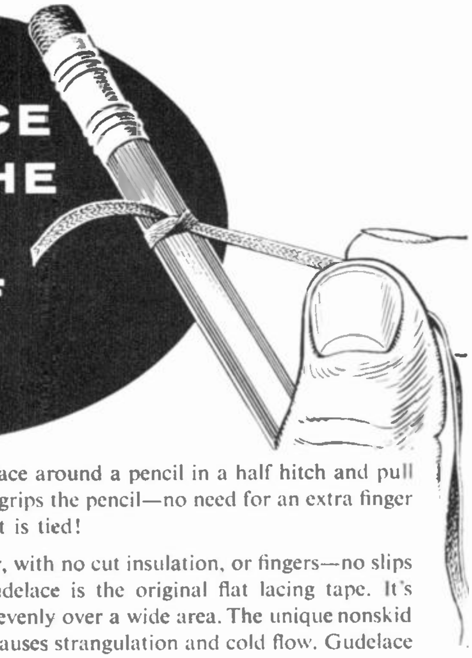

Try this simple test. Tie a piece of Gudelace around a pencil in a half hitch and pull one end. Gudelace's flat, nonskid surface grips the pencil—no need for an extra finger to hold Gudelace in place while the knot is tied!

Gudelace makes lacing easier and faster, with no cut insulation, or fingers—no slips or rejects—and that's *real* economy. Gudelace is the original flat lacing tape. It's engineered to *stay* flat, distributing stress evenly over a wide area. The unique nonskid surface eliminates the too-tight pull that causes strangulation and cold flow. Gudelace is made of sturdy nylon mesh, combined with special microcrystalline wax, for outstanding strength, toughness, and stability.

Write for a free sample and test it yourself. See how Gudelace takes the slips—and the problems—out of lacing.

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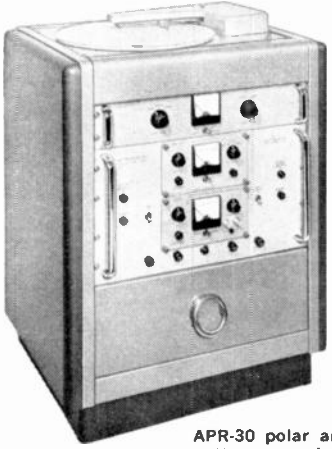


APR-30 polar antenna pattern recorder

...The reason most antenna pattern recorders come from S-A

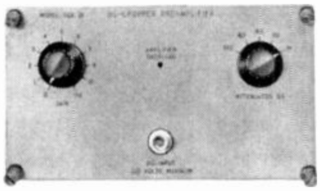
It's the little things that make the difference. Little things, refinements, "extras," and top-notch workmanship all add up to preference for S-A instrumentation.

Things Like Plug-In Balancing Potentiometers...

Series P plug-in pen balancing potentiometers

Series P potentiometers are used in both rectangular and polar coordinate pattern recorders. By interchanging potentiometers together with the appropriate pen function amplifier, different responses—linear, square-root, and logarithmic—are obtained. Interchanging these new self-aligning potentiometers can be accomplished in less than thirty seconds. Stocking spare units cuts downtime. Of dust and dirt proof construction, Series P plug-in balancing potentiometers are offered with exchange pricing.

DC Amplifiers...



DCA-21 amplifier for dc input signals

Scientific-Atlanta's DCA-21 amplifier lets APR 20/30 recorders accept dc input signals. A narrow band amplifier preceded by an electromagnetic chopper, the sensitive DCA-21 has a linear dynamic range of 80 db. The unit is directly interchangeable with Series CBA-20 Crystal-Bolometer amplifiers.

Recorder Pen Programmers...

Up to five different pen writing codes can be selected by adding the Model RPP-1 Recorder Pen Programmer to an APR 20/30 installation. Compact, lightweight, and rack mounted, the programmer provides solid line, dot, dash, dash-dot, and space-dot-dot codes at an adjustable code rate of 30 to 90 cycles per minute.

Modification C, Chart Compression...

Modification C, which must be ordered at the time of recorder purchase, provides both standard and compressed cycle charts from a single APR 20 Rectangular pattern recorder. Standard chart cycle is 20 inches, compressed 8 inches. Compressed recordings are conveniently sized to fit standard 8½ x 11 notebooks and reports.

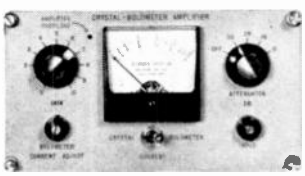
Chart Paper, Recording Pens, Ink, and Accessories...

Scientific-Atlanta offers its customers one-day service by stocking, for immediate delivery, a wide variety of chart paper, recording pens, and other recording necessities.

But above all, it's the engineering philosophy of a company run by antenna engineers for antenna engineers.

Call your nearby S-A engineering representative for more information on S-A pattern recorders and accessories. For complete technical information, please write to Box 86.

Crystal Bolometer Amplifiers...



High gain, low noise crystal-bolometer antenna

Sensitive, narrow-band Crystal-Bolometer amplifiers are miniaturized units designed for use as preamplifiers in S-A polar and rectangular pattern recorders. Five models, CBA-21 through CBA-25 are available. Features include bolometer burnout protection, low noise figure, triaxial signal ground return, up to 108 db gain, 80 db linear dynamic range, adjustable bandwidth (CBA-23), high rejection (CBA-24), variable center frequency (CBA-25).

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IRE People

(Continued from page 121A)

Phi Kappa Phi, Eta Kappa Nu, Tau Beta Pi, and the Acoustical Society of America.

❖

William J. Slawson (M'53) has joined the sales staff of Daystrom, Inc., Weston Instruments Division, Newark, N. J., as Product Sales Manager of Vamistors, it was recently announced.

W. J. SLAWSON

He brings to Weston twenty-one years of experience in electronic and industrial sales, with specialization in circuit components. Before coming to Weston, he was General Sales Manager for the Industrial Division of Telectro Industries Corporation. Prior to that, he held sales management posts with companies including PRD Electronics, Pyramid Electric Company, and ITT Federal Division.

Mr. Slawson attended New York University, New York, N. Y., and is a member of the Professional Group on Component Parts.

❖

Whom and What to See at the IRE Show

March 20-23, 1961 **New York Coliseum**

These pages list the exhibitors at the IRE Show, with a brief description of what each exhibitor is showing, and a list of company personnel manning the booth. In each listing the booth number is given. Almost all booths have a 4-digit number. The first digit indicates the floor, the second digit indicates the aisle (aisle numbers increase from south to north). A few booths have one or two digit numbers, preceded by the letter "M". These booths are on the mezzanine at the back of the first floor. The show is divided into sections of related products, to help you in finding the products of your primary interest as easily as possible. These sections are:

First and Second floors—Components.

Third Floor—Instruments and Complete Equipment. Communications equipment and systems, computers, and instruments for test and measurements, microwave equipment.

Fourth floor—Production. Machinery, tools, and raw materials; fabricators and services.

ACF Electronics Div., ACF Industries, Inc., Booth 1226
Riverdale, Md.

John H. Fournier, William McCranor, Joseph Kersey, Ralph Will, ▲ Leon Bawer, Gabe Viera, Jack Becker, William Pharmer, Fred Dusto

Microwave components, CSX band radar beacons, data processing modules, automatic fault isolation system, pictorial display navigation units, motor controls.

ADC Incorporated, Booth 1623
2833 13th Ave., S.
Minneapolis 7, Minn.

▲ W. Lehnert, ▲ N. Sprecher, D. Engebretson, W. Holmbeck, E. Lewis

Transformers; filters; *magnetic amplifiers and sub-systems; telephone coils; *printed circuit plastic molded audio transformers, five sizes (.08 to 1.2 cubic inches), 14 standard impedance ratios, voice power ratings 30 milliwatts to 10 watts; telephone type jacks; panels; terminal blocks.

APC, Booth 2835
See: Antenna Products Company

AMP Incorporated, Booths 2527-2531
3822 Eisenhower Blvd.
Harrisburg, Pa.

G. Brett, H. Crees, P. Crowe, B. Elmblad, F. Feaster, J. Flynn, C. Frambes, J. Galli, W. Griffith, E. Groves, D. Hajjar, R. Hansen, C. Hummel, W. Keay, J. Lewis, B. Miles, N. Olsen, L. Perkins, J. Taylor, C. Whitmore, W. Wood

Patchboard Programming systems—universal and shielded systems and accessories. Pin boards—for matrix programming. Double throw instrumentation switches—(80-1500 pole). AMP-MECA (maintainable electronic component assemblies)—New modular assembly technique. AMPin-cert connectors—pin and socket and printed circuit edge connectors. "Thermashield," coaxial connectors, RF connectors, taper technique.

AMP Incorporated, Capitron Division, Booth 2527
155 Park St.
Elizabethtown, Pa.

R. Ball, J. Bowen, G. Latch, J. Sullivan, W. Weber

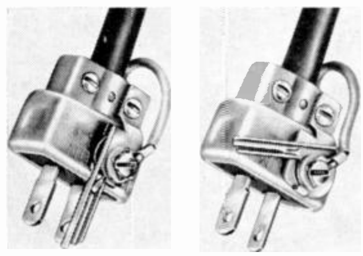
High voltage capacitors; quadruplers—circuit arrangement of rectifiers and capacitors that allow a set-up of voltage from transformer to output of 4 to 1; delay lines—lumped constant and distributed constant types featuring fast rise times and low attenuation. Power supplies, pulse-forming networks, MAD (multiple aperture devices).

PLAN IN ADVANCE!

Use this issue of *Proceedings of the IRE* to make your plans well before you get to the convention and show. Decide which technical sessions and social events you want to attend, and what exhibits at the show you will find of most interest. Advance planning will save you a great deal of time and effort, and will insure that you do not miss seeing or hearing about that one new product or technique which may be of vital importance to you in your work during the next year.

A.P.M. Corporation, Booth 1229
41 Honeck St.
Englewood, N.J.

▲ Riva Solins, ▲ Milton Morse, ▲ Nat Kornstadt, Joseph Solins



NUP121M Power Connector

Power connectors with automatic, self-grounding feature will provide ground connection when plugged into either 2 or 3 pole receptacles without need for special adaptor. Switch and shaft seals, self-sealing fasteners. All products meet military specifications.

ARRA, Booth 3015
See: Antenna & Radome Research Associates

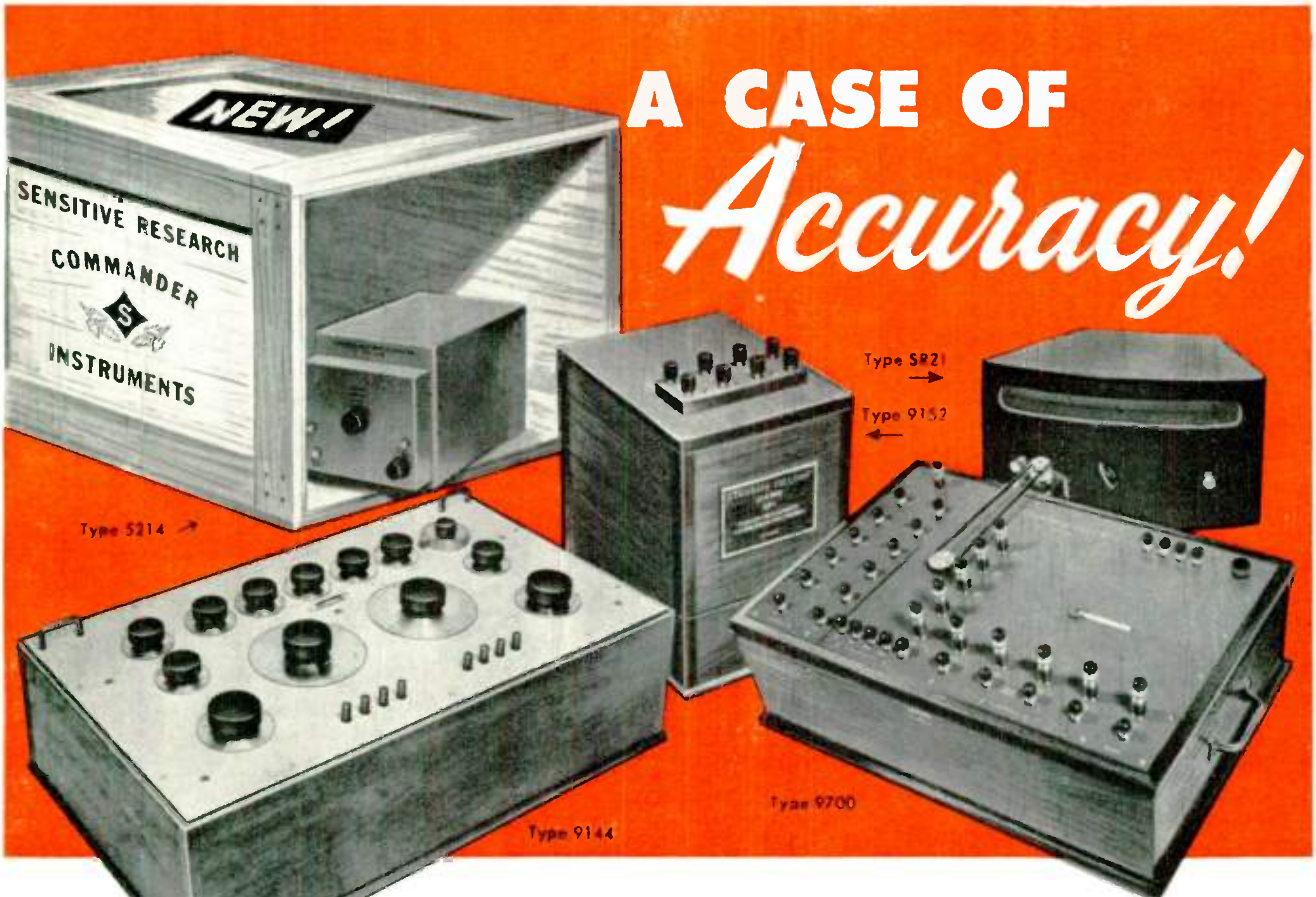
Ace Electronics Associates, Inc., Booths 1912-1914
99 Dover St.
Somerville 44, Mass.

▲ Aaron Solomon, ▲ Stanley Rudnick, ▲ John J. Kennedy, ▲ John Mastromarion

Manufacturers of precision wirewound and conductive plastic potentiometers and trimmers, in a full range of resistances, sizes from 3/8" to 3". Linear and nonlinear. Bushing and servo mountings, rotary and rectilinear. All designed to MIL specs. Specials, prototypes and production.

(Continued on page 128A)

▲ Indicates IRE member.
* Indicates new product.



The "COMMANDER" instruments described below have a 5-year accuracy guarantee. By using NBS or NRC reported values, total cumulative errors for a complete measurement system can be as low as ±.002%.

DAUPHINEE POTENTIOMETER TYPE 9144

ACCURACY ±.001%

A new 6-figure DC vernier potentiometer with a total measuring range of 2.101010V. *Accuracy is at least 10 x that of similar commercially available equipment.* Direct readout on 4 dials in increments of .1 μv (no slidewire). Thermal emf's less than .1 μv. Switch controlled ranges of x 1 & x .1. Contains 2 saturated standard cells in an internally thermostated enclosure. Completely "Self-Checking." *May be used with equal facility and accuracy as a Saturated Standard Cell or Resistance Comparator.*

VOLT RATIO BOX TYPE 9700

ACCURACY ±.005%

A volt ratio box similar to that used by the National Bureau of Standards as described by NBS Research Paper RP 1419. Self-heating and surface leakage negligible. Ranges: .15/.3/.45/.6/.75/1.5/3/4.5/6/7.5/15/30/45/60/75/150/300/450/600/750 V. (Type 9700A includes 1500 V. range). Furnished in a thermostated oil bath with a motor-driven impeller.

THE TYPE 5214 GALVANOMETER AMPLIFIER AND TYPE SR21 LIGHT SPOT GALVANOMETER.

The amplifier operates on the differential photocell principle in conjunction with a liquid-filled primary galvanometer. The secondary galvanometer has a scale length of 120-0-120 mm and is stable and free from the effects of external vibration. Over-all sensitivity is approximately 350,000 mm/μa and 35,000 mm/μv. It is ideally suited for use with the type 9144 potentiometer.

CONSTANT TEMPERATURE STANDARD CELL ENCLOSURE TYPE 9152 AND SATURATED STANDARD CELL TYPE 4305

ACCURACY ±.001%

Enclosure accommodates up to 4 cells and is air thermostated at 28°C ± .01°C. Transistorized circuit. Operates on 110V/60 cps (Battery standby). Type 9152A holds 12 cells.

SEE THESE NEW INSTRUMENTS AT BOOTHS 3409-3411 NEW YORK IRE

MODEL UX • 51 RANGE AC/DC POLYRANGER • Self Checking • Automatic Overload Protection • Expanded Scale.

MODEL FLH • AC/DC TRANSFER STANDARD • Accuracy .01% to 1,000 V. and 50 kc. • Resolution .005%.

MODEL PC • "POCKET SIZED" DC CALIBRATOR & MEASURING INSTRUMENT • Accuracy .05% of Reading • Self Contained Galvanometer & Reference Source.

MODEL LTC-1 • AC/DC CALIBRATION CONSOLE • Accuracy .05% of Reading to 25 kc. • "Per Cent Error" Readout • Automatic Overload Protection • Shielded Case.

TYPE 5212 M • FREQUENCY SELECTIVE AMPLIFIER • Versatile Null-Detector for Use with AC Bridges, Potentiometers, etc. • Frequency Range 10 cps-10 kc. • Amplification 85 to 110 db. • Selectivity Equivalent Q, 30.

TYPE 9001 SERIES • VARIABLE STANDARD MUTUAL INDUCTORS • Range .1 μh – 111.10 mh. • For Use on DC Through 1000 Cycles.

SENSITIVE RESEARCH INSTRUMENT CORPORATION

NEW ROCHELLE, N.Y.

ELECTRICAL INSTRUMENTS OF PRECISION SINCE 1927

Symbol of Quality

Whom and What to See at the IRE Show

(Continued from page 126A)

Ace Engineering & Machine Co., Inc., Booths 3928-3930
Tomlinson Rd.
Huntington Valley, Pa.

▲ Charles C. Borden, ▲ Edwin S. Kesney, ▲ Harry W. Kenny, ▲ Samuel M. Mitchell, ▲ Barton L. Conrad, ▲ David R. Beattie, C. Randall Schaller

Accurate model of most complex r-f shielded enclosure ever built. Unit incorporates advanced engineering principles, materials, and construction technique. Two shielded rooms separated by large anechoic and r-f shielded enclosure. Large access doors, air conditioning, special lighting also included.

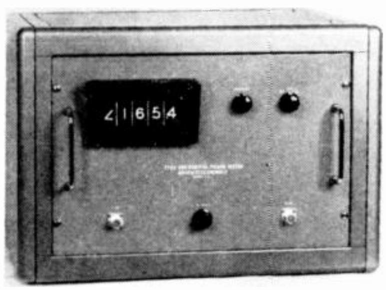
Acoustica Associates, Inc., Booth 4129
10400 Aviation Boulevard
Los Angeles 45, Calif.

▲ Paul Turkheimer, Joel Haynes, ▲ Moe Star, Tony Sabatino, Neil Small, Mickey Howell, Bill Katsara, Art Liers

Exhibiting ultrasonic cleaners—*featuring 20 kc model of our "semiconductor" line—smaller, more powerful. Also, *liquid-level sensors for (a) dairy industry; (b) temperature range (−450°F to 1200°F); (c) storable fuels and corrosive liquids. *Sonometer for continuous liquid-level gage systems.

Ad-Yu Electronics Lab. Inc., Booth 3909
219 Terhune Ave.
Passaic, N.J.

▲ Dr. Paul Yu, ▲ Annibale Lupi, Oscar Santos, ▲ Roland St. Louis



Type 524 Digital Phase Meter

Digital phase meter (above)—direct reading in degrees represented in four digits; accuracy 0.1° relative and ½° absolute from 20 cps to 20 kc; no frequency or amplitude adjustment; signal amplitude fluctuation or signal frequency continuous variation do not affect accuracy of phase reading. Also, precision phase meter, precision millimicrosecond phase detector, ultra-fast rise time delay line, millimicrosecond delay line, continuously variable delay network.

Advance Relays, Booth 2233

See: Elgin—Advance Relays

Advanced Acoustics Corp., Booths 2830-32

Acoustic transducers. See: Electronic Research Assoc., Inc.

Advanced Vacuum Products, Inc., Booth 1928
430 Fairfield Ave.
Stamford, Conn.

Robert L. Hurley

Hermetic Seals

Aeroprojects Inc., Booth 4235

See: Sonobond Corp.

▲ Indicates IRE member.
* Indicates new product.

Aeroquip Corporation, Booth 4032
Jackson, Mich.

David Horst, Bob McColley, Tom Houle, Harvey Irons

"Saf-Loc"® quick disconnects and hose for all electronic coolant and air conditioning applications. Rewirable aircraft and missile cables for special purpose applications (Jackson Div., Jackson, Mich.). "Conoseal"® for quick connection of coaxial tubing and accessory equipment; special instrument clamps (Marman Div., Los Angeles).

Aetna Electronics Corporation, Booth 3004
Readington Rd.
North Branch, N.J.

▲ Joseph F. McDonald. John W. Perkins, Frank P. Hunter, Henry J. Buser, Robert Wentworth

New compact low cost servo analyzer .05 to 60 cycles. 200 cycle to 20 kc carrier input. Phase measurement 0 to 360°. Other models from .0008 cycles to 100 cycles per second.

Affiliated Manufacturers, Inc., Booth 4131
Box 211
Oldwick, N.J.

B. M. Austin, Charlie Keiter

Batch and preset electronic counters for small and miniature parts. Material handling and gaging systems. Electrical vibratory feeders. Photoresist and evaporation masks.

Agastat Timing Instruments, Div. Elastic Stop Nut Corp. of America, Booth 2343
1027 Newark Ave.
Elizabeth, N.J.

W. A. Feitner, H. G. Bostrom, S. S. Knapp, E. Searle, W. Witt

AGASTAT time delay relays. Miniature time delay relays—Solid state time delay relays.

Ainslie Corp., Booth 1819
531 Pond St.
South Braintree 85, Mass.

▲ H. W. Ainslie, L. D. Ainslie, A. L. Stabile, F. W. Turner, S. Hassan, D. J. Cantelli

Ainslie CORPORATION

Microwave, telemetry, radar antennas and reflectors. Pedestals, large waveguide components, ground support equipment. Precision fabrications in aluminum and magnesium for the electronic industry.

(Continued on page 130A)

Be sure to see all four floors for a complete view of 800 new ideas!

reliability

rejects

In the drive to attain a level of reliability that really sticks, every engineer knows that nice guys finish last.

Firms supplying PCA Electronics with the raw materials that go into our products have learned long, long ago that the engineers in our Quality Control Department are *not* nice guys.
In fact, some of them are downright ornery. Our personnel in quality control subject every ounce of raw materials to two separate electrical and/or mechanical inspections — once, when the material is received, and a second time, before it is issued to production.

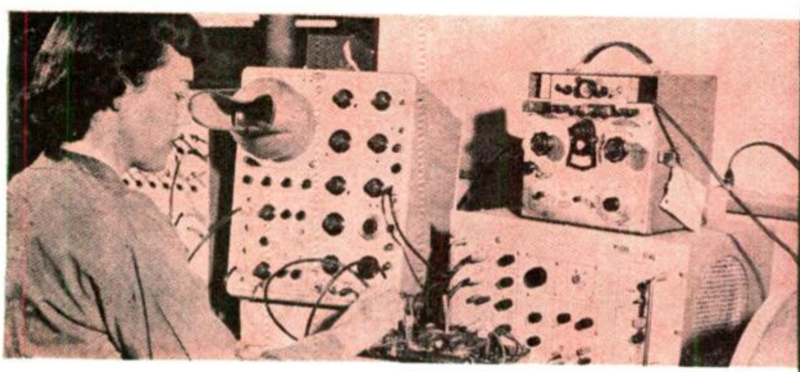
Any incoming material that does not meet the most stringent standards set up by the military or ourselves — is promptly rejected.

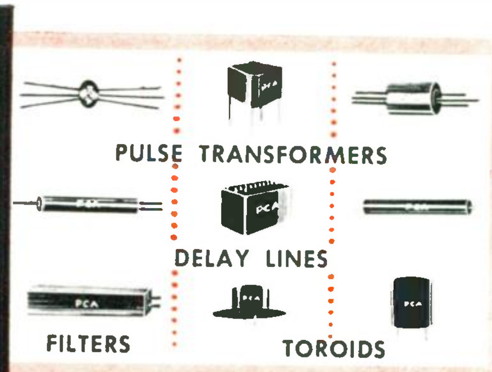
These *pre-production rejections*, coupled with continuous process controls, are your guarantee of *post-production* performance.

And what is that performance?

Day in, day out, our returns from customers on all PCA production average slightly less than 3 parts per 1,000.

If reliability is a critical factor in any of the items shown below, call the company whose Q.C. engineers may not be "nice" — but whose standards of quality assurance are among the highest in the industry.





Booth 1335 IRE Show

Leading Manufacturer of Pulse Transformers and Delay Lines

PCA ELECTRONICS, INC.

16799 SCHOENBORN STREET, SEPULVEDA, CALIFORNIA, EMpire 2-0761

Whom and What to See at the IRE Show

(Continued from page 130A)

Aircom, Inc., Booth 1121
18 Cummington St.
Boston 15, Mass.

▲ Robert A. Rivers, ▲ Edward J. Stack

AIRCOM INCORPORATED
48 CUMMINGTON ST., BOSTON, MASS.

*Diplexers, *beacon antennas, *telemetering antennas, *microwave transmitters, *waveguide variable couplers, *3-20DB high directivity sidewall couplers, *40 DB cross guide couplers, *step twists, *impedance plotter, *dessicators, tees, couplers, hybrids, detectors, attenuators, loads, phase shifters.

Airflyte Electronics Co., Booth 1205
535 Ave. A
Bayonne, N.J.

Milton Feinman, Thomas Monaco, Raymond Ferri, Richard O'Brien, Ben Novy

Slip ring and brush block assemblies for synchros, gyros, instrumentation. Switching commutators for telemetry, pulsing, sampling, analog-digital conversion. *New products: 24-circuit capsule slip ring assembly, 2^7 drum type A/D converter, size 5 synchro mounted commutator switch.

Airpax Electronics Incorporated, Booths 2306-2308
6601 N.W. 19th St.
Ft. Lauderdale, Fla.
and
Jacktown Road
Cambridge, Md.

▲ H. A. Cook, ▲ W. D. Heisler, H. Hoover, F. Marsh, W. Kouzoulas, J. Griffin, O. Scherini, A. Cairns, T. Dee, ▲ M. Rogers, ▲ D. Robinson, B. Linthicum

Remote Indicating Circuit Breaker

Remote indicating circuit-breakers—series 500-R. Electro-magnetic military and commercial and remote indicating circuit-breakers; micro-midget low-noise choppers; power, audio and pulse transformers; telemetering equipment; tachometers; magnetic amplifiers; frequency detectors; servo-mechanisms.

† See PROCEEDINGS OF THE IRE—Jan., March, May, Aug., Oct., Dec. (1960), Jan., March, May, Aug., Oct., Dec. (1961) for further information on our products.
See 1961 IRE DIRECTORY, pages 82-83, for complete information on our products.

Airtron, Inc., Booths 1610-18 & 1709-17
See: Litton Industries, Inc.

Aladdin Electronics Division, Aladdin Industries, Inc., Booth 1918
703 Murfreesboro Rd.
Nashville 10, Tenn.

▲ W. W. Stifler, Donald W. Grodske, ▲ Paul E. Dicker, F. G. Bassler, ▲ Andrew Ewing, Jr., C. C. Hopper, ▲ William B. Kincaid

Ferrite cored inductors, pulse transformers and wide-band coupling transformers miniature and microminiature styles. Missile quality IF transformers, computer components. Featuring *new DURACLAD pulse transformer and wide-band coupling transformer product line.

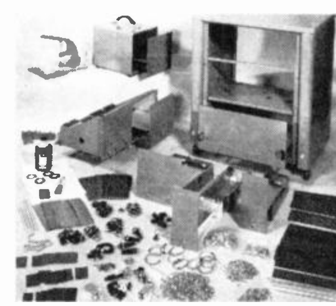
Alden Electronic & Impulse Recording Equipment Co., Inc., Booth 1611
P.O. Box 125, Washington St.
Westboro, Mass.

▲ John M. Alden, Edward D. Cross, L. A. Farrington, G. F. Stafford, T. B. Thompson, A. D. Wassall

Hi speed direct instant graphic component recorders—Recorder component controls—Multi-channel stylus and broad electrode recorders—*100 channel per inch recorders—Photo-optical scanners, facsimile recorders—Supporting electronic components—*Real-time spectrum analyzer.

Alden Products Co., Booths 1613-1615
117 N. Main St.
Brockton 64, Mass.

Mal Partridge, Russell Hawkins, William Northrup, N. A. Duhamel, Clayton Moore



Building Block Electronics Kit

*Building block components to mount, house, fasten, connect, and monitor electronic circuitry including terminals, terminal cards, tube sockets, plug-in chassis, racks and circuit kits. Integrally molded connectors, sub-miniature indicating lights, switches, test jacks & products. Detachable power cords and convenience outlets.

Aldis Brothers Ltd., Booths 3406-08
Digilights. See: British Industries.

Alfax Paper and Engineering Co., Inc., Booth 1609
Box 125, Washington St.
Westboro, Mass.

S. C. Sviokla, Milton Alden, ▲ John M. Alden

Alfax recording paper—an easy to use and interpret instant graphic recording paper for instant pulse presentation in helix and stylus (100 to inch) recorders. Records up to 1400″/sec., keeping up with latest transducers in instrumentation and sending high priority graphic information by facsimile.

(Continued on page 134A)

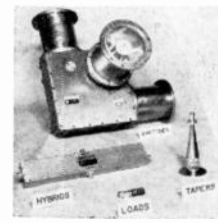
▲ Indicates IRE member.
* Indicates new product.
† Exhibitor is servicing IRE Engineers through the IRE Package Plan.

Whom and What to See at the IRE Show

(Continued from page 132A)

Alford Manufacturing Company, Booths 1718-1720
299 Atlantic Ave.
Boston 10, Mass.

▲ Andrew Alford, ▲ Harold H. Leach, Thomas E. MacKenzie, ▲ Nelson R. Powers, Gerald Cohen, David P. Flood



Coaxial Components

Transmission line hybrids, coaxial switches, tapered reducers, RF loads, impedance standard lines, line stretchers, adjustable matching networks, antennas, attenuators, slotted lines, and automatic impedance plotters.

Alfred Electronics, Booth 3314
897 Commercial St.
Palo Alto, Calif.

▲ Fred W. Kruse, Jr., Paul N. Fulton

Microwave amplifiers, providing 1 watt from 12.4 to 18 kmc; precision microwave sweep oscillators; microwave power levelers; precision microwave power supplies.

Alite Div., Booths 2238-40
See: U.S. Stoneware Co.

All Products Company, Booth 2835
See: Antenna Products Co.

Allegheny Electronic Chemicals Co., Booth 4023
207 Hooker-Fulton Bldg.
Bradford, Pa.

N. J. Egli, R. L. Leslie

"Silicon in all forms"—densified chunk, billets, cast rods, seeds, doping alloys, single crystals, slices and special forms.

Allegheny Ludlum Steel Corp., Booths 2314-20
See: The Arnold Engineering Co.

Allen-Bradley Co., Booths 2211-2213
136 West Greenfield Ave.
Milwaukee 4, Wis.

George Vater, Peter Leow, Erv Liban, Clarence Dickinson, ▲ Heinz Schlicke, ▲ Leonard Beaudion, Dan Kelly

Fixed and variable composition resistors, hermetically sealed composition resistors, precision metal film resistors, ceramic encased ceramic disc capacitors, ceramic disc feed-thru and stand-off capacitors, high frequency low pass feed-thru filters, ferrite cores, ceramic permanent magnets, antenna and transmitter multiplexers.

▲ Indicates IRE member.
* Indicates new product.
† Exhibitor is servicing IRE Engineers through the IRE Package Plan.

Allied Chemical Corp., General Chemical Division, Booth 4305
10 Rector St.
New York 6, N.Y.

R. F. Blessington, H. L. Eisen, R. George, D. A. Duffy, G. Lordi

Baker & Adamson ® line of electronic-grade chemicals.

Allied Control Co., Inc., Booths 2905-2907
2 East End Ave.
New York 21, N.Y.

Edward Bachorik, ▲ Kirby B. Austin, James A. Diciolla, Ronald Ebert, H. A. Yates, B. E. Larsen, Gerard T. Wilson, Frank C. Ebert, Stanley B. Snyder

Relays: Subminiature general purpose, sensitive magnetic latching, subminiature telephone and miniature power types. Subminiature switches: Toggle and push button types. Solenoid valves.

Allied Paper Corp., Booth 2340

See: Phillips Control Corp.

Allied Radio Corp., Booths 3831-3833

See: Knight Electronics Corp.

Alpha Corporation, Subsidiary of Collins Radio Company, Booths 3302-3308
820 East Arapahoe Road
Richardson, Texas

D. C. Arnold, T. A. Campobasso, D. G. Johnson, V. R. Manning, F. F. Merrill, B. Warriner, C. M. Harris

Specializing in design and construction of complex electronic systems. Complete service—from acquiring site to operating and maintaining the complete facility.

Alpha Metals, Inc., Booth 4328
56 Water St.
Jersey City 4, N.J.

Jack Hagestad, Martin A. Boyle, Harold Hertzog, Fred Disque, Arthur Krail, Walter Swanson, A. Mann, H. Greenberg, Norman Bilsky

See *new CCC alloy coated base tab material. Subminiature ultra high purity spheres, discs, washers. Demonstration: Flux filled solder preform for transistor closures. New AAA solder for printed circuit boards, more usage per pound and brighter connections.

(Continued on page 136A)

First and Second floors—Components

Third floor—Instruments and Complete Equipment

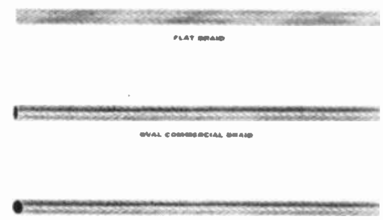
Fourth floor—Materials, Services, Machinery

Whom and What to See at the IRE Show

(Continued from page 135A)

Alpha Wire Corp., Booth 4103
200 Varick St.
New York 14, N.Y.

Howard B. Saltzman, Jack Kirschbaum, Donald Rappaport, Maxwell Harts, Nat Frost, Saul Kaplan, Sidney Manners



Electronic wire and cable for military and commercial use: Alphlex insulated tubing, sleeving, zipper tubing, 'new heat-shrinkable tubing, and lacing cord. 'Shielding and braiding. Special facilities for harnesses, assemblies, and custom cables.

Alphaloy Division, Booth 4328
See: Alpha Metals, Inc.

Altec Companies Inc., Altec Lansing Corp., Booths 3802-06
See: Ling-Temco Electronics, Inc.

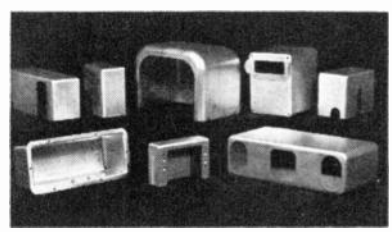
Amco Engineering Co., Booths 4501-4503
7333 W. Ainslie St.
Chicago 31, Ill.

R. C. Komarek, Ted Hendel, Joseph Freid, Herb Bass, W. F. Satterthwaite, Gerald Fine

Amco modular instrument enclosure system for packaging of electronic gear. Introducing new, flexible line of aluminum racks, two new style lines with standard color selections, a low silhouette console and miscellaneous added accessories. 'Four completely different structural lines of racks.

American Aluminum Co., Booth 4014
230 Sheffield St.
Mountainside, N.J.

Charles W. Hunter, Eugene O. Davis, Bernie Jenkins, William H. Dempsey, Robert D. Williamson, Henry Brucker, Milton Klausmann, Edward Parsell



Deep drawn round and rectangular cans in aluminum. Aluminum assemblies based on deep drawn or formed aluminum shapes. Deep drawn brass and mu-metal parts. Spun aluminum parts and assemblies based on spun aluminum shapes. Combinations of spun and drawn parts.

American Bosch Arma Corp., Booths 3921-3923
320 Fulton Ave.
Hempstead, N.Y.

Wallace C. Baker

Inertial guidance systems, telemetering systems.

American Electrical Heater Co., Booth 4033
6110 Cass Ave.
Detroit 2, Mich.

▲ Robert A. Kuhn, ▲ Frank W. Kuhn, John P. Verlinden, Evan Edwards

Full line of American Beauty electric soldering irons and Wassco Glo-Melt line of resistance type soldering equipment. New item is our Catalog No. 3114 American Beauty electric soldering iron, and also our Wassco Glo-Melt wire stripper.

American Electronic Laboratories, Inc., Booth 3053
121 N. Seventh St.
Philadelphia 6, Pa.

▲ Robert D. Freedman, Joseph Graham, George Landfear, ▲ Moe Polayes, William Bornmann

Extremely broadband 2-20 KMC (in only two units) microwave TWT amplifiers. Waveguide and coaxial crystal switches, attenuators, limiters, modulators. Conical helix and log periodic antennas. Microwave components as filters, horn antennas, crystal detector mounts. Transistorized video amplifiers. *Automatic transistor lead selector.

American Electronics, Inc., Booth 1327
1725 W. 6th St.
Los Angeles 17, Calif.

Jack McNutt, Hans E. Bannies, Al Romano, William W. Buckley, Albert Izuel, Jack T. Cairns

*20-second accuracy resolver (size 25); temperature compensated motor tachometer (size 9); missile launcher frequency changer; *missile main dc-dc power converter; line voltage regulator; electric pulsed servo actuator for control of missile flight; airborne clutches, gears motors and blowers.

American Enka Corp., Booth 4308

See: Brand-Rex Div., William

American Lava Corporation, Booth 4401
Cherokee Blvd. & Manufacturers Road
Chattanooga 5, Tenn.

W. H. Rennick

Technical ceramics.

American Machine & Foundry Co., Booths 2702-04

See: Potter & Brumfield, Inc.

American-Marietta Company, Adhesive, Resin & Chemical Div., Booth 4517
3400 13th Ave., S.W.
Seattle 4, Wash.

M. M. Eikenberry, Paul S. Byrd, R. J. Peters, G. H. Johnson

EMC epoxy molding compounds are easily handled, dry, single component materials. They are low pressure, soft flow, non-outgassing, non burning compounds suitable for low temperature transfer or compression molding of delicate parts or structural members. EMC provides an exceptional balance of physical, chemical, and electrical properties.

† See PROCEEDINGS OF THE IRE—Jan., March, May, July, Sept., Nov., 1961, for further information on our products.

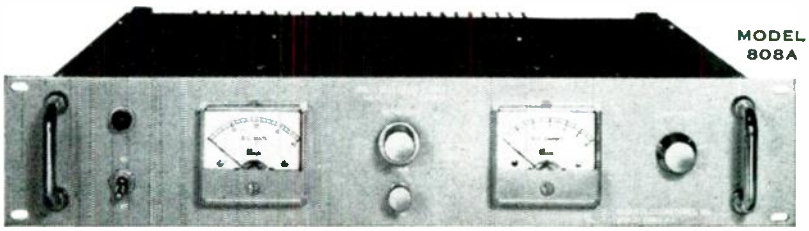
See 1961 IRE DIRECTORY, page 691, for complete information on our products.

(Continued on page 138A)

▲ Indicates IRE member.
Indicates new product.
† Exhibitor is servicing IRE Engineers through the IRE Package Plan.

HLAB* REGULATED POWER SUPPLIES

NEW Plug-In Card Selects Mode of Operation



- Constant voltage or constant current operation
- Units can be combined in series and parallel
- Printed card makes all internal wiring changes
- Continuously variable output voltage and current
- No overshoot on turn-on or turn-off
- No moving parts

H-Lab Model 808A is a versatile compact constant voltage/constant current transistor power supply possessing a combination of features that make it a truly unusual and exceptional power supply. All internal wiring changes for adaptation to constant voltage, constant current, auto series, and auto parallel modes of operation are accomplished by simply inserting one of the several plug-in printed circuit cards provided with the 808A supply.
The model 808A also features a continuously adjustable current limit control located on the front panel. The output current will not exceed the preset current limit value under any load conditions including a short circuit. This fast acting, adjustable protection circuit not only provides full protection for the power supply, but gives optimum protection to the load device as well.

For more stringent regulation requirements, chopper-stabilized Model 808AX is available. H-Lab Model 808A is priced at **$475**

SPECIFICATIONS

Output: 0-36 volts, 0-5 amps.
Constant Voltage or
Constant Current

Input: 105-125 VAC 50 cps

Load Regulation:
Constant Voltage
0.01% or 3.6 mv
Constant Current
0.1% or 5 ma

Ripple:
Constant Voltage 500μv rms
Constant Current 3 ma rms

Size: 3½″ H x 16¾″ D x 19″ W

Remote Programming • Remote Sensing
Short-Circuit Proof

OTHER PRECISE, VERSATILE AND COMPACT POWER SUPPLIES INCLUDE:

Model	E Out	I Out	Bench Model	Rack Model	Continuously Variable	Special Comments	Price
400D	150-315	0-1.5		X	No	Vacuum Tube Type	$595.00
520A	0-36	0-20		X	Yes	High Efficiency	575.00
800A-2	0-36	0-1.5	X	X	Yes	Dual Output	580.00
800B-2	0-36	0-2.5	X	X	Yes	Low Cost Medium Current Supply	339.00
802B	0-36	0-1.5		X	Yes	Dual Output Remote Sensing	580.00
806AM	0-20	0-2.0		X	Yes	Remote Sensing Remote Programming	350.00
810A	0-50	0-7.5		X	Yes	Remote Sensing	895.00
812C	0-32	0-10		X	No	Remote Sensing	550.00
855	0-18	0-1.5	X	X	Yes	Can be connected in series or parallel	175.00
865	0-40	0-0.5	X	X	Yes	Continuously Variable Current Limit	185.00
880	0-100	0-1.0	X	X	Yes	Wide Voltage Span	375.00

Write on your letterhead for new, illustrated catalog describing the complete H-Lab line.

HLAB HARRISON LABORATORIES, INC.
45 Industrial Road • Berkeley Heights, New Jersey
See us at the IRE Show—Booths 1429-1431

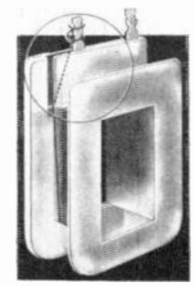
*TRADEMARK

Whom and What to See at the IRE Show

(Continued from page 137A)

American Microphone Co., Booth 2337
Microphones, connectors. See: G. C. Electronics Co.

American Molded Products Co., Booth 4233
2727 W. Chicago Ave.
Chicago 22, Ill.
A. P. Hultgren, A. Weyrich, R. Hauser



Nylon, *epoxy, *diallyl pithalate, bobbins and coil forms complete with insulated lugs and insulated lead slots. Instrumentation magnetic tape reels and containers. Strain relief bushings.

American Optical Co., Instrument Division, Booth M-3
Eggert & Sugar Road
Buffalo 15, N.Y.
Andrew Liberty
Test equipment.

American Seal-Kap Corp., Booth 2842
See: Hardwick, Hindle, Inc.

American Sealants Company, Booth 4521
705 N. Mountain Rd.
(Newington),
Hartford 11, Conn.
R. H. Krieble, C. E. Heilig Jr., P. G. Haviland, R. E. Carroll Jr., C. E. Lee, James P. Lee, Robert N. Rose, Douglas C. Lee, Ted Patlovich
LOCTITE sealant screw staking compound for securing threaded fasteners in electronic equipment. Called out as preferred method in MIL-P 11268D. Easy to apply, no heat, no mixing. Locks screws more securely than mechanical fasteners at much less cost. Also used for retaining bearings and sealing applications.

American Silver Company, Inc., Booths 4228-4230
36-07 Prince St.
Flushing 54, N.Y.
▲ Monroe Sherman, Arnold Goodridge, N. Sullivan, C. Wisneski

New .00004 in. Gap Foil (40 Millionth)

Platinum Gap Foil For Maximum Fidelity

- Non-Magnetic
- Non-Porous
- High Strength
- Can Be Cut To Size Without Crumbling

ASC

ASC all-metal magnetic recording tapes for video, computers, telemetry (high strength, high temperature, high output, long play). Metals for recording heads: Gap foils as thin as .00004"—Mumetal for head laminations—Shielding foils (copper and magnetic metal laminates)—copper foil. Metals for semiconductors: Hyper pure Gold (99.999%), doped alloys, clad metals.

▲ Indicates IRE member.
* Indicates new product.
† Exhibitor is servicing IRE Engineers through the IRE Package Plan.

American Television & Radio Co., Booths 2821-2823
300 E. Fourth St.
St. Paul 1, Minn.
Albert A. Goffstein, Lee Rocke, Tom Marchiano, Bernie Tonn

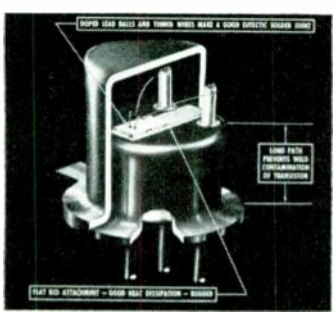
DC-AC inverters, auto radio and communication vibrators, heavy duty inverter vibrators, battery eliminators, battery chargers, *emergency lighting and power supply units, power transformers, *relays, shav-paks, tube protectors, customized karadios, truck karadios, and table model radios. Also, portable plug-in inverters, vibrator power supplies, rectifier power supplies, customized TV sets.

† See PROCEEDINGS OF THE IRE—March 1960 through March 1961, for further information on our products.
See 1961 IRE DIRECTORY, page 472, for complete information on our products.

American Transformer Div., Dynamics Corp. of America, Booth 1202
25 West 43rd St.
New York 36, N.Y.
R. F. Kelley, Z. P. Giddens, ▲ C. L. Allen
Specialty transformers, toroids, power supplies.

Amersil Quartz Div., Booths 4406-14
See: Engelhard Industries, Inc.

Amperex Electronic Corp., Booths 2522-2524
230 Duffy Ave.
Hicksville, L.I., N.Y.
Frank Randall, John Messerschmitt, ▲ Irwin Rudich, Charles Roddy, ▲ Roger LaPlante, George Elliot, Ed Feinberg, Ed Meagher, Myron Smoller, Bill Minowitz, Bron Kutny



PADT-40 Switching Transistor

Electron tubes and semiconductors for all applications. *PADT-40 switching transistor and full line of PADT types for communications, instrumentation and military applications. Silicon and germanium diodes. Power and transmitting tubes, rectifiers, microwave tubes, special purpose tubes, digit and numerical indicator tubes, cadmium sulphide cells.

† See PROCEEDINGS OF THE IRE—February 1960 through February 1961, for further information on our products.
See 1961 IRE DIRECTORY, pages 42-45, for complete information on our products.

(Continued on page 140A)

Whom and What to See at the IRE Show

(*Continued from page 139A*)

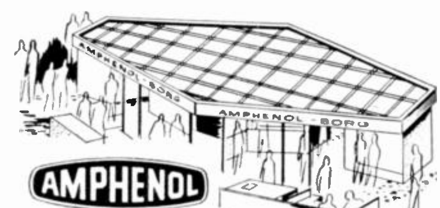
Ampex Computer Products Co., Div. of Ampex Corp., Booth 1900
(Formerly Telemeter Magnetics, Inc.)
9937 Jefferson Blvd.
Culver City, Calif.

▲ Graham Tyson, Gene McClenning, W. W. Follin, Todd Murphy, Marvin Weitzenhoffer, Alan Fletcher

Magnetic cores, arrays, and stacks. Type RB buffer-memory.

Amphenol Connector Div., Amphenol-Borg Electronics Corp., Booths 2402-2408, 2501-2507
1830 South 54th Ave.
Chicago 50, Ill.

Arthur J. Schmitt, Matthew L. Devine, William H. Rous, Rodolfo M. Soria, J. Frank Leach, Richard E. Hall, Herbert F. Motz, John Bucholz, Ned Spangler, Bill Brontsema, Glenn Omholt, Ed Beavan, Charles Kucera, Richard Parissidi, Martin Taraski, Robert Meade



BOOTHS 2402-2408

Miniature 200°C electrical connectors: MIL-C-26500 circular and MIL-C-26518 rack and panel; MIL-C-26636 crimp Poke Home contacts and accessory tools. Other connectors with crimp Poke Home contacts: Miniature MinRac 17, 93 Series and 94 Series rack and panels, MS-type "R" connectors.

† See PROCEEDINGS OF THE IRE—Jan. through Dec. (1960), Jan. through Dec. (1961) for further information on our products.
See 1961 IRE DIRECTORY, page 146, for complete information on our products.

Amphenol-Borg Electronics Corp., Booths 2402-2408 and 2501-2507

See also: Borg Equipment Div. and RF Products Div. (formerly Industrial Products-Danbury Knudsen Div.)

Amplex Division, Chrysler Corp., Booth 4523

See: Beemer Engineering Co.

Amplivox Ltd., Booth 2929

See: Rye Sound Corp.

Analab Instrument Corp., Booth 3951
30 Canfield Road
Cedar Grove, N.J.

▲ Morton G. Scheraga, ▲ Clee O. Marsh, Theodore Lasar, ▲ Harold Roth, Philip G. Schifflin, Max Schneiderman, Edwin J. Sommers, Haig H. Soojian

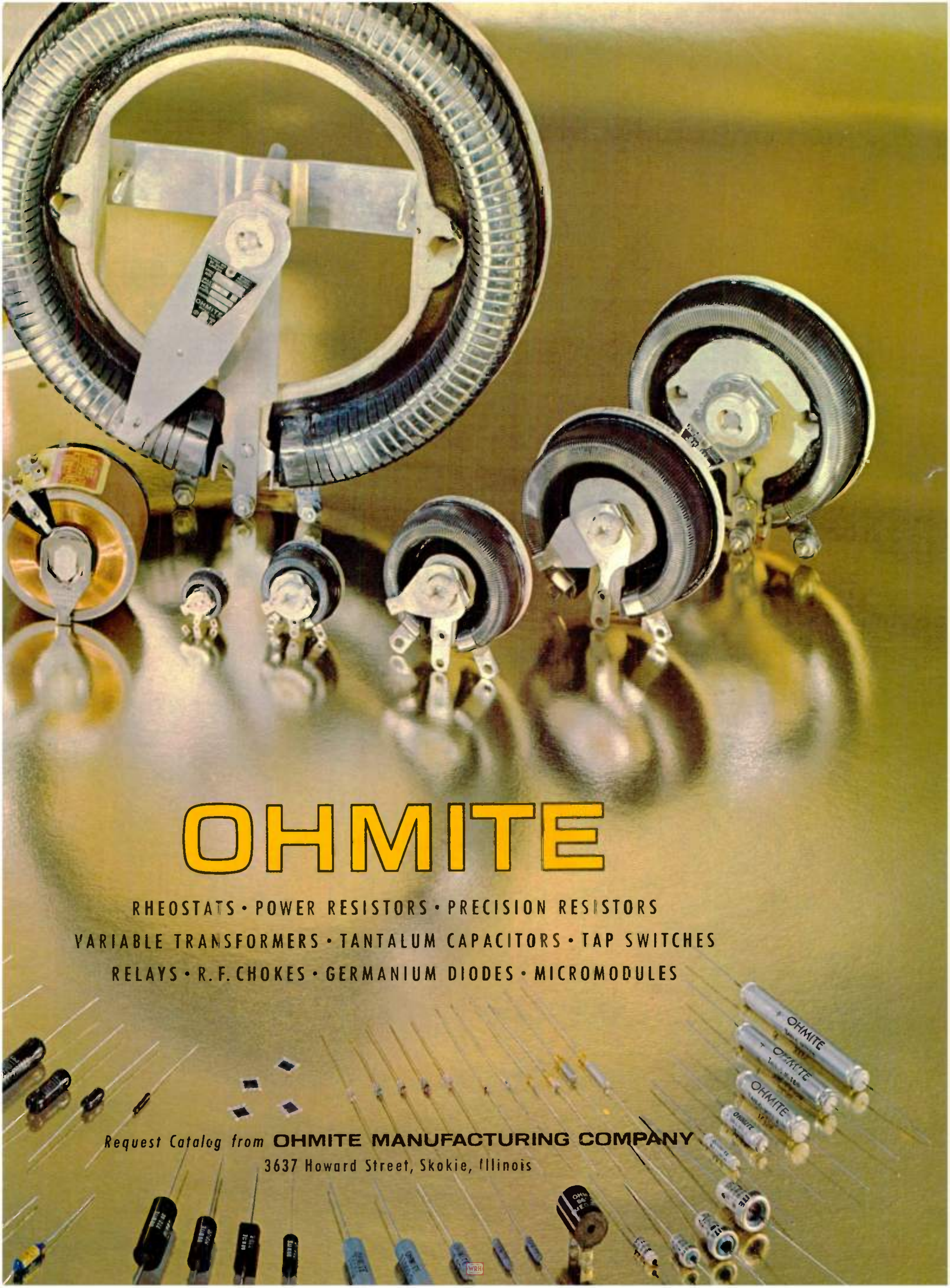
*1120, 1120-R dual trace oscilloscopes, 1100, 1100-R oscilloscopes; dual-channel plug-ins, including 100 X-Y plotter, *200 and 300 1.0 millivolt/CM plug-ins, 500, 600, 700 precision null readout plug-ins; oscilloscope cameras; scope carts; scope accessories.

(*Continued on page 144A*)

▲ Indicates IRE member.
* Indicates new product.
† Exhibitor is servicing IRE Engineers through the IRE Package Plan.

The Standard of Reliability

Ohmite components are designed to withstand the most severe operating conditions...rigidly tested at every stage of manufacture...improved by continuous research and development. That is why Ohmite products are the "standard of reliability."


OHMITE
RHEOSTATS • POWER RESISTORS • PRECISION RESISTORS
VARIABLE TRANSFORMERS • TANTALUM CAPACITORS • TAP SWITCHES
RELAYS • R. F. CHOKES • GERMANIUM DIODES • MICROMODULES
Request Catalog from OHMITE MANUFACTURING COMPANY
3637 Howard Street, Skokie, Illinois

Whom and What to See at the IRE Show

(Continued from page 140A)

Anchor Metal Co., Inc., Booth 4042
966 Meeker Ave.
Brooklyn 22, N.Y.

M. Adler, D. Neumann, W. R. Cole, H. Drapkin

Rosin core solder, fluxes, bar solder, printed circuit solder to meet federal specifications. Preforms of solder. High purity metal for semiconductors, clad metals, base tabs, discs, washers, spheres.

Anchor Metals, Inc., Booth 2129
See: D. S. Kennedy & Co.

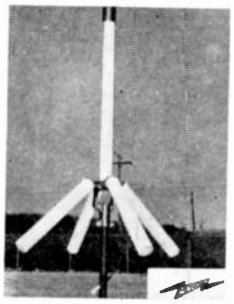
Andrew Antenna Corp. Ltd. & Andrew-California Corp., Booths 1502-04
See: Andrew Corp.

▲ Indicates IRE member.
* Indicates new product.
† Exhibitor is servicing IRE Engineers through the IRE Package Plan.

One registration entitles you to permanent entry to the show for all four days. Be sure to keep your identification badge or pocket card and bring it with you when you return. Registration is not transferable.

Andrew Corporation, Booths 1502-1504
P.O. Box 807
Chicago 42, Ill.

▲ R. P. Lamons, ▲ R. C. Bickel, ▲ C. R. Lane, ▲ K. Robinson, ▲ H. Detlefs, ▲ L. R. Krahe, ▲ J. Wyman, ▲ J. Brown, ▲ Dr. R. Yang, ▲ J. Montgomery Jr., E. Heitsch, ▲ R. Matthews



*Helipole Antenna

Heliax flexible air dielectric cable. *Hubloc antennas, a new concept in large dish construction. Helipole antennas. *New 2-way base station antennas. High power transmission lines and waveguides. Antenna systems for microwave, UHF/VHF, ground-to-air telemetry.

†

See PROCEEDINGS OF THE IRE—Feb., March, May, Aug., Nov., Dec. (1960), Jan. and March (1961) for further information on our products.
See 1961 IRE DIRECTORY, page 371, for complete information on our products.

Arthur Ansley Manufacturing Co., Booth 1328
New Hope, Pa.

▲ Arthur C. Ansley, Anne Klein Ansley, Rita Neuls, Bruce Burdett, Barrett Border, Barry Houser, Bob Miller

High reliability printed circuits for military and industrial electronic equipment, printed circuit assemblies, Ansley "plus module," "missile module," and "mini-module," 3 dimensional printed circuit structure. Design service for "packaging" of circuits into modular, printed circuit, or miniaturized form.

Antenna Products Company, Division of All Products Company, Booth 2835
P.O. Box 110
Mineral Wells, Texas

Kenneth H. Read, ▲ John H. Dunlavy, ▲ Joseph Bohar, ▲ James Buzbee, ▲ Richard A. Pomroy, Thomas Black, ▲ Thomas Smith, ▲ Thomas Minton

Antenna-systems research, development, design, and production—from VLF through microwave. Complete line of towers, rotators, and antenna hardware.

Antenna & Radome Research Associates (ARRA) Booth 3015
27 Bond St.
Westbury, L.I., N.Y.

▲ Harold B. Isaacson, ▲ Norman Spector, Paul L. Bleifer, ▲ Howard Feiner, Ed Conte

*Miniature microwave "zero" insertion loss continuously variable attenuators—*3" "s" series, *3" micrometer series, *3" vamp (with attenuation flat with frequency), *5" vamp (attenuation flat with frequency). Complete line "zero" insertion loss continuously variable attenuators from 250-11,000 mc. *Waveguide and coaxial components.

Antenna Systems, Inc., Booth 2009
349 Lincoln St.
Hingham, Mass.

▲ Charles W. Creaser Jr., ▲ W. W. VanderWolk Jr., ▲ Albert K. Fowler, ▲ Donn S. Randall

Complete line of antennas for scatter, tracking, radio telescope, and communications applications. *New 30-foot mobile antenna. Also feed horns, diplexers, and waveguide components.

ANTENNA SYSTEMS INC.
HINGHAM, MASS

†

See PROCEEDINGS OF THE IRE—March, June, Aug., Oct., Dec. (1960), Jan., March (1961) for further information on our products.
See 1961 IRE DIRECTORY, page 369, for complete information on our products.

Antlab Inc., Booths 3233-3235
6330 Proprietors Rd.
Worthington, Ohio

M. M. Robison, B. J. Robison, ▲ G. C. Monter, ▲ Cliff Hopkins, ▲ D. W. McMahill

Antenna Pattern Instrumentation: *Totally enclosed multi-axis antenna mounts with associated servo and electromechanical control systems; model support towers; position indicators; compact, broadband *microwave receivers; polar and *rectangular recorders; high accuracy, low drift pattern integrators.

(Continued on page 146A)

Whom and What to See at the IRE Show

(Continued from page 144A)

Anton Electronic Laboratories, Inc., Div. of Lionel Corp., Booth 2002
1226 Flushing Ave.
Brooklyn 37, N.Y.

George Weinman, Pat Morrisey, R. McCarthy, Ben Remondino, James Gulick, Charles Montagna, William E. Thompson, Al Octavio, Herb Kalisman, Nat Paris, Pat Tomaro, John Digirolamo

Precision connectors, potentiometers, voltage regulating tubes, radioactive tubes, nuclear equipment, relays, miniature motors, time delay and power switches, powdered metal products.

Applied Dynamics, Inc., Booth 1722
See Bowmar Instrument Corp.

Applied Research, Inc., Booth 1903
76 S. Bayles Ave.
Port Washington, L.I., N.Y.

N. M. Poulos

UHF receiving system featuring new approaches to design of communication equipment. Bandpass filters, UHF converters, UHF broadband amplifiers, variable attenuators, multicouplers, *multiplexers, type BNC, TNC and fixed pad attenuators and terminations.

Ardente Acoustic Laboratories Ltd., Booth 1822
Miniature switches. See British Radio Electronics Ltd.

Armed Forces Communications & Electronics Association, Booth 4226
See: SIGNAL Magazine.

The Arnold Engineering Co., Booths 2314-2320
P.O. Box G
Marengo, Ill.

Benjamin Falk, J. L. Jones

Permanent magnets of Alnico and ceramics. Silectron transformer cores. High permeability tape wound cores of Deltamax, Permalloy, Supermalloy, Supermendur, as well as bobbin cores. Powder cores of molybdenum Permalloy, carbonyl iron and Sendust. Barium titanate transducers. Special magnetic materials.

†

See PROCEEDINGS OF THE IRE—Jan. through Dec. (1960), Jan. through Dec. (1961) for further information on our products.

See 1961 IRE DIRECTORY, pages 72 and 73, for complete information on our products.

Arnoux Corp., Booths 1230-1232
11924 W. Washington Blvd.
Los Angeles 66, Calif.

J. Thomason

Airborne high performance power supplies (ac/dc, dc/dc); inverters (dc/ac); temperature measuring systems (probes, bridges, signal conditioning equipment); electronic commutators; de-coms; *signal simulators (PCM); *projection decade counter; instrumentation tape recorder performance tester; umbilical connectors.

Artos Engineering Co., Booth 1108
2757 S. 28th St.
Milwaukee 46, Wis.

Haakon T. Randar, Anders Moline, Patricia Harris, C. W. Terry, James Comito

Automatic wire stripper model CS-6 with new attachment for color coding wires.

Arwood Corp., Booth 4111
321 West 44th St.
New York 36, N.Y.

W. I. Matthes, W. O. Sweeny, G. H. Main, N. Davidson, C. W. Storey, H. B. Brown, R. M. Patterson, P. F. Pfau, A. Kirby, R. Webb, A. Diamond, W. McDorman

Investment cast aluminum, magnesium, bronze microwave plumbing. Castings used for chassis, brackets, heat sinks and switches. Gimbal rings, motor housings and other gyro components.

Assembly Products, Inc., Booths 3916-3918
75 Wilson Mills Rd.
Chesterland, Ohio

▲ John D. Saint-Amour, Robert H. Pugsley, ▲ George J. Crowdes, Tom Swiler, Saul Cohen, Irwin Moss, Glen Krebs

Meter-relays, both locking contact and continuous reading types; small automatic temperature controls, *Model 450 "Temp-Tendor"; panel meters; miniature "Temprint" temperature recorders; controlling wattmeters; controlling volt-ohmmeters; LIAD multi-contact meter-relays; "memory" meters; maximum reading meters; VU meters; linear transducer systems.

(Continued on page 148A)

This Top Team of Application Engineers Represents You at Bourns!

NUMBER 12—APPLICATION SERIES

See us March 20-23 at the IRE Show/Booths 1816-1818.

Consider this crack Trimpot® engineering group an extension of your own staff... because that's exactly what it is. Each of these men is a graduate engineer; each has extensive experience in potentiometer applications; and each is responsible for technical subjects within a specific geographic area. The Bourns specialist assigned to your region therefore becomes well acquainted with your requirements—to help you solve today's problems today!

Because Bourns offers the widest selection of adjustment potentiometers in the nation, these men are in the best possible position to steer you to fast answers for your potentiometer needs. If modifications or specials are in order, they'll come up with sound, low-cost solutions. If your problems require direct engineer-to-engineer contact on problems involving design, quality control, or testing, they'll provide it... on the phone or in your office.

Here, in short, is a group of engineers devoted to giving you personal service and personal follow-through on your projects. The phone is right there on your desk—call anytime!

BOURNS

BOURNS, INC., TRIMPOT DIVISION
6135 MAGNOLIA AVE., RIVERSIDE, CALIF.
PLANTS: RIVERSIDE, CALIFORNIA
AMES, IOWA, TORONTO, CANADA

Exclusive designers and manufacturers of Trimpot® potentiometers. Pioneers in transducers for position, pressure, acceleration.

Whom and What to See at the IRE Show

(Continued from page 146A)

Associated American Winding Machinery, Inc., Booths 4224-4226
750 St. Ann's Ave.
New York 56, N.Y.

L. I. Guttman, G. B. Franklin, W. Forster, G. Embree, W. O'Gorman, H. Fritschy, F. Lederer, B. Hammerman, B. Scannelii

Automatic radio coil winder. Deflection yoke winder for new split ferrite cores. Automated fast winder for horizontal TV tube yokes. Meteor fine wire precision winder with electrical "No-Dwel" traverse. Quick set-ups, no gears or cams. Meteor calibrated tension de-reelers.

Associated Testing Laboratories, Inc., Booths 3931-3933
Route 46 at Route 23
Wayne, N.J.

William Tonkowich, Bernard Novack, Robert Goldsmith, Frank Keena, Steve Cocheo, John Down, Norman Ressler, Albert F. Erdman, Daniel Schochet, Joe Beattie

On exhibit will be radically new All-Lucite "Ful-Vue" Humidity Chamber. Also, new All CO_2 humidity chamber; Econ-O-Line high-low temperature chamber; Lucite salt-spray chamber; and vibration table. Testing capabilities of our Southeastern and New England Divisions.

Astron Corp., Booth 2602
255 Grant Ave.
East Newark, N.J.

I. I. Ser, ▲ P. M. Maler, J. Gordon, ▲ H. R. Mutz, J. Barg, ▲ M. Katz, Amnon Gordon, L. Bush, A. Merola, R. Black, R. Carr, F. Heringer, I. Halfin, S. Berenstein

Capacitors: (Fixed) Paper (up to 20.000 V.D.C.); metallized paper, mylar, metallized mylar, electrolytic, tantalum, feed thru. R. F. Noise Suppression Filters: Band pass, band elimination, low pass, high pass custom made to your particular requirements.

Atlantic Research Corp., Booth 3229
See: Northeastern Engineering, Inc.

Atlantis Electronics Corp., Booth 3942
P.O. Box 451
Garland, Texas

▲ Richard L. Bickel, ▲ Wendell C. Brooke, ▲ Stanley R. Nelson, Ted J. Davi, John L. Perry

Automatic diode test equipment, automatic transistor test equipment, toroid winding machine (microminiature type), transistor test sockets (Transocket), automatic diode sorting systems, automatic transistor sorting systems, and material handling device (Handy Dolly).

Audio Development Co., Booth 1623
See: ADC Incorporated

Audio Devices, Inc., Booth 2521
444 Madison Ave.
New York 22, N.Y.

Rolf Haag

Audiotape, EP Audiotape, Audiofilm, Audiodiscs.

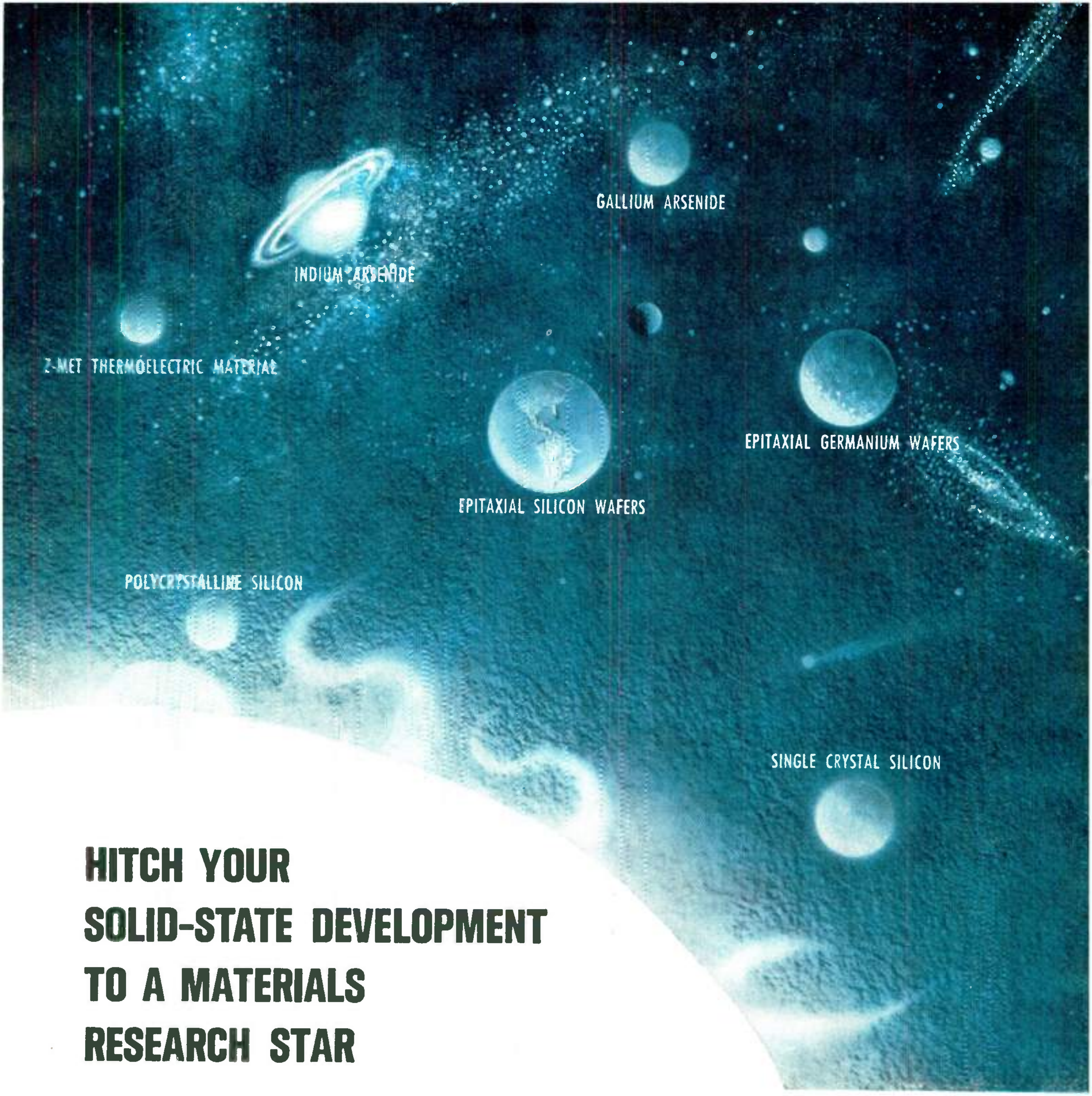
Audiotex Mfg. Co., Booth 2337
See: GC Electronics Co.

Augat Bros., Inc., Booth 1227
33 Perry Ave.
Attleboro, Mass.

E. H. Augat, R. S. Laurence, N. F. Damon, R. C. Hoy

Transistor heat sinks, transistor sockets, crystal can relay sockets, crystal sockets, battery holders, component clips & holders, tube clamps, mounting brackets, potentiometer clamp rings, test jacks, "Elastaclamp" for S/M tubes.

(Continued on page 150A)



HITCH YOUR SOLID-STATE DEVELOPMENT TO A MATERIALS RESEARCH STAR

Your profits in the next decade will be greatly benefited by the right choice of supplier of solid-state materials.

The key question is what criteria to use in making the choice. The simplest, most reliable criterion has to be PAST PERFORMANCE. Judged on this basis the Electronic Chemicals Division of Merck & Co., Inc. deserves your attention. In just four short years, it has achieved these exclusive major breakthroughs:

1958 Float zone, vacuum refined, doped single crystal silicon · 1959 Z-Met* Thermoelectric materials
1960 Epitaxial silicon N+ N wafers and III-V Compounds · 1961 Epitaxial germanium P+ P wafers

When you hitch your product development to Merck materials research you are enlisting a proved producer. If you want to be the first to exploit new solid-state materials breakthroughs, join the ranks of Merck customers today. Write, wire or phone your needs, problems, hopes.

*Trademark

Visit our Booth #4513, I. R. E. Convention

Electronic Chemicals Division

MERCK & CO., INC. · RAHWAY, NEW JERSEY

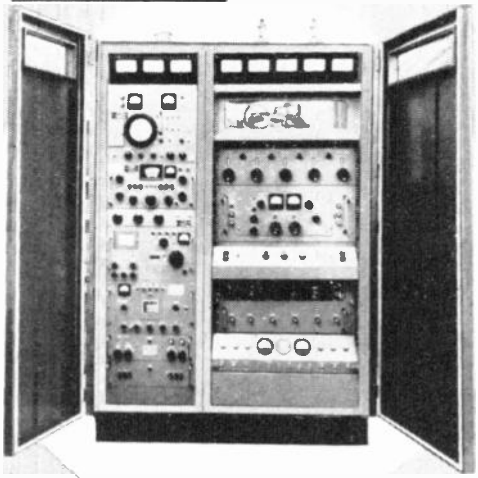
RESEARCH and PRODUCTION FOR BETTER SOLID-STATE MATERIALS

WRH

10,000 WATTS

SINGLE SIDEBAND HI-POWER TRANSMITTER

GPT-10K



The TMC Model GPT-10K, Radio Transmitter, is a conservatively rated, general purpose unit capable of providing 10 kw PEP output throughout the range of 4 to 28 megacycles. Containing all components within a single attractive enclosure, the GPT-10K includes exciter, spectrum analyzer, F.S. Exciter, and complete "on the air" testing circuitry.

AN/FRT-39

SEND FOR BULLETIN 207B

THE TECHNICAL MATERIEL CORP.

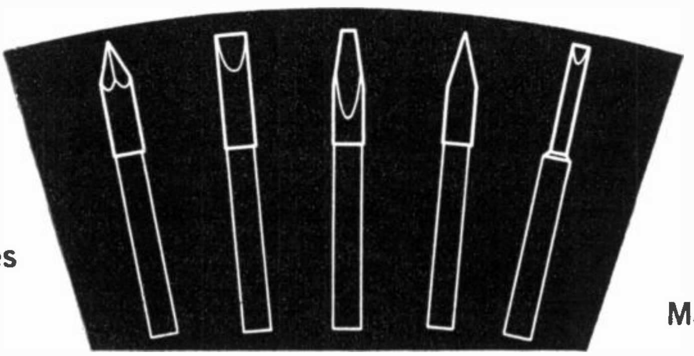
MAMARONECK, NEW YORK

ANOTHER IMPORTANT BREAKTHRU!

DUROTHERM

Non-freezing Long-Life SOLDERING TIPS

In ALL Shapes and Sizes



Fit ALL Makes

HI-PERFORMANCE Tips for use in HI-PERFORMANCE, HI-TEMPERATURE Irons. Tips positively cannot stick or freeze in any iron—easily removed after months of service. No need to remove tips daily. Minimum loss of heat delivery. Tip shank immunized from solder, except on working surface at end of tip—prevents creeping of solder into element tip hole and spilling of solder on components.

INDUSTRY'S No. 1 HEXACON SOLDERING IRON

SEND FOR CATALOG—showing the most complete line of industrial Soldering Irons and Long-Life Clad Tips.

HEXACON ELECTRIC COMPANY

181 West Clay Ave., Roselle Park, New Jersey

SERVING INDUSTRY FOR OVER A QUARTER OF A CENTURY

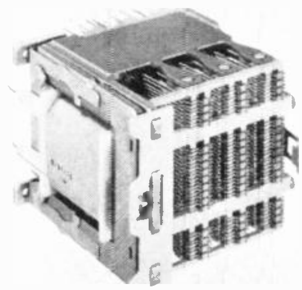
VISIT BOOTH 4002 IRE SHOW

Whom and What to See at the IRE Show

(Continued from page 148A)

Automatic Electric Corp., Booths 1908-1910
Northlake, Ill.

▲ R. B. Liepold, ▲ J. W. Ayers, ▲ T. E. Smith, ▲ L. B. Mitchell, ▲ H. P. Hohberger, ▲ A. T. Brennan, J. F. Harm, G. W. Downs, J. K. Kallas, J. P. Costello, D. C. Leis, A. Grady, R. Winthrop, R. O. Cuevas



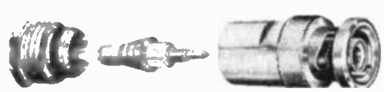
Wire Spring, Multiple Transfer Relay

*New mercury-wetted contact and wire spring contact relays, plus a full line of telephone-type relays and rotary stepping switches. All can be furnished either hermetically sealed or open. Also, sub-assemblies and complete control systems, including private communications systems.

Automatic Mfg. Div., Booths 1103-06
See: General Instrument Corp.

Automatic Metal Products Corp., Booth 1432
315-323 Berry St.
Brooklyn 11, N.Y.

M. W. Martin, P. Gilbert, X. B. K. Green, E. Bergenfeld, M. Ross, J. Onore, H. A. Feiner, George Smith



*Wedge-Lock Cable Clamping Connectors

Coaxial connectors and fittings, subminiature coaxial connectors, microminiature connectors, printed circuit coaxial connectors, coaxial relays and switches, coaxial filters (low, high and band pass, band elimination from 100 to 4000 mc), coaxial cable assemblies, insulated shafts, power plugs, attenuators, directional couplers.

Automatic Seriograph Corp., Booths 1610-18 & 1709-17
See: Litton Industries, Inc.

Autotronics Incorporated, Booth 1111
Box 208
Florissant, Mo.

▲ E. F. White, ▲ Mrs. F. Haynes, ▲ Art Lee

Multispeed transmission units, torque indicator, clutch-brake potentiometer, new spring-return, torque standard, aim-electromagnetic brake and clutch (industrial), pancake brake clutch.

(Continued on page 152A)

High selectivity, unique convenience, extreme accuracy

hp 302A Wave Analyzer

easily convertible to a sweep oscillator-tuned voltmeter with this hp AC-97C Sweep Drive!

No calibration or stabilization is required with the hp 302A Wave Analyzer, a completely transistorized instrument which represents significant improvement in design. Operating as a highly selective tuned voltmeter, the instrument provides a front panel control which selects the frequency to be measured. Voltage then is read directly on the front panel meter. Basically, Model 302A separates an input signal into individual components so that each—the fundamental, harmonics and any intermodulation products—may be evaluated separately.

With the AC-97C Sweep Drive, the hp 302A is converted to a sweep oscillator-tuned voltmeter for automatic frequency response measurements, even in noisy systems. The AC-97C motor accessory permits sweeping the entire frequency range of the 302A, 20 cps to 50 KC; provides fast sweep for covering the spectrum rapidly, slow sweep for high resolution plot. The Sweep Drive with an X-Y recorder permits automatic plots of harmonics or intermodulation products. Model AC-97C attaches to the 302A panel, or may be bench mounted on an adjustable stand.

SPECIFICATIONS

hp 302A Wave Analyzer

Frequency Range:	20 cps to 50 KC
Frequency Calibration:	Linear graduation 1 division/10 cps. Accuracy ± (1% + 5 cps)
Voltage Range:	30 μv to 300 v, full scale, 15 ranges
Warm-up Time:	None
Voltage Accuracy:	± 5% of full scale
Residual Modulation Products & Hum Voltage:	Greater than 75 db down
IF Rejection:	Intermediate frequency in input signal rejected by at least 75 db down
Selectivity:	± 3½ cycle b.w. — at least 3 db down ± 25 cycle b.w. — at least 50 db down ± 70 cycle b.w. — at least 80 db down Beyond ± 70 cycle b.w. — at least 80 db down
Input Impedance:	Determined by setting of input attenuator: 100,000 ohms on 4 most sensitive ranges, 1 megohm on other ranges.
Dimensions:	20¾" x 12½" x 14½" (cabinet), 19" x 10½" x 13½" (rack mount)
Weight:	43 lbs. (cabinet), 35 lbs. (rack mount)
Price:	hp 302A (cabinet), $1,800.00 hp 302AR (rack mount), $1,785.00

hp AC-97C Sweep Drive

Sweep Range:	50 revolutions
Sweep Limits:	Any interval from 50 revolutions to 5 degrees
Sweep Speed with hp 302A:	170 cps/sec and 17 cps/sec
Mount:	Front panel of hp 302A or bench stand, adjustable, 4" to 12"
Price:	$275.00

HEWLETT-PACKARD COMPANY
1062D Page Mill Road, Palo Alto, California, U.S.A.
Cable "HEWPACK" DAvenport 6-7000

HEWLETT-PACKARD S. A.
Rue du Vieux Billard No. 1 Geneva, Switzerland
Cable "HEWPACKSA" Tel. No. (022) 26. 43. 36

Sales representatives in all principal areas

Whom and What to See at the IRE Show

(Continued from page 150A)

Avco Corporation, Electronics and Ordnance Division, Booth 3932
Cincinnati 15, Ohio
Donald L. Haas, Gordon Burrer, Fred P. Drummond, Richard E. Stockwell
Infrared scanning equipment suitable for aircraft and missile detection. Model of FPS-26 radar equipment now in production for U.S. Air Force.

Avco Corporation, Research & Advanced Development Div., Booth 3931
201 Lowell St.
Wilmington, Mass.
Richard J. Burns
Shock test machines for 100 and 25 lb. specimens, PlasmaGun coating equipment. Rotating mirror camera and Avco Kerr Cell shutter.

Avion Division, Booth 1226
See: ACF Electronics Div.

Show Hours
10 a.m. to 9 p.m. daily
Monday through Thursday
March 20-23, 1961

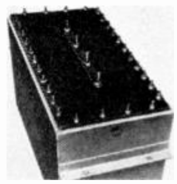
Avnet Electronics Corp., Booth 1112
70 State St.
Westbury, L.I., N.Y.
Clark J. Grey, ▲ Richard Erhardt, ▲ Gene Cooney, Barry Rava, George Contino, Vincent Moore, ▲ Charles Merz, Joe Walsh, Stanley Wood, ▲ Jack Reynolds


Automatic Insulation & Circuit Tester

Automatic insulation and circuit tester—performs automatic production testing of electrical components, particularly connectors and cables, for continuity, insulation resistance and high potential breakdown. Bendix connectors, Microdot connectors, Clare relays, Semcor and Sperry semiconductors, TIC trimmers, Robertson splice cases, King capacitors, Gremar connectors.

Avo Ltd., Booths 3406-08
Testmeters. See British Industries Corp.

Axel Electronics, Inc., Booth 1221
134-20 Jamaica Avenue
Jamaica 18, N.Y.
▲ J. P. O'Donnell, R. H. Elkes, M. Matnick, C. D. Bittetti, C. B. Axel, S. Spiegel



Low inductance capacitors, high voltage capacitors, pulse transformers, pulse networks, pulse packages, RF suppressor filters. New development in low inductance capacitors 1.0 MFD-50KV, ringing frequency, 1.3 megacycles.

B & F Instruments, Inc., Booth 3122
3644 N. Lawrence St.
Philadelphia 40, Pa.
Marshall L. Stein, Eugene Frank, Richard M. Kuehner, Al Leiby
Strain gage and transducer input conditioning equipment, bridge balance units, power supplies, strain gage and transducer recording and plotting systems, torque meter systems, temperature calibrators and accelerometers.

Babcock Relays, Inc., Booth M-15
1640 Monrovia Ave.
Costa Mesa, Calif.
Carl L. Martin, Wilhelm F. Juptner, Ed Landa, John Hunter, Joe Roche
Several series of miniature and subminiature relays of highest order accuracy and reliability, including BR18, BR3, BR7, BR8, BR9, BR12, and BR14 for airborne and ground applications involving high G load, extreme shock and vibration.

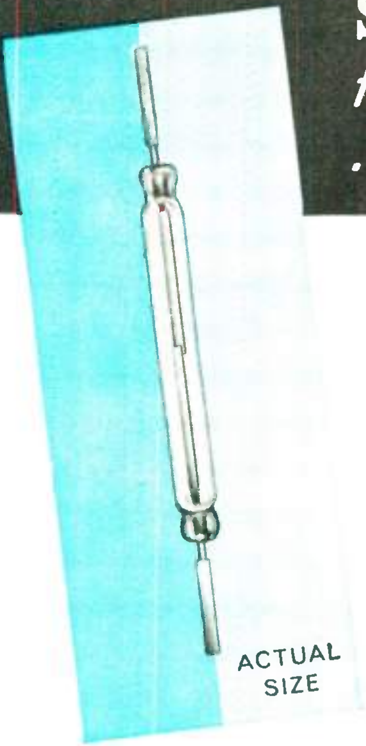
(Continued on page 154A)

▲ Indicates IRE member.
• Indicates new product.
† Exhibitor is servicing IRE Engineers through the IRE Package Plan.

CLAREED®

Sealed Contact Relays...

for contamination-free operation
...positive on-off switching



CLAREED solves the vexing problem of contact contamination. Its sealed, gold-plated contacts operate indefinitely in an in-built ideal environment, give positive on-off switching for up to millions of cycles. It is a relay you can install and forget.

This maintenance-free operation makes CLAREED sealed contact relays ideal components for such critical applications as transistor drives, computers, data processing equipment and many other high-speed devices.

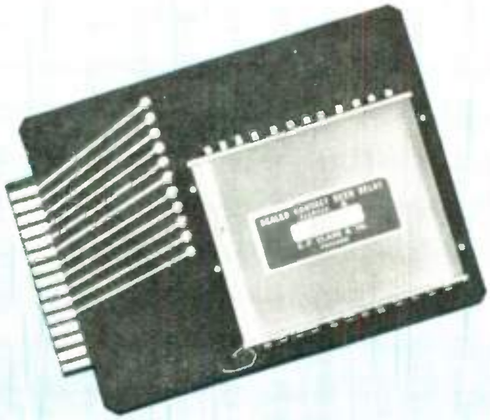
CLAREED design is simplicity itself—a pair of magnetically operated contacts, hermetically sealed in an atmosphere of inert gas within a glass capsule. Compact size permits almost unheard-of flexibility of assembly and application.

See Clareed Relays in working logic modules... No tubes, no transistors.

IRE SHOW BOOTHS 2218 & 2220

Typical space-saving Clareed Relay Assemblies

This cylindrical can contains one, two or three CLAREED switch capsules which form the core of a common coil. Numerous variations of this design are possible to meet customer requirements.



CLAREED relay consists of 12 switch capsules enclosed in a rectangular container and mounted on printed circuit board. Varied coils and contact arrangements available.

Here is a CLAREED relay module for printed circuits. Quick, convenient mounting on your own prototypes or assembly line. High component density. Sturdy steel cover provides magnetic shielding.

C. P. CLARE & CO.

Relays and Related Control Components

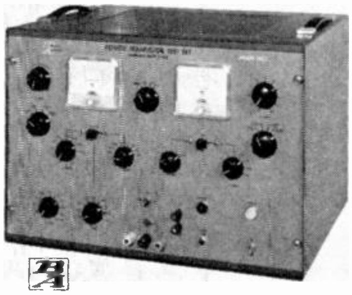
If you use relays, it will pay you to know all about CLAREED relays ...an entirely new concept in relay design. To obtain Bulletin CPC-10, address: C. P. Clare & Co., 3101 Pratt Blvd., Chicago 45, Illinois. In Canada: C. P. Clare Canada Limited, 840 Caledonia Road, Toronto 19, Ontario. Cable Address: CLARELAY.

Whom and What to See at the IRE Show

(*Continued from page 152A*)

Baird-Atomic, Inc., Booths 3216-3218
33 University Rd.
Cambridge 38, Mass.

Eugene J. Cronin, Chuck Whims, ▲ Sy Futran, ▲ Sam Kenton, George H. Blinn



Power Transistor Test Set

Transistor test instrumentation, including the KT-1 portable beta tester, OVKP-2 medium power tester, MW-1 characteristic curve tracer with circuit test adapter, and NC-1 variable duty cycle power tester. Latest additions to DEKATRON and DIGITRON lines of cold cathode counting and readout tubes are also displayed.

Baker & Adamson, Booth 4305
See: Allied Chemical Corp.

Baker Contact Div. & Baker Platinum Div., Booths 4406-14
See: Engelhard Industries, Inc.

Balco Capacitors, Division of Balco Research Laboratories, Booth 2131
19-53 Edison Pl.
Newark 2, N.J.

▲ Maxwell K. Goldstein, Hans W. Goetting, Ray E. Crawford

Capacitors: Precision, high temperature (to 250°) and high performance types. Small size, close tolerance (to 0.1%), high stability (low drift, excellent retrace), high insulation resistance, low absorption and dissipation characteristics. Processed teflon, polystyrene, mylar, and other dielectrics including foil and metallized types.

Ballantine Laboratories, Inc., Booths 3101-3103
90 Fanny Rd.
Boonton, N.J.

▲ A. W. Parkes Jr., ▲ Frank R. Zayac, ▲ Dr. Endel Uiga, ▲ Wallace F. White, ▲ Henry Kruger, ▲ Gustav Mannik, ▲ Uwe Beckmann, Herbert Vorwerk, Edward Cahalan

Sensitive electronic voltmeters, true RMS voltmeters, very low frequency voltmeter, AC-DC precision calibrator, decade amplifier, sensitive electronic inverter, electronic capacitance meter, linear AC-DC converter, laboratory voltage standards to 1,000 megacycles. *True RMS ¼% accuracy sensitive voltmeter, 10 CPS to 11 megacycles, 300 microvolt sensitivity.

† See PROCEEDINGS OF THE IRE Jan. through Dec. (1960), Jan., Feb., March (1961) for further information on our products.

See 1961 IRE DIRECTORY, page 144, for complete information on our products

(*Continued on page 156A*)

In the packaging field, "protection" takes on a new meaning when it's related to the nation's mighty air-sea arm with its fast-growing missile defense systems.

The "brains" of the inertial guidance systems that steer and control such missiles as the Polaris are the intricately adjusted gyroscopes, valued at over $15,000 each. The slightest malfunction caused by temperature variations or shock damage to these small but vital components can make the difference between an accurately-controlled defense weapon—or a dud.

These critical performance requirements are the reason why rigid and flexible urethane foams were selected to cushion and insulate the gyro mechanisms of the Polaris. Standard Plastics, Inc., a leader in urethane foam container design, was commissioned to custom build the package that would protect the gyros against shock loading up to 50 G's, while maintaining, without external heat source, a temperature of 140°F ± 4° for 36 operational hours in a −10° climate. The result is the Transit Heet® shipping container—another "first" in the fast-growing series of packaging "firsts" for urethane foams.

For further detailed case history information on how leading packaging experts are taking advantage of urethane foam's lightweight, shock absorbency and excellent insulating properties, write MOBAY CHEMICAL COMPANY, Code PI-2, Pittsburgh 5, Pa.

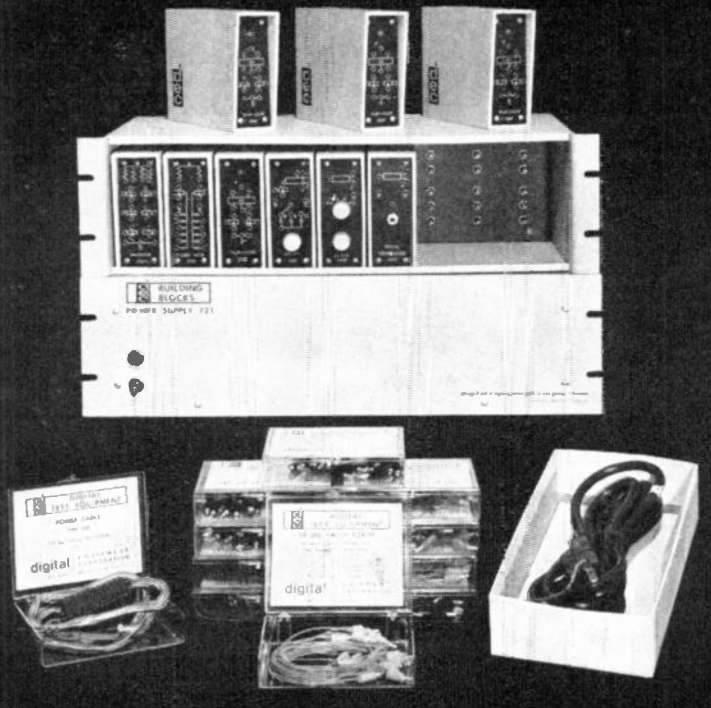
® Standard Plastics, Inc.,
Fogelsville, Pa.

f-21

Mobay is the leading supplier of quality chemicals in the manufacture of both polyether and polyester urethane foams.

MOBAY
First in Urethane Chemistry

DEC BUILDING BLOCK LOGIC KIT



Includes everything needed to perform a wide variety of logical operations

Now Digital offers a basic selection of 500 kilocycle logic circuit packages which can be used to design, test and demonstrate up counters, down counters, four-bit shift registers, decimal decoders, Gray-to-binary decoders, two-binary-digit adders and subtracters, and other similar digital pulse apparatus.

Graphic front panels (a Digital first) permit all logical interconnections to be made quickly and easily by means of handy stacking banana-jack patch cords. And the units can be assembled and reassembled in any number of different combinations in the plug-in mounting panel.

Included in the Basic Kit are nine DEC Digital Test Equipment units — one inverter, one diode nor, four flip-flops, one delay, one clock, and one pulse generator — and tne necessary accessory equipment — power supply, power cable, mounting panel, and one hundred patch cords. Other Building Blocks from Digital's fully compatible 500 kilocycle, 5 megacycle and 10 megacycle lines can be added to increase the versatility of this unique new kit.

Complete Kit (FOB Maynard) $1038

Write for your copy of Digital's popular new logical operations handbook — "DEC Building Block Logic"

digital
EQUIPMENT CORPORATION
MAYNARD · MASSACHUSETTS

WEST COAST OFFICE • 8820 SEPULVEDA BOULEVARD • LOS ANGELES 45, CALIFORNIA

Whom and What to See at the IRE Show

(Continued from page 156A)

Belden Manufacturing Co., Booths 4116-4118
415 S. Kilpatrick Ave.
Chicago 44, Ill.

Warren Stuart, John McEwen, E. V. Blake, A. Kayworth, G. Kyros, E. Stull, Ray Reading, ▲ Richard Maddox, Frank Timmons

Belden
WIREMAKER FOR INDUSTRY
SINCE 1902 — CHICAGO

Microphone cables, audio cables, control cables, special cables to customer design, multipair Beldfoil shield cables, coax cables, mil spec hook-up wire, teflon insulated wire, shielding, magnet wire all insulations, lead wire, braided and stranded wire, rectifier and alternator leads, cord sets.

Bell Sound Div., Booths 1435-1635
See: Thompson Ramo Wooldridge Inc.

Belling & Lee Limited, Booth 2110
Great Cambridge Rd.
Enfield, Middlesex, England

C. H. Frank Jr., R. J. Meldrum, George Rose, D. M. Harris

The Collecon—"Connects Tomorrow with Today"

Plugs, sockets and connectors—single and multi-way, miniature and subminiature, including printed circuit and coaxial types. Fuses, fuseholders, and circuit protection devices. Terminals and terminal blocks. Bi-metal cut-outs and delay switches. Interference suppressors.

Bellows Mfg. Div., Booth 3942
See: Atlantis Electronics Corp.

Bendix Corporation, Booths 2222-2232, 2329-2331
401 N. Bendix Drive
South Bend 20, Ind.

L. L. Swartz

Telemetering airborne and receiving systems and components. Radar, sonar, data transmission and missile guidance systems and components. Auto, aircraft and industrial radios, aircraft navigational equipment. Components for servomechanism and computing equipment. Transistors. Special purpose electron tubes. Electrical connectors. Synchros.

(Continued on page 160A)

▲ Indicates IRE member.
Indicates new product.
† Exhibitor is servicing IRE Engineers through the IRE Package Plan.

Whom and What to See at the IRE Show

(Continued from page 158A)

Bendix Corporation, Bendix-Pacific Div., Booths 2222-2232, 2329-2331
11600 Sherman Way
North Hollywood, Calif.

Ed Nolan, Lane Ramsey, Dick Nicol, John Familetti

Radar altimeter, airborne radar, *new "300" series telemetry equipment (signal amplifier, voltage amplifier, subcarrier oscillator and discriminator, voltage regulator).

Bendix Corporation, Bendix Radio Div., Booths 2222-2232, 2329-2331
E. Joppa Road (Towson)
Baltimore 4, Md.

W. W. Price, A. A. Fiedler, E. King, T. Jones, T. Schillo, C. Burton, H. Woodson, J. Jarrett, J. Pearce, M. Whitney

Inertialess array 3-D radar, air defense radar, air traffic control radar, ECCM devices, ground/air communications, airborne radio navigation, twilight scatter communications and detection, air/ground data links, integrated aircraft radio controls, space communications, space vehicle tracking, automatic checkout systems, training devices, field support.

Bendix Corporation, Eclipse-Pioneer Division, Booths 2222-2232, 2329-2331
Teterboro, N.J.

J. A. Sullivan, C. W. Baun, F. J. Thornton, F. A. Peters, T. H. Sprink, J. M. Koltz, B. G. Boer, V. E. Hagen, M. Sagalow, F. L. Spencer, Jr., L. S. Kahn, W. H. Wickersham, G. C. Sturges, F. C. Smith, K. D. Whitaker

Ground and airborne radar antenna devices, free vertical and directional gyros, rotating components, Autosyn synchros, tachometer generators, low inertia motors and special instrumentation.

Bendix Corporation, M. C. Jones Electronics Co., Inc., Booths 2222-32 & 2329-31
See: M. C. Jones Electronics Co., Inc.

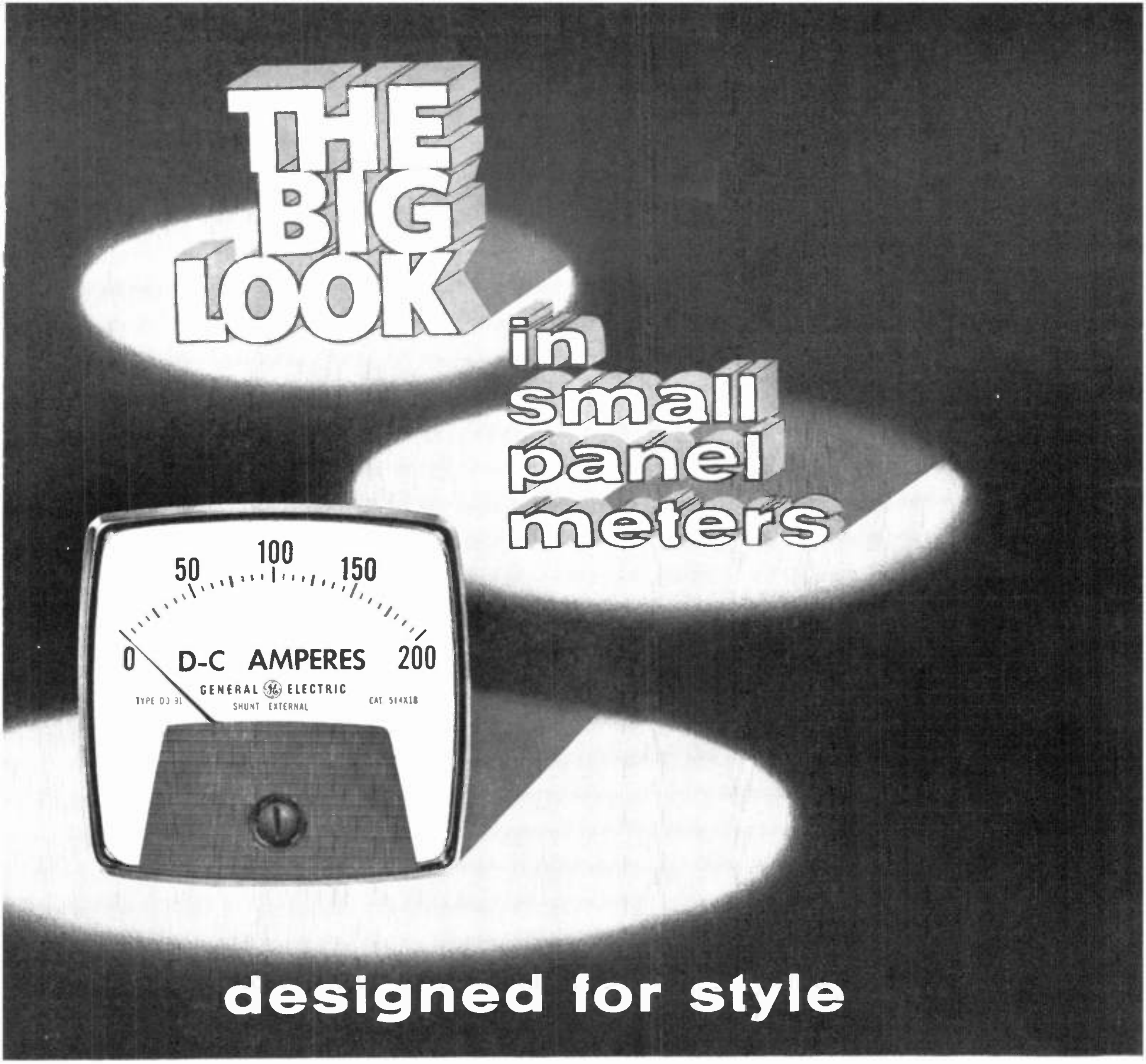
Bendix Corporation, Montrose Div., Booths 2222-2232, 2329-2331
South Montrose, Pa.

Richard F. Henry, David G. Snyder, James H. Speicher, Malcolm G. Douglas, Richard W. LeGrand, W. V. Fiore, C. C. Honeywell, Ray Gillen, S. Beers, V. Ellison, H. Sarrides, M. Sanchez

Complete line of military synchros from size 11 through size 37 in A/W the latest military specifications. Pressure indicators and transmitters, including latest integrally lighted types. *New line of precision permanent magnet gear reduced motors.

(Continued on page 162A)

First and Second floors—Components
Third floor—Instruments and Complete Equipment
Fourth floor—Materials, Services, Machinery


THE BIG LOOK
in small panel meters
50
100
150
0
D-C AMPERES
200
GENERAL ELECTRIC
SHUNT EXTERNAL
designed for style

Whom and What to See at the IRE Show

(Continued from page 160A)

Bendix Corporation, Red Bank Div., Booths 2222-2232, 2329-2331
Eatontown, N.J.

Daniel J. Bell, Donald B. Blanchard, ▲ Joseph F. Bozzelli, James M. Degnan, Rudolph K. Forsman, Thomas B. MacCullough, John H. Moor, R. A. Soerhoff, ▲ Eugene W. Swenarton, ▲ R. R. Meijer, B. L. Gilluly, R. C. Lancaster, B. D. Gentry, D. I. Snell, ▲ H. Newman, ▲ E. Belmont

Electron tubes and semiconductors.

Bendix Corporation, Scintilla Division, Booths 2222-2232, 2329-2331
Sidney, N.Y.

H. F. Gallup, A. E. Fitzelle, W. B. Steinhilper, H. M. Avey, R. E. Rice, W. P. Whallon, D. L. Quinney, D. W. Newcomb, S. B. Merritt, O. F. Forsberg, C. Groff, F. N. Bulken, A. T. S. Peck, D. B. Morse, F. O. Rettberg

Electrical Connectors—MS, Pygmy miniature, heavy duty, umbilical, rack and panel, and other types. Custom designed cable and wiring assemblies for aircraft, electronic, and missile applications. High temperature capacitors.

†

See PROCEEDINGS OF THE IRE—Feb., April, Aug., Nov. (1960), Jan., March, May, July, Sept. (1961) for further information on our products.

See 1961 IRE DIRECTORY, page 148, for complete information on our products.

Bendix Corporation, Semiconductor Products, Booths 2222-2232, 2329-2331
Holmdel, N.J.

▲ R. R. Meijer, W. L. Hopkins, D. I. Snell, S. Iovin, F. P. McGrail, R. A. Griffin, B. L. Gilluly, H. Newman, R. Simko, F. McKendry, P. Balthasar, R. Miller

25 ampere DAP diffused alloy power transistor. Diffused silicon power rectifiers. Diffused silicon glass diodes. Power transistors ranging up to 25 amperes and 120 volts. Electron tubes.

Benrus Watch Co., Booth 1517
See: PIC Design Corp.

Bergen Laboratories Inc., Booth 2806
60 Spruce St.
Paterson 1, N.J.

▲ Max Hoberman, ▲ Tom Bright, Fred Seekamp, Dave Ettelman, Ed Nemeth, ▲ Harvey Ross, Hy Lewis

Silicotrig triggers for silicon controlled rectifiers, transistor inverters dc to 400 cps, 60 cps to 400 cps, *lamp dimmers, regulated power supplies, chronistor elapsed time indicators, chronistat timer, *torquemeter for jet engines.

James G. Biddle Co., Booth 3105
1316 Arch St.
Philadelphia 7, Pa.

O. X. Heinrich, A. Q. Lange, A. P. Salter, K. Fugitt, P. P. Emery, P. E. Sellers, S. C. Sommer

"Frahm"® resonant reed relays and oscillator controls, demonstrating circuits for several applications. Biddle corona testing equipment—an operating display for testing specimens. "Frahm"® resonant reed frequency meters—an operating display of all standard and precision instruments.

(Continued on page 164A)

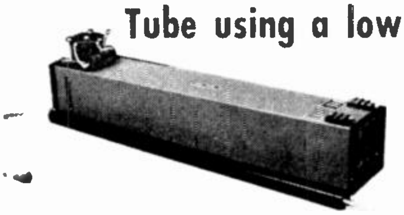
▲ Indicates IRE member.
* Indicates new product.
† Exhibitor is servicing IRE Engineers through the IRE Package Plan.

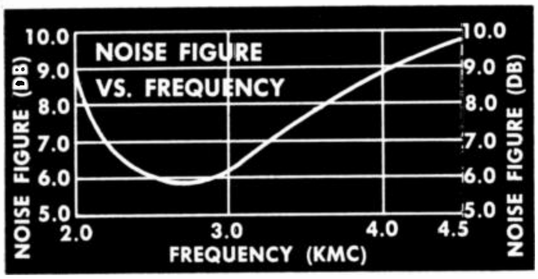
A list of all persons who have registered for the IRE Show and Convention, brought up to date daily, is posted on the first floor mezzanine.

Greater than octave bandwidth with 10 DB maximum noise figure!

HA-70

An advanced design Traveling Wave Tube using a low power solenoid.





A 10 db maximum noise figure over a 2.0 kmc to 4.3 kmc frequency bandwidth may be obtained with the Huggins HA-70 traveling wave tube. Simultaneously, 7 db maximum noise figure is obtained over 15% to 20% of the band with no change in operating voltages. Small-signal gain is nominally 40 db narrow band, and 30 db or greater from 2.0 to 4.3 kmc.

The HA-70 operates in a very low power solenoid—125 watts maximum, with typical power requirements in the neighborhood of 95 watts.

The solenoid is lightweight—22 pounds, with further weight reduction possible depending upon the cooling media available. The noise figure and gain performance listed above can be obtained with a solenoid power supply which provides current regulation of 5% or less. In fact, a solenoid current change of 10% in the range of optimum value results in a noise figure change of no more than 0.3 db in most tubes.

This tube and solenoid combination is not developmental—it is presently in field use. Tubes can be shipped within 4 to 6 weeks after order is received. Firm price and delivery quotations are available upon request.

The topic of low-noise is discussed in detail in Huggins' new ten-page "Engineering Note" entitled "Low-Noise Traveling Wave Tube Amplifiers." Write for your copy.

Low-noise TWTs will be among the new products featured by Huggins Laboratories at the IRE Show. Stop by our booth, number 2925-2926, and discuss your applications.

HUGGINS LABORATORIES, INC.

HUGGINS LABORATORIES
manufacture
development
engineering
design
research

999 East Arques Avenue Sunnyvale, California Regent 6-9330

Whom and What to See at the IRE Show

(Continued from page 162A)

Bird Electronic Corporation, Booths 3217-3219
30303 Aurora Rd.
Cleveland 39 (Solon), Ohio

▲ J. R. Bird, F. B. Smith, ▲ H. J. Calderhead, J. H. James, ▲ H. E. Stevens, ▲ H. H. Heller, ▲ R. J. Scott, ▲ R. Chakerian, M. A. Rickman

THRULINE Directional RF Wattmeter

"Thruline"—Directional RF wattmeters. "Termaline"—Absorption RF wattmeters. "Termaline"—RF load resistors. "Coaxwitch"®—RF coaxial switches. Coaxial RF filters.

▲ Indicates IRE member.
* Indicates new product.
† Exhibitor is servicing IRE Engineers through the IRE Package Plan.

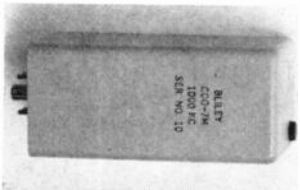
Birnbach Radio Co., Inc., Booth 4416
145 Hudson St.
New York 13, N.Y.

Morris Birnbach, Aaron Danziger, Shirley Martin, Mary Mendelsohn

Wire, cable, tubing; electronic hardware—plugs, jacks, insulators, terminals, retractile coiled cord, shielded multi-conductors. BB-1000 1000°F continuous service hook-up wire. Mil spec hook-up wire. Custom multi-conductors, mil spec miniature and subminiature wire; teflon, Kel-F, PVC, teflon tubing, wire and cable.

Bliley Electric Company, Booth 1318
Union Station Bldg.
Erie, Pa.

George Wright, ▲ J. M. Wolfskill, R. T. Schlaudecker, W. S. Riblet, H. A. Yocum



*New Packaged Plug-In Oscillator

Quartz crystals for all military and commercial applications. High precision crystals for frequency standards and counters. Crystal filters, packaged crystal oscillators, solid ultrasonic delay lines, crystal and component ovens.

† See PROCEEDINGS OF THE IRE—Jan., March, May, July, Sept., Dec. (1960), March (1961) for further information on our products.
See 1961 IRE DIRECTORY, pages 92-93, for complete information on our products.

(Continued on page 166A)

why Ampex uses NIKON OPTICAL COMPARATORS

VISIT NIKON BOOTH M-1, IRE SHOW

The new Ampex AR-300, developed principally for military and scientific applications, is the only recorder capable of covering a 4-megacycle bandwidth. It can capture and record phenomena beyond the range of any equipment in use today.

The most vital component in the AR-300 is its rotating recording head, designed to achieve the high, head-to-tape velocity required for wide band response, yet maintaining a relatively low, reel-to-reel speed.

Nothing in the manufacture of the AR-300 proved as critical as the production of this head. Most of its parts did not lend themselves to conventional inspection methods. While .0001" tolerances had to be maintained, Ampex standards call for inspection equipment capable of at least 10 times the required accuracy.

This inspection problem was finally solved when the task was assigned to a Nikon 6 Optical Comparator. Not only did the Nikon Comparator provide the exact measurements required during 'in-process' inspection, but it also permitted consistent duplication of these measurements, time after time.

Today, the Nikon 6 has a permanent position on the AR-300 production team. Furthermore, there are now five additional Nikon comparators serving Ampex in other production projects, and in development—helping to maintain the high quality standards for which Ampex products are justly famous.

Why not investigate what a Nikon comparator can do for you? Write for complete, illustrated catalog to Dept. IRE.

NIKON INCORPORATED, 111 FIFTH AVE., NEW YORK 3, N. Y.

Ferride Coil Under Inspection Showing Size Relationship

Whom and What to See at the IRE Show

(*Continued from page 161A*)

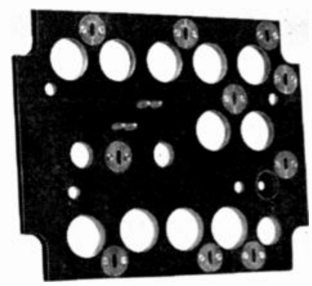
Blue M Electric Company, Booth 3008
138th and Chatham St.
Blue Island, Ill.

Philip Lazzara, Joseph A. Lawler, George Eshliman, Claude A. Gates, Richard Gates

Controlled humidity cabinets, MIL-202B, method 106A, steps 1-6, incorporates "Power-O-Matic 60" saturable reactor controls; no contacts, cams, refrigeration, or non-cycling. Also, "Ultra-Temp" ovens (1200°F); "Magni-Whirl" water and oil baths; "Stabil-Glow" furnaces; "Constant-Flow" portable cooling units; "Power-O-Matic 60" mechanical and gravity type ovens.

Bodnar Products Corp., Booth 4104
238 Huguenot St.
New Rochelle, N.Y.

▲ John Lesser, David Gannon, Irving Handelman, Walter Jacoves, Ed T. Lovasz, B. J. Bodnar



Plastic lighting plates in accordance with MIL-P-7788A. Integral lighting of instruments and meters in accordance with MIL-L-25467A. Embedded and printed circuit wired panels with flush removable embedded lamps. Illuminated knobs and dials.

† See PROCEEDINGS OF THE IRE—Aug., Sept., Oct. (1960), Feb., March, April (1961) for further information on our products.

See 1961 IRE DIRECTORY, pages 598 and 632, for complete information on our products.

Boesch Manufacturing Division, Waltham Precision Instrument Co., Inc., Booth 4300
15 River St.
Danbury, Conn.

L. R. Ripley, ▲ A. H. Boesch, ▲ F. D. Schatzle, Fred M. Burmann, Leon Yarrish, Howard Wallner, W. W. Clarke, ▲ K. Murch, Henry Walendzik, Leslie McKeen, Alice Jaber, F. LaFemina, G. Banks, J. Taborsak, P. Cicala, T. Debarros, W. Dawes

Toroidal coil winding machines. Models *TW-500, TW-300, TW-201, SM "Minitor," HW12 "Maxitor." Attachments 601 and FT6 assemblies. *Model TW-600 tape winder, permeameter. Coils 1/32" I.D. to 14" O.D. wire sizes 7 to 50 AWG. Miniature cutting tools, Waltham Tru-Lok lock nuts, hair springs, contract manufacturing.

(*Continued on page 168A*)

▲ Indicates IRE member.
* Indicates new product.
† Exhibitor is servicing IRE Engineers through the IRE Package Plan.

Typical field application of NF-105 in mobile Radio Interference Laboratory

Assure Reliability under Adverse Conditions...

in the Field and in your Plant

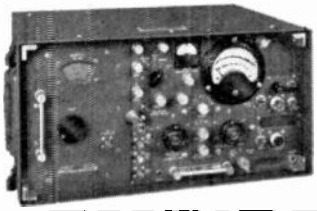
SPECIFY EMPIRE'S COMPACT AND RUGGED

NOISE and FIELD INTENSITY METER

MODEL NF-105

- Measures 150 kilocycles to 1000 megacycles accurately and quickly with only one instrument.
- For measurements in accordance with Specifications: MIL-I-6181B, Class I; MIL-S-10379A; MIL-I-11683B; MIL-I-11748B; MIL-I-12348A; MIL-I-13237; MIL-I-16910A; MIL-I-26600 (USAF), Category A; F.C.C. Specifications.
- Direct substitution measurements by means of broad-band impulse calibrator, without charts, assure repeatability.
- Economical...avoids duplication.
- True peak indication by direct meter reading or aural slideback.
- Four interchangeable plug-in tuning units, for extreme flexibility.
- Safeguards personnel...ALL antennas can be remotely located from the instrument without affecting performance.
- Self-calibrating, for reliability and speed of operation.
- Compact, built-in regulated "A" and "B" power supply, for stability.
- Minimum of maintenance required, proven by years of field experience.

DELIVERY FROM STOCK



The unique design of Model NF-105, with 4 plug-in tuning units, avoids costly repetition of circuitry and components common to all frequency ranges, at savings in size, weight and cost. Simple to operate, this instrument permits fast and accurate measurements of both broadband or CW signals. *Send for our Catalog*

Plan to attend our next seminar on interference instrumentation, details upon request.

edp

EMPIRE DEVICES PRODUCTS CORP.

AMSTERDAM, NEW YORK VICTOR 2-8400

MANUFACTURERS OF:

FIELD INTENSITY METERS • DISTORTION ANALYZERS • IMPULSE GENERATORS • COAXIAL ATTENUATORS • CRYSTAL MIXERS

VISIT OUR BOOTH 3818-20 AT THE IRE SHOW

Whom and What to See at the IRE Show

(Continued from page 166A)

Bogart Manufacturing Corp., Booth 2312
315 Seigel St.
Brooklyn 6, N.Y.

▲ David Israel, ▲ P. Schiffres, ▲ S. Hirsch, J. Sachs, K. Bergen, G. Sweedler, B. Friedman, A. Frank, ▲ R. Scholer, R. O'Neill, G. Wernerspach, F. DePalo, P. Fleiss, W. Bishop, J. Sinclair, G. Zanis, B. Jaffe

New entries in the components field will include coaxial attenuators and tee pads, quadrature hybrids, coaxial directional couplers, coaxial to coaxial transitions, water loads, coaxial dc returns, coaxial switches and terminations, and a "new series of coaxial tee-hybrids.

Bogue Electric Mfg. Co., Booths 2115-2117
52 Iowa Ave.
Paterson 3, N.J.

T. G. Watkins, D. F. Hunt, W. Zeisler, D. W. Dauphinais, W. H. W. Skerrett, W. N. Hudson, K. R. Gerlach, W. T. Quimby

Solid state computer power supplies. High cycle power supplies. Ultrasonic liquid level controls.

Bomac Laboratories, Inc., A Subsidiary of Varian Associates, Booths 2708-2712
Salem Road
Beverly, Mass.

Cyrus Haller, Willard Ferris, Peter Roberts, ▲ Robert W. Andrews, Richard Booth, ▲ Earle Benson

BLP-017D 4.3 mm Balanced Duplexer

Microwave tubes and components.

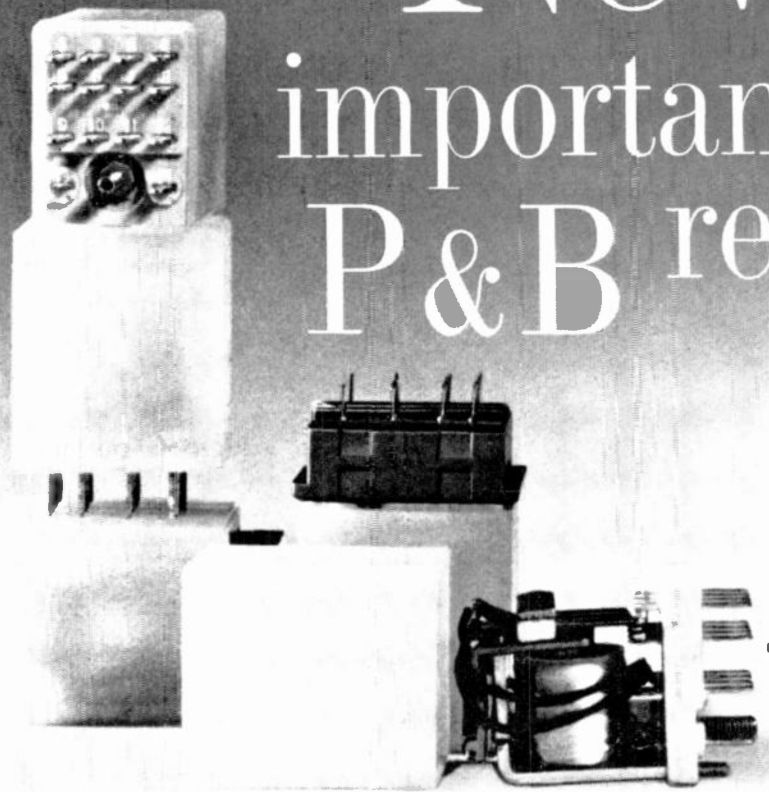
†

> See PROCEEDINGS OF THE IRE—Jan. through Nov. (1960), March (1961) for further information on our products.
>
> See 1961 IRE DIRECTORY, page 150, for complete information on our products.

(Continued on page 170A)

Your registration admits you to the show for all four days, and to all technical sessions at the Coliseum and the Waldorf-Astoria. Be sure to keep your badge or pocket card with you at all times on the floor. Registrations are not transferable.

a New and important P&B relay....

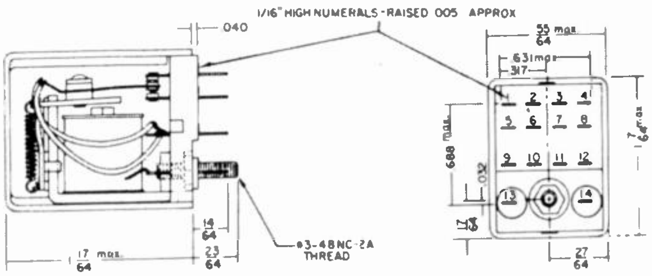


KHP SERIES SHOWN ACTUAL SIZE

having rare longevity

This small, 4-pole relay has the happy faculty of maintaining its original operating tolerances over an exceptionally long life. Example: tests (by customers!) show this relay has variations in electrical characteristics of less than 5% after more than 100 million operations.

But that's far from all. This is a *small* relay . . . about a one inch cube. This relay is easy to install using the conveniently spaced solder lugs or a socket. Thus you save time and production costs. This relay is versatile . . . its 4PDT contacts will switch loads from dry circuit up to 3 amperes. This relay—well, why not order samples and see for yourself! Order today from your P&B representative or call us at Fulton 5-5251, in Princeton, Indiana.



KHP SERIES SPECIFICATIONS

CONTACTS:
Arrangement: 4 Form C, 2 Form Z.
Material: 3/32" dia. Silver standard. Silver cadmium oxide and gold alloy available.
Rating: 3 amps @ 30 volts DC or 115 volts AC resistive for 100,000 operations.

COILS:
Resistance: 11,000 ohms max.
Temperature: Operating Ambient: —45°C. to +70°C.
Power: 0.5 watts min operate @ 25°C. 0.9 watts nom. @ 25°C. 2.0 watts max. @ 25°C.

TIMING VALUES:

Nominal Voltage @ 25°C.	Max. Values
Pull-in time	15 ms
Drop-out time	5 ms

INSULATION RESISTANCE: 1500 megohms min.
DIELECTRIC STRENGTH:
500 Volts RMS 60 cycles between contacts.
1000 Volts RMS 60 cycles between other elements.
MECH. LIFE: In excess of 100 million cycles.
SOCKET: Solder lug or printed circuit terminals. Available as accessory.
DUST COVER: Standard.
TERMINALS: Solder lug and taper tab.

P&B STANDARD RELAYS ARE AVAILABLE AT YOUR LOCAL ELECTRONIC PARTS DISTRIBUTOR

POTTER & BRUMFIELD

DIVISION OF AMERICAN MACHINE & FOUNDRY COMPANY • PRINCETON, INDIANA
IN CANADA: POTTER & BRUMFIELD, DIVISION OF AMF CANADA LIMITED, GUELPH, ONTARIO

Whom and What to See at the IRE Show

(Continued from page 168A)

Boonton Electronics Corp., Booths 3114-3116
738 Speedwall Ave.
Morris Plains, N.J.

▲ E. A. Porter, ▲ John H. Mennie, J. Frucht, John M. Young, ▲ Raymond E. Lafferty, ▲ Earle Dilatush, ▲-Vincent A. Schauler

*91D Sensitive RF Voltmeter

*RF power meter, *sensitive RF voltmeter, 1 mc and 100 kc capacitance (3 terminal) bridges, capacitance standards, inductance bridge with built-in 1-100 kc OSC-DET, dc and ac null detectors, sensitive dc voltmeter, differential dc voltmeter, RF distortion and UHF grid dip meters.

† See PROCEEDINGS OF THE IRE—March, and May through Dec. (1960), Jan. through Dec. (1961) for further information on our products.
See 1961 IRE DIRECTORY, page 256, for complete information on our products.

Boonton Radio Corp., Booths 3101-3102
50 Intervale Rd.
Boonton, N.J.

▲ H. J. Lang, ▲ C. W. Quinn, W. J. Cerney, B. A. Barnes, ▲ J. Van Duyne

*New 200-600 UHF Q meter; *new DMET/ATC test set; *new 10-500 mc signal generator power amplifier; high precision transistor test set; signal generator calibrators; FM-AM and telemetering signal generators; production Q comparator.

† See PROCEEDINGS OF THE IRE—Jan., March, May, Sept., Oct., Dec. (1960), for further information on our products.
See 1961 IRE DIRECTORY, page 328, for complete information on our products.

(Continued on page 174A)

IRE MEMBERSHIP

The IRE membership booths at the Waldorf-Astoria Hotel and the Coliseum main lobby can provide you with information and application blanks for IRE membership and professional group membership. Also available here are membership cards and pins, IRE publications, and order blanks for the "Convention Record" which gives the complete text of all papers presented at the convention.

Is This New Printed Circuit Process For You?

Have you heard about the remarkable new "scribe 'n' peel" technique for making printed circuit layouts? One of the first major companies to adopt this new method reports saving $27,000 on a single project involving 300 precision printed circuits.

"Scribe 'n' peel" is quite simple, actually. With the conventional method, you lay out your printed circuit by putting ink or drafting tape *on* a surface. With "scribe 'n' peel", you scribe your design *into* the surface of a specially coated STABILENE® Film with a sharp steel instrument. After a few simple processing steps, you've got a complete negative master!

In addition to impressive savings, the "scribe 'n' peel" technique allows much more flexibility than is possible with the old ink and tape methods. The scribing tools, which make it a cinch to execute uniform circuit paths, will enable your least experienced draftsmen to produce work almost impossible to tell apart from the work of your most highly skilled veterans. And your best men will be giving you the same top-quality work as they do now . . . only faster and more easily.

Various mechanical advantages are enjoyed with "scribe 'n' peel", too. For one thing, it's the only practical method which allows the preparation of double-sided boards where perfect register is essential. For another, it makes possible ready duplication of sections of the printed circuit master without the slightest risk of damage to the original.

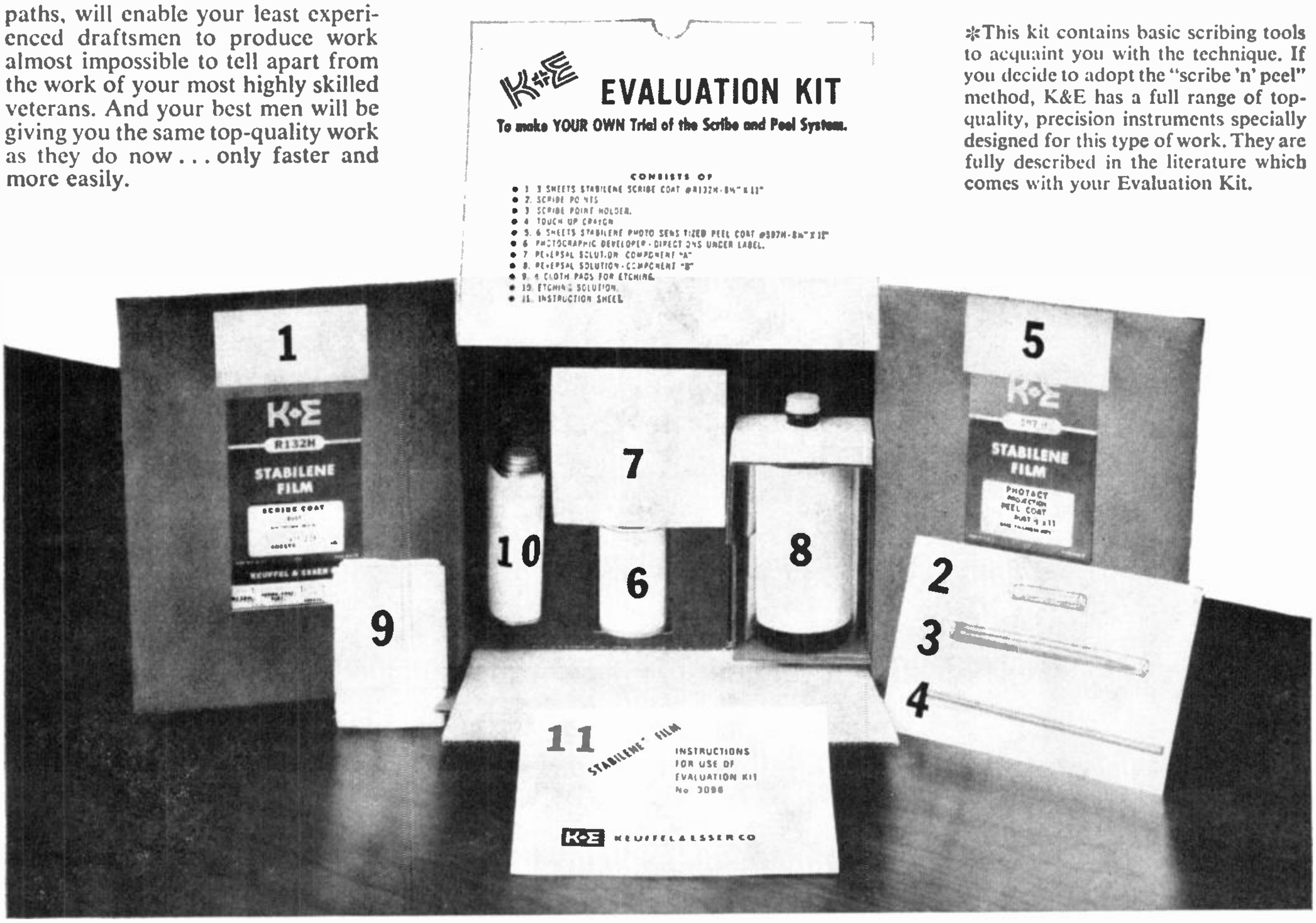
This new "scribe 'n' peel" technique may or may not be for you . . . but the advantages it presents are so significant that we'd like to offer you a practical means of finding out. We've put together a complete "scribe 'n' peel" Evaluation Kit with everything you'll need to test this new technique, including easy-to-follow instructions. Using the kit, you'll be able to render an actual printed circuit master and see first hand what "scribe 'n' peel" can mean to *you* in terms of increased accuracy, flexibility, speed and savings.

We're charging only $5 to cover materials and handling . . . a modest investment which can reap tremendous dividends in terms of up-dating your printed circuit techniques. Simply fill out the coupon below and a K&E representative will deliver it promptly to your door. (see coupon below).

STABILENE "Scribe 'N' Peel" Evaluation Kit*

1. 3 sheets Stabilene Scribe Coat #R 132H • 8½" x 11"
2. Scribe Points
3. Scribe Point Holder
4. Touch Up Crayon
5. 6 sheets Stabilene Photo Sensitized Peel Coat #597H • 8½" x 11"
6. Photographic Developer • Directions under label
7. Reversal Solution • Component "A"
8. Reversal Solution • Component "B"
9. 4 Cloth pads for etching
10. Etching Solution
11. Instruction Sheet

*This kit contains basic scribing tools to acquaint you with the technique. If you decide to adopt the "scribe 'n' peel" method, K&E has a full range of top-quality, precision instruments specially designed for this type of work. They are fully described in the literature which comes with your Evaluation Kit.



K+E

KEUFFEL & ESSER CO.

NEW YORK • HOBOKEN, N. J. • DETROIT • CHICAGO
MILWAUKEE • ST. LOUIS • DALLAS • DENVER
SAN FRANCISCO • LOS ANGELES • SEATTLE • MONTREAL

KEUFFEL & ESSER CO., Dept. IR-3, Hoboken, N. J.

Gentlemen:
Please send me a STABILENE EVALUATION KIT and bill me later.

Name & Title: ______________________

Company & Address: ______________________

____

3077

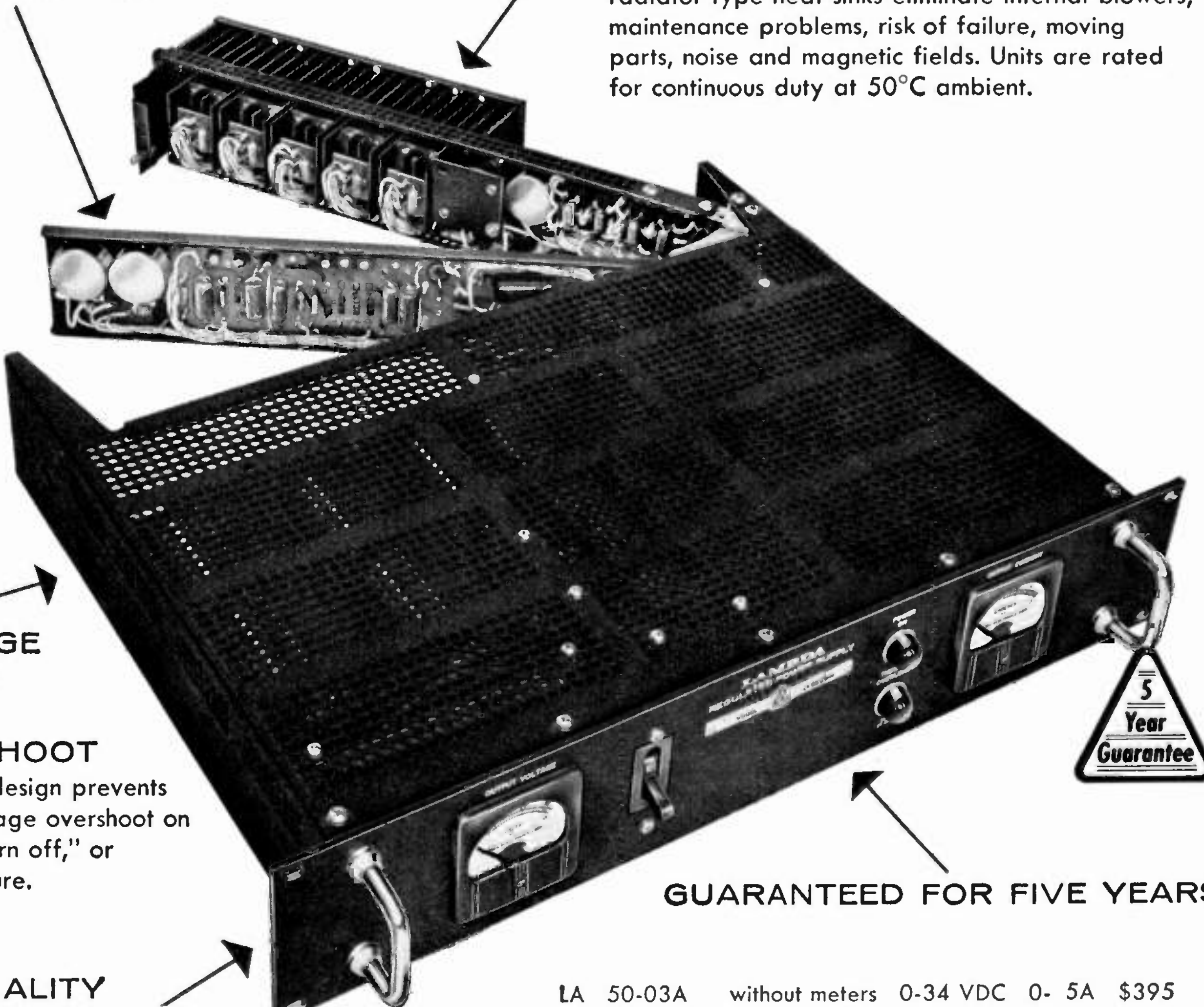
VISIT K&E BOOTH 4506 AT THE IRE SHOW

VISIT LAMBDA AT THE IRE SHOW
BOOTHS 2917-18

NEW
20 AMP 0-34 VDC
Regulated POWER SUPPLY joins

EASY SERVICE ACCESS
Dual-deck, swing-out back construction provides simple and fast service access without the need to remove unit from rack. All major component terminals are accessible from rear.

CONVECTION COOLED— no blowers or filters— maintenance free
Advanced design and special, highly efficient, radiator type heat sinks eliminate internal blowers, maintenance problems, risk of failure, moving parts, noise and magnetic fields. Units are rated for continuous duty at 50°C ambient.



NO VOLTAGE SPIKES OR OVERSHOOT
Lambda's design prevents output voltage overshoot on "turn on, turn off," or power failure.

GUARANTEED FOR FIVE YEARS

MIL QUALITY
Hermetically-sealed magnetic shielded transformer designed to MIL-T-27A quality and performance. Special, high-purity foil, hermetically-sealed long life electrolytic capacitors.

LA 50-03A	without meters	0-34 VDC	0- 5A	$395
LA 50-03AM	with meters	0-34 VDC	0- 5A	425
LA 100-03A	without meters	0-34 VDC	0-10A	510
LA 100-03AM	with meters	0-34 VDC	0-10A	540
LA 200-03A	without meters	0-34 VDC	0-20A	795
LA 200-03AM	with meters	0-34 VDC	0-20A	825

COMPACT
NO BLOWERS

5 AMP 3½" HIGH
10 AMP 7" HIGH
20 AMP 10½" HIGH

PATENTS PENDING

Lambda LA Series Power Supplies are compact, convection cooled and rated for continuous duty at 50°C ambient temperature.

LAMBDA Transistorized 5 and 10 AMP LA Series

COMPLETE SPECIFICATIONS OF LAMBDA LA SERIES (Including improved data on 5 and 10 AMP Models)

DC OUTPUT (Regulated for line and load)

Model	Voltage Range[1]	Current Range[2]	Price
LA 50-03A	0-34 VDC	0- 5A	$395
LA 50-03AM	0-34 VDC	0- 5A	425
LA100-03A	0-34 VDC	0-10A	510
LA100-03AM	0-34 VDC	0-10A	540
LA200-03A	0-34 VDC	0-20A	795
LA200-03AM	0-34 VDC	0-20A	825

[1]The output voltage for each model is completely covered in four steps by selector switches plus vernier control and is obtained by summation of voltage steps and continuously variable DC vernier as follows:

MODEL	VOLTAGE STEPS
LA 50-03A, LA 50-03AM	— 2, 4, 8, 16 and 0-4 volt vernier
LA100-03A, LA100-03AM	— 2, 4, 8, 16 and 0-4 volt vernier
LA200-03A, LA200-03AM	— 2, 4, 8, 16 and 0-4 volt vernier

[2]Current rating applies over entire output voltage range

Regulation (line) .... Better than 0.05 per cent or 8 millivolts (whichever is greater). For input variations from 100-130 VAC.

Regulation (load) ... Better than 0.10 per cent or 15 millivolts (whichever is greater). For load variations from 0 to full load.

Transient Response (line) ..... Output voltage is constant within regulation specifications for step function line voltage change from 100-130 VAC or 130-100 VAC.

Transient Response (load) .... Output voltage is constant within regulation specifications for step-function load change from 0 to full load or full load to 0 within 50 microseconds after application.

Internal Impedance .. LA 50-03A less than .008 ohms
LA100-03A less than .004 ohms
LA200-03A less than .002 ohms

Ripple and Noise ..... Less than 1 millivolt rms with either terminal grounded.

Polarity .... Either positive or negative terminal may be grounded.

Temperature Coefficent .... Better than 0.025 %/°C

AC INPUT .... 100-130 VAC, 60 ± 0.3 cycle[3]
LA 50-03A .. 360 watts[4]
LA100-03A 680 watts[4]
LA200-03A. . . 1225 watts[4]

[3]this frequency band amply covers standard commercial power lines in the United States and Canada.
[4]with output loaded to full rating and input at 130 VAC.

AMBIENT TEMPERATURE AND DUTY CYCLE ..... Continuous duty at full load up to 50°C (122°F) ambient.

OVERLOAD PROTECTION:

Electrical .... Magnetic circuit breaker front panel mounted. Special transistor circuitry provides independent protection against transistor complement overload. Fuses provide internal failure protection. Unit cannot be injured by short circuit or overload.

Thermal .... Thermostat, manual reset, rear of chassis. Thermal overload indicator light front panel.

INPUT AND OUTPUT CONNECTIONS .... Heavy duty barrier terminal block, rear of chassis. 8 foot, 3 wire detachable line cord.

METERS .... Voltmeter and ammeter on metered models.

CONTROLS:

DC Output Controls . Voltage selector switches and adjustable vernier-control rear of chassis.

Power .... Magnetic circuit breaker, front panel.

Remote DC Vernier Provision for remote operation of DC Vernier.

Remote Sensing ..... Provision is made for remote sensing to minimize effect of power output leads on DC regulation, output impedance and transient response.

PHYSICAL DATA:

Mounting .... Standard 19" Rack Mounting

Size	LA 50-03A	3½" H x 19" W x 14⅜" D	
	LA100-03A	7" H x 19" W x 14⅜" D	
	LA200-03A	10½" H x 19" W x 16½" D	
Weight	LA 50-03A	55 lb Net	85 lb Ship. Wt.
	LA100-03A	100 lb Net	130 lb Ship. Wt.
	LA200-03A	140 lb Net	170 lb Ship. Wt.

Panel Finish .... Black ripple enamel (standard). Special finishes available to customers specifications at moderate surcharge. Quotation upon request.

Send for complete Lambda Catalog.

LAMBDA ELECTRONICS CORP.
515 BROAD HOLLOW ROAD, HUNTINGTON, L. I., NEW YORK 516 MYRTLE 4-4200

LA114

Whom and What to See at the IRE Show

(Continued from page 170A)

Borg Equipment Division, Amphenol-Borg Electronics Corp., Booths 2402-2408, 2501-2507
120 South Main Street
Janesville, Wis.
R. E. Ackerman, John Arnold, William Dunn, R. K. Johnston, Sam Johnston, Robert Kordatzky, D. T. Van Alen

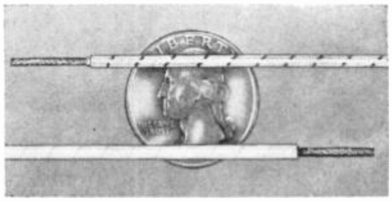
Micropot precision potentiometers, Microdial turns-counting dials, sub-fractional horsepower instrument motors, ultra-precision frequency and time standards.

† See PROCEEDINGS OF THE IRE—Jan., March, May, July, Sept., Nov. (1960), Jan., March (1961) for further information on our products.
See 1961 IRE DIRECTORY, page 524, for complete information on our products.

Borg-Warner Corp., Booths 4225-29 & M-20
See: Emcor Ingersoll Products Div. & Pesco Products Div.

Boston Div., Booth 2208
See: Minneapolis-Honeywell Regulator Co.

Boston Insulated Wire & Cable Co., Booth 4017
65 Bay St.
Boston 25, Mass.
Robert Cowen, Hubert Goodwin, Brad Preston, Alfred Garshick, Robert Buckingham



Radiation Resistant Satellite Wire

Water pressure cables, armored tow cables, ground support cable, 1000°F coaxial cable, radiation resistant wire and cable, high voltage cables, missile wire and satellite wire, low temperature multiconductor cable, silicone rubber wire and cable, special cables.

Bourns, Inc., Booths 1816-1818
6135 Magnolia Ave.
Riverside, Calif.
R. C. Archer, R. C. McColloch, Russ French, A. T. Agern, S. Skilnyk, E. J. Goeppinger, Robert Todd, Ken Doty

Adjustment potentiometers—over 22 models in 4 mounting styles and three terminal types, including high-temperature, humidity-proof, high-reliability units in wirewound and carbon. Transducers for position, pressure, acceleration, and instrument/systems. Extra long travel and high-temperature position instruments. *New miniaturized high pressure instrumentation. *New high-accuracy accelerometers.

(Continued on page 176A)

LITTON INDUSTRIES MICROWAVE TUBES

P, L, S, X, K BANDS

KLYSTRONS

Type Number	Frequency Range Megacycles	Peak Power (Minimum) Megawatts	Cathode Pulse Length Microseconds	RF Duty Ratio	Remarks
L-3270	1250 to 1350	2	8	0.0025	Broadband (100 megacycles between 2 megawatt points)
LT-7504 (L-3035)	1240 to 1360	2.2	8	0.0025	Long range search radar
L-3257	1280 to 1330	4	30	0.0003	For linear accelerator
L-3227	1280 to 1330	5	8	0.002	For linear accelerator
L-3250	1250 to 1350	10	7.2	0.0015	Long range search radar and linear accelerator
L-3387	1250 to 1350	30	7.2	0.0033	Long range search radar
L-3302	2855	10	7.2	0.0015	For linear accelerator and radar
L-3355	1250 to 1350	20	7.2	0.0015	Long range search radar

TRAVELING WAVE TUBES

Type Number	Frequency Range Megacycles	Power Output	Focusing	Duty Factor
L-3266	7000 to 11,000	20 mw	PPM	CW
L-3236	7000 to 11,000	2 W	PPM	CW
L-3470	4000 to 8000	20 mw	PPM	CW
L-3471	4000 to 8000	2 W	PPM	CW
L-3472*	8500 to 9600 7000 to 11,000	10 W 5 W	PPM	CW
L-3264*	100 to 300	100 W	Solenoid	CW

* *In development*

M-TYPE BACKWARD WAVE OSCILLATORS

Type Number	Frequency Range Megacycles	Power Output	Focusing	Factor	Remarks
L-3148	8500 to 11,000	150 watts minimum	Permanent magnet	CW	No holes in a 1.5/1VSWR

A complete line of M-BWO's is available but classified

PULSE MAGNETRONS

Type Number	Frequency Range Megacycles	Peak Power (Min.) KW	Duty Ratio	Remarks
L-3204	8800±25	0.04	0.25	Extremely high duty
L-3105	9300±40	0.10	0.027	Highly ruggedized; frequency stable
L-3028	9280 to 9320	0.12	0.027	Frequency stable; pulse train capability
L-3379	8800 to 9500*	1.0	0.003	Highly ruggedized; frequency stable
L-3058	9330 to 9350*	1.0	0.003	Frequency stable
L-3358	16,000 to 16,500*	1.0	0.001	Highly ruggedized; frequency stable
L-3380	8800 to 9500*	2.0	0.002	Highly ruggedized; frequency stable
L-3359	16,000 to 16,500*	2.0	0.001	Highly ruggedized; frequency stable
L-3381	8800 to 9500*	3.0	0.001	Highly ruggedized; frequency stable
L-3382	8800 to 9500*	4.0	0.001	Highly ruggedized; frequency stable
LT-6233	9280 to 9345	7.0	0.003	High duty beacon magnetron
L-3103	8500 to 9600*	30.0	0.002	High duty version of LT-6543
L-3168	9375±30	30.0	0.002	High duty version of LT-4J52A
L-3306	16,000 to 17,000*	30.0	0.002	High duty version of L-3083A
L-3083A	16,000 to 17,000*	60.0	0.001	Recommended for new systems
LT-6543A	8500 to 9600*	65.0	0.001	Recommended for MTI systems
L-3305	8600 to 9500*	65.0	0.001	Recommended for frequency diversity
LT-6510	9375±30	65.0	0.001	Recommended for MTI systems
LT-4J52A	9375±30	70.0	0.001	Recommended for new systems
L-3312	8500 to 9600*	200.0	0.001	In development
L-3313	8600 to 9500*	200.0	0.001	Hydraulically tunable for frequency diversity
LT-4J50A	9375±30	225.0	0.001	Recommended for new systems

**Fixed frequency versions available generally throughout tunable range.*

CW MAGNETRONS

Type Number	Frequency Range Megacycles	Minimum Power Watts
L-3456	350-590	500
L-3459	590-975	500
L-3465	975-1500	400
L-3464	1500-2350	400
L-3460	2350-3575	500
L-3461	3575-4975	400
L-3467	4975-6175	400
L-3468	6175-7275	300
L-3462	7275-8775	300
L-3463	8775-10,475	250

Remarks: These CW Magnetrons may be pulsed to approximately 2 kilowatts peak power and are recommended for component testing.

CROSSED-FIELD FORWARD WAVE AMPLIFIER TUBES • BARRATRON® TRANSMITTING TUBES • MINIATURE NOISE SOURCES • DUPLEXERS & TR TUBES • DISPLAY TUBES

"CAPABILITY THAT CAN CHANGE YOUR PLANNING"

LITTON INDUSTRIES
Electron Tube Division
San Carlos, California

Whom and What to See at the IRE Show

(Continued from page 174A)

Bowmar Instrument Corp., Booth 1722
P.O. Box 2835, 8000 Bluffton Rd.
Fort Wayne, Ind.

George F. McCarthy, Lowell D. Temple, C. G. Peterson, Howard P. Barry, F. Jack Hartley, ▲ Edward A. White

Precision mechanical components (speed reducers, gearheads, servomotor gearheads, differentials). Precision counters and indicators (angle, latitude, longitude, tape, decimal, internal pinion). Precision timing and programming devices (elapsed time, printed circuit, motor driven potentiometer, programming). Electro-shift gearchangers, servomotors, brake-clutches, precision servo packages.

Bradley Semiconductor Corp., Booth 2922
275 Welton St.
New Haven 11, Conn.

▲ Dr. Charles D. Bradley, ▲ Thomas C. Pridmore, ▲ Joseph Evon, ▲ Edward C. Keough

Silicon diodes, rectifiers to 50 amps per cell 3000 PRV; bridges—*assemblies to 250,000 PRV; *high voltage, silicon, selenium cartridges; *silicon vacuum tube replacements; selenium and copper oxide diodes, rectifiers, assemblies and bridges; dual diodes; suppressors; limiters; varistors; modulators; demondulators.

W. H. Brady Co., Booths 4101-4102
727 W. Glendale Ave.
Milwaukee 9, Wis.

Richard D. Adams, Walter S. Aldrich, Fred C. Kluhsman, James C. Malley, C. M. Byron, Jr., George H. Famy, Robert L. Klumpp, T. W. Wise, Joseph I. Stone, John T. Ruof

Self-sticking wire markers, special made-to-order markers, nameplates, component markers, pre-cut self-sticking insulation, Markermatic automatic marking machine, write-on labels, printed circuit tapes and shapes, layout tapes.

William Brand-Rex Division, American Enka Corp., Booth 4308
31 Sudbury Rd.
Concord, Mass.

▲ James D. Kelly, James J. O'Keefe, James A. Maguire, Robert H. Robinson, Dr. Roger Guthrie, Howard E. Pendergast, Walter H. Bamford, ▲ Arthur K. Schuh

Rexolite microwave dielectric materials: Rods, sheets, copper clad (one side or two sides), copper clad for strip line. Rexolite components: Dielectric tapers, microwave stripline, radar dummy load partitions, radar de-icer panels, coil forms, coaxial cable inserts.

Branson Corp., Booth 2434
41 So. Jefferson Road
Whippany, N.J.

J. A. Witzler, ▲C. G. Braun

Four pole microminiature relay; time delay relays—10 milliseconds to 10 minutes, multipole, voltage compensated and instantaneous recycling. Special combinations of magnetic and thermal relays for control or protective purposes.

▲ Indicates IRE member.
* Indicates new product.
† Exhibitor is servicing IRE Engineers through the IRE Package Plan.

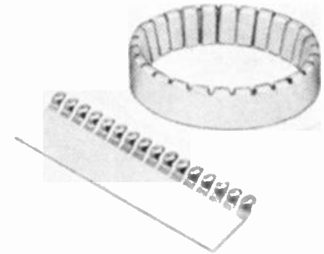
First and Second floors—Components

Third floor—Instruments and Complete Equipment

Fourth floor—Materials, Services, Machinery

H. Braun Tool & Instrument Co., Inc., Booth 4208
140 Fifth Ave.
Hawthorne, N.J.

W. K. Lange, E. Olmstead, R. C. Boderck, W. A. Lange, H. O. Kellerman



BTI Contact Strips

B.T.I. specializes in Beryllium Copper custom made stampings which offer the design engineer endless possibilities in parts fabrication. By special processing intricately formed pieces can be made to precision tolerance and flatness. Available: Contact strips, transistor, capacitor, and fuse clips.

Bristol Co., Booth 1322
Waterbury 20, Conn.

W. H. Faeth, H. E. Beane, F. W. Borchers, H. R. Bristol, W. D. Calvert, Jr., A. Brick, R. R. Varsell, T. V. Goldern

Synchroverter choppers and high-speed relays including DPDT choppers. Low-noise external coil miniature high-speed relays and general purpose high-speed miniature relays. Low-noise thermal stability choppers.

British Industries Corp., Booths 3406-3408
80 Shore Rd.
Port Washington, L.I., N.Y.

Leonard Carduner, Eugene Carduner, Sy Bosworth, Arthur M. Gasman, Jack Reynolds, Melvin Zalkin, Franklin S. Hoffman, Leo Holtz

Ersin Multicore 5-core solders standard and patented Savbit alloys. *Gold Lion custom replacement tubes. Genalex special purpose tubes. Widney-Dorlec prefabricated cabinet components. Avo test meters. Sullivan laboratory standards. Aldis Digilights. S. G. Brown headsets. Servo Consultants Nyquist diagramplotter.

British Radio Electronics Ltd., Booth 1822
1833 Jefferson Pl., N.W.
Washington 6, D.C.

▲ F. D. Harris, P. O. Haris, M. Brown, E. R. Albert, R. H. S. Langston, ▲ J. Moreno

Very high precision non-linear potentiometers, miniature switches, *air dielectric temperature compensating capacitors, air dielectric trimmers, subminiature deposited carbon resistors, silvered mica capacitors.

S. G. Brown Ltd., Booths 3406-08
Headsets. See British Industries Corp.

Brubaker Electronics, Booth 2126
See: Telecomputing Corp.

Brush Instruments Div., Booths 2616-26
See: Clevite Corp.

Buchanan Electrical Products Corp., Booth 2341
225 U.S. Route 22
Hillside, N.J.

Hendrik Van Ysseldyk, Kenneth Todd, William J. Waldron, Paul E. Vance

Terminal blocks, solderless connectors, splice caps, hand and pneumatic Pres-*Sure*-tools.

(Continued on page 177A)

Whom and What to See at the IRE Show

(*Continued from page 176A*)

Buckbee Mears Company, Booth 4422
245 East Sixth St.
St. Paul 1, Minn.

Norman C. Mears, A. W. Amundson, Harvey T. Holsapple

Electroformed mesh and evaporation masks for electron tubes and subminiature transistor manufacturing, etched metal and glass precision parts for special projects or mass produced component parts, precision printed circuits, micro mesh sieves for submicron particle size determination.

H. H. Buggie Division, Booths 1735-37

Electrical connectors. See: Burndy Corp.

Budd-Stanley Co., Inc., Booth 1810
43-01 22nd St.
Long Island City 1, N.Y.

▲ Jules Simmonds, ▲ William Quinn, Stanley Gartman, Budd Meyers, John Sweeney

Microwave components for radio frequency transmission applications. In aluminum, brass, and magnesium. Including mixers, duplexers, antenna feeds, directional couplers, rotary joints, attenuators, phase shifters. Construction includes welding, torch and dip brazing, and casting.

Bulova Watch Co., Electronics Division, Booths 1821-1823
61-10 Woodside Ave.
Woodside 77, N.Y.

James D. Harlin, Edward M. Walsh, M. Melik, John L. Denman, D. L. Rieder

Frequency control systems, filters, crystals, crystal ovens, servo amplifiers, coils.

Burgess Battery Co., Division of Servel, Inc., Booth 2709
Freeport, Ill.

W. F. Gallagher, Calvin Broughton

Complete line of dry batteries, mercury batteries, sealed nickel cadmium batteries, reserve power units, magnetic recording tape.

Burlingame Associates, Booths 3814-3816
510 South Fulton Ave.
Mount Vernon, N.Y.

Harold Bogin, Roland Reisley, Gerry Sullivan, Arnold Ackerman, Al Beckman, Richard Bullock, Robert Crane, Bernie Greenberg, Dick Hubbell, Don Lander, Al Lee, Marty Maloy, Court Rutherford, Bert Rudofsky, John Takakjian, John Potocnak, William Crooks, Jim Bogin

Coordinated test equipment display. Also new: *Precision, low-cost digital voltmeters; *new meter; ac/dc lab standard calibration system.

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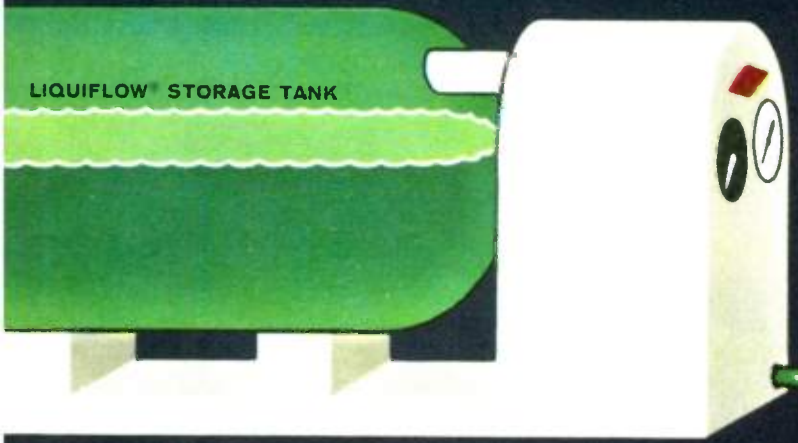
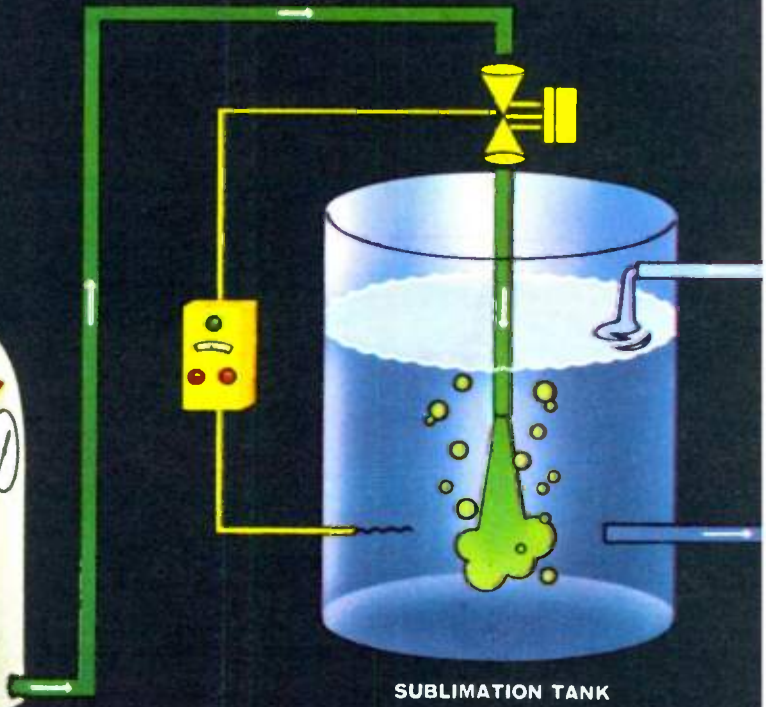
† See PROCEEDINGS OF THE IRE—Feb., April, June, Aug., Oct., Dec. (1960) for further information on our products.
See 1961 IRE DIRECTORY, pages 245, 247, 257, 273, 274, 283, 288, 293, 294, 305, 311, 313, 327, 354, 365, 417, 439, 465, 475, 481, 489, 491, 569, and 583, for complete information on products of our principals.

(*Continued on page 180A*)

efficient . . . low cost . . . flexible

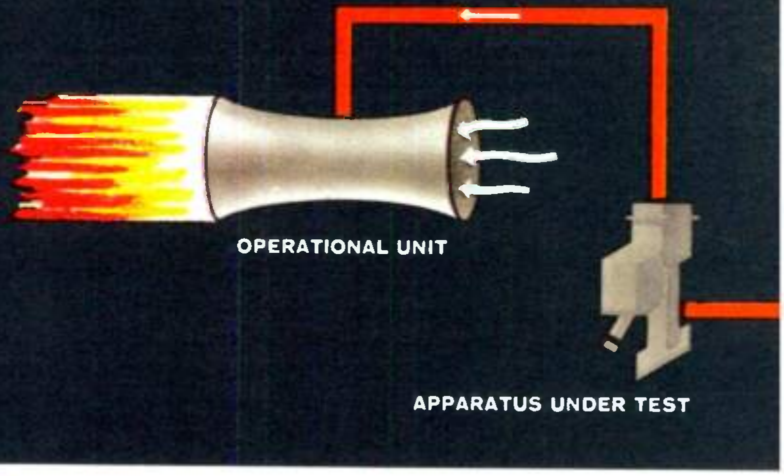
From the smallest component parts to giant aircraft and missiles, Liquid Carbonic has the equipment . . . and the answers . . . to solve your low-temperature test problems. Your Liquid application engineer is only a phone call away, ready to help you any time. He can use your existing equipment or bring his own—and whatever your problem or product, he will gladly demonstrate the fast, easy Liquid method of handling it.





LIQUID'S INDIRECT SOLVENT SYSTEM

Ideal for fuel, vacuum, hydraulic fluid or altitude testing. This unique indirect system can be adapted to existing overloaded mechanical systems, and is suitable for cooling jet engine fuels or for such human factor testing as space suits. Here's the fast, easy way to make environmental low-temperature tests—resulting in better, more dependable products. For top performance wherever normal atmospheres must be maintained, Liquid's indirect solvent system is the answer.



MULTIPLY YOUR ENGINEERING MANPOWER!

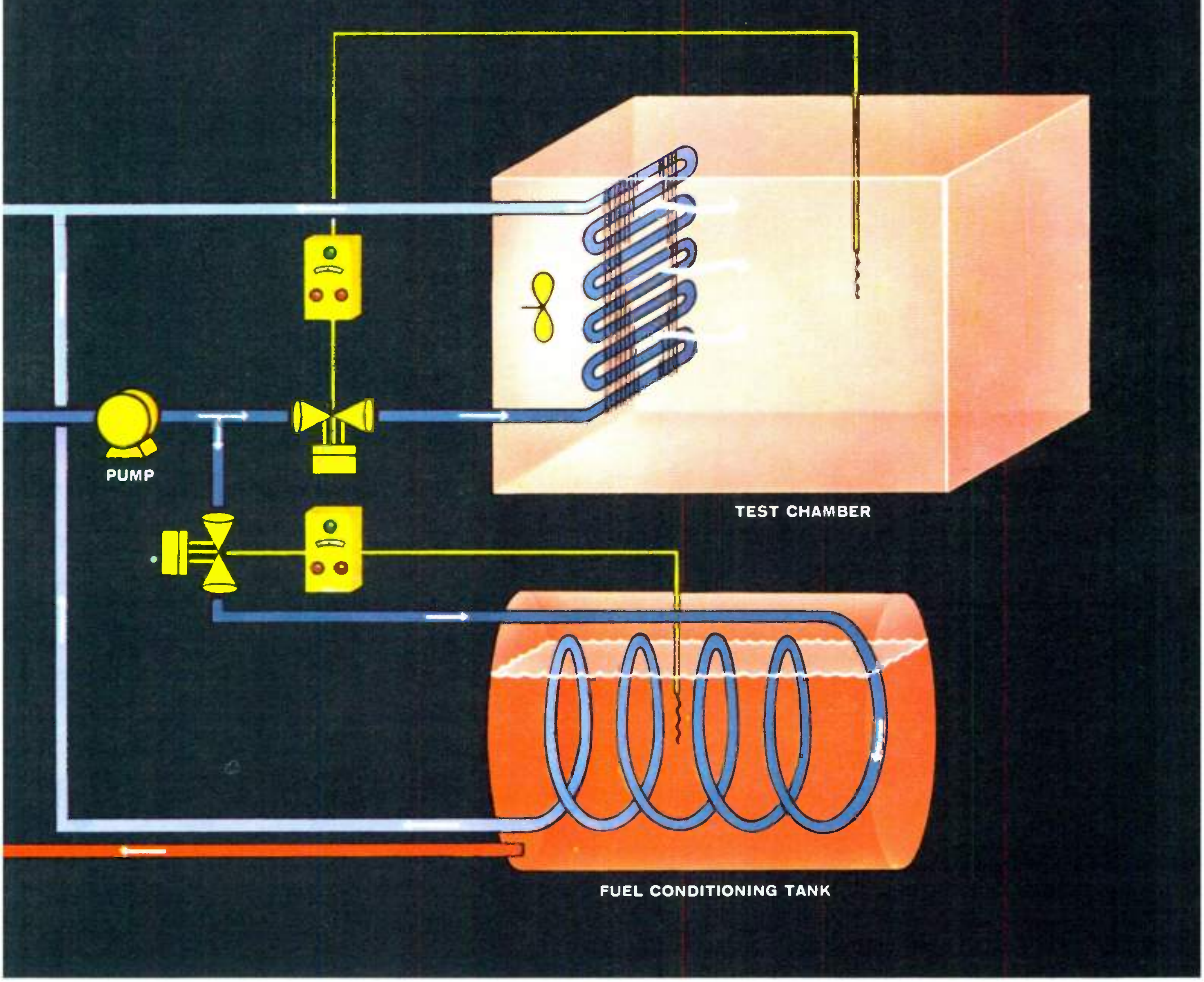
If your mechanical refrigeration unit is taking 8-10 hours to pull down from 200° F. to —65° F., CO_2 will do the same job in 8-10 minutes! Liquid's direct CO_2 injection pulldown to mechanical hold actually increases productive engineering time. Here is the ideal unit for your "fast-drop" tests to save both time and money.

Ask your Liquid Carbonic application engineer how *you* can save with a fast, improvised test on *your* product! Contact him today for a demonstration with this portable CO_2 testing equipment right in your own plant or laboratory at no obligation.

WORLD'S LARGEST PRODUCER OF CO_2

A Major Producer of Compressed Gases: Oxygen, Acetylene, Nitrogen, Hydrogen, Argon, Carbon Dioxide, Nitrous Oxide, Helium and Various Gas Mixtures.

environmental testing with CO_2



DIRECT INJECTION

You can have unlimited refrigeration capacity with only a temperature controller and valve, chamber, and low-cost CO_2. In fact, for one ton of refrigeration per hour, you need only approximately one pound of CO_2 per minute! This handy unit is inexpensive and easy to operate, gives immediate pulldown to −109° F., and lends itself to simple automation.

GENERAL DYNAMICS CORPORATION

GD CORPORATION | L-C DIVISION

Liquid Carbonic Division
135 South LaSalle Street
Chicago 3, Illinois

In Canada:
Liquid Carbonic Canadian Corporation, Ltd.

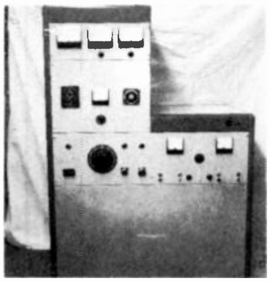
Whom and What to See at the IRE Show

(Continued from page 177A)

Burmac Electronics Co., Inc., Booth M-21

142 South Long Beach Rd.
Rockville Centre, L.I., N.Y.

▲ Stephen F. Delligatti, Albert Luna, ▲ Thomas C. McGowan, Earl M. Klemer, ▲ Joseph Cittadini



Universal Pulse Forming Network Tester

A new idea in a high power pulse test modulator, featuring operating simplicity, servicing ease, and modern mobile construction. *Specialty power supplies, milliwatt to kilowatt; pulse modulators, hard tube and line type; pulse components, pulse forming networks, transformers, chokes.

Burndy Corporation, Omaton Division, Booths 1735-1737

Norwalk, Conn.

▲ Alan Aune, ▲ David Dibner, Sidney Bergman, Fred Heller, Lewis Gage, Ed Salz, Jack DeWitt, William Fitzgerald, John DePalma, Jerry Noeth, Bud Desmond, Morris Elkind, Albert Behnke, Raymond Smith, LeRoy Gray, Louis Harrod, Paul Butler, Charles Asklund, Ian Hinton, Jim Payne, Pat Putignano, William Cotro, Michael Potenza, M. G. Fisher, Lee Berkley

Miniature electronic junction block "Mini-lok." Complete line solderless "Hyfen" connectors, crimp-type snap-locked contacts. Edge type, pin-type printed circuit "Hyfens." *"Hyfen" receptacle for plug-in components. Coax "Hyfens" for regular coax, miniature coax. Rack, panel "Hyfens." Uniring, Modulon, Stapin lines. Related hand, semi-automatic, and automatic tooling.

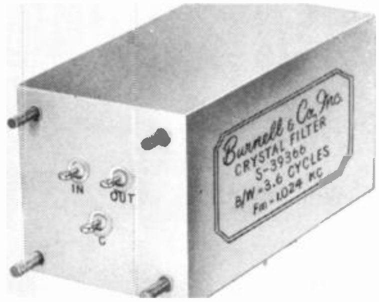
† See PROCEEDINGS OF THE IRE—Jan. through Dec. (1960), for further information on our products.
See 1961 IRE DIRECTORY, page 411, for complete information on our products.

See all four floors

Burnell & Co., Inc., Booths 2909-2910

10 Pelham Pkwy.
Pelham Manor, N.Y.

▲ L. G. Burnell, ▲ N. Burnell, ▲ Bernie Feinerman, L. Schwartz, D. Feldman, R. Burri, J. Tischkewitsch, R. Bello, M. Nemiroff, N. Cohen, ▲ B. Norvell



Crystal Filter

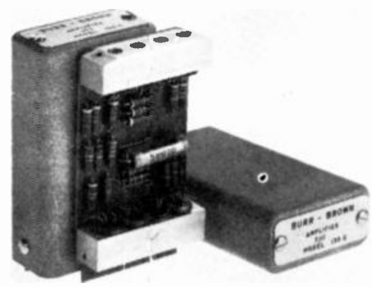
Crystal filters, delay lines, discriminators, audio filters, hermetically sealed and encapsulated variable inductors, hermetically sealed and encapsulated toroidal coils, *Adjustoroids, *Microids, and *Kernels.

† See PROCEEDINGS OF THE IRE—Feb., March, April, July, Sept., Nov. (1960), Jan., Feb., March (1961) for further information on our products.
See 1961 IRE DIRECTORY, pages 88-89, for complete information on our products.

Burr-Brown Research Corp., Booth 3052

Box 6444
Tucson, Ariz.

▲ Thomas R. Brown, Jr.



Operational Amplifier

All transistorized operational and instrumentation amplifiers designed for plug-in rack mounting or as individual instruments. Also featured are several "half-rack" transistorized instruments, oscillators, voltmeters, power supplies, and amplifiers.

(Continued on page 182A)

▲ Indicates IRE member.
* Indicates new product.
† Exhibitor is servicing IRE Engineers through the IRE Package Plan.

Don't wear yourself out

carrying heavy loads of literature. Use the "Lead-Master" system, and exhibitors will send literature direct to your home or office, as given on your registration card. Simply circle the appropriate number on the "Lead-Master" card and leave it with us in the Coliseum Lobby as you go.

A Progress Report

How a Minnesota Investment Firm Is Helping Technological Growth

By Arnold J. Ryden, President Midwest Technical Development Corporation

In two short years of existence, Midwest Technical Development Corporation has furnished capital funds to help the organization and progress of scientific companies located throughout the United States. While this reversal of the traditional flow of capital from the East would have seemed unusual a few years ago, today it is perfectly natural.

Science has no geographic boundaries. The close-knit profession of researchers, engineers and skilled technicians communicates quickly, accurately and—to a large extent—outside the historic channels of commerce and finance.

Today the Twin Cities area is recognized for its ability and its intense interest in scientific industry. Local capital is aiding technological growth in Connecticut, Texas, California and other states. At the same time, MTDC and other young, publicly-owned companies have attracted the investments of stockholders from all parts of the country—investments that are, in large measure, helping the rapid growth of our Minnesota technological companies. Midwest Technical Development Corporation, for example, now has more than three thousand shareholders, located in forty-three states.

Located as it is in one of the fastest-growing technical industry centers in the United States, MTDC is acutely aware of the very special needs of young, scientifically-oriented companies. It is also aware of the growth opportunities that exist for its shareholders in early investment in young companies that operate in advanced technological areas.

In meeting the dual objectives of providing attractive growth investments for its own shareholders and of assisting development of scientific industries, MTDC has these special advantages:

- MTDC is an attractive source of capital because company policy is to avoid controlling companies in which it invests and such investments are ordinarily limited to a minority interest.
- MTDC's Board of Directors combines broad technical experience with the financial and management abilities necessary to properly evaluate investment opportunities.
- Through its associated firms, MTDC can provide companies in which it invests with expert and specialized services in both technical and management fields.

Functioning as a closed-end, non-diversified investment company, Midwest Technical Development Corporation has to date invested more than $3,000,000 in 15 carefully-selected companies, usually through debt securities with conversion rights. These companies are:

Avien, Inc., Woodside, N.Y.
Propulsion control and systems for aircraft and missiles

Electro-Logic Corporation, Los Angeles, Calif.
Electronic instruments and data acquisition systems for industrial and scientific applications

Electro Nuclear Systems Corporation, Minneapolis, Minn.
Research, development and manufacture of specialized equipment and systems for industrial and military use

Kauke & Co., Los Angeles, Calif.
Telemetering equipment and systems

Lumen, Inc., Joliet, Ill.
Amplifiers, engine and generator controls, specialized electronic devices and optical equipment

Minco Products, Inc., Minneapolis, Minn.
Industrial and military temperature-sensing and control instruments

Narda Ultrasonics Corporation, Westbury, N.Y.
Commercial, industrial and scientific ultrasonic cleaning equipment

National Semiconductor Corporation, Danbury, Conn.
Semiconductor devices for the electronics industry

San Diego Scientific Corporation, San Diego, Calif.
Instruments and controls for military and industrial data systems

Soroban Engineering, Inc., Melbourne, Fla.
Input, output and accessory equipment for data processing industry

Telemeter Magnetics, Inc., Los Angeles, Calif.
Magnetic cores and core memory units for data processing systems

Telex, Inc., St. Paul, Minn.
Data processing equipment, hearing aids, communications equipment, amplifiers, switches and relays, and special electronic controls and systems

Washington Scientific Industries, Inc., Minneapolis, Minn.
Precision components and electro-mechanical instruments

For additional information on the history and objectives of Midwest Technical Development Corporation, please write

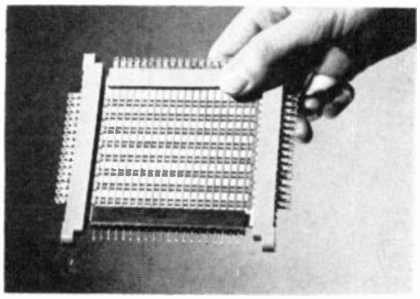
MIDWEST TECHNICAL DEVELOPMENT CORPORATION
2615 First National Bank Building
Minneapolis 2, Minnesota
Room 720, 120 Broadway
New York 5, N. Y.

Whom and What to See at the IRE Show

(Continued from page 180A)

Burroughs Corporation, Electronic Tube Div., Booths 1211-1215
P.O. Box 1226
Plainfield, N.J.

▲Saul Kuchinsky, Arthur Shesser, Richard Brady, ▲ John Bethke, John Pittman

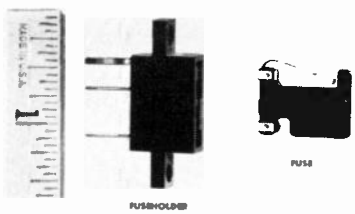


Tomorrow's electronics today in form of BIPCO® modules (Built-In-Place components in modular form) featuring *thin film memory planes and *solid state multi-element modules. New "Nixie" indicator tubes and *"Beam-X"® modules. "Beam-X" switches in modular form for counting, distributing, decoding and multiplexing applications.

Burton-Rogers Co., Booth M-13
See: Hoyt Electrical Instrument Works

Bussmann Mfg. Division, McGraw-Edison Co., Booth 2740
University at Jefferson
St. Louis 7, Mo.

▲ J. A. Bussmann, Jr., ▲ L. E. Edwards, ▲ F. M. Sibley, ▲ A. L. Branning, ▲ J. D. Rambo, ▲ C. J. Dane, ▲ E. F. H. Revell, ▲ A. H. Lucas, ▲ T. P. Lawless, ▲ E. E. Schelper



BUSS Fuse and Fuseholder

New miniature fuse and holder combination. For use where space is at a premium, in communication or other equipment. Fuseholders mount on ¼ inch centers. Fuses give visual indication and activate alarm circuit. Fuse ratings 0 to 10 amperes, for voltages up to 300. Ask for BUSS Bulletin GMCS.

† See PROCEEDINGS OF THE IRE—Jan. through Dec. (1960), Jan. Feb., March (1961) for further information on our products.

See 1961 IRE DIRECTORY, page 448, for complete information on our products.

(Continued on page 184A)

▲ Indicates IRE member.
Indicates new product.
† Exhibitor is servicing IRE Engineers through the IRE Package Plan.

Show Hours
10 a.m. to 9 p.m. daily
Monday through Thursday
March 20-23, 1961

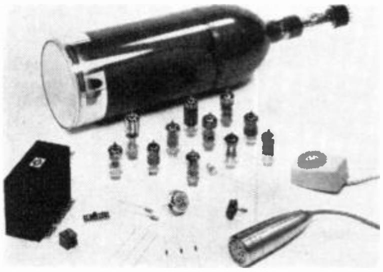
Whom and What to See at the IRE Show

(Continued from page 182A)

CBS Electronics, A Division of Columbia Broadcasting System, Inc., Booths 1401-1403

100 Endicott St.
Danvers, Mass.

▲ J. Shenk, ▲ W. Bevitt, Q. Adams, A. Clark, ▲ J. Lipnick, ▲ R. Gibson, R. Bacher, L. Emmans, ▲ J. Cunningham, G. Colburn, ▲ E. Boise, R. Tomer, G. Wilde, W. Miller, D. Ore



CBS Electronics displays receiving and industrial tubes, semiconductors, audio components, microelectronic devices, and customized control and instrumentation equipment. New products featured are 12-pin receiving tubes, instrumentation and communication tubes, high-speed computer diodes and transistors, ceramic microphones and phonograph cartridges, microcircuits, computer memories.

CBS Laboratories, Div. Columbia Broadcasting System, Inc., Booth 3214

High Ridge Road
Stamford, Conn.

Robert Azud, John Cavanaugh, Francis Coughlin, Jr., Odom Fanning, John Hancock, ▲ John Koushouris, John Manniello, Kenneth Moore, David Safer, Paul Rogell

*VIDIAC (visual information display and control) solid state character generator model 3SG10; vacuum bearings and dry film lubricants; line scan tubes; universal image transmission systems.

C & K Components Inc., Booth 1629

103 Morse Street
Newton 58, Mass.

Richard E. James, ▲ Charles M. Sutherland, David E. Miller, ▲ Charles A. Coolidge, Jr., ▲ Marshall M. Kincaid, ▲ Franklin W. Hobbs, ▲ Robert H. Sturdy

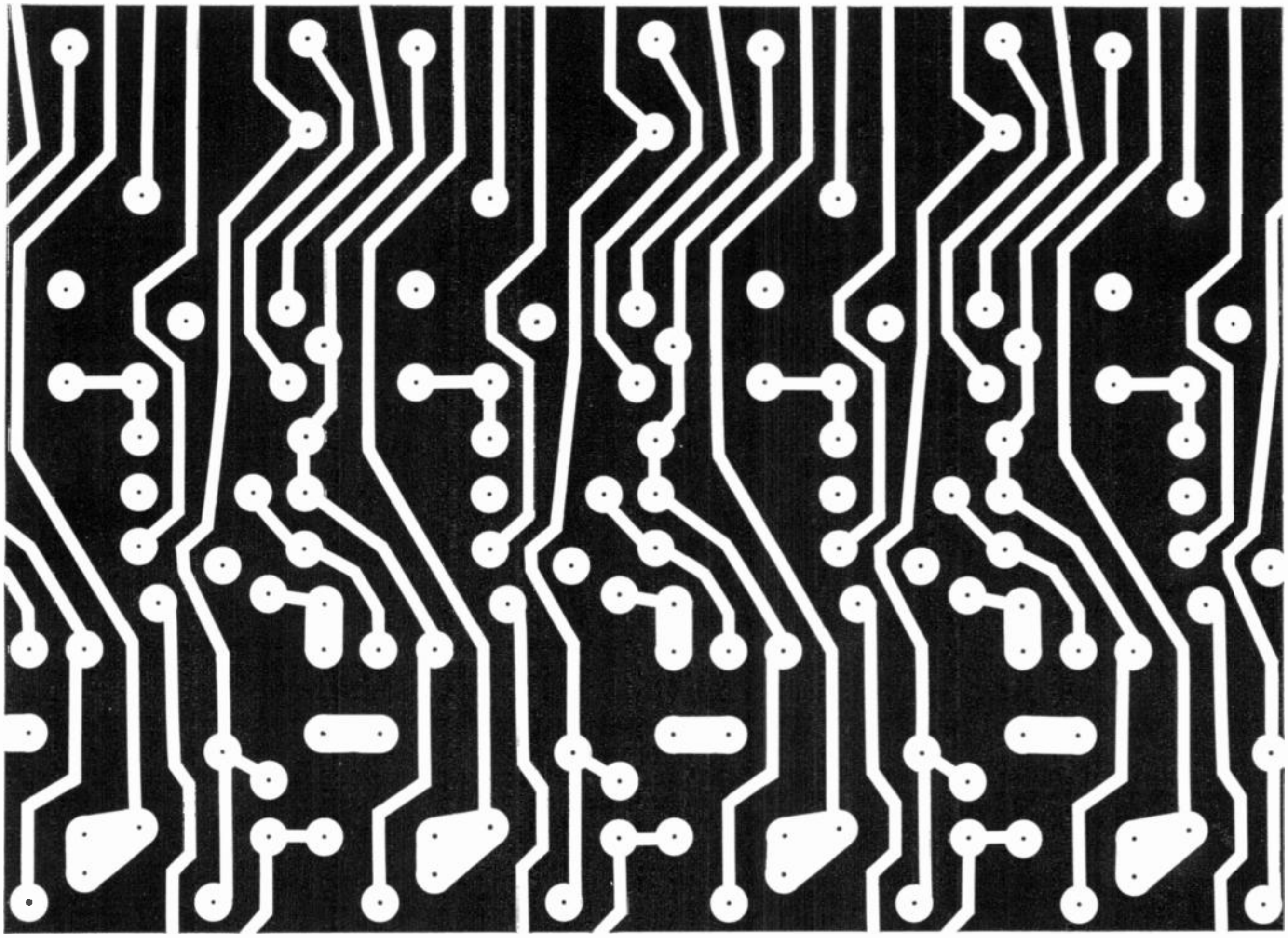
Encapsulated circuit modules, encapsulated magnetic shift registers, transistorized indicator lights including new high-speed memory light and low voltage neon indicator.

CQ Magazine, Booth 4126

See: Cowan Publishing Company

(Continued on page 186A)

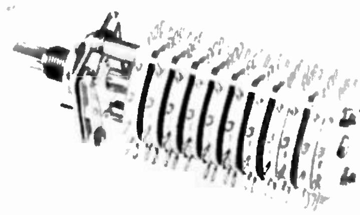
Be sure to see all four floors!



Whom and What to See at the IRE Show

(Continued from page 184A)

CTS Corporation, Booth 1400
1142 W. Beardsley Ave.
Elkhart, Ind.
Henry E. Sanders, R. L. Wilson, J. C. Tidwell



Selector Switch (Star Wheel Detent)

Variable resistors and associated switches, rotary selector switches. TV tuner wafers. Motor driven potentiometers. Metal film potentiometers. Tube savers. Rotary, push-pull and push-push power switches, precision wirewound fixed resistors, subminiature variable resistors for hearing aids. Modular Ceremet resistance elements.

C W S Waveguide Corp., Booths 1311-1313
301 West Hoffman Avenue
Lindenhurst, L.I., N.Y.
Oei Ing Bian, Carl W. Schutter, Virginia Schutter

Components for all sizes of waveguides, including bends, "E" and "H", twists, tees, flanges, attenuators, adapters, assemblies, antennas and duplexers. *WR-2100, WR-1800, WR-1500, WR-1150 and WR-975 waveguide tubing.

Cable Designs, Inc., Booth 4013
66 Rushmore St.
Westbury, L.I., N.Y.
George D. Newman, ▲ John W. Holland, R. A. Colucci, Charles Bateman

Compression molded neoprene jacketed cable assemblies, single trunk or multi breakouts. Bulk neoprene jacketed multiconductor cable to MIL-C-3432. Harness assemblies with molding and connector potting. High temperature hook-up wire and miniature multiconductor shielded and jacketed cable. High temperature magnet wire.

Calidyne Co., Booths 3802-3806
See: Ling-Temco Electronics, Inc.

California Technical Industries Div. of Textron Inc., Booths 3108-3110
1421 Old County Rd.
Belmont, Calif.
J. R. McGuinn, Dickinson Buell, John Varley, Joseph Juarez, Caesar Nuti

*Tape-programmed cable harness analyzer, model 230. Supertester 180/210 model. Cable harness analyzer model 165.

Camblock Corp., Booth 2006
Natick Industrial Centre
Natick, Mass.
M. Ross, M. Good, B. Doktor, W. Cummings

*Terminal block connector using new principle for wire fastening. Eliminates use of solder lugs and does not require any special tools. High impact shock proof and vibration proof. Cuts wiring time by 75%.

Cambridge Thermionic Corp., Booth 2219
445 Concord Ave.
Cambridge 38, Mass.
William G. Nowlin, Roger W. Appel, Lowell Wilkes, ▲ W. A. Melanson

Terminals, coils, coil forms, plugs, jacks, handles, panel hardware, knobs, capacitors, insulated terminals, flip flops, *level triggers, buffer amplifiers, AND gates, OR gates, *inverters, terminal boards, swaging tools, component clips, taper pins, patch panels, battery holders, panel screws, shaft locks.

(Continued on page 188A)

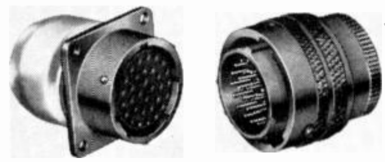
Whom and What to See at the IRE Show

(Continued from page 186A)

Cannon Electric Company, Booths 2727-2731

3208 Humboldt Street
Los Angeles 31, Calif.

Floyd Cate, M. Toomey, Wally Conover, R. Callahan, Bob Strich, R. Borden, Ken Fleck, J. Gillen, Olie Olsen, C. Constas, Merle McKinley, H. Connor, R. J. Hippert, G. McCormack, R. B. Davidson, L. C. St. Pierre, G. S. Sunderland, F. P. Darcy, D. C. Wing



KPT/KSP Plugs

Full line of Cannon Plugs including hermetics, RF coaxial, rack/panel, miniature, and umbilicals. Plug/Harness systems and magnetic devices. CWLD ground support plugs. *Miniature MS multi-purpose plugs. *Crimp snap-in contacts. *Crimp tools. *Environmental D-Subminiatures. *Microplugs. *Tang lock umbilicals.

† See PROCEEDINGS OF THE IRE—March, June, Sept., Oct., Nov., Dec. (1960), Feb., March (1961) for further information on our products

See 1961 IRE DIRECTORY, page 410, for complete information on our products.

Capitol Machine Co., Booth 2532

36 Balmforth Ave.
Danbury, Conn.

Arthur E. Wilson, Michael Baldasare, H. Frank Taylor, ▲ John Biernbaum, Bill Gorman, Bill Brennen, Bill Conlon, Arthur T. Hatton, Chan Robbins

*New compact illuminated multiple position push button switch using the new Sylvania "short base indicator lamp." Also, single and multiple position non-illuminated push button switches and lever switches. 3 amp rating.

Capitol Radio Engineering Institute, Inc., Booth 1326

3224 Sixteenth St., N.W.
Washington 10, D.C.

▲ Karl O. Bathke, ▲ Henry I. Metz, ▲ L. M. Upchurch, ▲ E. H. Rietzke, ▲ Norman Potter, ▲ A. J. Harvey, H. E. McCallick, Fred Waldner, ▲ Charles DeVore, ▲ James P. Evans, ▲ J. A. Morrisey, Earl Maze

New and expanded programs in advanced electronic engineering technology, aeronautical and navigational, communications, television, automation, and industrial electronics engineering technology. Management, advanced mathematics, and nuclear engineering technology.

Capitron Div., Booths 2527-2531

See: AMP Incorporated

(Continued on page 190A)

▲ Indicates IRE member.
* Indicates new product.
† Exhibitor is servicing IRE Engineers through the IRE Package Plan.

Whom and What to See at the IRE Show

(Continued from page 188A)

Carborundum Co., Booths 2930-2931
Refractories Div.
Perth Amboy, N.J.

▲ H. R. Emes, ▲ L. H. Hardy, L. E. Buyers, T. J. Kuehn, J. D. Harper, C. E. Menozzi, D. C. Warren, E. J. Straus, W. G. Fix, K. T. Robinson

High power, non-inductive resistors, thermistors, varistors, custom-built RF and pulse loads. Ceramics, metal-bonded ceramics, ceramic-to-metal assemblies. Kovar® alloy.

Carlisle Corp., Booth 4330
See: Tensolite Insulated Wire Co., Inc.

Carr Fastener Div., United-Carr Fastener Corp., Booths 2535-36
See: Cinch Mfg. Co.

Carrier Corp., Booths 1907-09
See: Spectrol Electronics Corp.

Carter Parts Co., Booth 2109
3401 W. Madison St.
Skokie, Ill.

Nick Frantz, Joseph Rinaldi, J. P. Barthell, Al Hubert, J. W. Richardt

Standard and miniature "Imp-Molded" jacks, commercial pots and L-Pads, telephone jacks and plugs, and stack and lever-switches.

Centronix, Inc., Booth 1922
See: Delta Coils, Inc.

Century Electronics & Instruments, Inc., Booths 3612-3614
1333 North Utica Street, Box 6216
Tulsa, Okla.

J. M. Simpkins, M. A. Xavier, Carroll Stoecker, Ray Niemela

Semiconductor strain gage, *pressure transducer, *direct writing oscillographs (Ultragraph), portable null-balance recorder, strain gage amplifiers, galvanometers, *standard volt, dynamic pressure switches including *solid-state switch.

Ceramaseal, Inc., Booth 1724
Box 25
New Lebanon Center, N.Y.

Herbert A. Omley, Paul F. Ost, Gene D. Swain, A. M. Bredbenner

Alumina ceramic-to-metal sealed terminals and bushings, semiconductor housings, M.I. cable terminations, sapphire-to-metal seals, high pressure seals, magnetron wells, vacuum tight by mass-spectrometer, operating voltages to 100kv-dc. *Improved design, high reliability porcelain-to-metal sealed bushings.

Chassis-Trak, Inc., Booth 4001
525 S. Webster Ave.
Indianapolis 19, Ind.

Lawrence M. Vaughn, John E. McShay, O. E. May

Complete line of slides for electronic cabinets and chassis. Pencil thin slides support from 50 to 275 lbs. Tilt, non-tilt and detent models. Complete line of chassis handles. Factory assembled, pre-aligned, from rail (gusset) slide assemblies.

(Continued on page 192A)

Whom and What to See at the IRE Show

(Continued from page 190A)

Chatham Electronics Div., Booths 2334-36 & 2427-29
See: Tung-Sol Electric, Inc.

Chemical Micro Milling Co., Booth 4523
See: Beemer Engineering Co.

Chicago Dynamic Industries, Inc., Precision Products Div., Booth 1925
1725 Diversey Blvd.
Chicago 14, Ill.

J. C. Koci, ▲ S. Heide

Removable wafer rotary switch, removable wafer thumbwheel switch, precision counters.

Chicago Standard Transformer Corp., Booth 1214
3501 West Addison St.
Chicago 18, Ill.

William Wilson, Karl Crease, Jack Hall, Gene Keys, Newton Cook, Bob Burns, George Mena, Oliver Williams, Vern Howell

Complete line of transformers, filters and coil products for military, industrial, communications, radio and television applications.

Chicago Telephone of California, Inc., Booth 1400
See: CTS Corporation

Chicago Telephone Supply Corp., Booth 1400
See: CTS Corporation

Chilton Publishing Co., Booth 4202
See: Electronic Industries

Christie Electric Corp., Booth 2911
3410 W. 67th St.
Los Angeles 43, Calif.

▲ F. Benjamin, R. Z. Smith

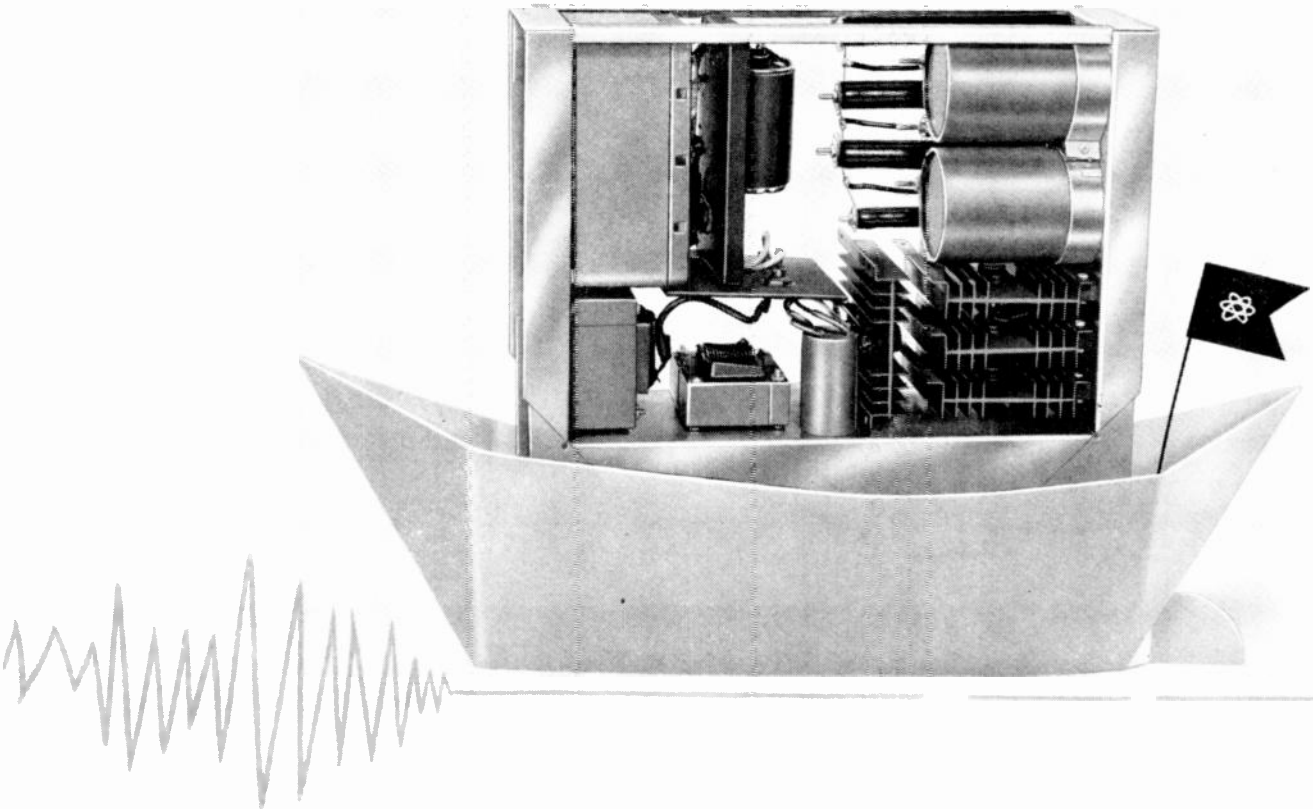
DC power supplies up to 1500 amperes with magnetic amplifier, transistor and silicon controlled rectifier regulation. Automatic float, vehicle and general purpose chargers for lead-acid, nickel-cadmium, nickel-iron, silver-zinc, and silver-cadmium batteries.

Chrysler Corp., Booth 4523
See: Beemer Engineering Co.

(Continued on page 194A)

▲ Indicates IRE member.
Indicates new product.
† Exhibitor is servicing IRE Engineers through the IRE Package Plan.

new SOLA transistorized d-c supply...



reliably regulates d-c voltage— right down to the last "ripple"!

New highly sensitive SOLA "CVQ" provides transistor-regulated d-c output ideal for computers and other *voltage-sensitive equipment*. Response to voltage change is so rapid the CVQ even attenuates 120-cycle ripple! Yet, with it all, this new d-c supply introduces a revolutionary circuit simplicity — providing significant savings in sizes . . . more watts per dollar!

CVQ combines exclusive transistorized shunt regulation with SOLA's inherently self-protecting, static-magnetic transformer . . . easily meets the most taxing demands of dynamic loading. Voltage holds in spite of widely fluctuating loads. The result is longer equipment life, more trouble-free operation. Contact our area representative for complete specifications and prices. Or write today for literature on CVQ.

SEE IT AT THE I.R.E. SHOW

- Standard models available at 5, 6, 10 and 12 volts d-c (100-130/181-235/200-260 volt input).
- Output regulated within ±0.04% for line voltage variations ±15%; 0.2% static-load regulation, 0 to full load.
- Excellent transient response.
- Inherent protection against output over-voltage safeguards both supply components and external circuitry.
- Short-circuit proof design.
- Compact mechanical layout — only $12\frac{1}{4}$ x $5\frac{1}{4}$ x 19″

SOLA

Division of
Basic Products Corp.

B P
C

SOLA ELECTRIC CO.
Busse Road at Lunt,
Elk Grove Village, Ill.
HEmpstead 9-2800.
IN CANADA, Sola-Basic
Products Ltd., 377 Evans
Ave., Toronto 18, Ontario

Whom and What to See at the IRE Show

(Continued from page 192A)

Cinch Mfg. Corp., Booths 2535-2536
1026 S. Homan Ave.
Chicago 24, Ill.

E. J. Pool, ▲ G. H. Hunt, J. L. Elsely, G. S. Maynard, R. K. Byers, E. P. DiMarco, C. W. Nelson, J. M. Litman, George Hart, J. G. Giampiccolo

Tube sockets and shields, micro-connectors, terminal strips, battery plugs and sockets, transistor sockets, semiconductor components, strapnuts, T-nuts, tube holders, metal stampings, printed circuit boards, printed circuit sockets and components, battery connectors.

Cinch Mfg. Co., Howard B. Jones Div., Booths 2535-36

See: Howard B. Jones Div.

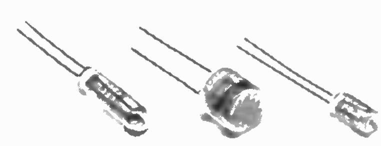
Circo Corporation, Ultrasonic Division, Booth 4007
51 Terminal Ave.
Clark, N.J.

Wellington Vandeveer, Severn S. Carlson, ▲ Benson Carlin, Don J. Kolb, Edward M. Eriksen, Marvin Schechtman, Richard A. Marbois

3 kilowatt ultrasonic cleaning unit. Model Six ultrasonic flaw detection instrument. Standard line of ultrasonic cleaning equipment; white room, ultrasonic agitator and ultrasonic basket. Also vapor degreasers and metal cleaning equipment, metal parts washers of the Equipment Division.

Clairex Corp., Booth M-12
19 West 26th St.
New York 10, N.Y.

▲ A. F. Deuth, J. G. Rabinowitz, S. Cottrell



Photoconductive Cells

Photoconductive cells, cadmium sulfide and cadmium selenide, 25 different types in 400, 500, 600 series to suit most design applications, a wide variety of salient characteristics; also, new "L" types for transistor and other low-voltage usage. Live system demonstrations to be described by engineers at booth.

† See PROCEEDINGS OF THE IRE Dec. (1960), Jan. through May (1961) for further information on our products.

See 1961 IRE DIRECTORY, page 534, for complete information on our products.

(Continued on page 196A)

Whom and What to See at the IRE Show

(Continued from page 194A)

C. P. Clare & Co., Booths 2218-2220
3101 Pratt Blvd.
Chicago 45, Ill.

T. J. Buroojy, A. E. Corwith, J. M. Grofik, J. H. Riley, M. J. Ryan, R. Shires, H. W. West, J. R. Stone, D. Stehle, A. Rasiel, A. Kaminski

Mercury-wetted relay modules ideal for your printed circuit boards. Life expectancy over several billion operations. Clareed relays, excellent for transistor drive circuits, a new concept in relay design. The microminiature Type "F" for missiles. Complete line of open and hermetic sealed relays and rotary switches. Germanium transistors.

Clevite Corporation, Brush Instruments Division, Booths 2616-2626
37th & Perkins
Cleveland 14, Ohio

▲ N. R. Klivans, R. Von Kamecke, ▲ D. E. Pierce, W. K. Whittemore, R. M. Jewitt

Amplifiers, oscillographs, direct writing recording systems, operations monitors, trans-switchers, Brush recorder Mark II, Metrisite, magnetic heads.

Clevite Corporation, Clevite Electronic Components, Booths 2616-2626
3405 Perkins Ave.
Cleveland 14, Ohio

G. E. Eubanks, J. A. Mahoney, D. F. Rachek, D. Markeson, M. J. Luch

High voltage generating piezoelectric ceramic transducer elements. Piezoelectric ceramic sonar and ultrasonic transducer elements. Ceramic "Transfilter" combination IF filters. Piezoelectric self-generating accelerometers.

Clevite Corporation, Clevite Transistor Products, Booths 2616-2626
200 Smith Street
Waltham 54, Mass.

▲ R. F. Morey, ▲ R. F. Keegan, E. M. Barry, G. J. Mozek, R. F. Chase, C. F. Raimondi, J. F. Ordway, C. Carrigan, R. S. Humphrey, N. S. Bernstein, L. C. Huff, H. R. Bothe, V. Sabella, A. S. Nelson, L. F. Norris, R. A. Dusault, F. S. Leitzel, D. M. Feaster, G. J. Brodeur

Germanium gold bonded diodes. Silicon diodes. Silicon rectifiers. Germanium power transistors in diamond base and spacesaver packages.

† See PROCEEDINGS OF THE IRE—Jan. through Dec. (1960), for further information on our products.
See 1961 IRE DIRECTORY, page 536, for complete information on our products.

(Continued on page 198A)

Don't wear yourself out

carrying heavy loads of literature. Use the "Lead-Master" system, and exhibitors will send literature direct to your home or office, as given on your registration card. Simply circle the appropriate number on the "Lead-Master" card and leave it with us in the Coliseum Lobby as you go.

Whom and What to See at the IRE Show

(Continued from page 196A)

Sigmund Cohn Corp., Booths 4322-4324
121 S. Columbus Ave.
Mount Vernon, N.Y.

Adolph Cohn, Richard Cohn, James Cohn, ▲ Alvin H. Rosenbaum, ▲ Harold M. Lang, Frank Krombach, F. Stevens, Jr.

Precious metal wire, gold and alloys, platinum and alloys, precious metal electroplating on bare metal wire, precious metal sheet preforms and ribbon. "Pyrofuze"®, a unique fuze wire. Electroplated wire. Rhodium plating solution.

†

See PROCEEDINGS OF THE IRE Jan. through Dec. (1960), Jan., Feb., March (1961) for further information on our products.

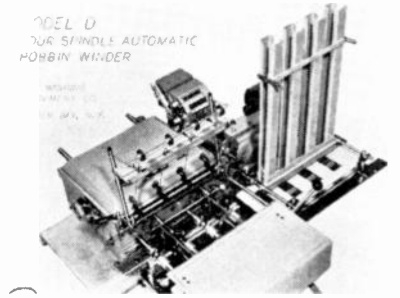
See 1961 IRE DIRECTORY, page 609, for complete information on our products.

Cohu Electronics, Inc., Booths 3601-11

See: Kin Tel Div., Massa Labs., & Millivac Instruments Div.

Coil Winding Equipment Co., Booth 1426
Railroad Plaza
Oyster Bay, L.I., N.Y.

▲ Howard A. George, ▲ Blanche A. George, James H. George, Lloyd George, P. W. Newell, Jr., William Meister, Joseph O'Neill, William Summerbell, Jerome Berliner



Emphasis on automatic and semi-automatic turret-type winders. Completely automated winding machines and a new high-speed four-spindle machine. Also a line of laboratory and conventional machines for winding all coils including lattice, bobbin and paper-interleaved types.

Collins Electronics, Inc., Booth 1206
Stevensville, Md.

L. H. Collins, ▲ J. A. Simberkoff, ▲ S. W. Simberkoff, William H. Reid, Al Linke, Dick Scholfield, H. Lewis, Glen Scott

DC/AC choppers. Chopper test set.

Collins Electronics Mfg. Corp., Booth 1206

See: Collins Electronics, Inc.

Collins Radio Company, Alpha Corp., Booths 3302-3308

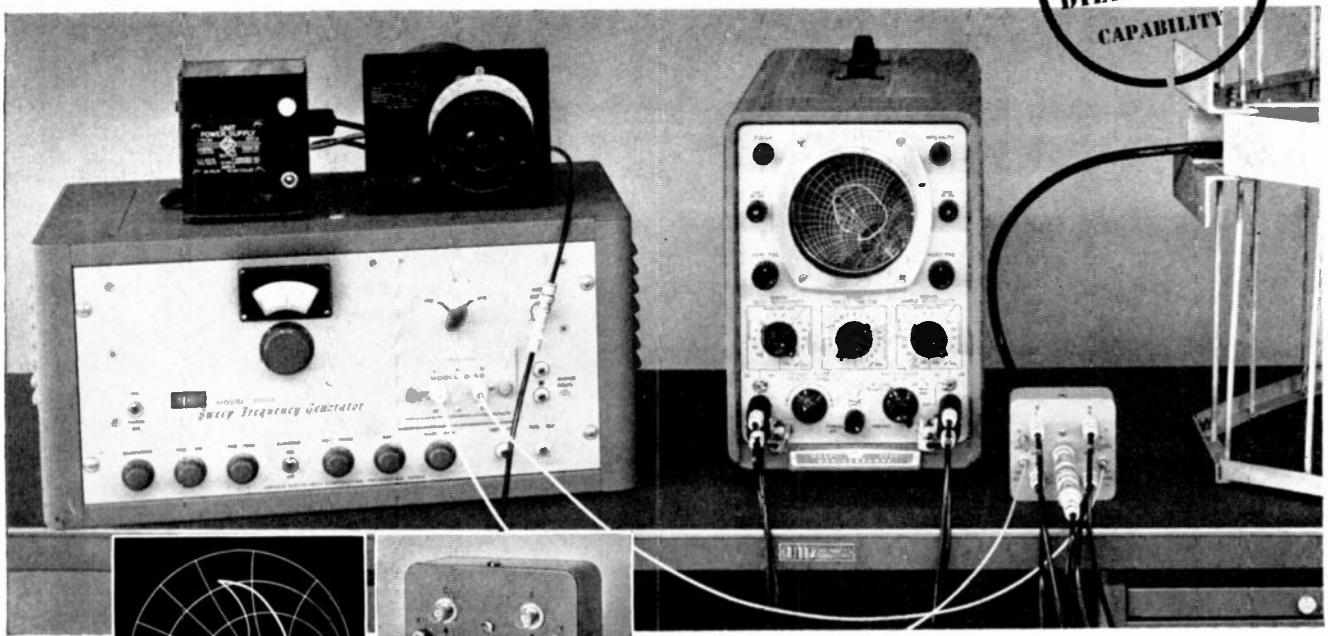
See: Alpha Corporation

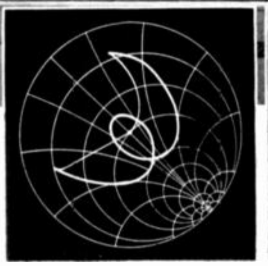
(Continued on page 200A)

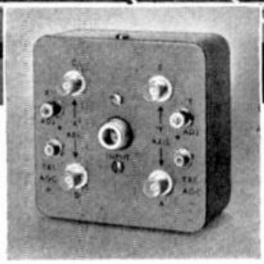
Why carry a load of literature? Exhibitors will send their literature direct to you by mail if you circle their number on your "Lead-Master" card.

The best way yet to measure complex impedances

ANOTHER MEASURE OF DIELECTRIC'S CAPABILITY







Here — for the first time — is an approach to the measurement of complex impedance over a band of frequencies that, for speed, simplicity and reliability, surpasses anything yet used.

It's the Smith Chart Plotter, specially developed by Dielectric Products Engineering Company to obtain instantaneous display of impedance as a continuous function of frequency. There are five coupler models spanning 10 to 3000 mc/s.

This unique coupler — along with appropriate auxiliary equipment to form the complete plotter — eliminates the need to tie up highly skilled technical personnel during prolonged test routines that characterize slotted line measurements. As precise as it is versatile and easy to operate, the Plotter functions simply and quickly to deliver peak accuracies.

HOW IT WORKS

With Dielectric's Smith Chart Coupler, a sweep generator sweeps over the frequency band of the unknown load. A continuous trace of impedance versus frequency is displayed directly on the Smith Chart faceplate. This can be either a full scale chart or one expanded to 1.5:1 VSWR. As adjustments are made, impedances change as does the corresponding trace. Since the Plotter is direct viewing, load changes can be observed immediately. When a permanent record is required, the oscilloscope trace may be directly photographed. Or, if preferred, an X-Y chart recorder may be used.

If you're a designer looking for a faster, easier way to obtain more accurate impedance and admittance measurements of diverse components such as antennas, filters, load resistors, transformers and other r-f networks, you'll find the Smith Chart Plotter one of your most essential tools.

SPECIFICATIONS (ALL MODELS)

Nominal impedance	50 ohms
RF input voltage	0.2 volts, rms
Oscillograph signal voltage (0.1 volt input to plotter)	40 millivolts x reflection coefficient
Accuracy of reflection coefficient measurement	
a. Amplitude	± 5% of reflection coefficient ± 0.01
b. Phase	± 3 degrees ± arc tan $\left(\frac{.01}{\text{reflection coeff.}}\right)$
Sweep rate (maximum)	60 sps
Spot rotation rate (maximum for full accuracy)	1000 rev/sec
RF input and output terminals	Type N female
Oscilloscope signal terminals (balanced)	Type BNC female
Automatic level control terminals	Amphenol Series 27 female

For complete description and for details of operation of the Smith Chart Plotter, write for Bulletin 60-3.

Other areas of **DIELECTRIC** capability in coaxial, waveguide and open wire techniques . . .

TRANSMISSION LINE & COMPONENTS • NETWORKS
SWITCHES • TEST EQUIPMENT • R&D ENGINEERING

dial DIELECTRIC for solutions to communications problems.

DIELECTRIC PRODUCTS ENGINEERING CO., INC.

RAYMOND, MAINE

See the Smith Chart Plotter in operation during the IRE Show, Booth 2004.

Whom and What to See at the IRE Show

(Continued from page 198A)

Collins Radio Company, Cedar Rapids Division, Booths 3302-3308

855 35th St., N.E.
Cedar Rapids, Iowa

W. J. McKnight, G. M. Bergmann, W. G. Dostal, L. H. Leggett, G. Tritt, C. S. Carney, T. H. Jones, D. E. Busse, J. M. Haerle, R. Bruland

51S-1 HF Communication Receiver

Single sideband equipment including KWM-2 amateur transceiver, *51S-1 communications receiver, 618T-3 airborne transceiver. LPS antennas.

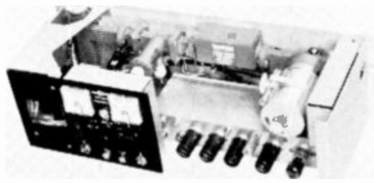
Collins Radio Co., Booth 2809

See: Communication Accessories Co.

Collins Radio Company, Texas Division, Booths 3302-3308

1200 North Alma Road
Richardson, Texas

B. Farquhar, C. W. Service, R. S. Willard, R. L. Halvorson, C. W. DeVoll, J. F. Beckerich



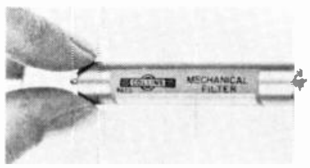
11 to 15 KMC MW Transmitter

49 lbs. WP-103 Weather Radar. *11-15 KMC microwave transmitter with heaterless klystron chamber; transistorized fault alarm system.

Collins Radio Company, Western Division, Booths 3302-3308

2700 West Olive
Burbank, California

V. A. Gill, C. F. Zilm, J. W. Campbell



Mechanical Filter with Ferrite Transducers

*Ferrite mechanical filters, a new line of crystal filters with ranges of 20 kc to 30 mc.

Columbia Broadcasting System, Inc., Booths 1401-03 & 3214

See: CBS Electronics Div. & CBS Laboratories

(Continued on page 202A)

Whom and What to See at the IRE Show

(Continued from page 200A)

Columbia Technical Corp., Booth 1329
21-30 Brooklyn-Queens Expressway West
Woodside 77, N.Y.

▲ Dimitri R. Stein, ▲ John C. Jacobs, ▲ Bernard Stapler, John Waryold, ▲ Philip Geffe, Mitchell Popick

Lumped constant delay lines (Q lines), distributed constant delay lines (Mini-Lines, delay line flats), variable delay lines (VariLines), audio delay lines, magnetic-core delay cable, wide band RF transformers, electric wave filters, Hurm-Seal protective and insulating coatings.

Columbus Electric Mfg. Co., Booth 1122
2005 E. Main St.
Columbus 5, Ohio

F. G. McCloskey, Bob Garachi

Precision snap switches, temperature control.

Columbus Electronics Corp., Booth 2935
1000 Saw Mill River Road
Yonkers, N.Y.

▲ Manlio Goetzl, ▲ Milton Lowenstein, Gustav Bard, ▲ Paul Petrack, ▲ Irwin Wolf, ▲ Al Genser, Howard Kleinick, Raymond Kurtz

Hermetically sealed, double diffused silicon power rectifiers from 50 to 2,000 PIV and 200mA to 25 amps. High KV combinations. Up to 250 KV, up to 20 amps. All seven JAN power types. High power RF variable capacitor (inert gas dielectric).

Colvern Limited, Booth 1822

Precision potentiometers. See British Radio Electronics Ltd.

Comar Electric Co., Booth 2927
3349 West Addison St.
Chicago 18, Ill.

Leonard D. Chocola, Jack A. Walker, Robert L. Valleau

Relays, solenoids, switches.

Combined Book Exhibit, Inc., Booth 4123
950 University Ave.
New York 52, N.Y.

Thomas J. McLaughlin, William G. Tarbox, Dolores Carrio

Recent technical books of many leading publishers, arranged by subject. A bibliography for Radio Engineers has been prepared and is given free at this booth.

Cominco Products, Inc., Booth 1507
933 Third Ave.
Spokane 1, Washington

K. H. Spurr, R. Ellison, D. A. Swan, R. I. Blake, B. M. King

Cominco indium antimonide, fabrications, dot materials and high purity metals. Cominco 59 and 69 grades, antimony, arsenic, bismuth, cadmium, indium, lead, tin and zinc.

Communication Accessories Co., Subsidiary of Collins Radio Co., Booth 2809
50 Highway & 71 By-Pass
Lee's Summit, Missouri

Guy B. Entrekin, ▲ Carl R. Rollert, William J. Monroe, Joseph L. Brickner

High-voltage transformers to 40 kv, *pulse transformers, *miniature transistor transformers, networks, toroidal coil products. Standard or designed to customer specifications.

Community Engineering Corp., Booth M-19
234 East College Ave.
State College, Pa.

▲ James R. Palmer, ▲ E. I. Mundy

Low-noise and wide band amplifiers for UHF and VHF. Transistorized video amplifiers. UHF and VHF to VHF inverters. Complete systems for the RF distribution of television and other signals.

Computer Control Company, Inc., Booths 3905-3907
983 Concord St.
Framingham, Mass.

John V. Cockin

High speed, 16 megacycle, digital computer modules; random access magnetic core memories; code bar switches; information storage systems; numerical control systems; digital test equipment; computer language translators; coordinate conversion systems; "Deltic" time compression systems; data error comparators; special purpose computers.

Computer-Measurements Company, Booths 3226-3228
12970 Bradley Ave.
Sylmar, Calif.

▲ Austin F. Marx, ▲ John K. Rondou, Charles E. Storie, B. Chandler Shaw

Complete line of new solid-state digital counter-timers 250kc, 1mc, 10mc, and 100mc. Heterodyne frequency converters to 220mc. Solid-state digital printer. Transistorized 150 kc reversible counter. *Portable 10mc universal counter timer for battery operation. Solid-state automatic production checkout system.

Computer Systems, Inc., Booths 3835-3837
Culver Road
Monmouth Junction, N.J.

W. George Van Vliet

Advanced precision analog computers for real time and high speed sequential operation with dynamic memory. Automatic read-in, read-out and display equipment. Multi-channel recorders and X-Y plotters.

Condenser Products Company, Booth 1333
140 Hamilton St.
New Haven 4, Conn.

John Yule

Film type capacitors, high voltage power supplies, pulse forming networks.

Connector Seals Corp., Booth M-5
300 North Lake Ave.
Pasadena, Calif.

W. P. Speer, Don D. Allen, Joseph Spadafora, Leroy Beier, Arnold Rattner, Fred Arenstrup, James Adams

Complete line of hermetically sealed connectors featuring 1.) rack and panel type; 2.) miniature and subminiature; 3.) M.S. type; 4.) *combo glass; 5.) *floating socket contacts; 6.) both socket and pin-type; 7.) special design application type.

Consolidated Avionics Corporation, Booth 1114
800 Shames Drive
Westbury, N.Y.

▲ Carl Pilnick, ▲ William Perzley, ▲ Frank Sposato

Transistorized laboratory power supplies. Modular power supplies. *Narrow range high current power supplies. Digital logic modules and accessories.

(Continued on page 204A)

Whom and What to See at the IRE Show

(Continued from page 203A)

Consolidated Mining & Smelting Co. of Canada Ltd., Booth 4507
See: Cominco Products, Inc.

Consolidated Resistance Co. of America, Inc., Booth 1109
44 Prospect St.
Yonkers, N.Y.
J. J. Wilentchik, Gerard H. Lathrop
Precision wire wound resistors. .0001% voltage dividers. .005% resistance decades. .01% wheatstone bridges. Banana plug resistors. R-stacks, ultra-miniature dividers and decades.

Constanta Co. of Canada Ltd., Booth 1107
280 Regina Ave.
Montreal, P.Q., Canada
R. P. Aldred, R. A. Seifred
Deposited cracked carbon high stability precision resistors. Wattage range from 1/10 watt up to 2 watts. Standard, molded and hermetically-sealed.

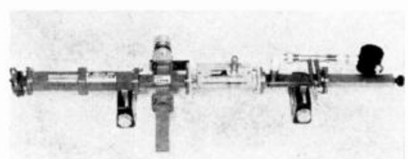
L. L. Constantin & Co., Booths 1217-19
See: Isotronics, Inc.

Constantine Engineering Labs Co., (Celco), Booth 2114
Route 17 and Island Ave.
Mahwah, N.J.
Steven Stephano, ▲ Angeline Constantine, ▲ Pano Constantine, John Constantine, Paul Vasquez, Frank Bainhuber, Walter Faust, Robert Meres.
Centrifugally cast squirrel cage rotors for instrument motors using pure virgin aluminum, aircraft transformers, magnetic amplifiers, hermetically sealed types and special terminations; 400-cycle and dc aircraft motors to customer specifications, inverters, universally and layer wound coils, punch press and special machined parts, "fly back" transformers, deflection yokes for radar systems.

Continental Connector Corp., Booths 2307-2309
34-63 56th St.
Woodside 77, N.Y.
Martin Lesser, Ed Brautigam, John A. O'Brien, Sid Dexter, Lester Callan, Ed Redgate, Sam Giovino, David Harkavy
Precision electronic connectors for computers, aircraft, guided missiles, and communications. *Complete line of printed circuit types, microminiature, subminiature, miniature, center screwlock, power, special designs and crimp-type removable contact plug and socket series* in a variety of sizes.

Continental Electronics Mfg. Co., Booths 3802-3806
See: Ling-Temco Electronics, Inc.

Control Electronics Co., Inc., Booth 1911
10 Stepar Place
Huntington Station, L.I., N.Y.
Vincent Pirro, Frank Battista, Victor Verdolino, Kieran Dunne, ▲ Bertram Magenheim, Waldron E. Bliss, Elaine Schapiro



Parametric Amplifier

Electromagnetic delay lines: Fixed and variable, lumped constant and distributed constant. Magnetostrictive delay lines: Fixed and variable, tapped, associated amplifiers, NRZ circuitry, microwave components and test equipment, parametric amplifiers, filters, dummy loads, power meters, frequency calibrators. Phase Meters. Audio filters.

(Continued on page 206A)

ARNOLD: YOUR H.Q. FOR MAGNETIC MATERIALS AT THE IRE SHOW

BE SURE TO VISIT OUR EXHIBIT...

2nd Floor to the left of the Escalators

1355A

★ **PERMANENT MAGNETS**

Cast Alnico • Sintered Alnico • Arnox • Vicalloy • Cunife

★ **MAGNETIC CORES**

Tape Wound Cores of Deltamax, Supermalloy, Permalloy, Supermendur, etc.

Type "C," "E" and "O" Cores of Silectron • Bobbin Cores

Mo-Permalloy Powder Cores • Iron Powder Cores • Sendust Cores

★ **SPECIAL MATERIALS**

Barium Titanates • Permendur • Vibralloy

AT THE ARNOLD EXHIBIT:
Booths 2314-16-18 and 20

ARNOLD
SPECIALISTS in MAGNETIC MATERIALS

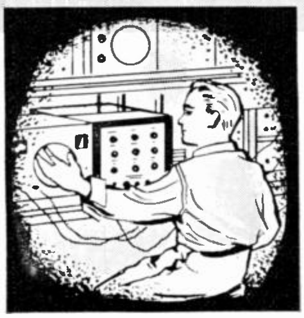
THE ARNOLD ENGINEERING COMPANY, Main Office: MARENGO, ILL.
BRANCH OFFICES and REPRESENTATIVES in PRINCIPAL CITIES

NEW NEW NEW NEW NEW

Rutherford

MODEL
B-10

TRANSISTORIZED / PORTABLE
PULSE GENERATOR



A revolutionary new, highly versatile, general purpose, portable pulse generator for field and laboratory use. Featuring a self-contained rechargeable battery pack which allows independent operation "in-the-field" as well as from standard line voltages.

SPECIFICATIONS:

Main Pulse—plus or minus, 18 volts into 50 ohm amp.
Repetition Rate from 20 CPS to 2 MCS in 5 ranges.
Pulse Delay from 0.0 to 10,000 USEC in 5 ranges.
Pulse Width from 0.05 USEC to 10,000 USEC in 5 ranges.
Overshoot and undershoot—5% or less.
Duty factor—60% max. at any rep. rate.
Sync. Pulse Out—positive, 8 volts min., open circuit amplitude.
Size: 8″ wide x 8¾″ high x 12″ deep.

Also available as rack mounted unit.

See the complete line of Rutherford Pulse Generators at the IRE SHOW, Booth 3317.

Write for complete catalog to Dept. P 3-1.

Rutherford
ELECTRONICS CO.

8944 Lindblade Street · Culver City, California · TWK-CVR-CY-4133

pulse generators / pulse systems / accurate time delay generators

Whom and What to See at the IRE Show

(Continued from page 204A)

Control Switch Div., Controls Company of America, Booths 1727-1731
1420 Delmar Drive
Folcroft, Pa.
& 4218 W. Lake St.
Chicago 24, Ill.

▲ Ed Kaufholz, ▲ D. Haws, ▲ G. Ballee, ▲ H. Ames, K. C. Brine, C. Czadinski, B. Provart, B. Law

Industry's most complete line of basic switches, hermetically-sealed switches, indicator lights, toggle switches, switchlites, lighted switches, push button switches, special assemblies, electroluminescent panels. Special assemblies as well as rotary and interlock switches.

Controls Company of America, Electron Division, Booths 1727-1731

Diodes and semiconductors. See: Control Switch Div.

Cook Electric Co., Data-Stor Div., Booth 3056
8100 Monticello Ave.
Skokie, Ill.

E. L. Washburn, E. Beck, ▲ R. E. Young, R. S. Tveter, F. P. McGowan, A. J. Padurr, ▲ H. Grimme

Model 59 all solid state, high speed digital magnetic recording system. Model 84 solid state photoelectric tape reader. Model 90 solid state, militarized, photoelectric tape reader. Model DR-25-2 solid state airborne magnetic recording system. Model 750-7300 solid state militarized high speed digital magnetic recorder.

Coors Porcelain Co., Booth 2132
600 Ninth St.
Golden, Colo.

John McManus, Warren McDonald, R. Schulee, Dan Howes, L. C. Hageman, Larry Ferreira

New terminal insulator assemblies. Custom and standard ceramic components and ceramic-to-metal assemblies. High alumina and beryllia ceramic components.

Cornell-Dubilier Electronics Div., Federal Pacific Electric Co., Booths 2721-2725
50 Paris Street
Newark 1, N.J.

▲ Lou Alexander, Jerry Bakalar, Marvin Beck, Paul Benvie, D. Busick, A. Cavuto, Joseph Cox, Roy Edwards, ▲ John Feder, John Glynn, Denis Hagerty, A. Kohn, Jerry Larkin, Andy Loeffler, William Maginnis, Dick Olsen, Arnold Rapport, Fisk Shailer

CDÉ

High reliability components and systems including capacitors, semiconductors, relays, pulse networks, filters, delay lines, packaged circuitry, converters, vibrators, test instruments.

† See PROCEEDINGS OF THE IRE—Jan. through Sept., Nov. (1960), Jan., March (1961) for further information on our products.
See 1961 IRE DIRECTORY, third cover, for complete information on our products.

(Continued on page 208A)

Whom and What to See at the IRE Show

(Continued from page 206A)

Corning Glass Works, Booths 2627-2633
Corning, N.Y.

▲ A. W. Dawson, W. C. Howe, ▲ R. K. Whitney, G. T. Backer, R. L. Jones, D. MacMillan, H. R. Slibaugh, W. A. Gleason, J. S. DeMaio, P. L. Roederer, R. A. Hildebrand, J. T. Amsden, B. A. Conroe, ▲ K. G. Pollack, G. E. Bosseler, J. E. Peterson, R. J. Power, Jr., L. R. Madden, ▲ J. L. Sheldon, S. J. Muccigrosso, A. I. Chatfield, J. R. Murphy, T. V. Hartnett, W. G. Bonner

TV bulbs, glass and glass parts for receiving tubes and semiconductors, substrates for microcircuitry and thin films, 'glass microminiature transistor enclosures, '"Lorad"® glass, "Multilead"® bulbs, "Clearform"® power tube flares, "Fotoform"® tube spacers, glass to metal seals.

▲ Indicates IRE member.
Indicates new product.
† Exhibitor is servicing IRE Engineers through the IRE Package Plan.

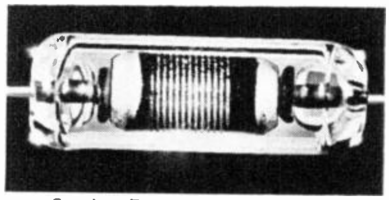
First and Second floors—Components

Third floor—Instruments and Complete Equipment

Fourth floor—Materials, Services, Machinery

Corning Glass Works, Corning Electronic Components, Booths 2627-2633
High Street
Bradford, Pa.

M. H. Hunt, C. C. Harwood, ▲ J. F. Riley, ▲ C. J. Lucy, ▲ M. R. Berell, ▲ I. Cooper, ▲ N. Lazar, J. P. Ronco, A. P. Bodner, W. S. Brennan, G. E. Gauss, H. W. Hanson, ▲ U. H. Martz, ▲ A. J. Hotte, ▲ J. G. Curtis, ▲ L. S. King, J. G. Landers, ▲ R. V. Hamjian, ▲ K. S. McIntosh



Corning Fusion Sealed Resistors

Resistors and capacitors fusion sealed in glass. Tin oxide film resistors to mil specs and for commercial application. Fixed and variable glass capacitors in Mil sizes and smaller. "Fotoceram"® printed circuits. Ultrasonic delay lines. Inductors, enclosures, delay line coil forms.

† See PROCEEDINGS OF THE IRE—Jan. through Dec. (1960), Jan. through Dec. (1961) for further information on our products.
See 1961 IRE DIRECTORY, pages 390 and 523, for complete information on our products.

Cowan Publishing Corp., Booth 4126
300 W. 43rd St.
New York 36, N.Y.

Richard A. Cowan, Jack N. Schneider, Cary L. Cowan, Sanford R. Cowan, Arnold Trossman, ▲ Samuel L. Marshall, Selma Uslaner, Harold Weisner, Dick Ross, Oscar Fisch, Harry Turok

Semiconductor Products Magazine, CQ Magazine, technical books.

Crescent Petroleum Corp., Booth 2135
See: Kurman Electric Co.

Crosby Electronics, Inc., Booths 3615-17
See: Crosby Teletronics Corp.

Crosby-Teletronics Corporation, Booths 3615-3617
54 Kinkel St.
Westbury, L.I., N.Y.

Frank White, Ralph Gooden, ▲ B. C. Coffman, ▲ H. W. Schwiebert, ▲ R. T. Nelson, ▲ J. Feinstein, ▲ J. L. Peters, ▲ J. C. Simmons, J. O'Meara, ▲ R. Constable

Mass spectrometer leak detector, pulse generators and timers, telemetering oscillators, diode testers, frequency meter. Single sideband signal generator, receiver, receiver converter, transmitter. FM stereo multiplex equipment.

Crosley Division, Booth 3932
See: Avco Corp.

Crown Tool, Incorporated, Booth 2933
See: Deluxe Coils, Inc.

Croydon Precision Instruments Co., Booth 3230
See: Muirhead & Co., Ltd.

Crucible Steel Co. of America, Booth 1617
P.O. Box 88
Pittsburgh 30, Pa.

J. M. Delahanty, W. G. Scharnberger, John Hansen, ▲ E. M. Underhill, ▲ Irene Wagner, J. K. Stanley, John McVay, G. P. Byrne, Edward Styple, Robert Schmucker, Neil W. Kantor, T. D'Amico, J. Martin, L. Kranes, J. Schmidt, D. H. Sheridan, E. L. L'Esperance, J. P. Sharkey, F. P. Chepko

Alnico permanent magnets, magnet assembly and ferrimagnetic materials.

Cubic Corp., Industrial Division, Booth 3111
5575 Kearny Villa Rd.
San Diego 11, Calif.

▲ James G. Tabler, John Kenny, William Boyd, Donald E. Root

V-45 industrial digital voltmeter with AC-45 converter. Model 2100 military type digital voltmeter. DC amplifiers. Digital accessories.

James Cunningham Son & Co., Inc., Booth 2237
P.O. Box 516
33 Litchfield St.
Rochester 8, N.Y.

John Sykes, Alden Hine, George Knackstedt, Jack Russell, Bud Wolf, Herb Alberger, Clark Smoll, P. F. Cunningham, ▲ Fred Bartlett, ▲ John DeWolf, ▲ A. W. Vincent, ▲ Benjamin Margolin, Norman Silberberg, ▲ Robert Kelly, ▲ Jim Luscombe, ▲ William H. Bradley, Myron R. Smith, George R. Appleton, Bud McDonald, Herbert Gentry

Complete line crossbar switches for data handling, scanning, monitoring, telemetering, test equipment, automatic control, television broadcast, radar, sonar, thermocouples, and strain gage switching. Self-stepping crossbar scanner. Also switching and scanning systems. High speed miniature solenoid actuators.

(Continued on page 210A)

Whom and What to See at the IRE Show

(Continued from page 209A)

Curtis Development & Mfg. Co., Booth 2315
3266 North 33rd St.
Milwaukee 16, Wisc.

H. C. Curtis, R. E. Miller, R. A. Larsen

Electronic component terminal boards custom built to rigid government specifications for mounting and wiring transistor amplifier circuits and similar electronic circuit packaging. Complete line of terminal blocks for control and power wiring. A type for every purpose.

Curtiss-Wright Corporation, Booth 1521-1523
304 Valley Blvd.
Wood-Ridge, N.J.

N. L. Mead, R. A. Johnson, J. G. Saver, D. H. Garretson, L. O. Davis, A. L. Bastian, J. S. Gasior, J. Donnelly, M. Fedoriw, ▲ V. Myers, ▲ R. T. Rust, ▲ T. E. Lommasson

Electronics Div. (Intermountain Branch) and Princeton Division: Rotary solenoids, stepping motors, solid state relays, time delay relays, delay lines, connectors, airborne digital systems, peak reading voltmeters, transistor curve tracers, test instruments and components. Automatic checkout systems, waveform analyzers. Models PRV-3 and PRV-4 reading voltmeter, timing and control systems.

Cutler-Hammer, Inc., Booth 1825
315 N. Twelfth St.
Milwaukee 1, Wis.

Al Schmidt, Art Pancheri, Tom Nagel, Fred Weiss, Joe Parkhust, Jim Mattych, H. D. Wilkins, W. G. Rauch, R. J. Santo, George Marcos, R. D. Thomas, A. F. Raatz, W. C. Spaude

Hermetically sealed power relays. Miniature positive action switches. Sealed-lever switches. Manual circuit breakers. Dry-circuit test equipment. Precision limit switches. Computer switches. Static regulator modules. Electronic motor speed control.

See also Airborne Instruments Laboratory.

D & R, Ltd., Booth M-24
402 East Gutierrez St.
Santa Barbara, Calif.

Bryant C. Rogers

Attention focused on Frozen Diode Power Blocs. A radical new power concept employing no transistors or capacitors. Outstanding characteristics—zero overshoot, negligible ripple, excellent regulation and ultimate reliability, better than 10,000 hours service guarantee.

Dage Electric Co., Inc., Booth 2435
67 N. Second St.
Beech Grove, Ind.

A. N. Strickland, M. H. Burdett, William Slater

Coaxial cable connectors, glass-to-metal seals.

Dage Television Div., Booths 1435-1635

See: Thompson Ramo Wooldridge, Inc.

Dale Electronics, Inc., Booths 2234-2236
Box 488
Columbus, Neb.

Ray Root, Ike Gates, Bernie Hay, Chet Peitsch, Carroll Novicki, Glen Carter, Bill Simpson, Jim Brandfas, ▲ Lyle Fraka, Bill Shadwick, Mark Bulloyt

Resistors, wire wound—carbon film—metal film—T-pots, new square configuration. *New hi-temp wire wound resistors, new ceramic capacitors in paper and mica range. *New line of coils, filters, and ferrite antennas (Sioux Division). T-pots (Pacific Div.)

Dallons Laboratories Inc., Booths 2901-2903

"Physio-Tel Monitoring Pack" designed to measure, telemeter, visualize and record physiological phenomena of man in space.

See: International Rectifier Corp.

(Continued on page 212A)

ANDREW

Production scenes

Applying insulation to inner conductor

Take up of cable core

Splice welding strip stock

Forming and welding outer conductor over cable core

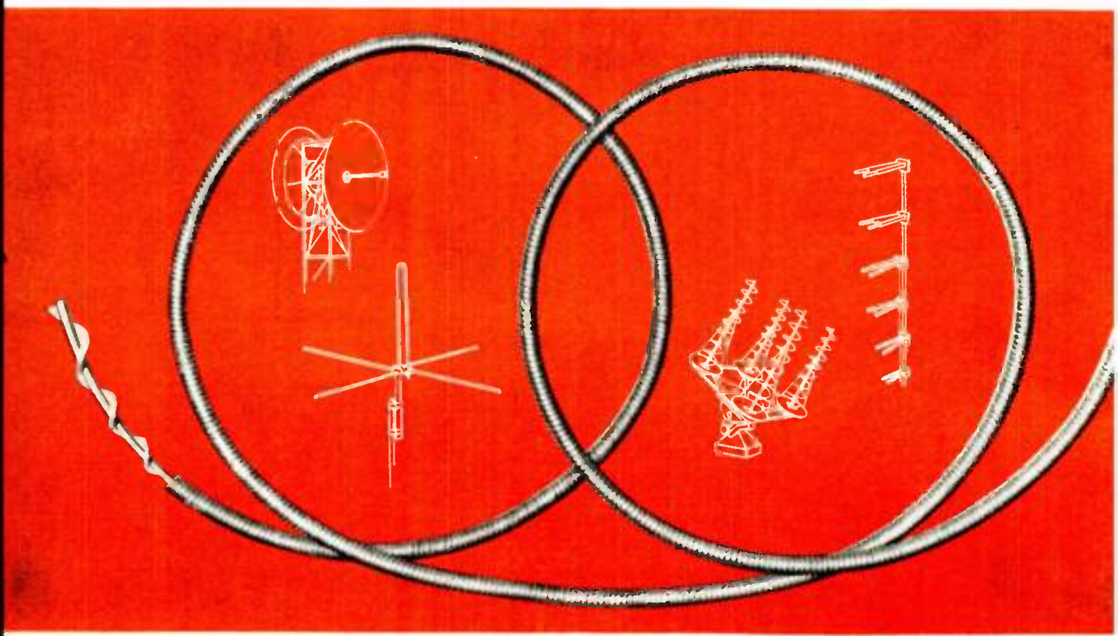
Corrugating outer conductor

Final cable assembly

HELIAX

THE FLEXIBLE AIR DIELECTRIC CABLE

meets every communication requirement



Easiest to install...longest to endure

Produced in the new ANDREW plant facilities, HELIAX is the flexible, low loss, low VSWR coaxial cable for use in all applications from VLF through microwave.

The production cycle in which the copper sheet stock is formed around the cable core, welded and corrugated on a continuous basis is depicted in the film strip. Rolled sheet stock provides considerably closer tolerance tubing than is possible by extrusion or other methods.

HELIAX is the *only flexible* air dielectric cable. This flexibility is imparted by the unique, continuous helical corrugated construction. Bending torque required is about one-half that required for straight wall aluminum or copper tubing of the same size.

HELIAX has the greatest resistance to crushing or kinking. Again this is due to its unique construction. Resistance to physical damage from crushing or kinking forces is about twice that of conventional aluminum or copper cables of comparable size.

HELIAX is the only U. S. produced air dielectric coaxial cable capable of being manufactured in continuous lengths. Critical applications need no longer depend on splicing 1,000 feet or shorter lengths to make up a long cable run. HELIAX affords the only splice free, trouble free air dielectric cable installation.

STANDARD SIZES AND TYPE NUMBERS

SIZE	IMPEDANCE	TYPE NO.
3/8	50	H3-50
7/8	50	H5-50
7/8	75	H5-75
7/8	100	HT5-100
1 5/8	50	H7-50
1 5/8	75	H7-75
1 5/8	100	H7-100
3 1/8	50	H2-50
3 1/8	75	H2-75

ANDREW is your *only* fully integrated source capable of the design and manufacture of cable *and* fittings as well as antennas. ANDREW offers a wealth of engineering experience in the field of RF transmission devices.

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Whom and What to See at the IRE Show

(Continued from page 210A)

Danbury-Knudsen Div., Booths 2402-2507
See: RF Products, Div. Amphenol-Borg Electronics Corp.

Dapon Department, Booth 4041
See: Food Machinery & Chemical Co.

Data-Stor Division, Booth 3056
See: Cook Electric Co.

Datex Corporation, Booth 3935
1307 S. Myrtle Ave.
Monrovia, Calif.
Michael Joncich, John Macalla
Digital data recording and control equipment for science and industry, including radiotelescope antenna systems, steel mill automation systems, laboratory automation equipment.

Daven Company, Booths 2717-2719
530 W. Mt. Pleasant Ave.
Livingston, N.J.
▲ E. L. Grayson, R. J. Curley, ▲ K. K. Garrison, C. Taylor, ▲ C. G. Jones, ▲ F. Schaner
New low T.C. metal-film resistor per MIL-R-10509-D, synchronous switch for diode and rectifier testing, microminiature wire wound resistors. Airborne high temperature inverters and converters.

Davies Div., Booths 2202-2214
See: Minneapolis-Honeywell

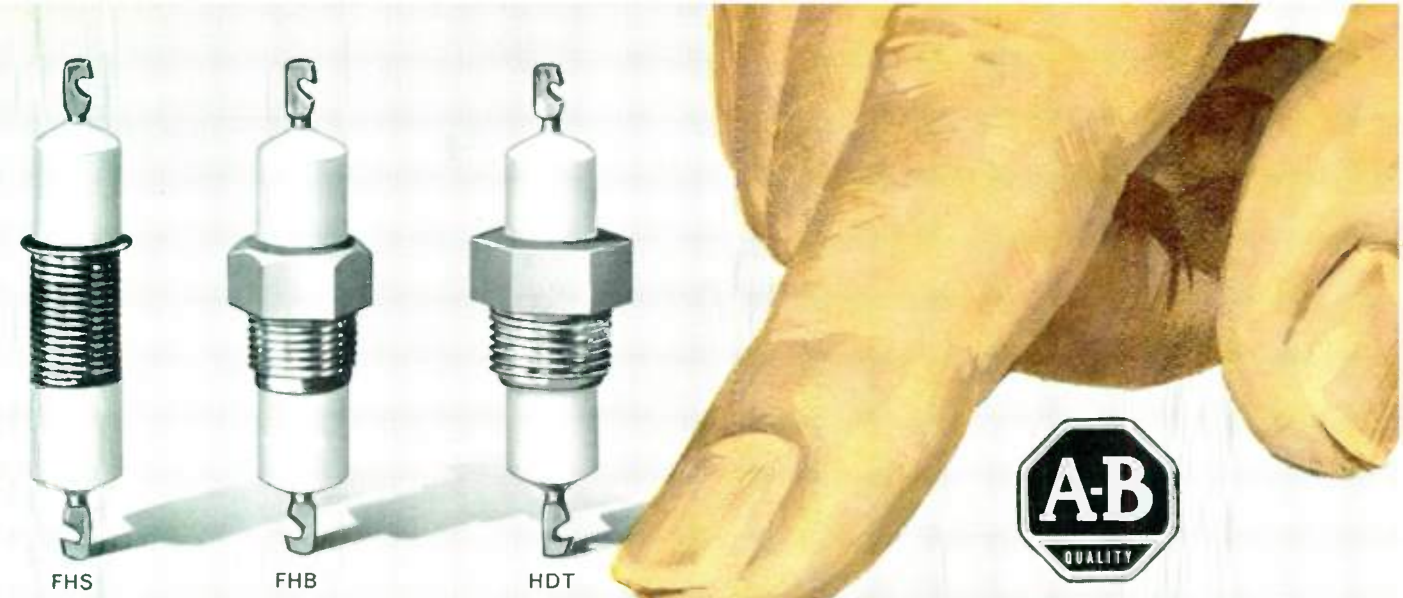
Daystrom, Inc., Booth 1807
430 Mountain Ave.
Murray Hill, N.J.
Rita Robinson
Servo systems, computer systems, aircraft instrumentation, automation equipment, components.
See also Heath Co., Pacific Div., Transicoil Div. Weston Instruments Div.

Daystrom, Incorporated, Potentiometer Division, Booths 1704-1706
Archbald, Pa.
Howard J. Warnken, Robert E. Wolin, Frank Butteri, Hank Brooks, Elias Blanco
Complete line of miniature and subminiature squaretrim precision trimming potentiometers. *New model 200—3/8" squaretrim. *New model 349—multiturn precision potentiometer. Model 319 patent gangable phasable type rotary. Model 341—1/2" diameter multiturn precision type potentiometer.

Dearborn Electronic Laboratories, Inc., Booth 2001
P.O. Box 3431
Orlando, Fla.
▲ R. J. Simpson, ▲ Eamonn Geoghegan, ▲ Allen S. Nace, ▲ A. H. Hilker, ▲ Tom Crawford, Jack J. Perlmuth, Russ Perry, ▲ M. W. Stollmack, Fred Link, G. D. Smith, ▲ Richard R. Burton
True subminiaturization highlights Dearborn's Deltaply® lamination technic featuring three new products this year. *Deltaply lamination with high voltage radial terminals on PFN's. *Hi-Var® capacitors (CP70 style) should be seen. *RF Clear-Pass® filters miniaturized through revolutionary developments and special threaded neck.

Decade Instruments Co., Booths 3512-18
See: Kay Electric Co.

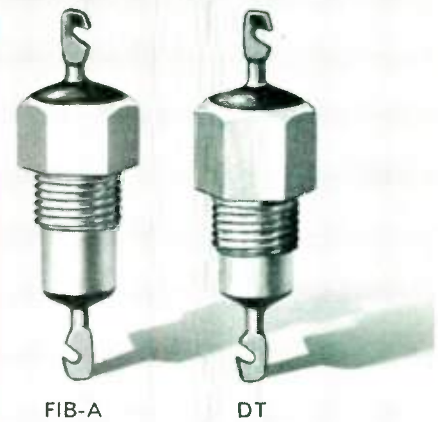
(Continued on page 216A)



These Miniature Low Pass High Frequency Filters*

Eliminate Spurious R.F. Radiation and Troublesome Feedback

*Shown here one and one half actual size



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Prevent Undesired Radiation...100 Mcps to 8000 Mcps

Where—at high frequencies—conventional feed-thru capacitors become useless—these Allen-Bradley low pass filters insure effective filtering of undesired frequencies. Their performance surpasses the theoretically ideal capacitor—the effective filtering actually increases with frequency over a wide band. And here's another "plus" feature—there are none of the undesirable parallel resonances experienced with standard tubular capacitors. Thus, unusual attenuation—75 db and more—is possible in the frequency range from 100 Mcps to 8000 Mcps.

Although designed for low power applications, the Allen-Bradley low pass filters are available in ratings up to 2000 volts and with maximum d-c or low frequency a-c current ratings up to 20 amperes. These miniature filters provide single hole mounting—directly on metal shields. Also, they are usually interchangeable with conventional feed-thru capacitors, but provide far greater suppression of undesired radiation and feedback. Send for Technical Bulletin 5410.

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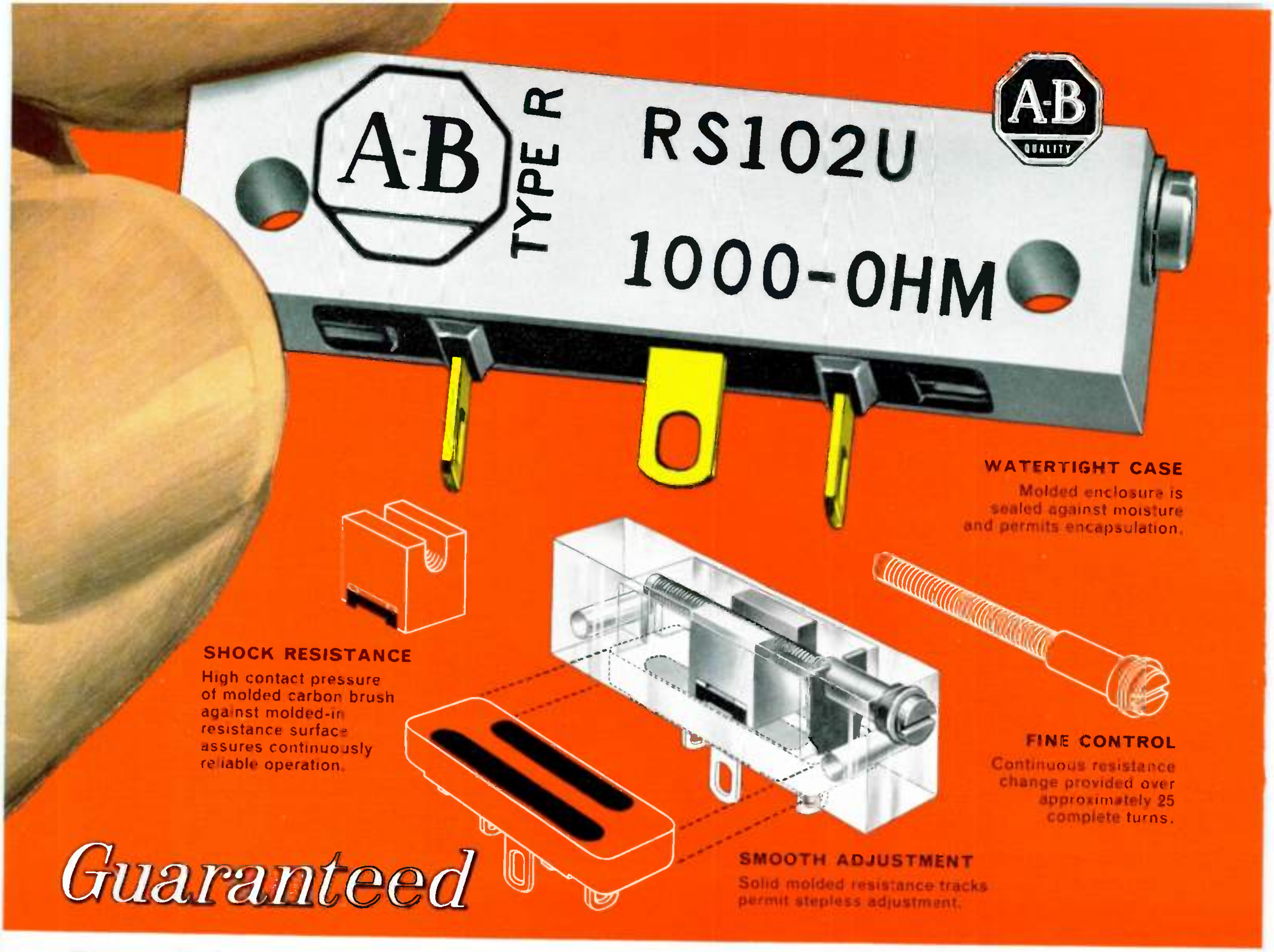


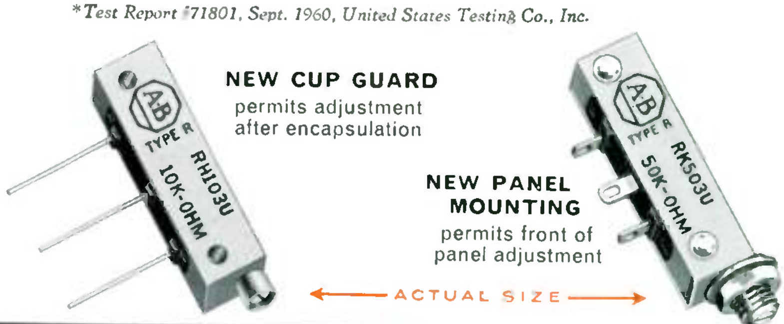
Reliable Performance and Stable Settings

UNDER EXTREME ENVIRONMENTAL CONDITIONS

In critical applications, Allen-Bradley Type R adjustable fixed resistors are *without equal*. For example, in recent tests* Type R resistors successfully withstood acceleration, shock, and vibration *five times* better than the latest MIL Spec requirements. Such wide margin of safety is your assurance of complete reliability. Virtual indestructibility is obtained through an *exclusive* Allen-Bradley process in which the solid resistance elements and the insulating mounting are hot molded into one integral unit. The moving element is self-locking for absolutely stable settings. Also, the Type R control allows "stepless" adjustment of its resistance.

The molded case of the Type R control is watertight and dust-tight. Rated ¼ watt at 70°C, these Type R controls are available in values from 100 ohms to 2.5 megohms.

**Test Report #71801, Sept. 1960, United States Testing Co., Inc.*



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Louis Zielinski, Vic Stein, Ed Drewitz, Richard Heitz, Ed Brautigam, Sam Giovino, Lester Callan, Sid Dexter, Ed Redgate, David Harkavy

*Precision linear and non-linear potentiometers from ½" to 5" diameter, single and multi-turn. †Commercial series panel instruments, custom types including ruggedized units from ½" to 4½", VU and DB, aircraft flight, elapsed time indicators, *digital transducers, †pressure instruments. See also Continental Connector Corp.

Del Electronics Corp., Booth 1919

521 Homestead Ave.
Mount Vernon, N.Y.

J. G. Delcau, H. J. DiGiovanni, Dr. R. Kaufman, D. Congiusti, Richard Landis, Saul Cohen, ▲ Sam Glassman, Irwin Brill, Ben Rubin, James L. Winget

High voltage power supplies, completely instrumented units; regulated, transistorized, compact power supplies. Low voltage silicon controlled transistorized regulated dc power supplies. 60 kv isolation transformers, low capacity filament transformers. MIL-T-27 types. High voltage meter multipliers, high voltage shorting switches.

† See PROCEEDINGS OF THE IRE-March, Aug., Oct., Nov. (1960), Jan., Feb., March (1961) for further information on our products.

See 1961 IRE DIRECTORY, pages 282, 481, and 567, for complete information on our products.

Whom and What to See at the IRE Show

(Continued from page 212A)

Delco Radio Division, General Motors Corp., Booth 1325

700 East Firmin St.
Kokomo, Ind.

M. J. Caserio, ▲ H. M. Stelzl, D. A. Sandberg, F. W. Young, Robert Earle, James Hicks, Martin Gillmon, ▲ Bernard Gershen, ▲ Dr. J. S. Schaffner, ▲ Dr. F. E. Jaumot

Delco Radio originated and is a leading manufacturer of highly reliable germanium power transistors in the T036 (round base) package. Also offers high quality and reliable germanium power transistors in the ½ ampere, 3, 5, and 7 ampere ranges.

Delevan Electronics Corp., Booth M-11

77 Olean Road
East Aurora, N.Y.

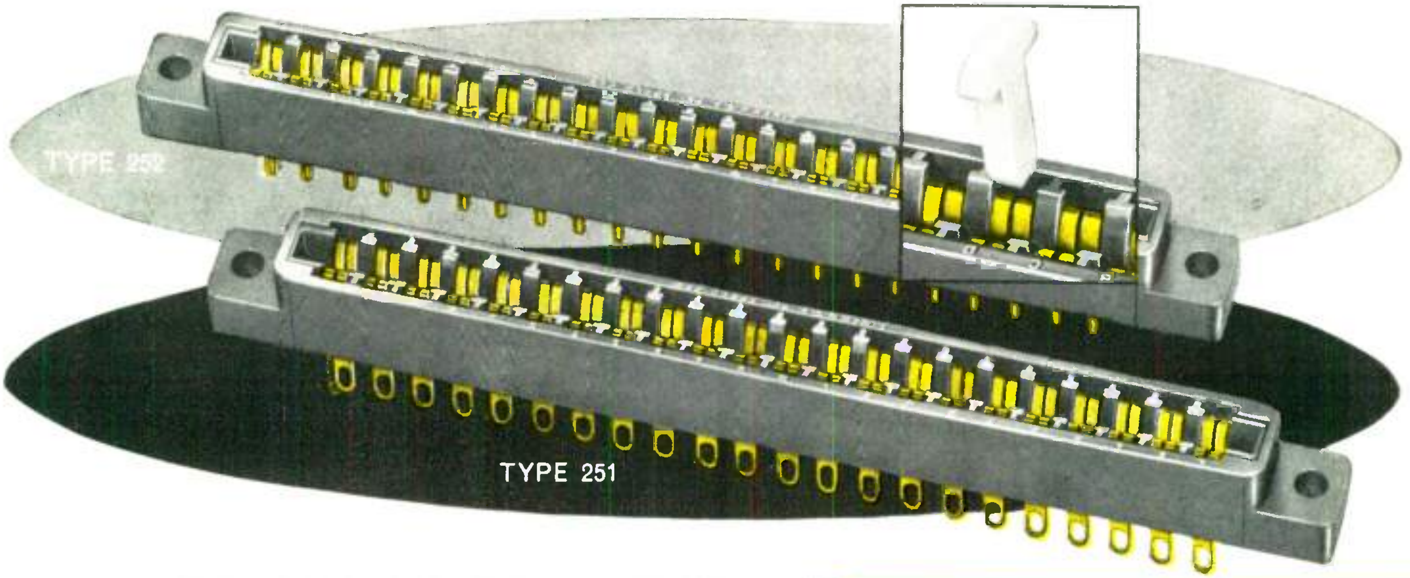
K. L. Richard, H. E. Rhoads, O. P. Marchand

Displaying in a unique display cabinet variable inductor coils, molded choke coils, a new series named "Ring Ding" for its miniature size in the molded choke line. In addition to the standard line, several custom coil variations will be displayed as well as a line of shielded coil units.

(Continued on page 219A)

VISIT BOOTH #2535
THE IRE SHOW

NEW FROM CINCH... BIFURCATED Printed circuit board edge connectors to maintain positive contact!



NOW AVAILABLE FOR IMMEDIATE DELIVERY! Bifurcated Contact Connectors with two flexing surfaces instead of one to provide positive contact! . . . accommodate irregularities in Printed Circuit Boards.

TWO TYPES—conventional wiring tail (type 251) or dip solder (for .051 dia. hole) (type 252) . . . with 6 to 25 contact positions (12-50 contacts).

INSULATION—glass filled diallyl phthalate type GDI 30 per MIL-M-19833.

POLARIZING KEYS—can be supplied loose, or inserted in any position designated.

FINISHES—phosphor bronze or beryllium copper . . . .00003 Min. Sel-rex. gold plated.

PART NUMBERS—customer part numbers imprinted when required.

MEETS MIL-C-21097A (ships) specs for printed wiring board connectors.

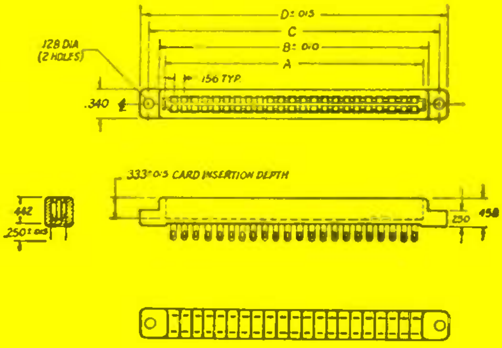
WRITE FOR FULL INFORMATION TODAY! Complete details and performance specifications on new Bifurcated Cinch Printed Circuit Board Edge Connectors are available for the asking. Write for full information now.

Cinch ELECTRONIC COMPONENTS

ELECTRONIC DOT ASSEMBLIES

CINCH MANUFACTURING COMPANY
1026 South Homan Avenue • Chicago 24, Illinois
Division of United-Carr Fastener Corporation, Boston, Massachusetts

Centrally located plants at: Chicago, Illinois; Shelbyville, Indiana; City of Industry, California and St. Louis, Missouri



Contact* Positions	DIMENSIONS A	B	C	D
6	1.098	1.239	1.531	1.785
7	1.254	1.395	1.687	1.941
8	1.411	1.552	1.844	2.098
9	1.567	1.708	2.000	2.254
10	1.723	1.864	2.156	2.410
11	1.879	2.020	2.312	2.566
12	2.036	2.177	2.469	2.723
13	2.192	2.333	2.625	2.879
14	2.348	2.489	2.781	3.035
15	2.504	2.645	2.937	3.191
16	2.661	2.802	3.094	3.348
17	2.817	2.958	3.250	3.504
18	2.973	3.114	3.406	3.660
19	3.129	3.270	3.562	3.816
20	3.286	3.427	3.719	3.973
21	3.442	3.583	3.875	4.129
22	3.598	3.739	4.031	4.285
23	3.754	3.895	4.187	4.441
24	3.911	4.052	4.344	4.598
25	4.067	4.208	4.500	4.754

*Number of contacts equals contact positions times two.

WRH

Whom and What to See at the IRE Show

(Continued from page 219A)

Di/An Controls, Inc., Booth 3016
40 Leon St.
Boston, Mass.

▲ Robert D. Kodks, ▲ David Goldman, Ted Greenberg, Sy Hochman, Stan Benerofe

*Digital integrator for use in missile and space vehicles. *Light-weight programmer for missile applications. *20-megacycle transistor logic circuits. *Indicator gate modules for use with magnetic core logic elements. Magnetic shift registers, memory systems, buffer storages, time code generator.

▲ Indicates IRE member.
* Indicates new product.
† Exhibitor is servicing IRE Engineers through the IRE Package Plan.

Your registration admits you to the show for all four days, and to all technical sessions at the Coliseum and the Waldorf-Astoria. Be sure to keep your badge or pocket card with you at all times on the floor. Registrations are not transferable.

Dialight Corp., Booths 2829-2831
60 Stewart Ave.
Brooklyn 37, N.Y.

▲ R. E. Greene, H. W. Goodman, ▲ J. Weil, M. Greene, M. Roberts, R. B. King

*New Dialco "Data Cap" Series 250

*Placard word warning lights. *telephone strips. *subminiature transistorized indicator lights, *ultra-miniature Datalite, Datastrip, Datamatrix, *subminiature neon and incandescent assemblies. *"Data Cap" indicator lights (feature removable cap and replaceable cartridge).

† See PROCEEDINGS OF THE IRE—Feb., March, May through Dec. (1960), Jan., Feb., March, April (1961) for further information on our products.
See 1961 IRE DIRECTORY, page 472, for complete information on our products.

Dialtron Corp., Booths 2829-31
Time delay relays. See Dialight Corp.

Diamonite Products Mfg. Co., Div. of U.S. Ceramic Tile Co., Booth 4105
Shreve, Ohio

▲ R. C. Mulligan, E. J. Rogers, G. I. Schmidhammer, ▲ Harry Halinton, ▲ Henry Lavin, ▲ W. F. Satterthwaite, William S. Mills, Howard Wadsworth

High alumina ceramics for electronics—high strength, low loss-factor, readily metallized, vacuum tight; fabricated in normal, miniature and *subminiature shapes. "Technical Ceramics," a brochure introducing Diamonite's service policies and engineering assistance, will be forwarded on request.

Diehl Manufacturing Company, Booths 1913-1915
1188 Finderns Avenue
Somerville, N.J.

▲ W. B. Hunter, J. C. Ike, F. C. Helies, J. E. Ryan, J. E. Haney, R. G. Runger, W. P. Cunniff, ▲ E. F. Hall

Transistor servo amplifier. Solid state power supply. Vacuum tube servo amplifier. 60 and 400 cycle servomotors through 1 hp. Ac and dc tachometers. Precision resolvers, size 11, 15 and 23. Precision phase shifters from 60 cycles through 2 mc. See also Singer-Bridgeport.

(Continued on page 222A)

Don't go away mad

because you tired yourself out carrying a heavy stack of literature. Use the "Lead-Master" card, and the exhibitor will send his literature to you by mail.

Whom and What to See at the IRE Show

(Continued from page 220A)

Dielectric Products Engineering Co., Inc., Booth 2001
Raymond, Me.

▲ Dr. Charles D. Brown, ▲ Joseph Kinney Jr., ▲ Edward Shively, ▲ Richard E. Fiore, ▲ Wilfred Beauregard, Weldon Brackett, Robert Hasch, Albert Super, ▲ David S. Smith

New Smith chart plotter, an unusual way to measure and display instantaneous complex impedance over a range of frequencies. Five models cover 10 to 3,000 mc/s. FM and base station antennas, dehydrators for transmission line pressurization, RF switches, directional couplers, rigid transmission line and components, other microwave and communication devices.

Digital Equipment Corporation, Booth 3840
Maynard, Mass.

▲ Kenneth H. Olsen, ▲ Harlan E. Anderson, Stanley C. Olsen, ▲ Richard L. Best, Robert A. Hughes, Theodore G. Johnson, David B. Denniston, ▲ Barbera W. Stephenson, ▲ Donald A. White, ▲ Russell C. Doane, ▲ James Cudmore, John B. Brown

*New solid state current drivers for thin film applications and *new low-cost quadruple flip-flop and capacitor diode gate circuit packages. Also complete lines of *new 10 megacycle packages and expanded 500 kilocycle and 5 megacycle lines of patchcord and plug-in modules.

DoALL Company, Booth 4520
254 North Laurel Ave.
Des Plaines, Ill.

Richard A. Carlson, Hildreth H. Strode, Harry Levine, Joseph J. Baxley, Harry B. Felton, Daniel P. Fanuele, Robert C. Gillies, Gerald A. Gray, Erwin Lieberman, Bernard H. Sopenoff, John H. McCabe

DoAll I/D Micro-Slicer, a machine for precision slicing and dicing of semiconductor materials. *Stainless steel gage blocks. *Trans-Chek, transistorized precision measuring unit. Reversible black granite surface plates. *Surface analyzer, for testing scratch and wear. Model DR-25 direct reading comparator.

Donner Scientific Co., Booth 3925-27

Analog computers. See: Systron-Donner Corp.

Douglas Microwave Co., Inc., Booths 2241-2243
252 East Third St.
Mount Vernon, N.Y.

Herbert Hendlin, Edward J. Warner, R. Harry Douglas, Henry Saltzman, Herbert Rickert, L. Geier

Douglas Microwave Co.: Microwave and macrowave (large waveguide) test equipment and components covering entire spectrum 0.320 to 90 KMC. Douglas Research Corp.: Development and manufacture of microwave antennas and RF subsystems. Torotron Corp.: Engineering and manufacture of toroidal inductors, filters, and magnetic amplifiers.

(Continued on page 224A)

First and Second floors—Components
Third floor—Instruments and Complete Equipment
Fourth floor—Materials, Services, Machinery

General Instrument Silicon Rectifiers

UP TO 25 AMPS...

PIV's—50v to 30,000v

1619 GI SILICON RECTIFIER TYPES

225 Top Hats . . . from 50 to 1,500 PIV

129 7/16" Medium Power Studs . . . from 50 to 1,000 PIV

7 JAN Top Hats & 7/16" Studs . . . from 100 to 600 PIV

52 Diode/Rectifiers . . . from 50 to 600 PIV

38 Plastic Units . . . from 50 to 600 PIV

110 7/16" Hi Power Studs . . . from 50 to 600 PIV*

47 11/16" Hi Power Studs . . . from 50 to 600 PIV*

WIDEST RANGE...

• Whatever your requirement, there is a GI type that exceeds military and industrial spec's • Top Hats • 7/16" Medium Power Studs • Hi Power Diodes • Plastic • 7/16" Hex Hi Power Studs • 11/16" Hex Hi Power Studs • Insulated Studs • All JAN Top Hats • Rectifier Stacks • Hi Voltage Cartridges • Custom Packages for Special Needs • New 25-Amp Stud Rectifiers

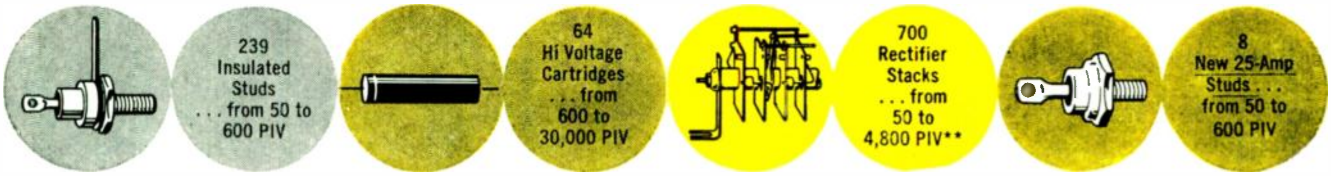
FASTEST DELIVERY...

• Immediately Available Off-The-Shelf • Realistically Priced • Contact General Instrument at the address below for the name of your local authorized stocking distributor.

*Also available with Reverse Polarity

**Available on request up to 480,000 PIV

SEE YOU AT THE IRE SHOW—NEW YORK COLISEUM, BOOTHS 1101-1106



GENERAL INSTRUMENT
GENERAL TRANSISTOR
TRANSISTORS, DIODES, RECTIFIERS

SEMICONDUCTOR
DIVISION OF GENERAL INSTRUMENT CORPORATION
65 Gouverneur Street, Newark 4, New Jersey

IN CANADA: General Instrument—F. W. Sickles of Canada Ltd., P.O. Box 408, 151 S. Weber Street, Waterloo, Ontario, Canada. Sherwood 4-8101.

Whom and What to See at the IRE Show

(Continued from page 222A)

Dow Corning Corp., Booths 4310-4312
Midland, Mich.

K. Anderson, R. Bloor, A. Bohn, D. Christensen, ▲ C. Currin, R. Dilger, E. Earleywine, D. Kauppi, M. Nakonechny, M. Nelson, R. Spraetz, G. Swartzbaugh, S. Wooten

*Two new silicone encapsulating, embedding materials will be on display. *Sylgard 182 is a transparent encapsulant—permits visual inspection, easy circuit repair. *Silastic® RTV 601 cures completely and uniformly in deep sections. Other silicone materials and hyper-pure silicon will also be displayed.

Drake Manufacturing Co., Booth 2713
4626 N. Olcott Ave.
Chicago 31, Ill.

H. Kenneth Foute, Jack Krutek

*MIL-standard indicator assembly—"Econoglo," "Mineon," "Tinylite," "Teleslide" indicator units for readout and similar purposes, both for neon and incandescent lamps—also other Drake special and standard miniature lighting assemblies and lampholders.

Wilbur B. Driver Co., Booths 4203-4205
1875 McCarter Highway
Newark 4, N.J.

Frederick A. Locke, George A. Fielding, ▲ Edward T. Kubilins, Howard A. Anderson, Edwin C. Bennett, Ernest W. Swift, Harry Mason, Peter Stefan, John Morse

*Ceramiseal, Evanohm, resistance wire for precision wire-wound resistors, glass-to-metal sealing alloys, grid and filament alloys, anode and cathode plate alloys. High temperature ceramics, low vapor pressure brazing alloys, precious metals for semiconductor uses.

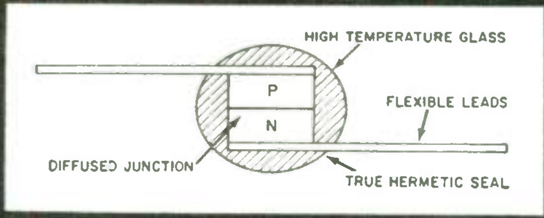
† ▲ See PROCEEDINGS OF THE IRE—Jan., March, May, July, Sept., Nov. (1960). Jan., March (1961) for further information on our products.
See 1961 IRE DIRECTORY, page 186, for complete information on our products.

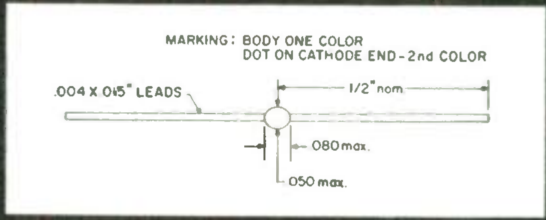
(Continued on page 228A)

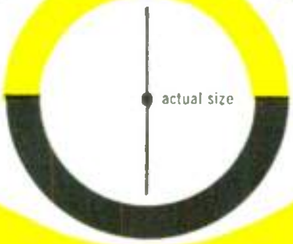
The Radio Engineering Show lasts four days
There are four floors in the Coliseum.
Why not spend one day on each floor to make sure you see all of more than 800 new ideas?

ANOTHER FIRST FROM

Transitron







WITH A **TRUE** HERMETIC SEAL

MICRO ZENER DIODES

NO COMPROMISE!

Development by Transitron scientists and engineers of a new concept in glass packaging has now made it possible to introduce the industry's first micro-diode with true hermetic sealing. This is the new micro voltage regulator ("zener") series . . . a series in which the glass is melted *around* the silicon body that forms the working part of the device. Achievement of a direct high-temperature glass-to-metal seal means that there are no plastics . . . no multi-part packaging . . . no "gunk" . . . no degrading of characteristics with humidity. Absolute hermetic sealing makes this the most reliable and efficient micro-regulator ever developed, ideal for voltage regulating and reference service wherever space and weight economies are required.

Micro Zener Diodes are produced exclusively by Transitron. The first series is available immediately; other diodes are under development and will be marketed shortly.

For more information write for Bulletin PB-71E.

SPECIFICATIONS @ 25° C			CURRENT RATINGS	
TYPE	Voltage (1) @ Iz = 5ma (Volts)	Maximum Dynamic (2) Resistance (ohms)	Maximum Average (3) Operating (ma) Current @ 25° C	@ 100° C
TMD-01*	5.1	15	17.8	4.4
TMD-02	5.6	15	15.5	4.0
TMD-03*	6.2	15	14.5	3.7
TMD-04	6.8	15	13.0	3.3
TMD-05	7.5	15	12.0	3.1
TMD-06	8.2	15	11.0	2.8
TMD-07*	9.1	15	10.0	2.5
TMD-08	10.0	15	9.0	2.3

(1) Voltage tolerance ± 10%. For ± 5% Voltage Tolerance use "A" suffix (e.g. TMD-03A)

(2) Dynamic Resistance is measured by imposing a small (10% of DC bias) AC current upon the DC Test Current, 5 MADC.

(3) Assume linear derating between 25° C and 100° C

*Production types

ADDITIONAL CHARACTERISTICS AND RATINGS

Operating and Storage Temperature Range	−55° C to +150° C
Maximum power dissipation at 25° C	100 mW
Typical forward voltage at 5.0 mA	0.75 volt

MEET US AT IRE—BOOTH NOS. 1220-1224

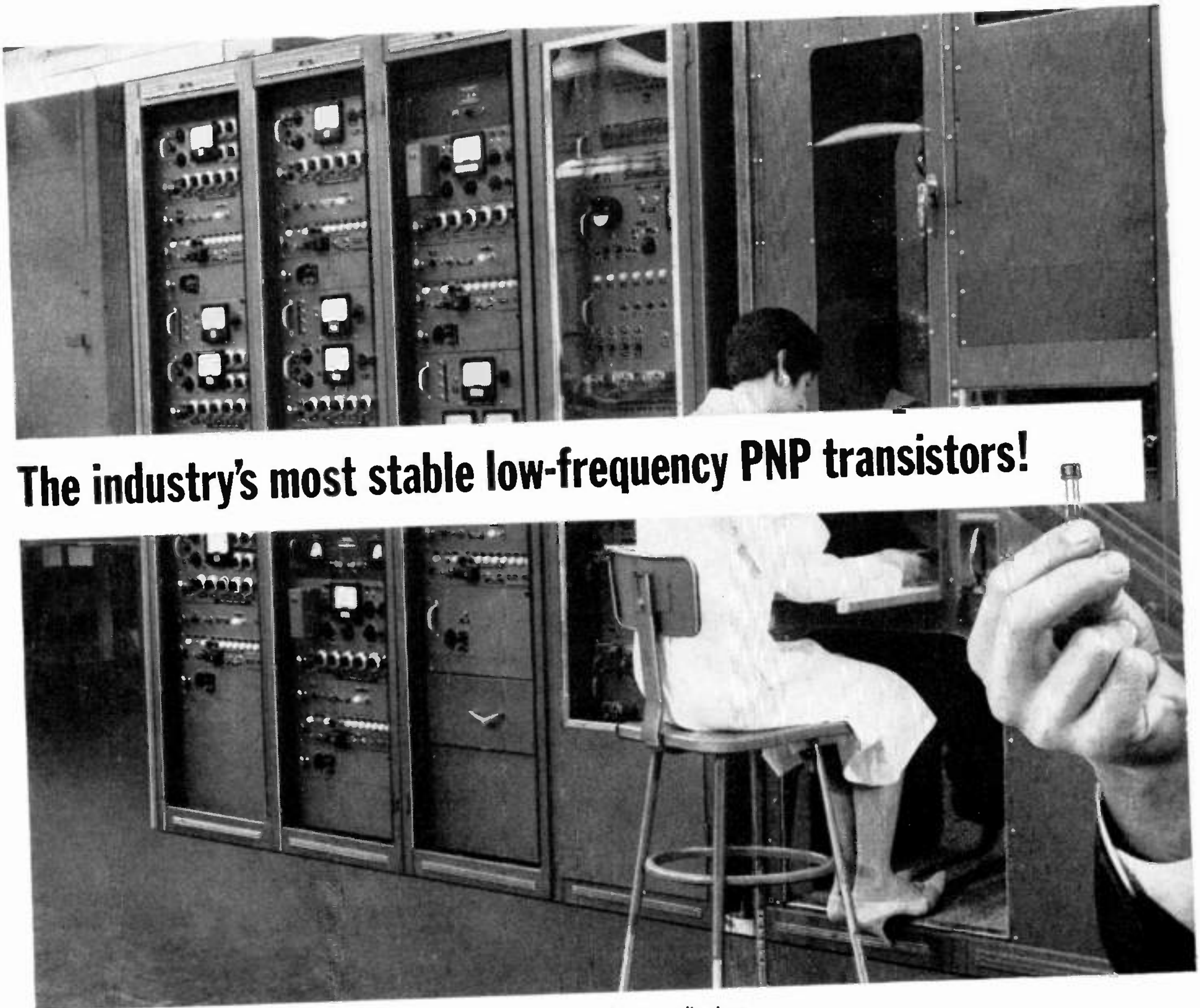
Transitron

electronic corporation

wakefield, melrose, boston, mass.

SALES OFFICES IN PRINCIPAL CITIES THROUGHOUT THE U.S.A. AND EUROPE • CABLE ADDRESS: TRELCO

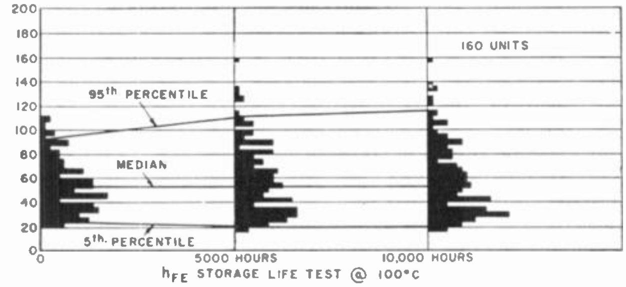
WRH

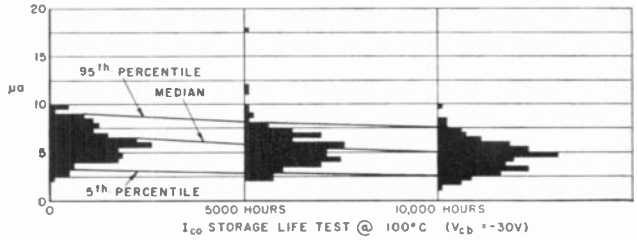


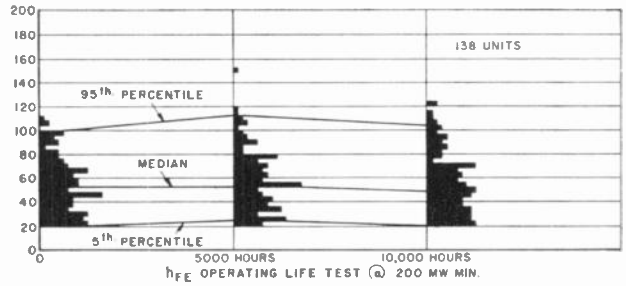
The industry's most stable low-frequency PNP transistors!

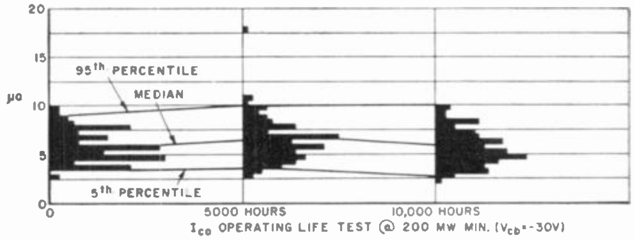
The man in the picture, Hugh Lowry, General Electric authority on semiconductor applications

TO-5 Type	Max. V_{CBO}	Max. V_{CER}	Max. I_C	Max. P_t	Max. Cutoff I_{CO}	@ V_{CB}	20 ma h_{FE} Min.	Max.	h_{FE} Min.	Max.	V_{CE} (SAT)	V_{BE}	Max. C_{OB}
2N524	45v	30v	500 ma	225 mw	10μa	30	19	42	16	41	.070v	.255	40
2N525	"	"	"	"	"	"	34	65	30	64	.075v	.243	"
2N526	"	"	"	"	"	"	53	90	44	88	.080v	.230	"
2N527	"	"	"	"	"	"	72	121	60	120	.090v	.216	"
2N1413	35v	25v	200 ma	200 mw	12μa	30v	25	42	20	41	.070v	.255	40
2N1414	"	"	"	"	"	"	34	65	30	64	.075v	.243	"
2N1415	"	"	"	"	"	"	53	90	44	88	.080v	.230	"









General Electric 2N1414 and 2N525 Series carry complete parameters backed up by 10,000-hour life tests

You don't buy a "pig in a poke" when you standardize on General Electric low-frequency PNP germanium alloy transistors, Series 2N1414 and 2N525. Parameters are completely spelled out, including "Minimum," "Typical" and "Maximum" values, and are backed up by 10,000-hour life tests on 138 units to date (see curves above). In fact, 300 new units start life-test each week.

The new lower-priced 2N1413, 2N1414 and 2N1415 types are designed for industrial audio amplifiers and low-frequency switching applications where cost is a prime consideration.

To assure top reliability under adverse environments, all units are hermetically sealed and subjected to 100 hours of high-temperature bake and a detergent pressure leak test. The transistor base is welded to the case for greater thermal efficiency.

For proved reliability in low-frequency PNP's, at a very pleasant price, see your G-E Semiconductor District Sales Manager or Authorized Distributor. General Electric Company, Semiconductor Products Department, Electronics Park, Syracuse, N. Y. *In Canada:* 189 Dufferin St., Toronto, Ont. *Export:* International General Electric Co., 150 E. 42nd St., N. Y. C.

GENERAL ELECTRIC

Whom and What to See at the IRE Show

(Continued from page 224A)

Driver-Harris Co., Booths 4417-4419
201 Middlesex St.
Harrison 7, N.J.

▲ W. P. Smith, ▲ Edwin Shuttleworth, C. E. Phayre, T. Packard, J. J. Pidgeon, P. W. Baubles, R. L. Johnson, D. E. Earle, D. R. Smith, J. L. Sawitke, G. L. Merritt

"Karma"® fine resistance wire for potentiometers and precision resistors; electronic alloys for cathodes, plates, grids, metal-to-glass sealing alloys. Teflon extrusions.

Allen B. Du Mont Labs., Electronics Tube Div., Booths 3501-3507
750 Bloomfield Ave.
Clifton, N.J.

Daniel Echo, Robert A. Mossi, Burtis E. Lawton, Richard J. Sparnon, Albert E. Beckers, William L. Hyde, Seymour Bossuck, Anthony Furlano

Dynamic display of direct view storage tubes 2¾ inches to 21 inches. Multiplier phototubes featuring type 7860. Cathode ray tubes designed for transistor circuits for high resolution for military applications and for all special purposes. Flying spot scanner types.

E. I. du Pont de Nemours & Co., Inc., Booths 4329-4331
1007 Market St.
Wilmington 98, Del.

W. B. Davis, J. T. Axon, M. L. White, C. R. McKay, R. D. Griste, C. D. Palmer, L. V. Baldwin, K. A. Ried, A. A. Nierenberg, R. S. Noyes, C. D. Cummings, G. M. Hoffmann

"Mylar" polyester film in wire and cable, capacitors, transformers and coils, magnetic tape, and motors. "Teflon" FEP fluorocarbon film in wire and cable, capacitors, formed parts, tapes, laminated to metal, and gaskets. "Teslar" PVF film, major applications.

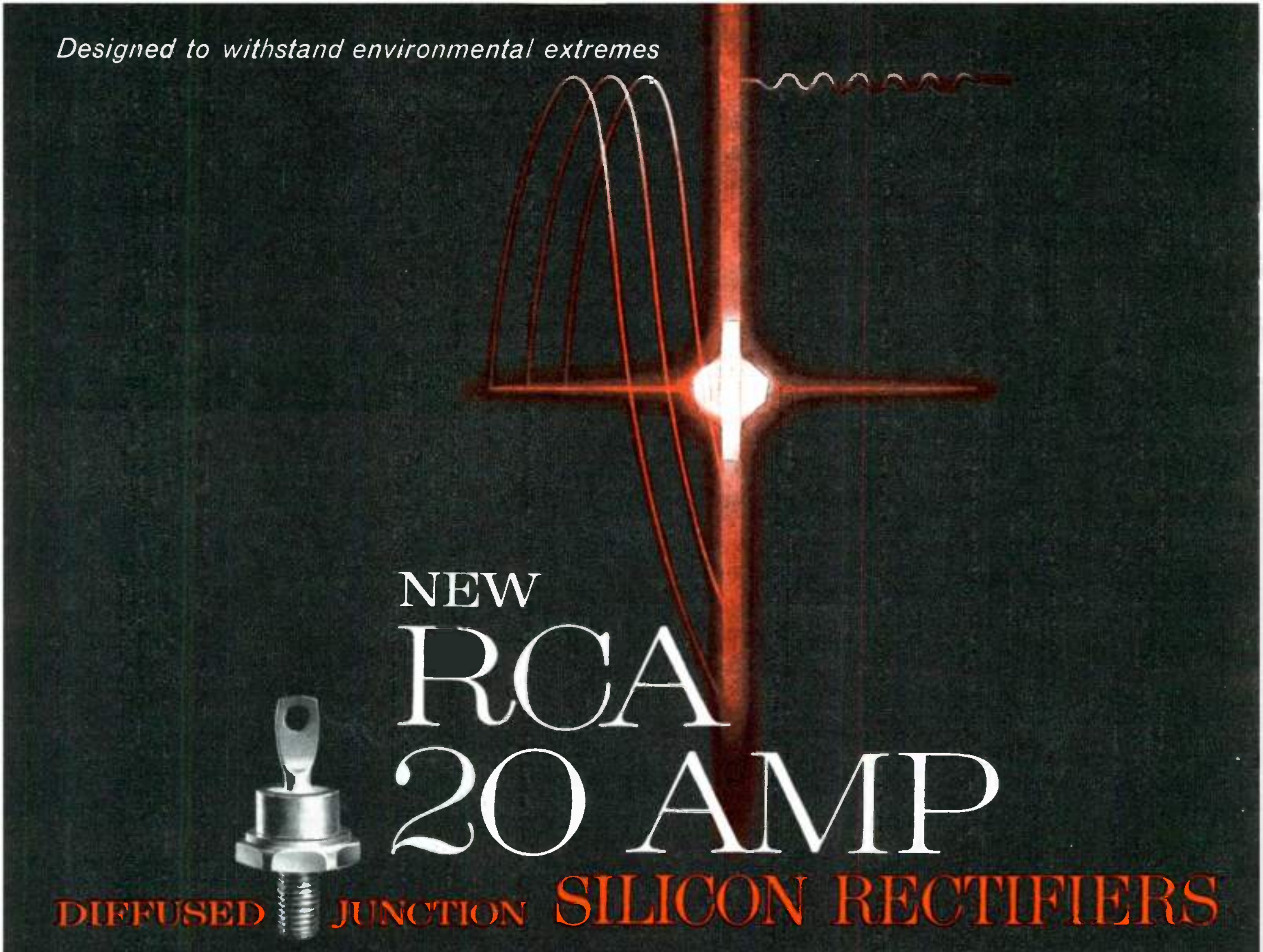
E. I. du Pont de Nemours & Co., Inc., "Freon" Products Div., Booths 4319-4321
Wilmington 98, Del.

T. D. Johnson, J. C. Feldmann, C. Wirth III, E. J. Bennett, J. H. Dowling, F. B. Hill, F. R. Zumbro, P. V. Ricciardi, J. C. Dilts

"Freon" safe solvents for electrical, electronic and precision components and complete assemblies. "Freon"-TF, "Freon"-BF, "Freon"-PC, "Freon"-MF.

(Continued on page 232A)

Be sure to visit
all four floors!
Every one of the more than
800 Radio Engineering Show Exhibitors
has at least one new idea to offer you.



Now, new improved 20-amp RCA Silicon Diffused-Junction Rectifiers, completely interchangeable with all prototypes, are ready to bring you these important advantages:

- **350 amp peak surge-current.**
- **Lower leakage rating** than prototypes.
- **High Output Current:** Up to 84 Amperes—6 rectifiers in 3-phase, full-wave bridge circuit; 60 Amperes—4 rectifiers in single-phase full-wave bridge circuit.
- **Diffused-Junction** Flat junction assures uniform dissipation over rectifying area.
- **Operation Rating**—All types can be used at maximum rated voltage and current with full assurance of reliability.
- **Specially designed copper-alloy stud** provides strength of steel and thermal conductivity of copper.
- **RCA Quality Throughout**—Hermetic seal, welded construction, extra heavy terminal lug, 100% testing—all of these features help to give these new 20-amp silicon rectifiers the ruggedness and reliability necessary to meet environmental extremes.

Call your RCA representative today for complete information on these new types. For further technical details write RCA Semiconductor and Materials Division, Commercial Engineering, Section C-35-NN, Somerville, N. J.

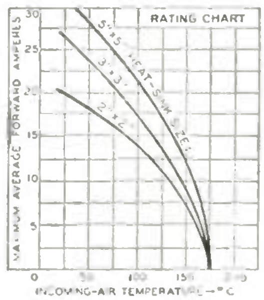
Available Through Your RCA Distributor

New RCA 20-Amp Diffused-Junction Silicon Rectifiers

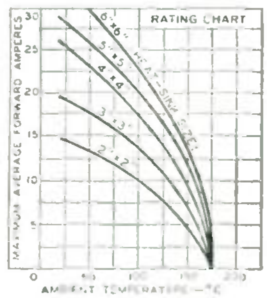
	Maximum Ratings ●			Characteristics at 150°C Case Temperature	
TYPES	PIV	Average Amperes @ 150°C Case Temp.	Peak Surge Amperes ▲	Max Reverse Milliamperes ■	Max Forward Voltage Drop (volts) ■
1N248C	55	20	350	3.8	0.6
1N249C	110	20	350	3.6	0.6
1N250C	220	20	350	3.4	0.6
1N1195A	300	20	350	3.2	0.6
1N1196A	400	20	350	2.5	0.6
1N1197A	500	20	350	2.2	0.6
1N1198A	600	20	350	1.5	0.6

▲ For One-Half Cycle.
● For 60 cps, single-phase operation, resistive or inductive load.
■ At Maximum Forward Current and Peak Inverse Voltage Ratings, and averaged over one complete cycle.

Reverse-Polarity Versions: 1N248RC, 2N249RC, 1N250RC, 1N1195RA, 1N1196RA 1N1197RA, 1N1198RA



Forced-air cooling: Air velocity = 1000 feet per minute parallel to plane of heat sink.
Single-phase operation.
Rectifier type is stud-mounted directly on heat sink. Heat sink: 1/16"-thick copper with a mat black surface and thermal emissivity of 0.9.



Natural cooling.
Single-phase operation.
Rectifier type is stud-mounted directly on heat sink.
Heat sink: 1/16"-thick copper with a mat black surface and thermal emissivity of 0.9.

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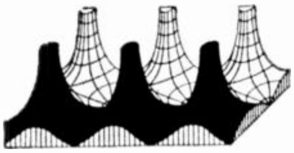
March, 1961
Vol. 49 *No. 3*

Proceedings of the IRE

Poles and Zeros



Collaboration Clarification. Cleverly conceived concepts can be carelessly confused by excessive attempts at clarity. The Editor learned this lesson from the Poles and Zeros item "Collaboration" (January, 1961). In commenting on the IRE-AIEE agreement concerning reciprocal membership privileges the Poles and Zeros item stated that the action of the Boards of the two societies applied *only* to the three grades of membership shown in the table accompanying the item. Immediately the question of the Fellow grade arose; since Fellow grade is an honor conferred by the society and is not, therefore, available by application in either IRE or AIEE, it should be self-evident that the Fellow grade is not subject to reciprocity. On the other hand, the intent of the agreement was that a Fellow in either society should have the right of joining the other society at any grade of his choice below that of Fellow. (Is it necessary to say that a Fellow could not choose Student grade?)

Clarification of one other aspect of this membership arrangement is herewith provided. IRE uses the designation of "Life Member" and AIEE, the designation of "Member for Life." In each case provision is made for exemption from further dues in recognition of 35 years of dues paying association with the society. It should not be difficult to understand that this privilege is not a part of the reciprocal membership agreement. The Editor sincerely hopes that there now exists a clear picture of the all facets of this historical cooperative plan.

"New Idea." The general theme of the IRE Show for 1961 is "For That New Idea, Visit The IRE Show." The show, held each year in connection with the Convention, has truly marched along. Its route has taken it through hotel ballrooms, Grand Central Palace, and the Kingsbridge Armory to its present home in the New York Coliseum. During its march it has continually demonstrated the phenomenal growth of the electronics industry. This industry, perhaps more than any other, has depended on "New Ideas" and has profited from a continuing flow from the minds and hands of the members of IRE. This year's show will be no exception, anticipating 70,000 visitors to witness the new ideas set forth in 850 exhibits.

If one has never been involved in exhibiting at an IRE Show, the amazing amount of work and the fascinating complications of setting up 850 exhibits may never have been thought of as the organizational triumph that it actually is. To give our readers an appreciation of the details of the organization of the IRE Show, the Managing Editor has prepared an interesting story which is presented in this issue. The success of last year's Show was recognized by the management of the Coliseum. On its behalf, U. S. Senator Jacob Javits presented to Executive Secretary George Bailey, representing IRE, a silver bowl inscribed "1960 New York Coliseum Award for the Outstanding Scientific and Technical Show Presented to the IRE Radio Engineering Show."

The IRE International Convention also carries the "New Idea" theme. The Tuesday evening Panel Session treats the subject "New Energy Sources." The panel will discuss thermoelectricity, magnetohydrodynamics, thermionic converters, fuel cells, and solar energy. It will also discuss the Russian thermoelectricity program and the status of new energy sources in Europe. The subject matter presages a stimulating and provocative evening.

A number of other sessions, of the total of 54, emphasize new ideas. "This World and the Adjacent One" presents, among others, three papers bearing on lunar exploration. "Broadening Device Horizons" deals with the frontier areas of optical maser and devices for the microwave-infrared gap and the rapidly expanding field of solid state devices. The sessions "Radar" and "Space Communications Systems of the Future" are among the others that treat new and challenging ideas. Examination of the 1961 program reveals that once again the Convention will provide a tasty bill of fare. See you there!

Switzerland and Chile. The internationality of IRE is emphasized again in the formation of IRE sections in Switzerland and Chile. The Geneva Section, number 109, and the Chile Section, number 110, were both recently approved by the Executive Committee. A cordial welcome is extended to these new sections. Best wishes for their growth and development.

New Faces of 1961. (Not the name of a Broadway show to your Editor.) Have you noticed the changes in IRE officers and directors that took place as of January 1, 1961? The names of new officers and directors were listed for the first time in the February issue of the PROCEEDINGS—see the masthead. They will be found in the same place throughout the succeeding eleven issues of the PROCEEDINGS. The new faces will appear as frontispieces during the year.

Awards. One of the highlights of the International Convention is the presentation of IRE awards at the Annual Banquet to outstanding leaders in our field. This year a new award is making its appearance, the Professional Group on Bio-Medical Electronics Prize Award in Memory of William J. Morlock. It will be presented for the first time at the 1961 Annual Banquet on the 22nd of this month. In future years it will be presented at a time and place selected by the Professional Group with the approval of the Executive Committee. This same pattern of presentation will be followed as future Professional Group Prize Awards are established.—F. H., Jr.

Ralph Bown

Winner of IRE Founders Award

Dr. Ralph Bown (M'22–F'25) (L) completed a career of 37 years with the Bell System when he retired from the Laboratories on March 1, 1956. Since March, 1954, he had served the Laboratories as Vice President in charge of patent activities and of long-range planning of programs. Previously, he had been Vice President in charge of research.

Much of Dr. Bown's technical work has been concerned with various aspects of radio broadcasting and overseas telephony and microwave radio relay systems. He directed the entire New York-Boston radio relay project, opened for experimental service in November, 1947, which was the first link in the transcontinental radio relay system.

A native of Fairport, N. Y., he received the Mechanical Engineering, Master of Mechanical Engineering, and Doctor of Philosophy degrees from Cornell University, Ithaca, N. Y. After serving as a Captain in the Signal Corps during World War I, he began his telephone career in 1919 with the Development and Research Department of the American Telephone and Telegraph Company. There he specialized in various aspects of radio broadcasting, and ship-to-shore and overseas telephony.

In 1934 he was appointed Assistant Director of Radio Research at Bell Laboratories, Director of Radio and Television Research in 1936 and, in 1944, Assistant Director of Research. In 1946 he became Director of Research, and, in 1951, Vice President in charge of research.

During World War II he served as a division member of and consultant to the National Defense Research Committee, specializing in radar, and in 1941 he visited England to study operations under combat conditions. He also served as expert consultant to the Secretary of War.

In November, 1955, he was appointed Chairman of the U. S. Patent Office Advisory Committee. He was also Chairman of a technical advisory committee on electricity and electronics to the National Bureau of Standards, and a member of the Army Scientific Advisory Panel.

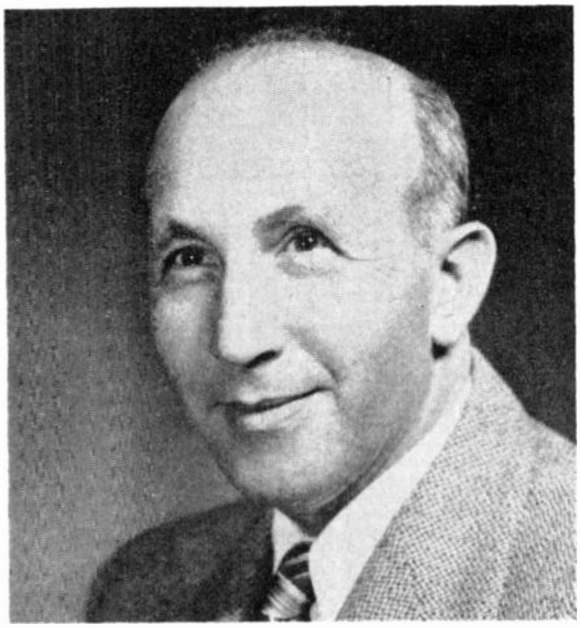
He is a member and past Chairman of the Joint Technical Advisory Committee and a Fellow of the American Association for the Advancement of Science, the Acoustical Society of America, the American Physical Society, and the American Institute of Electrical Engineers.

He was awarded the 1926 Morris Liebmann Memorial Prize by the IRE for his distinguished researches into wave transmission phenomena. He served as President of the IRE in 1927, and in 1949 received the Institute's Annual Medal of Honor for his leadership in Institute affairs and for his extensive contributions to the field of radio.

Dr. Bown is now associated with N. W. Ayer & Son Advertising Agency as a public relations consultant in the scientific field.

Ernst A. Guillemin

Winner of IRE Medal of Honor



Dr. Ernst A. Guillemin (A'41–SM'48–F'49) was born in Milwaukee, Wis., on May 8, 1898. He received the B.S. degree in 1922 from the University of Wisconsin, Madison, and the S. M. degree in 1924 from the Massachusetts Institute of Technology, Cambridge, both in electrical engineering. In 1926, he received the doctor's degree from the University of Munich, Germany, on the Saltonstall Traveling Fellowship. He returned to M.I.T. as an instructor, becoming Assistant Professor in 1928, Associate Professor in 1936, and Professor of Electrical Communications in 1944.

In 1940, he was appointed consultant to the Microwave Committee of the NDRC. In this capacity he devoted approximately half of his time to consultation with various groups in the Radiation Laboratory, M.I.T., on problems dealing with the design of electrical networks for special applications. In 1941, he took over the administrative responsibilities of the Communications Option, Department of Electrical Engineering, at M.I.T. He was appointed to the Edwin Sibley Webster Chair of Electrical Engineering in 1960.

In 1948, he was awarded the President's Certificate of Merit for his outstanding wartime contributions. He is the author of the volumes, "Communications Networks," "Introductory Circuit Theory," "Synthesis of Passive Networks," and a reference work entitled, "The Mathematics of Circuit Analysis."

Dr. Guillemin is a member of the American Society of Electrical Engineers and a Fellow of the American Institute of Electrical Engineers and the American Academy of Arts and Sciences.

Scanning the Issue

Date Line, New York Coliseum (p. 565)—The experience of a visitor to the IRE International Convention is much like that of a theater-goer on opening night. He witnesses an important event first hand and is rewarded by the personal impact which the performance has on him. But like the theatergoer he sees only what is in front of the curtain, not behind it. Since most convention attendees do not have an opportunity to see what goes on behind the scenes, an attempt has been made in this brief article to provide a view of the coming convention "from the wings." The reader is shown some of the things that will be visible from the audience and a number of things that won't. He will find that the 1961 IRE International Convention, which opens March 20th, is an event of major proportions; that it requires nearly 200 people to plan it, 3000 to set it up, and 6000 to operate it; that it will leave its impact on a world-wide audience of 70,000; and, most important of all, that it is an event no one in the electronics field can afford to miss.

Selective Erasure and Nonstorage Writing in Direct-View Halftone Storage Tubes (Lehrer, p. 567)—The ability of storage tubes to retain cathode-ray information longer and at brighter levels than can cathode-ray tubes makes them especially well suited for certain types of radar displays such as PPI presentations. This paper deals with a new type of storage tube which, because of its unique display capabilities, has a substantially wider range of applications. Unlike conventional storage tubes, the new tube makes it possible to erase a selected portion of the display without disturbing the rest of the display. The new tube can also simultaneously display stored and unstored information. In other words, cathode-ray information can be added to the display without disturbing other information already stored on the screen. This striking array of capabilities and the novel dual-effect screen which makes it possible will be of interest to a substantial number of readers.

Cross-Relaxation Masers (Bogle, p. 573)—Maser action was originally pictured as involving two types of energy-level transitions in which paramagnetic ions exchange energy with the electromagnetic field in one case, and with the lattice thermal vibrations in the other. This paper deals with a third type of transition which has come to light more recently. Called cross relaxation, this type involves the direct exchange of energy between neighboring paramagnetic ions. The author begins by giving an excellent survey of the state of the art of maser theory and goes on to reveal the highly significant consequences which result when cross-relaxation effects are taken into account. He shows, for example, that cross-relaxation processes explain why *L*-band ruby masers perform so well in high magnetic fields and so poorly in low fields. More important, he shows that the performance of masers can be substantially improved when proper advantage is taken of cross relaxation, even in the case of the low-field mode. It is shown that, as good as ruby is, a three-fold improvement or more should be possible with spinel, rutile and emerald. Also included are valuable formulas for assessing other new and promising maser materials.

Traveling-Wave Parametric Amplifier Analysis Using Difference Equations (Zucker, p. 591)—The recent widespread interest in parametric amplifiers has been marked by a particular interest in those of the distributed type. The chief advantage of this type of amplifier is the much wider bandwidth that can be obtained in comparison to the single-tuned amplifier. Previous analyses of distributed parametric amplifiers have been based on the assumption that only two frequencies, the idler and pump frequencies, need to be considered. However, recent work has shown that the higher frequency signals which are generated are of sufficient magnitude that they cannot be neglected. This paper derives a second-order difference equation which makes it possible to analyze amplifiers of this type, whatever number of frequencies need be considered.

IRE Standards on Video Techniques: Measurement of Resolution of Camera Systems (p. 599)—One of the major characteristics of a television system affecting over-all picture quality is the ability of the system to reproduce fine detail found in the original image. This ability to resolve detail is determined by a number of factors, such as the number of scanning lines employed, the frame repetition rate, and the over-all response of the electrical circuits. Performance of the optical imaging device, the camera tube, and the reproducing device also has considerable influence on the ability of the system to resolve detail. A satisfactory method for measuring this characteristic is therefore of utmost importance. Methods for measuring resolution were first standardized by the IRE in 1950. The progress of the past decade has made it necessary to revise the 1950 Standard and has led to the issuance of this new Standard to replace it.

Effects of Electrons and Holes on the Transition Layer Characteristics of Linearly Graded *P-N* Junctions (Sah, p. 603)—The characteristics of *p-n* junctions were first analyzed over a decade ago and have been studied by many authors since, so that today the major features of junction theory have for the most part come to be clearly discernible and quite accurately charted. However, the regions surrounding and underlying these promontories of knowledge are not everywhere distinct and are still undergoing exploration. This paper investigates one such unmapped area, namely, the free electron and hole charges in the transition region of graded junctions. The effect of these charges has been neglected in previous standard treatments, a simplification which is fully justified in the case of reverse-biased junctions. For forward-bias conditions, however, these effects become quite significant. By formulating a method of taking these effects into account, the authors have made a noteworthy extension of junction theory into a previously uncharted region that is of substantial interest to semiconductor device engineers.

IRE Standards on Electrostatographic Devices (p. 619)—This Standard deals with a relatively new field, electrostatography, which is defined as the formation and utilization of latent electrostatic charge patterns for the purpose of recording and reproducing patterns in visible form. Electrostatic charge patterns can be formed by either photoresponsive mediums or insulating mediums, giving rise to such terms as electrostatic electrophotography and electrostatic electrography and to sub-categories such as xerography, xeroradiography, and electrographic recording. This Standard clarifies the relationships within this somewhat confusing family of like-sounding terms by providing a family tree and an accompanying set of clear-cut definitions.

IRE International Convention and IRE Show—March 20 through 23 will be a busy as well as fruitful time for the 70,000 visitors to the 1961 IRE International Convention. Some of the things they will see and hear have been briefly outlined in the first article in this issue, as noted above. In addition, this issue contains the complete convention program (p. 652) and listing of exhibitors and their products (in the advertising section). The convention program itemizes the major events, gives the schedule of technical sessions, and provides 100-word abstracts of the 265 papers to be presented. The exhibits information given in "Whom and What to See at the IRE Show" is listed 1) alphabetically by exhibitor, 2) numerically by booth number, and 3) according to technical fields of interest. Readers will get much more out of the convention if they study these listings and plan their daily schedules in advance.

Date Line, New York Coliseum

(Special to the PROCEEDINGS OF THE IRE*)*

TUESDAY, MARCH 14—Reports of unusual activity have been received today from all over the world. In at least 40 countries abroad more than 1000 engineers and scientists have been observed making urgent preparations for a long and important journey. Their destination: New York. Their quest: new ideas.

Similar activity, on even a larger scale, has been noted in the United States. Great fleets of trucks were seen moving eastward this morning on scores of highways throughout the country. They are about to be followed by planes, trains, buses, cars—enough to transport 70,000 people—from virtually every major city in the land. Their destination: again, New York. Their quest: new ideas.

A great event is about to occur. The 1961 IRE International Convention.

WEDNESDAY, MARCH 15—The vanguard of a giant caravan of trucks began pouring into New York City last night from every part of the country. By 6 o'clock this morning these fourteen-wheel monsters were backed up nearly half a mile outside the Coliseum, waiting to disgorge hundreds upon hundreds of boxes.

All day the boxes have been streaming into the mammoth Coliseum. Inside, your reporter saw an awesome 3000-man army of movers, riggers, carpenters, iron workers, painters, and electricians begin the task of unpacking and setting up four floors of exhibits. Their movements are controlled by platoons of supervisors and messengers who keep in contact with each other and with a central command post by pocket radio. Fast communication is essential for this complex operation. The pocket radios are a relatively new addition; they replace messengers who were mounted, believe it or not, on bicycles and roller skates.

By late tonight, over 100 trucks will have filed to the loading platform, been unloaded and sent on their way. Tomorrow morning the line of waiting trucks will still be a half-mile long. In fact, the unloading process will continue at the rate of over 100 trucks a day for four more days before the seemingly endless stream ceases. Finally, by Sunday night, a four-mile line of trucks will be empty and the unpacking of 20,000 boxes will be completed. Only then will the world's largest technical convention and exhibit be ready to open its doors.

SUNDAY, MARCH 19—Preparations for the IRE Show, which opens here tomorrow, finally drew to a close this evening after five days of feverish activity at the Coliseum. The exhibits are fully assembled, all two and a quarter miles of them. A vast array of electrical wires is now hooked up to the exhibits, ready to feed them the one and a half million watts of power they will require. Three lecture halls with a total of 1500 seats have been built, as well as registration facilities capable of handling 70,000 visitors. The 6000 exhibit personnel required to man the booths have already registered. Seven acres of floor space are now completely filled with 25,000 items of electronic equipment. According to a Coliseum official, more equipment has been moved in for the IRE Show than for any other exhibition in New York.

Today was also the scene of much activity at the Waldorf-Astoria Hotel, a few blocks away, as the work of setting up five more lecture halls, convention headquarters, and 60 feet of registration desks neared completion. What is not visible is the seven months of hard work which 175 volunteer committee members spent in planning and making arrangements for the technical program, banquet, cocktail party, facilities, registration, publicity, and so on ad infinitum.

Many of the expected 70,000 attendees have already arrived in New York. According to a convention spokesman, by late tonight IRE convention visitors will have filled 70 Manhattan hotels.

MONDAY, MARCH 20—The Waldorf-Astoria Hotel and New York Coliseum began registering the first of an expected 70,000 engineers and scientists at 9 A.M. this morning as the 1961 IRE International Convention began its four-day program of technical meetings and exhibits. The IRE Show at the Coliseum opened its doors at 9:45 A.M., while the technical sessions started at 2:30 P.M. with five sessions at the Waldorf and three at the Coliseum.

Your reporter, upon entering the first session on the schedule, found himself in a large auditorium seating 500 persons. It was a pleasure to find that the session started exactly on schedule and that the auditorium was very well equipped; even the public address system worked. We learned from confidential sources, though, that on one occasion several years ago the PA system went dead as a doornail during the middle of a talk. It was a bitter moment for the 500 radio engineers in the audience, caught as it were with their communications down. But they certainly redeemed themselves and covered their profession with glory. For when a repair crew came dashing to the scene a few minutes later, they found to their astonishment that the PA system had already been fixed—by the audience, no less.

The papers presented this afternoon were only the first in an impressive program of 265 papers in 54 sessions ranging over every aspect of electronics and communications progress. The highlight of the program will be a special session tomorrow evening on "New Energy Sources" in the Grand Ballroom of the Waldorf. All told, the 265 papers to be presented might be likened to an enormous data-processing machine whose four-day output will measure no less than 10 million "bits" of information.

After the first session was over, your reporter went to the reservations desk to pick up his ticket for the cocktail party, which was to start at 5:30, and his reserve ticket for the IRE annual banquet on Wednesday evening. It was fortunate we made our reservations in advance because these social events are proving very popular. The cocktail party provides an excellent opportunity to see old friends and meet new ones, while the banquet is in many respects the climax, not only of the convention, but of the entire year. It is at this time that the leading contributors to the progress of the electronics profession are annually singled out for recognition by the IRE in an impressive awards ceremony. The highlight of the banquet will be an address by Patrick E. Haggerty, president of Texas Instruments, Inc., on the subject, "Where Are the Uncommon Men?"

The most popular spots at the convention, aside from the exhibit and session halls, are the Hospitality Desk at the Waldorf and the Information Desk at the Coliseum. Both centers did a land-office business throughout the day, helping visitors with a myriad of unusual questions and problems. During one 20-minute period your eavesdropping reporter overheard visitors asking the Hospitality Committee to aid in everything from getting a baby sitter to finding a lost wife. On one occasion an irate man stormed up to the desk and shouted, "I'm a member of the IRE and I'd like to know what you're going to do about this." And with those words he slapped down a parking ticket. It was the only time we saw the Committee stumped.

We haven't seen all the IRE Show yet, and while the exhibits are open until 9 tonight, as they are every night, we plan to put it off till tomorrow morning, when we are fresh.

From what we have seen, though, the IRE Show is simply fabulous. Besides being the largest engineering exhibit in the world, its opening marks the beginning of the year for the electronics industry. Almost every major manufacturer has planned his operations around this event so that his new products will be ready to be announced and displayed for the first time at this show.

There is much to see—10 million dollars worth of equipment filling all four floors of the Coliseum. When you are finished you will have seen the newest products of 850 exhibitors who represent 80 per cent of the entire production capacity of the electronics industry. Yet despite its size, the show is not so big that you can't see all that you want to see, especially if you follow some simple pointers.

First of all, it is well to remember that the IRE Show is essentially three shows in one, with the first two floors devoted exclusively to components, the third floor to completed equipment, and the fourth floor to fabrication and materials. This arrangement makes it easy to find the exhibits you are most interested in with a minimum amount of walking.

Second of all, you will get much more out of the show if you plan to make at least two visits, covering all four floors on the first trip, and then returning to spend more time on the exhibits you are particularly interested in. Your first trip will be easier for you if you start on the top floor and work your way down.

We have no idea of what we are going to see tomorrow. Nobody ever knows until well after the show has opened. We are likely to see anything from a fully instrumented missile to a cane being balanced on a movable table controlled by a computer. Incidentally, we have been told that after the show closes each night, many of the computers on display are made to earn their keep by solving various scientific problems until the wee hours of the morning.

It is reported that one year an exhibitor displayed a revolutionary lipstick radio, and when the press got wind of it 30 members of the exhibit manager's staff went crazy trying to find it for them. It was so small, it took them two days to locate the tiny item. It was finally found by a woman, and when she was asked how she had succeeded where so many had failed, she nonchalantly replied, "Oh, it was easy. I just asked myself, if I were a lipstick where would I be hiding. And sure enough, that's just where I found it."

Perhaps the greatest compliment ever payed to the IRE Show occurred in 1956, when two successive snowstorms left New York paralyzed by 18 inches of snow on the opening morning of the convention. The snow was so bad that it took one IRE Director longer to get from Idlewild Airport to the Waldorf than from Dallas, Texas, to Idlewild. Yet somehow 10,000 people fought their way through the drifts to the Kingsbridge Armory in the distant reaches of the Bronx, where the show was then located, to be on hand when the doors opened at 10 A.M.

Besides indicating that he is wearing a comfortable pair of shoes, there is very little else this correspondent can report to his readers. The rest is up to you. You have before you a host of important technical papers on virtually any and every topic. You have the fabulous IRE Show, a place where you can learn more about the electronics industry in four hours than you otherwise could in four months, or probably four years.

Perhaps most important of all, you and 70,000 others like you have one other thing to see—each other. The value of meeting in person other engineers is immeasurable, and the opportunities for it at the convention are limitless.

Many rich rewards await you at the 1961 IRE International Convention. But they cannot be had by staying home and reading about them.

—*The Managing Editor*

Selective Erasure and Nonstorage Writing in Direct-View Halftone Storage Tubes*

N. H. LEHRER†, MEMBER, IRE

Summary—A new type of direct-view halftone storage tube that can selectively erase as well as simultaneously display stored and nonstored information has been developed. Heretofore, incorporation of these features into direct-view halftone storage tubes has proved impractical because of the nature of the secondary-emission effect on which the writing and erasing of stored information depend. In this new tube, this limitation is overcome by the use of a dual-effects target. One effect, secondary emission, charges the storage surface positively, while the other, bombardment-induced conductivity, charges it toward the backing-electrode potential, wihch in this case is negative. Selection of the effect and, consequently, the charging direction, is determined by the incident beam energy. At low energies secondary emission predominates and the target is written on, *i.e.*, charged positively. At high energies, the bombardment-induced conductivity prevails and the target is erased, *i.e.*, the positively charged areas are discharged. The two effects cancel at an appropriate intermediate beam energy, thus permitting presentation of nonstored information without otherwise disturbing the display, by means of that portion of the beam current which passes through the backing electrode and strikes the viewing screen.

A 5-inch, direct-view halftone storage tube that utilizes such a dual-effects target is described. At writing speeds between 10,000 and 15,000 inches per second, the stored resolution is 40 to 50 lines per inch. At erase speeds between 30,000 and 40,000 inches per second, the stored resolution is 100 to 120 lines per inch. Stored and nonstored information can be displayed simultaneously; the stored information may be retained for one minute or more.

With this selective-erasure, direct-view halftone storage tube, new kinds of displays are feasible. For example, in any application it is now possible to erase selectively immediately preceding the writing beam scan, thereby retaining the stored signals at maximum brightness in any region until just before that region is rescanned by the writing beam. Almost the entire display is constantly maintained at full signal brightness and therefore can be viewed under optimum conditions. In contrast, the brightness of the stored information in both cathode-ray and conventional direct-view halftone storage tubes normally starts to decay immediately after the information is written.

Introduction

Conventional direct-view halftone storage tubes, such as the Tonotron,[1] can retain cathode-ray information at brightness levels substantially greater than those achieved with cathode-ray tubes; typically, the light output of long-persistence cathode-ray screens is only a few foot-lamberts as compared with thousands of foot-lamberts for storage tubes. Since the retention time of storage tubes can be varied over wide limits, these tubes are well suited for particular types of radar displays such as PPI presentations. The inflexibility of the retention feature, however, presents a problem in utilizing these tubes for certain other applications. For example, it is not possible to control the retention time of a region independently of the entire display as is necessary for selective erasure (the ability to rapidly erase one or more of the smallest written elements as opposed to erasing the entire display). Also, conventional storage tubes cannot be used for applications that require the simultaneous display of stored and nonstored information. Nonstored information may be defined as the presentation of cathode-ray information on the viewing screen without otherwise disturbing the written or erased areas.

The basic principles and detailed operation of these conventional direct-view halftone storage tubes are described in the literature.[2] Briefly, the limitations on their performance can be understood by considering the requirements that must be met: first, for selective (high-resolution) erasure, and second, for the simultaneous display of stored and nonstored information.

With regard to the selective-erasure requirements, a high erase-beam energy is needed to focus the beam into a fine spot. Also, the erasure process which discharges the storage-surface potential must be capable of discharging all erased regions to the same predetermined potential. This requirement must be met if the tube is to exhibit uniform writing characteristics; otherwise, equal writing-gun signals will not exhibit the same stored brightness everywhere on the viewing screen.

The simultaneous display of stored and nonstored information requires the use of a cathode-ray beam that has no charging effect on the written or erased areas of the display. The portion of the beam current that passes through the backing electrode to strike the viewing screen can then be used to present nonstored information without otherwise affecting the written or erased areas of the display.

For conventional direct-view halftone storage tubes which depend on secondary-emission charging effects for writing and erasing, selective erasure at beam energies beyond the second crossover seems promising on first consideration. In practice, however, several obstacles are encountered when this process is used to erase. Since the second crossover potential may be as high as 25 kv for some materials, deflection and insulation problems arise. The erasure process is slow because

* Received by the IRE, June 26, 1960; revised manuscript received, December 16, 1960.

† Hughes Res. Labs., a Div. of Hughes Aircraft Co., Malibu, Calif.

[1] Tonotron is a trademark of the Hughes Aircraft Co.

[2] M. Knoll and B. Kazan, "Advances in Electronics," Academic Press, Inc., New York, N. Y., vol. VIII, p. 447; 1956.

the secondary-emission ratio is close to unity just beyond the second crossover. Furthermore, since the secondary-emission ratio curve is quite flat in the region of the second crossover, the inherent nonuniformities in the process are substantial, *i.e.*, small changes in the secondary-emission ratio produce large changes in the charging characteristics of the surface. For example, the value of the second crossover may vary as much as several hundred volts or more across the surface of the dielectric and may actually shift under bombardment; hence, grossly nonuniform erasue results.[3] Similar objections concerning uniformity can be cited with regard to the simultaneous presentation of stored and nonstored information.

The nature of the secondary-emission effect, therefore, makes impractical both rapid high-resolution selective erasure and the simultaneous display of stored and nonstored information. The problem encountered here is, essentially, that negative charging at high beam energies cannot be effected uniformly with secondary-emission effects. The following discussion will demonstrate how to overcome this difficulty by utilizing bombardment-induced conductivity.

Bombardment-Induced Conductivity

Bombardment-induced conductivity may be defined as the ability of thin insulating films to conduct when they are subjected to bombardment by high-energy beams of ionizing particles, such as electrons, neutrons, and alpha particles. Although this effect was noted more than thirty years ago, it has been only in the last decade that materials exhibiting substantial bombardment-induced-conductivity effects have been reported. Fig. 1, a representation of this effect, shows a thin insulating film deposited on a conductive backing electrode. A description of the operation of bombardment-induced conductivity is presented below.

Assume that there is a positive charge on the dielectric surface while the backing electrode is grounded. Then, if a primary current I_p bombards the target, a current I_c will flow through the bombarded region of the insulator. Under appropriate conditions, the value of the induced current may be many times that of the primary current; a figure of merit for the process is given by the conduction ratio C_R, which is defined as the ratio I_c/I_p. If the induced current is in the same direction as the primary current, *i.e.*, the backing electrode is positive with respect to the dielectric surface, then the conduction ratio is positive. The conduction ratio is negative if the induced current opposes the primary beam current, *i.e.*, the backing electrode is negative with respect to the dielectric surface as shown in Fig. 1. Various materials have been investigated and described in the literature.[4–6] Fig. 2 summarizes the results and shows the conduction ratio plotted as a function of the bombarding energy with the field across the dielectric E as the parameter.

The curves shown in Fig. 2 are for positive values of the conduction ratio only; the curves for the negative values are essentially the same.

The following is a simplified explanation of the bombardment-induced-conductivity effect: When a high-energy electron passes through an insulator, it ionizes atoms along its path. Some of the low-energy electrons are thus raised into the conduction band and leave behind positive holes. If these holes and electrons come under the influence of an applied field and if recombination or trapping does not occur, they will acquire velocities in the appropriate directions and will eventually reach the electrodes. Since an energy of only about 5 ev is required for the production of an ion pair, large numbers of pairs may be generated by high-energy electrons. The maximum gain, according to one theory,

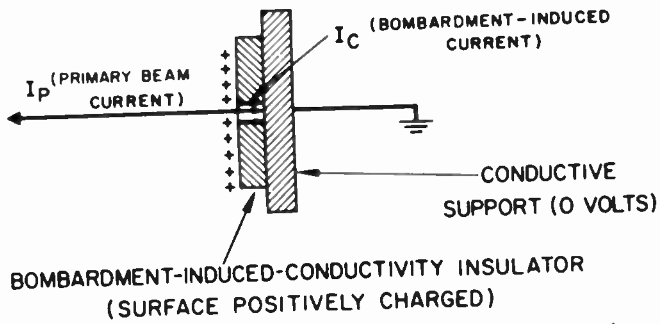


Fig. 1—Pictorial representation of bombardment-induced conductivity in a thin insulating film.

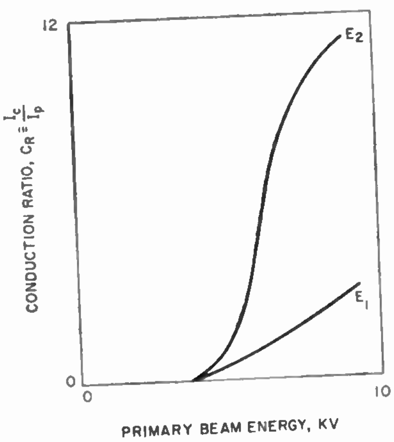


Fig. 2—Typical curves of bombardment-induced conductivity.

[3] *Ibid.*, p. 482.

[4] K. G. McKay, "Electron bombardment conductivity in diamonds," *Phys. Rev.*, vol. 74, pp. 1606–1621; December, 1948.

[5] L. Pensak, "Conductivity induced by electron bombardment in thin insulating films," *Phys. Rev.*, vol. 75, pp. 472–478; February, 1949.

[6] F. Ansbacher and W. Ehrenberg, "Electron-bombardment conductivity of dielectric films," *Proc. Phys. Soc.* (*London*) *A*, vol. 64, pp. 362–379; April, 1951.

will be equal to the number of pairs produced per primary electron. In practice, maximum gains far less and far greater than this value have been measured.

Bombardment-induced conductivity is important in storage-tube operation because it may be used to shift the surface potential of the dielectric. If the charges on the dielectric surface are not replaced, the surface potential will be conducted toward the backing-electrode potential by the currents induced in the dielectric. Since the conduction ratio diminishes with decreasing field, there is no danger of discharging past the backing-electrode potential. Small variations in the conduction ratio produce corresponding changes in the level to which the surface is discharged; however, these changes become less significant when they are compared with the total voltage change across the dielectric. Thus, the nonuniformities inherent in bombardment-induced conductivity discharging are substantially less than those encountered in discharging by the secondary-emission effect. It would therefore be advantageous to utilize a target which employs secondary emission to charge the storage surface positively and uses bombardment-induced conductivity to erase the charge. As will be shown in the following section, such a dual-effects target has many advantages over targets that discharge by the secondary-emission effect.

Dual-Effects Target

Fig. 3 is a schematic of the charging currents that occur when a dielectric film having secondary-emission and bombardment-induced conductivity properties is struck by a high-energy electron beam. Assume that the dielectric surface is charged positively with respect to the conductor. If the dielectric is treated as a series of elemental capacitors, the charging direction is determined by and the charging speed is proportional to the summation of all currents arriving at or leaving the surface of the element. If ΔV represents the change in voltage on the elemental surface of the dielectric during the time Δt, then the charging speed S is

$$S = \frac{\Delta V}{\Delta t} \sim \sum I_i = -I_p + I_s - I_c. \qquad (1)$$

where I_p is the primary current, I_s is the secondary current, and I_c is the bombardment-induced current. For secondary emission, where δ_e is the secondary-emission ratio,

$$|I_s| = \delta_e |I_p|. \qquad (2)$$

while for bombardment-induced conductivity,

$$|I_c| = C_R |I_p|. \qquad (3)$$

Substituting (2) and (3) in (1) yields

$$\frac{\Delta V}{\Delta t} \sim I_p(\delta_e - 1 - C_R). \qquad (4)$$

If the quantity inside the parentheses is positive, then positive charging, or writing, occurs; if it is negative, negative charging, or erasure, occurs; if it is zero, the storage-surface potential remains unchanged during bombardment. Both δ_e and C_R are functions of the primary beam energy V_p, as discussed previously. In Fig. 4, these functions are plotted with the primary beam energy as the common abscissa. The curve $(\delta_e - 1)$ in the positive region above the x axis represents the positive-charging contribution of secondary emission, while the curves for $(-C_R)$ located below the x axis indicate the negative-charging effects of bombardment-induced conductivity. The conduction ratio is plotted for two values of the field. Let us assume that the higher value of the field corresponds to the full-brightness condition of the storage dielectric, while the lower value corresponds to the cutoff potential.

Examination of Fig. 4 indicates that for the lower range of beam energies, the secondary-emission effect is at a maximum, while the bombardment-induced conductivity is negligible. These conditions are specified by

$$C_R \cong 0, \qquad \delta_e > 1. \qquad (5)$$

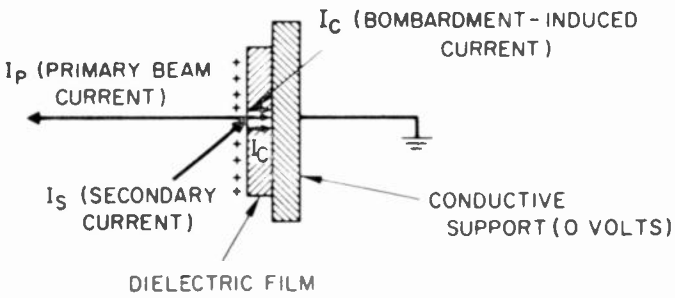


Fig. 3—Schematic of the charging currents for a dual-effects target when subjected to bombardment.

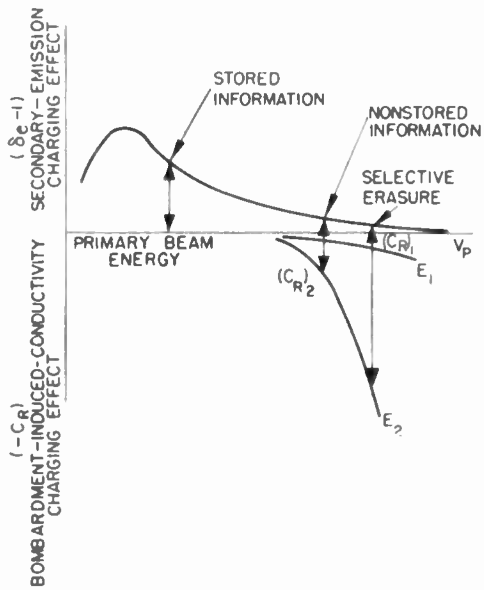


Fig. 4—Charging characteristics of a dual-effects storage target.

In this case,

$$S = \frac{\Delta V}{\Delta t} \sim I_p(\delta_e - 1). \tag{6}$$

Thus, in this energy region, the storage surface will be written on by secondary emission.

At the middle range of beam energies, the secondary-emission ratio diminishes while the conduction ratio increases and is approximately the same for both values of the field. At some value of the beam energy in this region, the two charging effects are of equal amplitude but of opposite sign. In this case,

$$\delta_e - 1 = C_R = (C_R)_1 \cong (C_R)_2; \tag{7}$$

consequently,

$$S = \frac{\Delta V}{\Delta t} \sim I_p(\delta_e - 1 - C_R) = 0. \tag{8}$$

When struck with an electron beam having this energy, the storage-surface potential will be undisturbed in both the written and the erased areas. The portion of the beam current that passes through the backing electrode to strike the viewing screen then serves to display nonstored information without otherwise disturbing the display.

At the higher range of beam energies, the secondary-emission ratio slowly approaches the second crossover, while the conduction ratio increases rapidly, particularly for the higher value of the field. In this case,

$$(C_R)_1 \gg \delta_e - 1. \tag{9}$$

Under these conditions, the bombardment-induced conductivity effect overrides the secondary-emission effect and erasure occurs. As the erasure process continues under sustained electron bombardment, the field across the dielectric is progressively reduced until, at some lower value of the field (closely approximating the cutoff potential of the storage surface), the conduction ratio is reduced to the point where

$$(C_R)_2 = \delta_e - 1. \tag{10}$$

Here the two charging effects cancel and, under bombardment, the storage surface is held at this reduced potential. In the higher-energy region adjacent to the second crossover potential, it is possible to erase to a point of equilibrium. Thus, with the dual-effects target, high-energy bombardment-induced-conductivity discharging is substituted for high-energy secondary-emission-effect discharging. The former technique involves discharging toward a fixed potential, and, consequently, the inherent nonuniformities are of the order of a few volts or less. This is in sharp contrast to high-energy secondary-emission effect discharging, where the nonuniformities are of the order of hundreds of volts or more.

The Bombardment-Induced Conductivity Selective-Erasure Tube

Fig. 5 is a schematic of a developmental five-inch, direct-view halftone storage tube that is capable of selective erasure as well as simultaneous presentation of stored and nonstored information. The components of this tube are essentially those of a conventional tube, with two important exceptions:

1) A high-energy erase gun that can erase selectively at a 6-kv negative cathode potential is added; when switched to -5 kv, it can be used for the presentation of nonstored information. If time sharing of a gun with respect to the various information is possible, then this gun may be omitted; and by appropriately switching the cathode potential, only one gun need be employed for writing, selective erasing, and displaying nonstored information.

2) A special storage target which exhibits the dual charging effects discussed in the previous section is used. In order to utilize the bombardment-induced conductivity discharging for erasure, the field across the dielectric must be of sufficient magnitude to permit the bombardment-induced conductivity effect to override the secondary emission until the storage surface is discharged past its cutoff potential. This means that the backing electrode must be operated at a more negative potential than the cutoff potential of the storage surface. Conventional tubes, in comparison, operate with the backing electrode sufficiently positive to permit the maximum amount of flood-gun current to reach the viewing screen at full brightness. These tubes typically employ mesh of 40 per cent transmission and 250 pitch. When such a mesh is operated at negative potentials of several volts, the viewing-screen current is completely cut off, as shown by the curve in Fig. 6. Essentially, the difficulty in obtaining fuller utilization of the flood-gun current, and therefore greater luminance at a particular value of the viewing-screen voltage, is that the backing electrode too effectively masks the flood electrons from the viewing-screen field. A higher transmission mesh of the same pitch does reduce the masking, but with the penalty of degraded resolution due to overlapping of the storage elements at the viewing screen. Although greater transmission of the current to the viewing screen can be theoretically achieved at higher viewing-screen fields, in practice, 25 to 30 kv/cm is found to be the limiting field because of arcing between the electrodes. These limitations on transmission and viewing-screen field do not make operation at negative backing-electrode potentials impractical. Examination of Fig. 6 indicates that operation at up to -7 volts on the backing electrode is possible at 300- to 400-fl luminance.

The storage operation is the same as that of a conventional tube. The erasure process can be accomplished by either or both of two methods. The entire display

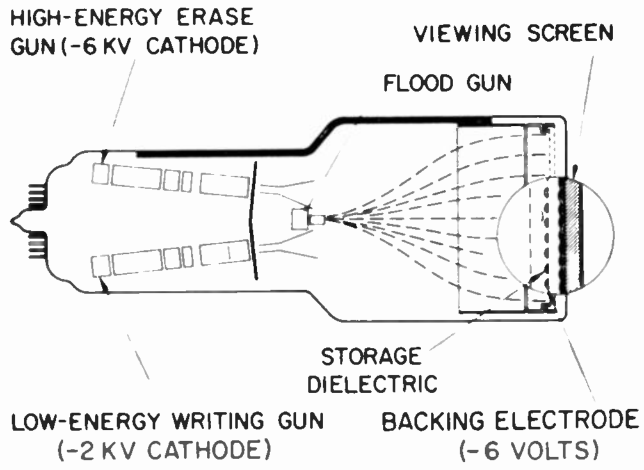


Fig. 5—Schematic of a bombardment-induced conductivity selective-erasure direct-view halftone storage tube.

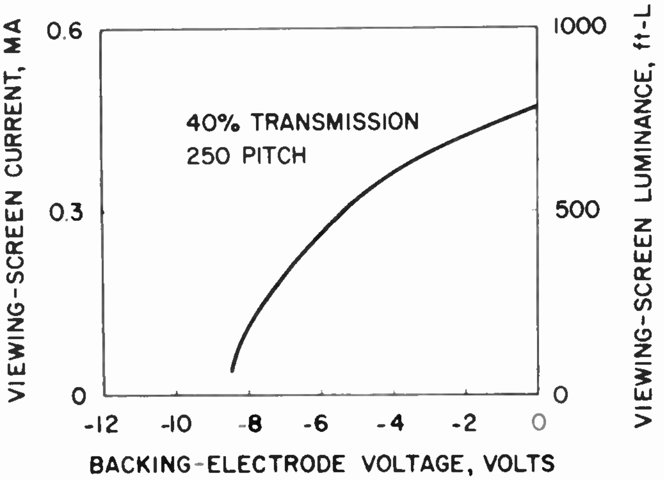


Fig. 6—Viewing-screen luminance as a function of backing-electrode potential. Storage-surface potential = 0; viewing-screen field = 22 kv/cm; collecting field = 380 volts/cm.

may be slowly erased with the flood gun by pulsing the backing electrode, as in conventional tubes. Partial or complete erasure of one or more of the smallest written elements with the 6-kv erase beam can be accomplished simultaneously with or independently of erasure by the flood gun. Nonstored information may be displayed at any time with the erase gun by switching its cathode to −5 kv.

In Fig. 7 performance data are given for a developmental 5-inch tube using a dual-effects target. The upper graph is a plot of linear charging speed and polarity as a function of storage-surface potential. Linear charging speed may be defined as the scanning rate at which the storage-surface potential is charged or discharged by 1 volt. The writing speed represents the average positive linear charging speed divided by the number of volts that the storage surface must be charged to carry it from its erased condition to full brightness (which is 4 volts in this case). The erase

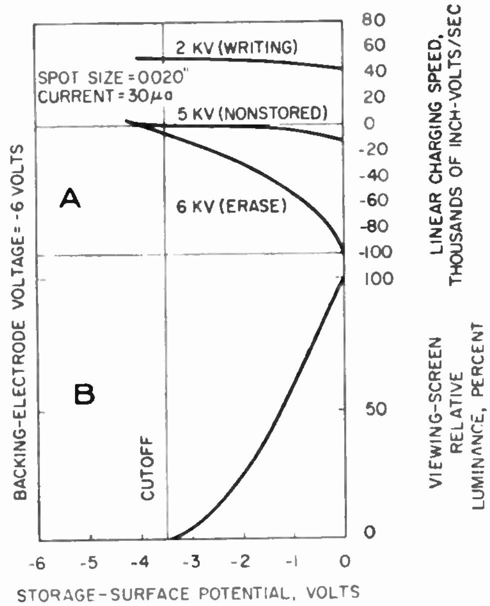


Fig. 7—The portion of the figure labeled "A" shows the charging speed vs storage-surface potential; the "B" portion is viewing-screen luminance vs storage potential.

speed represents the average negative linear-charging speed divided by the number of volts that the storage surface must be discharged to carry it from full brightness to the erased condition (this is also 4 volts). The lower graph shows the relative viewing-screen luminance as a function of storage-surface potential. From both these graphs, the effect of each value of beam energy on the display may be determined.

The 2-kv beam charges the storage surface positively at about 45,000 inch-volts per second almost independently of the storage-surface potential; such a characteristic is consistent with a predominant secondary-emission effect. The writing speed is therefore about 11,000 inches per second at a 30-μa beam current with higher speeds possible at higher values of beam current. The written resolution is 40 to 50 lines per inch. The stored information can be retained at luminance levels of from 300 to 500 fl for as long as one minute without serious deterioration.

The 6-kv beam discharges the storage surface most rapidly at the full-brightness condition; the discharging speed declines exponentially as the storage surface is carried toward equilibrium potential, which is about $\frac{1}{2}$ volt past cutoff. This action of the erase beam is consistent with the theory that the bombardment-induced conductivity effect initially overrides the secondary emission, but as the erasure process continues this conductivity declines exponentially until at equilibrium potential the two effects balance.

The average value of the erase speed is approximately 40,000 inch-volts per second (*i.e.*, 10,000 inches per second to charge 4 volts), as shown in Fig. 7. However, the high energy of the erase beam permits finer focusing than is possible with the 2-kv writing beam. Thus, with this high-energy beam, erase speeds of 30,000 to 40,000 inches per second can be attained with erase resolution of 100 to 120 lines per inch. Operation at still higher erase-beam energies makes it possible to approach the limit of resolution of the combined storage and collector meshes (about 150 lines per inch) without loss of erase speed.

In practice, the energy level for which both charging effects are equal over the entire range of storage-surface brightness is selected by permitting the discharging to slightly override the positive charging. The 5-kv beam energy was selected in this way. Note that the extremely slow erasure characteristic of this value of beam energy makes it suitable for the presentation of nonstored information.

Fig. 8 is a photograph of the developmental 5-inch, bombardment-induced conductivity selective-erasure tube. Fig. 9 shows a stored image on the face of the tube. The stored areas were written by means of a 2-kv beam and then selectively erased by means of a 6-kv beam. No attempt was made to demonstrate nonstored information, which is best shown in a dynamic display.

Applications

The new bombardment-induced conductivity selective-erasure tube possesses capabilities that are unique in the field of storage-tube operation. Information presentations that have never before been possible can now be achieved through use of this tube. Some of these applications are described below.

Selective Erasure

This capability suggests application of the tube to displays in which the erase beam immediately precedes the writing-beam scan. Stored information is then retained at full brightness until just before it is rescanned by the writing beam. Since almost the entire display is constantly maintained at full signal brightness, it will be viewed under optimum conditions. For presentations in which all the information moves from sweep to sweep, selective erasure prevents smearing caused by the display of successively stored images. Furthermore, by appropriately programming the erase beam, it is possible to erase only undesired information.

Nonstored Information

The nonstorage feature makes possible the addition of cathode-ray information to the display without otherwise disturbing it. This nonstored information may take the form of reference markers, horizon lines, or even maps superimposed over the stored signals. However, simultaneous use of the storage, selective-erasure, and nonstorage features requires the addition of a fourth electron gun. If time sharing of one gun with respect to two or more modes of operation is possible, then the number of electron guns can be reduced accordingly.

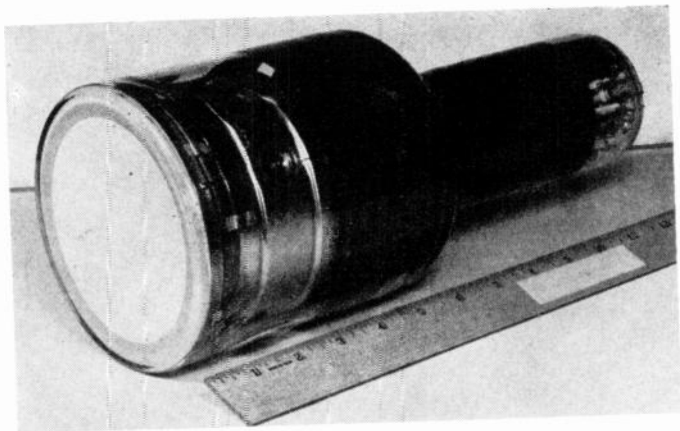


Fig. 8—Five-inch, bombardment-induced conductivity selective-erasure direct-view halftone storage tube.

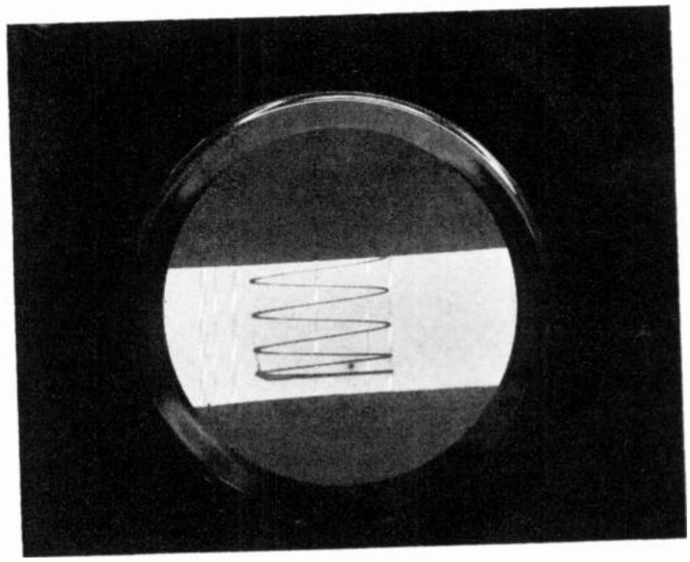


Fig. 9—Display obtained on selective-erasure tube.

Dark-Trace Tube

High-contrast displays can be obtained by using the erase gun as a "writing" gun; however, the viewing screen must be initially at the full-brightness condition. This condition can be brought about by scanning the storage surface with the 2-kv writing beam. The erase-gun grid is then modulated to vary the current as the erase beam is scanned over the storage target to produce a black picture on a white background, or a dark-trace image. Halftones can be obtained by modulating the grid signals to control the degree of erasure. Not only is a high-contrast display produced by this technique but, in addition, the higher energy of the erase beam permits higher resolution than that obtained with the 2-kv writing beam. If the dark-trace image is objectionable, the signals to the grid of the erase gun can be inverted to produce a normal image with considerably higher resolution and at higher charging speeds than can be achieved by means of the 2-kv writing beam.

Conclusion

Conventional direct-view halftone storage tubes depend on the secondary-emission effect for writing and erasing stored information. Such dependence imposes limitations on tube performance, particularly with regard to selective erasure and the simultaneous display of stored and nonstored information.

With the development of the selective-erasure tube, these limitations were overcome by using a dual-effects target, *i.e.*, a target that is written on by secondary emission and erased by bombardment-induced conductivity. Substitution of bombardment-induced conductivity discharging for secondary-emission effect discharging overcomes the nonuniformity difficulties inherent in the latter effect and makes practical selective erasure as well as the simultaneous display of stored and nonstored information. Data are given for a developmental 5-inch tube that writes at 2 kv, erases at 6 kv, and can present nonstored information at 5-kv beam energy. The construction and operating principles of this tube can be applied in the fabrication of larger tubes.

Acknowledgment

The author gratefully acknowledges the encouragement given him on this project by C. D. Beintema, and the suggestions of H. M. Smith and N. J. Koda. C. Trent substantially aided in the development of the storage target; H. Cawthon, R. Curran, and R. Solivan contributed to the fabrication of the tube.

Cross-Relaxation Masers*

G. S. BOGLE†

***Summary*—A survey is made of the available ways of using ruby, spinel, rutile and emerald in masers which amplify at frequencies small compared to their zero-field splitting frequencies. Particular attention is paid to means of taking advantage of cross relaxation which, it is shown, can give typically a two-fold improvement in maser performance. Analytic expressions for the energies are given which, to a large extent, remove the need for machine computations in the design of masers of this type.**

I. Introduction

Since the proposal of the three-level solid state maser in 1956,[1] three paramagnetic compounds have been used as working materials, and of these the most generally successful has been ruby.[2] The success of ruby has been due to its high zero-field splitting frequency (11.5 kMc), its high dielectric constant and mechanical strength, and its ready availability in large monocrystals. However, when attempts were made to utilize ruby in *L*-band (about 1400 Mc) masers at low magnetic fields (250 to 500 gauss), anomalous effects were found which prevented maser action,[3,4] and most development work was thenceforward concentrated on a high-field (2000 gauss) mode of operation in which the maser action is particularly good.[5] It will be shown below that cross-relaxation processes[6] (interchanges of energy between neighboring paramagnetic ions) provide an explanation of both the poor action at low fields and the particularly good action at the high field. It will be shown, further, that by a correct choice of conditions the low-field mode can be made to work in a way which derives advantage from cross relaxations.

Paramagnetic resonance data have already been measured for several materials, minerals and gemstones containing Cr^{3+}, which are even more promising than ruby for masers because of their higher zero-field splitting frequencies. A great many such materials no doubt await investigation. It is important to be able to assess

* Received by the IRE, July 18, 1960; revised manuscript received, December 5, 1960.

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[1] N. Bloembergen, "Proposal for a new type solid state maser," *Phys. Rev.*, vol. 104, pp. 324–327; October 15, 1956.

[2] J. Weber, "Masers," *Revs. Modern Phys.*, vol. 31, pp. 681–710; July, 1959.

[3] A. A. Penzias, "Maser Amplifier for 21 cm," Columbia Rad. Lab., New York, N. Y., Fourth Quarterly Progress Rept., pp. 7–9; December, 1958.

[4] G. S. Bogle and F. F. Gardner, "Cross-Relaxation Effects in a Ruby *L*-Band Maser," paper in preparation.

[5] F. R. Arams and S. Okwit, "Tunable *L*-band ruby maser," Proc. IRE, vol. 47, pp. 992–993; May, 1959.

[6] N. Bloembergen, S. Shapiro, P. S. Pershan, and J. O. Artman, "Cross-relaxation in spin systems," *Phys. Rev.*, vol. 114, pp. 445–459; April 15, 1959.

them without having to wait for machine computations of the energy levels such as are now available for ruby, and, to this end, approximate expressions for the energy levels are derived which are sufficiently accurate for maser design in cases where the splittings of the energy levels by the magnetic field are small compared to the zero-field splitting. These expressions, believed to be presented for the first time, are used to discuss the use in low-field masers of the new materials, with emphasis on obtaining assistance from cross relaxation.

In high fields the above approximate methods fail; but, provided that the field is applied along a symmetry axis, the equation for the energy levels may be solved exactly. The solutions are used to derive the field required as a function of amplifying frequency for ruby-like substances in general. The successful high-field ruby L-band maser is an example of a type of cross-relaxation-assisted maser action which is also possible with the new materials. The conditions for its realization are discussed, and it is found that the amplifying frequency is specific to the material concerned.

In what follows, we shall first review maser behavior in the absence of cross relaxation, then discuss the effect of cross relaxation, and finally consider the expected maser performance of the new materials, particularly when advantage is taken of cross relaxation.

II. Maser Action According to the Old Picture

In the old picture[1] of maser action, a system of three energy levels was considered and two types of transition between levels were taken into account. One type was the spin-lattice relaxation transition, in which energy is exchanged between the paramagnetic ions and the lattice thermal vibrations. The associated probability per second is termed w_{ij} where i and j are the participating energy levels. The other type was the radiation-induced transition, in which energy is exchanged between the paramagnetic ions and the electromagnetic field: the transition probability is termed W_{ij}. Cross-relaxation transitions (see below), in which energy is exchanged between paramagnetic ions directly, were not considered.

The method of operation of the three-level maser may be illustrated with the energy levels of Fig. 1, ignoring level 1 for the present time. The system of paramagnetic ions is subjected to a microwave field at the frequency $\nu_{42}=(E_4-E_2)/h$ and of such an intensity that W_{42} is much greater than the w's. In that case the resonance at ν_{42} is saturated and the populations of levels 4 and 2, *i.e.*, n_4 and n_2, are practically equal.[1] This process is described as "pumping the maser at frequency ν_{42}," or simply "pumping ν_{42}."

It can now be shown, if the w's are all of about the same magnitude and $\nu_{32}\gg\nu_{43}$, as in Fig. 1, that $n_4>n_3$. Then if weak radiation at frequency ν_{43} is applied, the system will emit power given by

$$P_{43} = W_{43}(n_4 - n_3)h\nu_{43}. \quad (1)$$

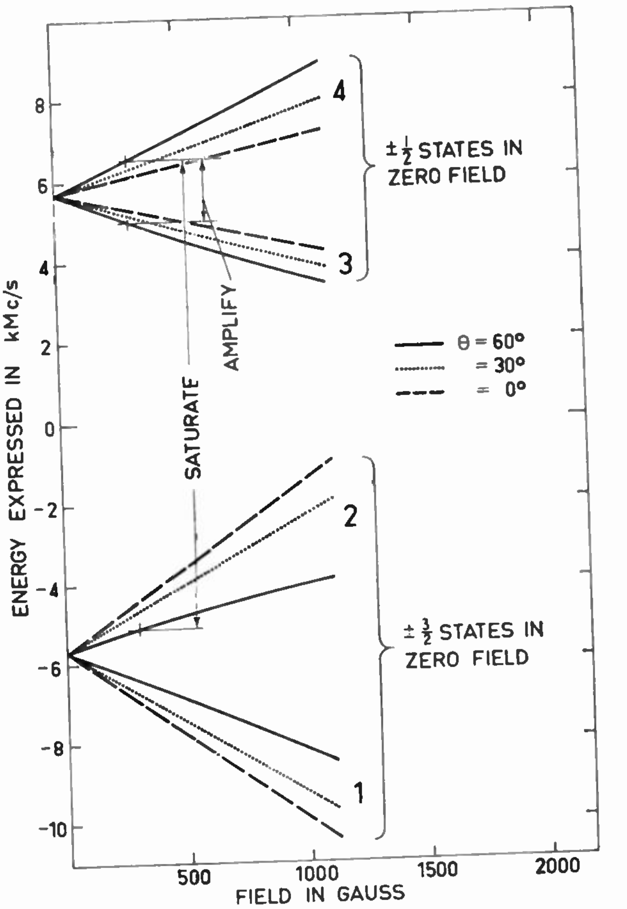


Fig. 1—Energy levels of ruby at low magnetic fields for several angles (θ) between the field and the crystalline axis. The maser saturating and amplifying transitions are indicated for $\theta=60°$.

With suitable circuits is may be possible to make P_{43} greater than the input power so that amplification is achieved.

A useful criterion of merit[2,7] of a maser material in a particular mode of operation is the quantity $-1/Q_M$ which is defined as $(1/2\pi\nu)$ times the ratio of power emitted to energy stored in the maser material.[2] Q_M corresponds to the Q of tuned circuits, but in the maser it is negative because energy is gained instead of lost as in passive circuits. The higher the value of $-1/Q_M$, the higher the maser gain which can be obtained for a given bandwidth. For example, in the case of a cavity maser with voltage-gain $G^{1/2}$ (*i.e.*, power-gain G) and bandwidth Δf, it may be shown that under reasonable practical conditions

$$G^{1/2}\Delta f \simeq 2\nu_s/|Q_M|, \quad (2)$$

ν_S being the frequency of the signal amplified.[2] By combining (1) and (4) of footnote 7 and adapting the level labels to the present case, it may be shown that

$$-1/Q_M = 4\pi g^2\beta^2|\langle 3|S|4\rangle|^2(n_4 - n_3)/h\Delta\nu, \quad (3)$$

[7] G. S. Bogle and H. F. Symmons, "Zero-field masers," *Aust. J. Phys.*, vol. 12, pp. 1–20; March, 1959.

where g is the spectroscopic splitting factor,[8] β is the Bohr magneton, $\langle 3|S|4\rangle$ is the matrix element of the spin operator between the states 3 and 4, and $\Delta\nu$ is the width of the transition intensity profile.

In a single material, $\langle i|S|j\rangle$ and $\Delta\nu$ do not vary greatly with mode of operation, so that different modes may be compared principally through their values of $n_4-n_3=\Delta n_{43}$ or, in general, Δn_{ij}. For the maser system under discussion at present, with levels ascending in the order 2, 3, 4 and with pumping at ν_{42} and a signal frequency of ν_{43}, Bloembergen's[1] equation becomes

$$n_3 - n_4 = \Delta n_{34}$$
$$= (hN/3kT)(w_{34}\nu_{43} - w_{23}\nu_{32})/(w_{34} + w_{23}), \quad (4)$$

where $N=n_2+n_3+n_4$. (Note that we are still dealing with a three-level system; the labels have been chosen as 2, 3 and 4 merely to accord better with the discussion later on.) The term $hN/3kT$ also occurs in the expression for n_3-n_4 in thermal equilibrium (*i.e.*, in the absence of pumping), *viz.*:

$$(n_3 - n_4)_0 = \Delta_0 n_{34} = (hN/3kT)\nu_{43}.$$

[The above equations and all similar equations in this paper are only true in the approximation that kT is much larger than the total energy separation of the lowest group of states of the paramagnetic ions (*e.g.*, those of Fig. 1) and much smaller than the energies of excited states (*e.g.*, those responsible for optical absorption). This is a good approximation for many paramagnetic compounds, including ruby, in fields of some thousands of gauss. As a consequence of the approximation there is no need to distinguish between w_{ij} and w_{ji} in writing expressions like those in (4).]

By dividing by $\Delta_0 n_{34}$, and expressing frequencies in terms of the pumping frequency $\nu_p=\nu_{42}$ and the signal (amplifying) frequency $\nu_S=\nu_{43}$, (4) can be put in the simpler form

$$\Delta n_{34}/\Delta_0 n_{34} = 1 - (\nu_p/\nu_S)/(1 + w_{34}/w_{23}). \quad (5)$$

This equation shows clearly how a large ratio of pump to signal frequency is desirable in order to obtain a large negative value of Δn_{34} and secure good maser action.

Because the emphasis is on negative Δn_{34}, and $\Delta_0 n_{34}$ is of course positive, it is customary to define an "inversion ratio" $I=-\Delta n_{34}/\Delta_0 n_{34}$. A higher inversion ratio connotes better maser action.

When account is taken of the fourth energy level E_1, (5) takes a more complicated form which has been given, for example, in (7) of footnote 7. With suitable change of labels, and expressing all frequencies as before in terms of ν_S and ν_p, the following equation is obtained for the inversion when ν_{42} is pumped:

$$I = -\Delta n_{34}/\Delta_0 n_{34}$$
$$= -1 + \frac{\nu_p}{\nu_S}\cdot\frac{w_1 w_{23} + w_{13}w_{12}}{w_1(w_{23} + w_{34}) + w_{13}(w_{12} + w_{14})}, \quad (6)$$

where

$$w_i = \sum_{j\neq i} w_{ij},$$

i taking the value 1 in this case and other values in later equations. It is seen that the predicted maser behavior is essentially the same with four levels as with three; in particular, to obtain a high inversion ratio a high value of ν_p/ν_S is desirable as before.

III. Energy Levels of Cr^{3+}

The energy levels of the paramagnetic Cr^{3+} ion in crystalline solids are derivable from a spin Hamiltonian of the form[8]

$$H = \beta B\cdot g\cdot S + D(S_z^2 - \tfrac{5}{4}) + E(S_x^2 - S_y^2) \quad (7)$$

where g and β are as defined above, B is the magnetic field, S is the spin operator, x, y and z are the axes of symmetry of the crystalline environment of the Cr^{3+} ions, and D and E are constants describing the effect of the crystalline electric field. If its symmetry is trigonal or higher, $E=0$, and z is parallel to the axis of symmetry.[8] It is often the case that the g-tensor is isotropic or may be assumed so with sufficient accuracy for maser design. Then $\beta B\cdot g\cdot S$ may be replaced by $g\beta B\cdot S$, and if at the same time $E=0$, the spin Hamiltonian takes the simpler form

$$H = g\beta B\cdot S + D(S_z^2 - \tfrac{5}{4}). \quad (8)$$

In zero magnetic field, the energy levels determined by (7) are two doublets separated by $2(D^2+3E^2)^{1/2}$ (see Appendix I-Section A); this separation is known as the zero-field splitting.[8] In the special case that $E=0$, the states in zero field are $S_z=\pm\frac{3}{2}$ at D and $S_z=\pm\frac{1}{2}$ at $-D$; and this description of the states is still approximately true when $E\neq 0$, provided that $|E/D|\ll 1$.

When the amplifying frequency is small compared to the zero-field splitting frequency, as it is in the cases to be discussed here, it may be seen from the figures, or from the expressions given below for the energies, that the pumping frequency is comparable to the zero-field splitting frequency. Eq. (6) shows that the population inversion is better the higher the pumping frequency; and later equations, which allow for cross relaxation, will show the same type of dependence. Thus special interest attaches to materials with high zero-field splittings.

Ruby has already been established as an important material for maser design.[2,5,9] Ruby consists of α-Al_2O_3

[8] K. D. Bowers and J. Owen, "Paramagnetic Resonance II," *Repts. Progr. Phys.*, vol. 18, pp. 304–373; 1955.

[9] C. Kikuchi, J. Lambe, G. Makhov, and R. W. Terhune, "Ruby as a maser material," *J. Appl. Phys.*, vol. 30, pp. 1061–1067; July, 1959.

(corundum, or clear sapphire) with a small proportion of the Al^{3+} ions replaced by paramagnetic Cr^{3+}. Its success in maser applications is due to its considerable mechanical robustness and to its high zero-field splitting frequency of 11.5 kMc.[9] From recent paramagnetic studies several other materials are at present known which have similar robustness and even higher splitting frequencies: emerald (beryl, $Be_3Al_2Si_6O_{18}$, containing Cr^{3+}), which has a zero-field frequency of 54 kMc,[10] rutile (TiO_2) containing Cr^{3+}, which has the frequency of 43 kMc,[11] and spinel ($MgAl_2O_4$) containing Cr^{3+}, 30 kMc.[12] Both ruby and emerald have the simpler Hamiltonian (8) with D negative; spinel has the same type of Hamiltonian with the sign of D unknown; rutile has a nonzero value of E and the signs of E and D are not yet known. The signs, however, are unimportant for maser action.[13] In all four substances the g-tensor may be taken as isotropic.

The spin Hamiltonians (7) and (8) each lead to equations[9] for the energies which are in general of the fourth degree for Cr^{3+} and require numerical solution. In the case of the simpler Hamiltonian (8) it is possible to express the energy equation in normalized form by writing $y=W/D$, W being the energy, and $x=g\beta B/D$, and the solutions for y are applicable to any material obeying (8). (W, meaning energy, is not to be confused with W_{ij}, meaning a radiation-induced transition probability.) The direction of the magnetic field needs only to be specified by its polar angle θ relative to the z-axis, since the directions of the x and y axes are not significant in (8). Diagrams and tables of the energy levels and transition probabilities as a function of field strength and direction are given for this case in Weber,[2] Schultz-DuBois[14] and Howarth.[15] (It should be noted that in Weber[2] and Howarth[15], the levels were labeled under the supposition that D in the spin Hamiltonian was positive; the level-labels 1, 2, 3, 4 in those references should be replaced by 4, 3, 2, 1, respectively, to accord with the discussion of ruby maser action presented here.)

In the case of the general Hamiltonian (7), the difficulties of tabulating solutions of the energy equation are much greater: tables would have to be prepared for each value of E/D and would depend on the azimuthal angle ϕ as well as on θ because the directions of the x and y axes are significant in (7). To the author's knowledge, no such tables have yet been published.

The energy levels of ruby are shown for low fields and for $\theta=0°$, 30° and 60° in Fig. 1, and for $\theta=90°$ and up to higher fields in Fig. 2. At fields of a few hundred gauss (Fig. 1) and with θ between 90° and about 20° the transition probabilities[2,14,15] are well adapted for a maser amplifying at ν_{43} and saturated ("pumped") at ν_{42} or ν_{41}. When ν_{43} is 1400 Mc the field required is about 500 gauss at $\theta=0$, varying smoothly to about 250 gauss at $\theta=90°$; and it will be shown that the same is approximately true of substances with higher zero-field splittings than ruby. This type of operation will be referred to as "the low-field mode" of operation, although strictly speaking, it comprises a class of modes each characterized by the value of θ and field used.

At $\theta=90°$ (Fig. 2) the transition probabilities are well adapted for a maser amplifying at ν_{21} and pumped at ν_{31} or ν_{41}. As can be seen from Fig. 2, a field of about 2000 gauss is required for amplification at 1400 Mc with ruby. It will be shown below that even higher fields would be necessary with emerald and spinel. Operation in this mode will be termed "the high-field mode" of operation; it is restricted to values of θ close to 90° since the transition probability between levels 1 and 2 rises to a sharp maximum at 90° and is very weak

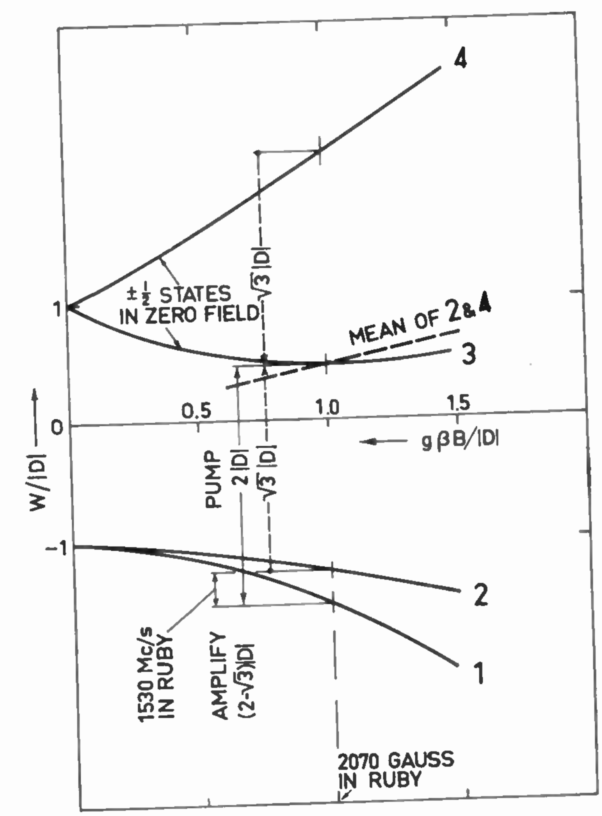


Fig. 2—Normalized energy $W/|D|$ vs normalized field $g\beta B/|D|$ plotted for ruby-like materials. At $g\beta B/|D|=1$, $W_4-W_3=W_3-W_2$, and a cross-relaxation process is possible in which an ion jumps from 4 to 3 while a neighbor jumps from 2 to 3; these are shown as dotted vertical lines. The pumping and amplifying transitions of the cross-relaxation-assisted maser mode are shown. (D is negative, as for ruby and emerald.)

[10] J. E. Geusic, M. Peter, and E. O. Schulz-Du Bois, "Paramagnetic resonance spectrum of Cr^{+++} in emerald," *Bell Sys. Tech. J.*, vol. 38, pp. 291–296; January, 1959.

[11] H. J. Gerritsen, S. E. Harrison, H. R. Lewis, and J. P. Wittke, "Fine structure, hyperfine structure, and relaxation times of Cr^{3+} in TiO_2 (rutile)," *Phys. Rev. Letters*, vol. 2, pp. 153–155; February 15, 1959.

[12] R. Stahl-Brada and W. Low, "Paramagnetic resonance spectra of chromium and manganese in the spinel structure," *Phys. Rev.*, vol. 116, pp. 561–564; November 1, 1959.

[13] Weber, *op. cit.*, p. 710.

[14] E. O. Schulz-Du Bois, "Paramagnetic spectra of substituted sapphires—Part I: ruby," *Bell Sys. Tech. J.*, vol. 38, pp. 271–290; January, 1959.

[15] D. J. Howarth, Properties of ruby as a maser crystal," Royal Radar Establishment, Malvern, Eng., Memo. No. 1525; October, 1958.

between 0° and 80°.[2,14,15] This is the reason why the transition at ν_{21} cannot be used for amplification in the low-field mode: it is well-allowed only when $\theta > 85°$, and then the field required is over 1000 gauss.

The above two modes are the most important modes of operating an L-band maser with ruby and with Cr^{3+} in other compounds where the zero-field splitting is similar to or higher than in ruby. The high-field mode is important because it has been used in the most successful L-band cavity maser yet reported.[5] This had a voltage-gain bandwidth product of nearly 40 Mc. The low-field mode is important, although the best voltage-gain bandwidth product yet achieved appears to be 4 Mc[16] because of the convenience of low magnetic fields.

In discussing these two classes of maser mode it is desirable to have analytic expressions for the energy levels, and it is fortunate that this can be achieved in both cases. At low fields, up to 500 gauss in ruby for example, the term $g\beta B \cdot S$ in the spin Hamiltonian (7) is small compared with the zero-field splitting $2|D|$, so that a series expansion with good convergence can be derived for the energies. This is done in Appendix I. The result, for materials which, like ruby, have $E=0$, is:

$$W_1 = D + \frac{3}{2}\lambda g\beta B\cos\theta + \tfrac{3}{8}\sin^2\theta(g\beta B)^2/D$$

$$W_2 = D - \frac{3}{2}\lambda g\beta B\cos\theta + \tfrac{3}{8}\sin^2\theta(g\beta B)^2/D$$

$$W_3 = -D + \tfrac{1}{2}\lambda g\beta B(1+3\sin^2\theta)^{1/2} - \tfrac{3}{8}\sin^2\theta(g\beta B)^2/D$$

$$W_4 = -D - \tfrac{1}{2}\lambda g\beta B(1+3\sin^2\theta)^{1/2} - \tfrac{3}{8}\sin^2\theta(g\beta B)^2/D, \quad (9)$$

where $\lambda \equiv D/|D|$. The energies so defined ascend in the order W_1, W_2, W_3, W_4 for negative D (as in ruby, Fig. 1) and descend in the same order for positive D. Subsequent terms are of order $(g\beta B)^3/D^2$ and are not greater than the equivalent of a few Mc in the present case. The corresponding equations for the general Hamiltonian (7) with $E \neq 0$ are more complicated; they are given in Appendix I.

Eq. (9) may be used to calculate the frequencies involved in maser action. A natural situation is one in which the signal frequency ν_{43} is to be held at a given value, and it is desired to know the required value of field as a function of θ. From (9) it is evident that $h\nu_{43} = g\beta B(3\sin^2\theta+1)^{1/2}$ with an error of order $(g\beta B)^3/D^2$. The numerical formula for the field B in gauss is

$$B = 0.357(2/g)\nu_{43}(1+3\sin^2\theta)^{-1/2} \quad (10)$$

where ν_{43} is in magacycles per second. The fractional error in the value of B given by the above equation is at most $(1/4)(h\nu_{43}/2D)^2$, for example 0.5 per cent for ruby when $\nu_{43} = 1440$ Mc. This shows that for substances with higher zero-field splittings than ruby the magnetic field required for L-band maser operation in the low-field mode is practically the same as for ruby. For materials obeying the general spin-Hamiltonian (7), (10) has to be replaced by

$$B = 0.357(2/g)\nu_{43}[\cos^2\theta(1-4\sin^2\alpha)^2 + \sin^2\theta(4\cos^4\alpha + 3\sin^2 2\alpha - 4\sqrt{3}\cos^2\alpha\sin 2\alpha\cos 2\phi)]^{-1/2} \quad (11)$$

where θ and ϕ define the direction of the applied magnetic field, and α is given by

$$\tan\alpha = \frac{E\sqrt{3}}{D + \lambda(D^2+3E^2)^{1/2}},$$

as shown in Appendix I. For rutile, with $|D| = 0.55$ cm^{-1} and $E = 0.27$ cm^{-1}, the expression under the radical sign in (11) becomes $0.275 + \sin^2\theta(4.09 - 3.94\cos 2\phi)$. It can be seen that the field strength required for L-band operation with rutile in the low-field mode is of the same order of magnitude as with ruby and emerald.

When the field is applied perpendicular to the z-axis of ruby-like materials the energies may be obtained exactly because the secular equation factorizes into two quadratics. The energies are given in (40). Rewriting for the case of negative D and putting $G = g_\perp\beta B$, the levels are

$$W_{4,2} = \tfrac{1}{2}G \pm (D^2+G^2+|D|G)^{1/2}$$
$$W_{3,1} = -\tfrac{1}{2}G \pm (D^2+G^2-|D|G)^{1/2} \quad (12)$$

labelled to accord with Fig. 2. For the purpose of comparing working materials, it is desirable to have an explicit expression for the field required for a given value of $\nu_{21} = (W_2 - W_1)/h$, which is the amplifying frequency in this mode. Expanding the radicals in W_2 and W_1, and writing $x = g_\perp\beta B/|D|$, one obtains

$$(W_2 - W_1)/|D| = (3/8)x^3 - (15/128)x^5 \cdots.$$

Preserving only the first term in the expansion, the field in gauss required for a given frequency ν_{21} is given by

$$B \simeq 0.31(2/g_\perp)\nu_{21}^{1/3}\nu_{ZF}^{2/3} \quad (13)$$

where ν_{ZF} is the zero-field splitting frequency and ν_{21} is the amplification frequency, and both are expressed in megacycles per second. The fractional error in (13) occasioned by the neglect of the x^5 term in the previous equation is about $0.3(\nu_{21}/\nu_{ZF})^{2/3}$, or 10 per cent for ruby and 3 per cent for emerald, both at L-band. From (13), the magnetic field required to operate the high-field mode with emerald, amplifying at about 1400 Mc, is about 5000 gauss. The inconvenience of this high field makes it important to attempt to utilize the low-field mode where the field would be only a few hundred gauss, in spite of the indifferent success of this mode hitherto in ruby.

IV. Effect of Cross Relaxations

The original theory[1] of maser action was shown to be in need of modification when it was found that there was a limiting chromium concentration in a potassium

[16] S. H. Autler, "Tunable L-Band Maser," Lincoln Lab., Lexington, Mass., Quarterly Progress Rept., p. 65; July 15, 1959.

chromicyanide maser, above which the population inversion necessary for maser action could not be obtained.[17] The explanation of this and other effects has been given in terms of cross-relaxation processes.[6,18]

A cross-relaxation process is one in which energy is exchanged directly between neighboring paramagnetic ions. (In contrast, spin-lattice-relaxation processes involve exchange of energy between paramagnetic ions and the lattice vibrations.) The probability of a cross relaxation is greater the closer the neighbors, and so the effect is concentration-dependent. We shall consider the situations in which cross relaxations affect *L*-band maser performance in ruby.

A distinction needs to be drawn between cross relaxations and the more familiar spin-spin relaxations conventionally characterized by the relaxation time T_2. Using Fig. 1 for illustration, a spin-spin relaxation consists typically in one ion jumping from level 1 to 2 while a neighbor does the opposite. This process does not change the level populations and therefore does not affect the maser equations. In contrast, a cross relaxation consists typically in an ion's jumping from level 1 to 2 while a neighbor jumps from 4 to 3. This process does change the level populations and radically affects maser behavior. Unlike spin-spin relaxations, cross relaxations may involve triple or multiple jumps and can occur only in a system of at least three levels with the energy gaps harmonically related.

A. Cross-Relaxation Processes in Ruby at Low Fields

1) *Cross relaxation near $\theta=29°$:* The cross-relaxation process may be illustrated with reference to ruby at low fields (Fig. 1). It may be shown from (9) that near $\theta=29°$, $2(W_4-W_3)=W_2-W_1$. It may be shown by a quantum-mechanical treatment[6] that if a paramagnetic ion in level 1 has two neighbors in level 4 there is a probability that the former will jump up to level 2, while the latter each jump down to level 3, the total energy being conserved in the process. The process is a resonance process, having its maximum probability when the total energy is exactly conserved—*i.e.*, when $2(W_4-W_3)$ is exactly equal to W_2-W_1. Like other resonance processes, it has a "line-width," and this width is of the same order of magnitude as those of the levels themselves (typically 50 Mc in maser materials). The probability of the transition, when "on resonance," depends on the proximity of the neighbors and on the nature of the states of the paramagnetic ion, and is independent of temperature except for the slight temperature-dependence of the lattice dimensions and of the spin Hamiltonian parameters. By contrast, the spin-lattice relaxation times vary rapidly with temperature: in 0.05 per cent ruby, for example, a typical relaxation time has the value 17 μsec at 90°K and 22 msec at 4.2°K.[19] A convincing classical picture of the cross-relaxation process is hard to give; it might be regarded crudely as a phenomenon in which the local magnetic fields of the two ions in state 4, each oscillating at ν_{43}, beat together to form a component at $2\nu_{43}$, which is the correct frequency, ν_{21}, to be absorbed by their neighbor in jumping from level 1 to 2.

As well as the cross-relaxation process just described above, the inverse process of course also occurs, and in the model of footnotes 6 and 18, the latter has the same probability as the former when the equality between $2(W_4-W_3)$ and W_2-W_1 is exact. When the equality is not exact, *i.e.* near but not at $\theta=29°$, the probabilities of the process and its inverse are not precisely equal, but the essential character of the cross-relaxation effect remains the same and this complication will be ignored.

The rate equations for the level populations may now be written in a way analogous to that of Shapiro and Bloembergen,[18] which deals with a two-spin process, whereas the present case is a three-spin process. The method is to write down the rates of change of population of each level and finally to equate them to zero. Following Bloembergen[1] one has, in the absence of cross-relaxation terms, a set of four equations like

$$\frac{dn_i}{dt} = \sum_{j\neq i} w_{ji}\left(n_j - n_i + \frac{Nh\nu_{ji}}{4kT}\right) + \sum_{j\neq i} W_{ji}(n_j - n_i). \quad (14)$$

W_{ji} is the radiation-induced transition probability between levels i and j, and $W_{ij}\equiv W_{ji}$. The equation is written for a system of four levels, as exemplified by Cr^{3+}.

The contribution of the cross-relaxation processes will now be derived. For a given ion in level 3 at the lattice site α, let us ask what is the probability of a cross-relaxation process in which ion α jumps from level 3 to 4 while simultaneously a neighbor in site β jumps from level 2 to 1 and another neighbor in site γ jumps from 3 to 4. This process is shown diagrammatically in Fig. 3. (We shall disregard the inverse process for the meantime.) The process can occur only if sites β and γ are each filled with paramagnetic ions, and the chance of this is c^2 where c is the concentration of paramagnetic ions in the crystal (usually less than 1 per cent in maser work). If β is filled, the chance that it is correctly filled with an ion in state 2 is n_2/N, where $N=n_1+n_2+n_3+n_4$; and the chance that γ is correctly filled is n_3/N. Thus $c^2n_2n_3/N^2$ is the probability that the appropriate situation exists. Let the probability of a cross-relaxation transition under these circumstances be $w_{\alpha\beta\gamma}$; $w_{\alpha\beta\gamma}$ depends on quantum-mechanical variables and the displacements of β and γ from α. The transition probabil-

[17] S. H. Autler and N. McAvoy, "21-Centimetre solid-state maser," *Phys. Rev.*, vol. 110, pp. 280, 281; April 1, 1958.

[18] S. Shapiro and N. Bloembergen, "Relaxation effects in a maser material, $K_3(CoCr)(CN)_6$," *Phys. Rev.*, vol. 116, pp. 1453–1458; December 15, 1959.

[19] J. H. Pace, D. F. Sampson, and J. S. Thorp, "Spin-lattice relaxation times in ruby at 34.6 kMc/s," *Phys. Rev. Letters*, vol. 4, pp. 18, 19; January 1, 1960.

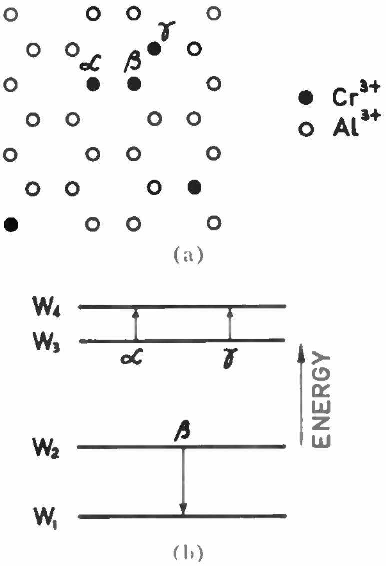


Fig. 3—(a) Sketch of a small region of a ruby crystal showing one of the occasional close groups of paramagnetic ions; and (b) the cross-relaxation process executed by the group when $W_2 - W_1 = 2(W_4 - W_3)$, as in ruby at $\theta = 29°$ in low magnetic fields.

ity associated with these particular sites is then $w_{\alpha\beta\gamma}c^2 n_2 n_3/N^2$, and to dispose of the contribution of site α we must sum over-all neighboring sites β and γ, by replacing $w_{\alpha\beta\gamma}$ by

$$w_\alpha = \sum_{\beta\gamma} w_{\alpha\beta\gamma}.$$

As w_α is not necessarily the same for all sites α, let w_c be its average over unit cell; then the total number of transitions in the crystal becomes

$$n_3 \cdot w_c c^2 n_2 n_3 / N^2.$$

In the notation of Shapiro and Bloembergen,[18] $c^2 w_c$ would be called $w_{21,34,34}$. Remembering now the inverse transitions, the net number is seen to be $w_c c^2(n_2 n_3^2 - n_1 n_4^2)/N^2$. The effect of these transitions may now be added to (14), noting that the transition which takes one ion from level 2 takes two from 3, and gives two to 4 and one to 1. Thus the rate equation for level 3, for example, is

$$\frac{dn_3}{dt} = \sum_{j\neq 3} w_{j3}\left(n_j - n_3 + \frac{Nh\nu_{j3}}{4kT}\right) + \sum_{j\neq 3} W_{j3}(n_j - n_3) - 2c^2 w_c(n_2 n_3^2 - n_1 n_4^2)/N^2. \quad (15)$$

This equation, together with the other equations, may now be solved generally by the methods of Shapiro and Bloembergen.[20] However, useful insight into the effect of the cross relaxations may be gained by a qualitative discussion, at any rate for the important case that $c^2 w_c$ is much greater than any w_{ij}. Suppose that it is intended to operate a maser to amplify at ν_{43} by pumping ν_{42} at low fields (Fig. 1) with $\theta = 29°$. Then $W_{42} \gg w_{ij}$, and the other W's are zero, so that no W enters (15). In the steady state $dn_3/dt = 0$, and hence the final term on the right-hand side of (15) is equal to the first. The first is at most of order Nw_{ij}, w_{ij} meaning a typical spin-lattice rate; hence

$$\frac{n_2 n_3^2 - n_1 n_4^2}{N^3} \sim \frac{w_{ij}}{c^2 w_c} \ll 1,$$

which means that $n_2 n_3^2 \simeq n_1 n_4^2$, the fractional difference between them being only of order $w_{ij}/(c^2 w_c)$. The same would be true even if the pumping was done at another frequency, because it would always be possible to choose a dn_i/dt which contained no W, and the above argument could still be applied.

We shall now consider maser action near $\theta = 29°$; it will be seen how cross relaxation introduces an additional constraint on the system. Suppose ν_{42} is pumped with the intention of producing stimulated emission at ν_{43}. The saturation of the resonance at ν_{42} makes n_4 equal to n_2; the cross relaxations make $n_2 n_3^2$ equal to $n_1 n_4^2$: therefore

$$n_3^2 = n_1 n_4.$$

That is, n_3 is the geometric mean of n_1 and n_4. Now consider n_1: it is not being forced into equality with any of the other populations by pumping, and, physically, it would be expected to be the greatest population since it belongs to the lowest level. That is, n_1 is greater than n_3, which is the geometric mean of n_1 and n_4. Therefore n_3 is greater than n_4 and the resonance at ν_{43} remains absorptive. The mathematical solution bears this out. For pumping ν_{42}, and with $c^2 w_c \gg w_{ij}$, the solution of (15) and its companions gives

$$I = \frac{-\Delta n_{34}}{\Delta_0 n_{34}} = -1 + \frac{\nu_{42}}{\nu_{43}} \frac{w_{32} - 2w_{14} - w_{13}}{w_3 + 4w_{12} + 4w_{14}}; \quad (16)$$

this shows that to get a maser effect, *i.e.* a positive inversion, it would be necessary for $2w_{14} + w_{13}$ to be small in comparison with w_{32}. This is a far more stringent requirement on the w_{ij}'s than applies in the absence of cross relaxation [see (6)]. Indeed, (16) shows that it is possible for the absorption coefficient at ν_{43} to be *increased* by pumping, which is found in practice with 0.05 per cent ruby at 4.2°K.[4] This could not happen on the basis of (6).

The situation is altered if the pumping power is applied instead at ν_{41}. Arguing qualitatively, as before, one may observe that the pumping now makes n_1 equal to n_4; the cross relaxations make $n_2 n_3^2$ equal to $n_1 n_4^2$, whence $n_2 n_3^2 = n_4^3$, and so $(n_4/n_3)^2 = n_2/n_4$. As n_2 belongs to a low level, which is not involved in pumping, it might be expected to be larger than n_4, so that, in turn, n_4 would exceed n_3 according to the last equation. Thus there is no obvious influence antagonistic to n_4

[20] Shapiro and Bloembergen, *op. cit.*, p. 4.

being greater than n_3 as required for maser action. In this case the solution of (15) and its companions gives, for $c^2w_c \gg w_{ij}$,

$$I = \frac{-\Delta n_{34}}{\Delta_0 n_{34}} = -1 + \frac{\nu_{41}}{\nu_{43}} \frac{3w_{32} + 2w_{21} + w_{31}}{4w_2 + 4w_{32} + w_3}, \quad (17)$$

showing that maser action should be obtained unless the w_{ij}'s in the numerator were particularly small.

It is interesting now to inquire how this cross-relaxation maser action compares with what would be expected if the concentration c were so low that $c^2w_c \ll w_{ij}$ and the "ordinary" maser equation still applied. Eq. (6) may easily be adapted for pumping at ν_{41} instead of ν_{42} by interchanging the suffices 1 and 2, yielding

$$I = -1 + \frac{\nu_{41}}{\nu_{43}} \cdot \frac{w_2 w_{13} + w_{23} w_{21}}{w_2(w_{13} + w_{31}) + w_{23}(w_{21} + w_{24})} \quad (18)$$

as the ordinary maser equation in this case. To compare the inversion ratios in the two cases we need an estimate of the ratios of the w_{ij}'s. Recent work[19] on relaxation rates in ruby at liquid helium temperatures suggests that they are proportional to the magnetic dipole transition probabilities, and, surprisingly, show no dependence on frequency. We shall therefore adopt what might be called a "magnetic dipole model" of relaxation rates by using the magnetic dipole transition probabilities for isotropic radiation. Using the charts given in Howarth,[15] the relaxation rates so calculated for $\theta = 30°$ and for the magnetic field which makes ν_{43} equal to 1400 Mc are, in arbitrary units: $w_{12} = 0.00$, $w_{13} = 1.22$, $w_{14} = 0.26$, $w_{23} = 0.29$, $w_{24} = 1.22$ and $w_{34} = 1.56$. For the cross-relaxation maser, (17), the inversion ratio is 3·1; whereas for the ordinary maser, (18) gives 2·8.

At this point it might be objected that, since the cross-relaxation maser gives only a slight improvement of inversion ratio, and, for other values of the w_{ij}'s, could conceivably give no improvement at all, the term "cross-relaxation-assisted maser" is a misnomer. It is true that on the basis of inversion ratio alone a better description in this case would be "cross-relaxation-compatible maser"; but this compatibility is in itself valuable. If cross-relaxation effects were to be avoided, the concentration would have to be lowered to about ten times below the value of 0.05 per cent commonly used in ruby masers at present, because at 0.05 per cent, the cross-relaxation rate is about twenty times higher than the spin-lattice[4] near $\theta = 29°$ at 4°K. (If the concentration were decreased ten-fold the cross-relaxation rate would decrease one hundred-fold.) Thus masers can work with much higher concentration if their action is compatible with cross relaxation than if it is incompatible, and higher concentration means greater power-handling ability and bandwidth.

Because the cross-relaxation rate at $\theta = 29°$, where the "resonance" condition $2(W_4 - W_3) = W_2 - W_1$ is exact, is many times higher than the spin-lattice relaxation rate, its influence continues to dominate the latter's even when θ is altered to as low as 25° and as high as about 35°.[4] The upper limit of the range is uncertain because of possible interference from a new cross-relaxation process which is "on resonance" at $\theta = 55°$ (see below). As a result of the "29° effect" and the "55° effect," no maser action can be obtained in 0.05 per cent ruby, when ν_{42} is pumped, at any angle between about 25° and 60°.[4] The 55° effect will now be considered.

2) *Cross relaxation near $\theta = 55°$*: At $\theta = 55°$ it follows from (9) that $W_4 - W_3 = W_2 - W_1$ (*cf.* Fig. 1 for $\theta = 60°$), and so a cross-relaxation process is favored in which an ion jumps down from level 4 to 3 while simultaneously a neighbor jumps up from 1 to 2. The discussion of this process may be given along the same lines as that of the 29° process given above, and it turns out that the contribution from cross-relaxation to the rate equation of, say, level 3 is

$$cw_c'(n_1 n_4 - n_2 n_3)/N$$

[*cf.* (15)]. Here, w_c' is determined by the lattice structure and the quantum-mechanical states of the paramagnetic ion at $\theta = 55°$, and is distinct from the quantity w_c used to describe the 29° process. The cross-relaxation process now tends to equalize $n_1 n_4$ and $n_2 n_3$, and it can be seen qualitatively that if ν_{42} were pumped, equalizing n_2 and n_4, n_1 and n_3 would be equalized as well. This is true not only at $\theta = 55°$, but for a range of angles which extends about ten degrees above and below 55° in pink ruby,[4] and experimentally the effect is to destroy maser action at *L*-band when the intended amplifying frequency is ν_{43} and the pumping frequency is ν_{42}. The solution of the cross-relaxation equation accords with this observation; we shall not quote it here, but merely observe that it is identical with the solution found when both ν_{42} and ν_{31} are intentionally pumped in an entirely different kind of maser mode called the "double-pumped" or "push-pull" mode.[9] In the latter mode, the angle θ is set as closely as possible to the ideal angle of $\cos^{-1}(1/\sqrt{3})$ or 54.7° where $\nu_{42} = \nu_{31}$; then pumping with a single frequency saturates both transitions, leading to very good inversion at ν_{32}.[9] The push-pull mode requires unusually precise design because, of the two degrees of freedom (field and angle) usually employed in setting up a maser, one is lost. Cross relaxation should be of assistance in the push-pull maser, for even though θ might be different from 54.7° and $\nu_{31} \neq \nu_{42}$, the cross relaxations should maintain both of the conditions $n_1 = n_3$ and $n_2 = n_4$ provided that one of them was maintained by pumping.

To continue with the low-field maser at $\theta = 55°$, we next consider the effect of the cross relaxations when ν_{41} is saturated. Just as with the $\theta = 29°$ case it is found that maser action is now obtainable. Solution of the equations analogous to (15) yields

$$I = -\frac{\Delta n_{34}}{\Delta_0 n_{34}} = -1 + \frac{\nu_{41}}{\nu_{43}} \frac{2w_{23} + w_{24} + w_{31}}{2w_{23} + w_2 + w_3}. \quad (19)$$

At $\theta = 55°$, adoption of the magnetic dipole model for the w_{ij}'s gives (in the same arbitrary units as before) $w_{12} = 0.00$, $w_{13} = 0.95$, $w_{14} = 0.50$, $w_{23} = 0.60$, $w_{24} = 0.95$ and $w_{34} = 1.35$, at the magnetic field necessary to make ν_{43} equal to about 1400 Mc; the pumping frequency is 12.9 kMc. The inversion ratio, from (19), is then 4.0. In the absence of cross relaxation it would be 2.2, from (18). At and near this angle it appears that good maser action should be possible in the presence of cross relaxation.

The angle of 90° is significant as being as unfavorable as possible to the cross-relaxation processes since $\nu_{21} \simeq 0$ at low fields. This angle is also the one used for the only successful low-field L-band maser yet reported[16] which, as mentioned above, had a gain-bandwidth product of 4 Mc, ten times poorer than that of the high-field maser. The inversion obtainable in 0.05 per cent ruby being 2.5 at $\theta = 90°$ in the low-field mode[4] as against 5.2 in the high-field mode (see next paragraph), it is probable that the best possible low-field maser performance has yet to be realized.

B. The High-Field L-Band Maser Mode in Ruby

An unusually high inversion ratio of 5.2 has been measured in ruby at liquid helium temperature at a field of about 2000 gauss perpendicular to the axis.[21] The energy levels are shown in Fig. 2; the levels of which the populations were inverted were 1 and 2, and the pumping transitions were from 1 to 3. At the field used in the measurements, ν_{21}, the monitoring frequency, was 1500 Mc and ν_{31} was about 11.5 kMc.

The high value of the inversion ratio is hard to understand on the basis of the ordinary maser equation, but may be explained in terms of cross relaxation. The ordinary maser equation for this case, obtainable by transposing level-labels in (6), is

$$I = -\frac{\Delta n_{12}}{\Delta_0 n_{12}}$$

$$= -1 + \frac{\nu_{31}}{\nu_{21}} \frac{w_4 w_{23} + w_{24} w_{34}}{w_4(w_{23} + w_{12}) + w_{24}(w_{34} + w_{14})}, \qquad (20)$$

and, in the magnetic dipole model of transition probabilities, the values of the w_{ij} are, in arbitrary units, $w_{12} = 1.89$, $w_{13} = 0.77$, $w_{14} = 0.15$, $w_{23} = 1.42$, $w_{24} = 0.26$ and $w_{34} = 1.42$. The inversion is calculated to be only 2.4.

The possibility of a cross-relaxation process in this mode suggests itself when the energy levels for about 2000 gauss are examined. A glance at Fig. 2 shows that $W_4 - W_3$ is nearly equal to $W_3 - W_2$. A cross-relaxation process is therefore possible in which a paramagnetic ion in level 4 jumps to 3 while simultaneously a neighbor jumps from 2 to 3. In the figure, a dotted line is drawn representing $1/2(W_2 + W_4)$; where this crosses the level W_3 the equality of $W_4 - W_3$ and $W_3 - W_2$ is exact. In Appendix II the field for this coincidence is found algebraically, and it is shown to be given by

$$g_{\perp} \beta B = |D|. \qquad (21)$$

It is also shown that the pumping (ν_{31}) and amplifying (ν_{21}) frequencies are given by

$$h\nu_{31} = 2|D|; \qquad h\nu_{21} = (2 - \sqrt{3})|D|. \qquad (22)$$

Eqs. (21) and (22) are true for any ruby-like Cr^{3+} compound, and they assert that the magnetic field required is that equivalent to half the zero-field splitting-frequency ν_{ZF}, the pumping frequency is equal to ν_{ZF}, and the amplifying frequency is $\nu_{ZF}(2 - \sqrt{3})/2$ or 0.134 ν_{ZF}. In the case of ruby, taking $\nu_{ZF} = 11.49$ kMc and $g_{\perp} = 1.987$,[14] one finds that the ideal magnetic field for the cross-relaxation process is 2065 gauss and the amplification frequency is 1535 Mc. As before, however, the cross-relaxation process can continue to dominate the spin-lattice relaxations even when the "resonance" is not exact. Referring to the 55° cross-relaxation process at low fields, discussed above, we find that it still has an important effect at $\theta = 65°$, at which angle it is "off-resonance" by about 400 Mc. Supposing that a similar latitude applies to the high-field case, it is easy to show, from the energy level curve, that the magnetic field could be about 140 gauss higher or lower than the ideal value of 2065, which means that the amplifying frequency ν_{21} could deviate similarly by ± 200 Mc from the ideal value of 1535 Mc. It is not strictly justifiable to appeal to the low-field 55° case in this way, since the nature of the quantum-mechanical states is not the same as in the high-field case; however, the orders of magnitude of the cross-relaxation line widths should be the same in the two cases.

The above discussion of line widths refers to the standard pink ruby of 0.05 per cent concentration. The type of ruby used in Geusic, *et al.*[21] is not stated; but the writer has little doubt that it was the standard pink ruby, which has been so much used in maser experiments. Hence the cross-relaxation process would be expected to be dominant in the experiments at 1500 Mc,[21] which gave such a high inversion ratio, and also in L-band masers operating at about 1400 Mc.[5]

Having presented reasons for believing that cross-relaxation processes must be occurring, we now examine what effect they would have on maser performance. The cross-relaxation process consists in a paramagnetic ion in level 4 jumping to 3 while simultaneously, a neighbor jumps from 2 to 3 (see Fig. 2), or in the inverse process. By analogy with the low-field 55° case, the contribution to the rate equation for, say, level 3 is

$$2cw_c''(n_2 n_4 - n_3^2)/N.$$

Just as before, if $cw_c'' \gg w_{ij}$ the process tends to equalize $n_2 n_4$ and n_3^2, *i.e.*, makes n_3 the geometric mean of n_2 and n_4. The action when ν_{31} is pumped may now be

[21] J. E. Geusic, E. O. Schulz-Du Bois, R. W. DeGrasse, and H. E. D. Scovil, "Three level spin refrigeration and maser action at 1500 mc/sec," *J. Appl. Phys.*, vol. 30, pp. 1113, 1114; July, 1959.

considered qualitatively. The pumping makes n_3 equal to n_1, so that n_1 is the geometric mean of n_2 and n_4. But, W_4 being so much higher than W_1 ($\nu_{41} \simeq 21.5$ kMc), and level 4 not being directly affected by pumping, n_4 tends to be considerably lower than n_1 so that n_2 must be correspondingly higher than n_1. This implies good maser action at ν_{21}. The solution of the equations analogous to (15), for the case that the cross-relaxation rate cw_r'' is much greater than any spin-lattice relaxation rate w_{ij}, and for saturating the resonance at ν_{31}, is

$$I = -\frac{\Delta n_{12}}{\Delta_0 n_{12}} = -1 + \frac{\nu_{31}}{\nu_{21}}\left(1 + \frac{w_{14} - w_{12}}{w_2 + 2w_{24} + w_4}\right). \quad (23)$$

Substituting the relative values of the w_{ij}'s already quoted, and with $\nu_{31} = 11.5$ kMc and $\nu_{21} = 1.50$ kMc, one obtains an inversion ratio of 4.4, which is in much better agreement with the experimental value of 5.2.[21]

An important question is whether the already good performance of the high-field ruby L-band maser mode would be still further improved by pumping at ν_{41}, 21.5 kMc, instead of at ν_{31}, 11.5 kMc. The solution for this case, with $cw_r'' \gg w_{ij}$, is:

$$I = -\frac{\Delta n_{12}}{\Delta_0 n_{12}} = -1 + \frac{\nu_{41}}{\nu_{21}}\left(1 - \frac{2w_{13} + 4w_{12}}{w_3 + 4w_{24} + 4w_{12}}\right), \quad (24)$$

which, with the w_{ij}'s already given, yields an inversion of 2.7, poorer than that predicted for pumping ν_{31}. Although it is not to be expected that the magnetic dipole model is a perfect guide to the values of the w_{ij}'s, it seems safe to predict that little advantage would be gained by changing to the higher pumping frequency.

V. Use of Working Substances with Higher Zero-Field Splittings than Ruby

Materials known at present in which the zero-field splitting of Cr^{3+} is higher than in ruby are: aluminum acetylacetonate, $Al[(CH_3CO)_2CH]_3$;[8] spinel,[12] $MgAl_2O_4$; rutile,[11] TiO_2; emerald (beryl),[10] $Be_3Al_2Si_6O_{18}$; and cyanite,[22] Al_2SiO_5. The acetyl acetonate is unsuitable for maser work both because its crystals shatter on cooling and because it exhibits six separate Cr^{3+} spectra at low temperatures.[23] Of the others, all exhibit the simple Hamiltonian (8) except rutile, and all have been produced artificially in monocrystalline form except cyanite, which is found as a mineral. Emerald is probably the most expensive of the materials to prepare as large monocrystals, and spinel the cheapest. Spinel contains four differently directed though otherwise equivalent Cr^{3+} sites, and this limits the freedom of orientation in a magnetic field since it is desirable to make the four sites play an equal part in maser action. Rutile contains two differently directed sites, and here the angular freedom is greater; emerald contains only one type of site. The number of different sites in cyanite has not been established by paramagnetic resonance. We shall now discuss the above materials in turn, paying particular attention to the possibility of cross-relaxation-assisted maser action.

A. Emerald: Zero-Field Splitting Frequency 53.6 kMc

To obtain the same kind of assistance from cross relaxation as does ruby in the 2000 gauss perpendicular mode, the frequencies and field would have to be scaled up in the ratio of the zero-field frequencies, *i.e.*, 53.6/11.5 or 4.66. Thus emerald should be a particularly effective maser with a field of 9700 gauss perpendicular to the axis, pumped at a frequency of 53.6 kMc and amplifying at 7200 Mc (*cf.* Fig. 2). The inversion ratio should be about 5, twice as good as if the cross-relaxation assistance were not employed. As an L-band amplifier (say 1400 Mc) emerald could be operated in the same kind of mode as above, *i.e.*, amplifying at ν_{21} (see Fig. 2), and the magnetic field required would then be, from (13), about 5000 gauss. The maser action would not be cross-relaxation assisted and the "ordinary" maser equation would apply, *i.e.*, (20). The pumping frequency, ν_{31}, would be about 50 kMc. Using the magnetic dipole model for the spin-lattice relaxation rates, one obtains an inversion ratio of about 13. In spite of this good inversion ratio, the high magnetic field requirement presents a deterrent to designers, particularly for a traveling wave maser. Hence, it is important to consider the possibilities of the low-field mode.

In low fields, cross-relaxation assistance is present at $\theta = 29°$ or $55°$ when the pumping and amplifying frequencies are respectively ν_{41} and ν_{43} (*cf.* Fig. 1). On the basis of the magnetic dipole model, the spin-lattice relaxation rates are practically the same as for ruby in the low-field applications discussed in Section IV. We shall treat only the 55° mode, which is the more promising. For amplification at 1400 Mc the field is 300 gauss and the pumping frequency 55.0 kMc. The inversion predicted from (19) is 20, as against about half this amount in the absence of cross relaxation.

B. Spinel: Zero-Field Splitting Frequency 29.7 kMc

The Hamiltonian is of the simple type (8), as for emerald and ruby. A disadvantage of the material is that the z-axes of the Cr^{3+} ions are aligned in four different directions, namely the four body-diagonals of the unit cube of the crystal structure. The most attractive application of this material is in a low-field mode, with the magnetic field applied along one of the cube axes. Then the axes of all the ions would be precisely oriented at the angle $\cos^{-1}(1/\sqrt{3})$ or 54.7° which is needed for the cross-relaxation-assisted maser mode at low fields. Operated as an amplifier for 1400 Mc (ν_{43}) the field

[22] O. Deutschbein, "The line emission and absorption of chromium phosphors. III Behaviour at low temperatures and in magnetic fields," *Ann. Physik*, vol. 20, pp. 828–842; 1934. Summarized in P. Pringsheim, "Fluorescence and Phosphorescence," Interscience Publishers, Inc., New York, N. Y., pp. 637–645; 1949.

[23] Bowers and Owen, *op. cit.*, p. 340.

would be 300 gauss, the pumping frequency (ν_{41}) 31 kMc, and the inversion ratio about 12. The ratios of the spin-lattice relaxation rates used in this calculation have been obtained from the magnetic dipole model with the help of the charts given by Howarth.[15] They are very similar to those of ruby in the corresponding mode.

C. Rutile: Zero-Field Splitting Frequency 43 kMc

Rutile presents a case of the more complicated Hamiltonian (7). There are two types of Cr^{3+} position per unit cell with the same Hamiltonian parameters and same z-axis but different x- and y-axes, the x-axis of one type being rotated 90° from that of the other.[11] In seeking a high-field mode analogous to the 2000 gauss perpendicular mode of ruby at L-band, we consider the energy level diagrams of Figs. 4(a), 4(b) and 4(c), next page, for field along the z, x and y directions of the Hamiltonian. (Actually the figures have been drawn for $E=\frac{1}{2}D$, whereas in rutile $E=0.27$ cm^{-1} and $D=0.55$ cm^{-1} with an experimental error presumably of about 0.005 cm^{-1}.[11]) A cross-relaxation-assisted mode is possible with a field of about 4400 gauss in the z-direction [Fig. 4(a)], and this direction has the advantage that the two types of Cr^{3+} ion have identical energies and play an equal part in the maser action. (For field along the x or y direction, only half the Cr^{3+} population could take part in a particular maser mode.)

As shown in Fig. 4(a), the average of W_a and W_d intersects W_c for a field of about 4400 gauss, and the situation is analogous to that in ruby with a perpendicular field of 2000 gauss. If the transition at frequency ν_{cb} is saturated, maser action at ν_{ab} will be cross-relaxation-assisted in the same way as in the ruby L-band maser. In Fig. 4(a) the cross-relaxation transitions are shown as dotted arrows.

The condition for the above-mentioned intersection is worked out in Appendix II. Eq. (45) for $G=g_c\beta B$ is of fourth degree and has to be solved numerically. For the case, $E=\frac{1}{2}D$, closely approximated by rutile, the solution is $G=0.75\ D$, whence $B=4400$ gauss. The pumping (ν_{cb}) and amplifying (ν_{ab}) frequencies are respectively 35 and 5.0 kMc.

To make an estimate of the inversion ratio in this mode it would be necessary to know the magnetic dipole transition probabilities between all the levels. To avoid very tedious computations a semi-quantitative approach will be adopted here. When the secular matrix of the Hamiltonian (7) is written down, following the methods of Bowers and Owen,[8] it is found that the states b and d belong to one sub-matrix and a and c to another. At high fields, a, b, c and d are pure states $|-\frac{3}{2}\rangle$, $|-\frac{1}{2}\rangle$, $|\frac{1}{2}\rangle$, $|\frac{3}{2}\rangle$. As the field is reduced to below the region of $g_z\beta B/D=1$, the states a and c tend to cross in energy, and are strongly mixed by the $S_x^2-S_y^2$ term in the Hamiltonian which produces matrix elements joining a and c. We assume that they are completely mixed, *i.e.*, that $|c, a\rangle=(1/\sqrt{2})(|-\frac{3}{2}\rangle\pm|\frac{1}{2}\rangle)$. The states $|b\rangle$ and $|d\rangle$ are also connected by matrix elements, but are not severely mixed since they do not approach closely in energy. These we assume to be completely unmixed, *i.e.*, we take $|b\rangle=|-\frac{1}{2}\rangle$ and $|d\rangle=|\frac{3}{2}\rangle$.

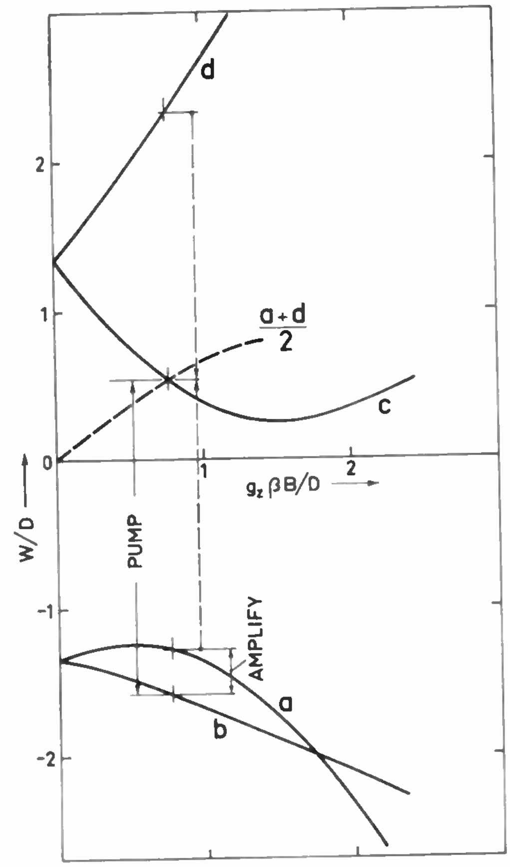
The magnetic dipole transition probabilities are then calculated by standard methods.[8] The labels a, b, c, d are changed to 2, 1, 3, 4, respectively, so that the notation corresponds to that of the high-field mode in ruby, already discussed, and so that (20) and (23) are directly applicable. The spin-lattice relaxation rates, in arbitrary units, are $w_{12}=7/4$, $w_{13}=7/4$, $w_{14}=0$, $w_{23}=1$, $w_{24}=\frac{3}{4}$ and $w_{34}=\frac{3}{4}$. The predicted inversion for cross-relaxation-assisted maser action is then [see (23)] 4.1, whereas without cross relaxation it would be 2.1.

A similar cross-relaxation-assisted mode is possible with the magnetic field in the y-direction [Fig. 4(c)]. Here it is the average of W_a and W_d which crosses W_b. The condition for the intersection, given in (54), is again an equation of fourth degree; the solution for rutile is approximately $g_y\beta B=0.57D$, or $B=3400$ gauss. The pumping frequency, ν_{cb}, and the amplifying frequency, ν_{cd}, are 35 and 8.0 kMc, respectively. Using the same kind of model for spin-lattice relaxation rates as for the z-direction, the inversion is predicted to be 2.2 with cross relaxation as against 0.9 without. The lower inversion ratio in this mode, and the fact that only half the Cr^{3+} population takes part, render it less attractive than the z-direction mode; but this is perhaps offset by the fact that the amplifying frequency is in the familiar X-band.

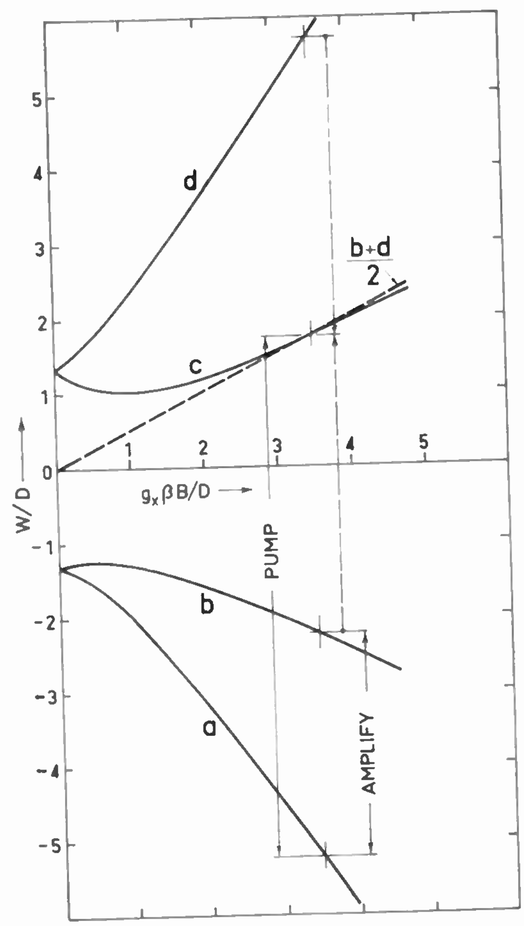
When the field is in the x-direction a cross-relaxation mode is again possible; but it occurs at a field of about 21,000 gauss in rutile, and the inversion is expected to be low. We shall not discuss this mode further. However, in Appendix II, the general conditions for this mode are discussed, and it is shown that for substances in which $E\ll D/3$ the field requirement is not prohibitive.

In anticipation of the use of substances with small E/D, Appendix II gives explicit expressions for field, and for pumping and amplifying frequencies, in the form of a series expansion up to terms in E^2/D^2, for the x, y and z directions. The author is not aware of any substances which are known to have small E/D and larger zero-field splittings than ruby together with its desirable mechanical and electrical properties; but it can hardly be doubted that such substances will be discovered as soon as a systematic survey of aluminum- and chromium-containing minerals is made.

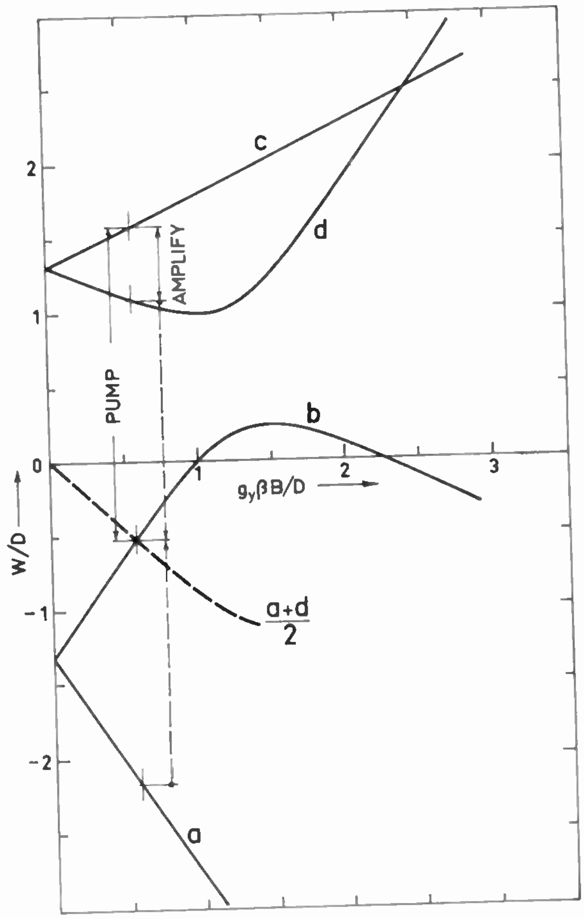
We next consider the possibility of low-field cross-relaxation action with rutile. The energy levels are given in Appendix I, (30), (31), and (32); and it may be seen that they depend on ϕ, the azimuthal angle describing the field-direction, through cos 2ϕ. Thus if the field is applied in the plane $\phi=\pi/4$ for one species of Cr^{3+} ion, cos $2\phi=0$ for both species and their energy levels are identical; thus the whole Cr^{3+} population may be used for maser action. We now assume, without loss of generality for maser discussion, that D is positive, and label the levels in the order in which their energies



(a)



(b)



(c)

Fig. 4—(a) Normalized energy W/D of Cr^{3+} in rutile vs normalized field $g_z\beta B/D$ for the z-direction of field. The conditions for cross-relaxation maser action are shown, the cross-relaxation transitions being indicated by the vertical dotted arrows. The amplifying frequency is 5.0 kMc and the required magnetic field is 4400 gauss. (b) Normalized energy vs field for Cr^{3+} in rutile with field in the x-direction. At the field shown (21,000 gauss), maser action is assisted by the cross-relaxation transitions (shown by dotted arrows). The amplifying frequency is 50 kMc. (c) Normalized energy vs field for Cr^{3+} in rutile with field in the y-direction. At the field shown (3400 gauss), maser action is assisted by the cross-relaxation transitions (dotted). The amplifying frequency is 8.0 kMc.

ascend at $\phi=\pi/4$, *viz.*, 1, 2, 3, 4, instead of $-\frac{1}{2}$, $\frac{1}{2}$, $-\frac{3}{2}$, $\frac{3}{2}$ as in the Appendix. Then, substituting Z for $(D^2+3E^2)^{1/2}$, we have

$$W_{4,3} = Z \pm \tfrac{3}{2} G \left[\cos^2\theta(1 - \tfrac{4}{3}\sin^2\alpha)^2 + \tfrac{4}{9}\sin^2\theta\sin^2\alpha(1 + 2\cos^2\alpha)\right]^{1/2}$$

$$W_{2,1} = -Z \pm \tfrac{1}{2} G \left[\cos^2\theta(1 - 4\sin^2\alpha)^2 + \sin^2\theta(4\cos^4\alpha + 3\sin^2 2\alpha)\right]^{1/2}, \quad (25)$$

where α, which describes the extent to which the states are mixed in zero-field, is given by (29). We shall confine attention to the condition that $W_4-W_3=W_2-W_1$, as in the 55° mode in ruby, since that mode is the more promising of the low-field modes. If $W_4-W_3=W_2-W_1$, it follows from (25) that $\cos^2\theta=1/3$, so that $\theta=54.7°$ as in ruby.

The question might now be asked whether, since $\nu_{43}=\nu_{21}$, the amplifying transition is from level 4 to 3 or from level 2 to 1. If E/D were zero we should be dealing with a ruby-like situation: the states 4 and 3 would be quite pure states $|\frac{3}{2}\rangle$ and $|-\frac{3}{2}\rangle$ and the radio-frequency transition probability between them would be zero, so that the amplifying transition could only be between levels 2 and 1. (This case has already been discussed for ruby, with the only difference that levels 1 and 2 were there labeled 4 and 3, and so on, because of the negative sign of D.) For $E/D\neq 0$, the zero-field states may be considerably mixed: for example, in rutile, $\sin\alpha=0.35$ and $\cos\alpha=0.94$, so (Appendix 1) the states of levels 4 and 3 are no longer $|\pm 3/2\rangle$ but $0.94|\pm\frac{3}{2}\rangle+0.35|\mp\frac{1}{2}\rangle$ and the radio-frequency transition probability between them in low fields is of the order of 0.35^2, or one tenth, as strong as the well-allowed transition between 2 and 1. It may be worth while to recall that the effect of the cross relaxations is such that if the resonance at either ν_{43} or ν_{21} becomes emissive, the other does also. Thus in rutile most of the amplification comes from the ν_{21} transitions.

The magnetic field required for a given amplifying frequency may be worked out from either of equations (25), putting $\cos^2\theta=1/3$. For example the second equation gives

$$h\nu_{21} = \sqrt{3}G = \sqrt{3}g\beta B, \quad (26)$$

which, it will be noted, is independent of α and hence of E/D. This gives the formula

$$B = 0.206(2/g)\nu_{21}, \quad (27)$$

B and ν_{21} being in gauss and megacycles per second. Eq. (27) applies not only to rutile, but to any Cr^{3+}-containing compound. For an amplifier for 1400 Mc a field of 290 gauss would be required. The fractional errors in (26) and (27) are similar to that in (10), *i.e.* about $(h\nu_{21}/2Z)^2$ or 0.1 per cent in the above example. Since the states are complicated, we shall not attempt to calculate relaxation rates and the inversion, but observe that the latter should be similar to that already worked out for emerald, *i.e.* of the order of 20. The pumping frequency (ν_{41}) in the above example would be about 45 kMc, from (25). In cases of higher amplifying frequencies ν_S it should be noted that ν_{41} is greater than predicted from (25) by an amount of order ν_S^2/ν_{ZF} [see (33) in Appendix I and the discussion following it].

D. Cyanite: Zero-Field Splitting Frequency 1000 kMc

Cyanite, Al_2SiO_5, containing Cr^{3+} ions was studied by optical absorption methods at low temperatures,[22] and a splitting of the ground level of 33 cm^{-1} or 1000 kMc was found. If sufficient pumping power could be obtained, for example, from an intense infra-red source, cyanite would offer extremely high inversion ratios. The high-field mode is practically out of the question, 30,000 gauss being needed for amplification at L-band. The low-field mode could be used, however, and the field required would be given by (10) or (11).

Application of this material will depend on progress of techniques in the unfamiliar region of 1000 kMc. The pumping radiation would require not only to be sufficiently intense, but also to possess a sharp cutoff at a frequency below the pumping frequency ν_{41} and above ν_{42} and ν_{31} (*cf.* Fig. 1), for pumping at the latter two frequencies, as well as at the former, would interfere with maser action.

E. Gallium Oxide and Yttrium Gallium Garnet: Zero-Field Splitting Frequencies 35.4 and 21.0 kMc Respectively

Measurements on Cr^{3+} in these substances have been reported only very recently.[24,25] The maser applications proposed below should be regarded with some reserve until the number of different Cr^{3+} sites per unit cell has been reported: this information is not stated in references available to the author.

Gallium oxide (β-Ga_2O_3) containing Cr^{3+} has a rutile-like Hamiltonian. Cross-relaxation maser action with an inversion of 3 should be obtained in both the following modes: 1) amplifying at 6.4 kMc with pumping at 28.3 kMc and a field of 2800 gauss along the z-axis of the Hamiltonian; 2) amplifying at 5.3 kMc, pumping at 28.5 kMc, with a 3200 gauss field along the y-axis.

Yttrium gallium garnet ($3Y_2O_3\cdot 5Ga_2O_3$) containing Cr^{3+} has a ruby-like Hamiltonian. It would give cross-relaxation maser action at 2.8 kMc with an inversion of 5 under these conditions: a field of 3800 gauss perpendicular to the magnetic symmetry axis and a pumping frequency of 21.0 kMc.

[24] M. Peter and A. L. Schawlow, "Optical and paramagnetic resonance spectra of Cr^{+++} in Ga_2O_3," *Bull. Am. Phys. Soc.*, vol. 5, p. 158; March, 1960.

[25] S. Geschwind and J. W. Nielsen, "Paramagnetic resonance of Cr^{3+} in yttrium gallium garnet," *Bull. Am. Phys. Soc.*, vol. 5, p. 252; April, 1960.

VI. Conclusion

Although ruby has given good maser performance, a three- or four-fold improvement should be possible with spinel, rutile and emerald. The reason for the good performance of the ruby L-band maser with a 2000 gauss perpendicular field is that cross-relaxation processes are occurring which assist the maser action. The same kind of action can be utilized with the other materials, and should approximately double the maser performance. However, the pumping and amplifying frequencies are specific to the material used. Emerald should give an inversion ratio of about 5 as an amplifier for 7.2 kMc with a pumping frequency of 53.6 kMc, and a field of 9700 gauss; and this is to be contrasted with the inversion of 0.95 which has been obtained with a representative ruby maser amplifying at 6 kMc.[26] It may prove difficult at the present time to obtain sufficient pumping power at the frequency of 53.6 kMc, and perhaps rutile is more promising, offering an amplifying frequency of 5.0 kMc (field: 4400 gauss; inversion ratio: about 4) or 8.0 kMc (field: 3400 gauss; inversion ratio: about 2) depending on the direction of field. The pumping frequency for either case is 35 kMc, which is close to the center of the well-developed 8-mm radar band for which klystrons are commercially available giving continuous power output of 15 watts.[27] This is far more power than is needed to saturate the paramagnetic resonance of rutile at liquid helium temperatures, and indeed would be sufficient at liquid air or even solid carbon dioxide temperatures, where a ruby maser has been successfully operated.[28] Rutile is a very promising material for these temperatures; it should be much easier to pump than ruby since its spin-lattice relaxation time at 77°K is 400 μsec[11] as against 40 μsec for ruby.[19] By comparison with the reported performance of ruby,[28] rutile should give a voltage-gain bandwidth product of about 30 Mc in a cavity maser amplifying at 5 kMc at liquid air temperature. The high dielectric constant of rutile will allow the cavity or traveling wave structure to be small, which will ease the requirements on the magnet used.

For amplifying at the lower microwave frequencies it is important to find maser modes which do not require too high a magnetic field, because a longer wavelength implies a larger structure and therefore a larger magnet pole separation. The ruby 2000 gauss mode for L-band is rather uneconomical in this respect, and spinel and emerald would be even more so in the corresponding mode as they would require 3600 and 5300 gauss, respectively. The better course will be to exploit the low-field modes in the new materials. It has been shown that the failures experienced with ruby in the low-field mode are due to cross-relaxation processes which can be not only avoided but put to good use by a correct choice of orientation and pumping transition. In the case of L-band amplification, spinel, rutile and emerald would require pumping frequencies of 31, 45 and 55 kMc, all with a magnetic field of about 300 gauss, and the maser performance would be about twice as good as in the absence of cross-relaxation.

As far as the improvement of maser action is concerned, cross-relaxation operation is approximately equivalent to push-pull or doubly-pumped operation,[9] which is possible with ruby-like materials at $\theta=55°$. However, in the push-pull mode the amplifying transition is between levels 2 and 3 which never approach closely: indeed, from (3.4) of Kikuchi, *et al.*,[9] it is readily demonstrable that the lowest possible amplifying frequency is half the zero-field splitting frequency. For example, ruby cannot amplify at a frequency below 5720 Mc in this mode.

Cross-relaxation masers are important, therefore, for achieving high inversion ratios at frequencies low compared to the zero-field splitting frequency of the maser material.

Other applications of cross relaxation have been described by Arams:[29] the most striking is the realization of a maser with signal frequency higher than the pumping. The price for this achievement is a rather low inversion ratio; but important applications may be foreseen in the millimeter-wave region. Chang[30] has described a further case in which the inversion was increased by cross relaxation: this showed that even a process involving as many as four simultaneous spin-flips could affect maser action. It may reasonably be expected that the cross-relaxation phenomenon, though first discovered through its ill effects, will eventually be best known for its beneficial effects on maser action.

Appendix I

Calculation of the Low-Field Energy Levels of a Cr^{3+} Ion Obeying the Hamiltonian

$$g\beta B\cdot S+D(S_z^2-\tfrac{5}{4})+E(S_x^2-S_y^2)$$

In this treatment it is assumed that the g-tensor is isotropic. The energy levels and states are derived exactly for zero field, and the effect on the energies of a small magnetic field obtained by first-order perturbation theory.

[26] E. O. Schulz-Du Bois, H. E. D. Scovil, and R. W. DeGrasse, "Use of active material in three-level solid-state masers," *Bell Sys. Tech. J.*, vol. 38, pp. 335–352; March, 1959.

[27] Klystron type B579, manufactured by Elliott Bros. (London) Ltd., Borehamwood, Hertfordshire, England.

[28] T. H. Maiman, "Maser behavior: temperature and concentration effects," *J. Appl. Phys.*, vol. 31, pp. 222–223; January, 1960.

[29] F. R. Arams, "Maser operation with signal frequency higher than pump frequency," Proc. IRE, vol. 48, p. 108; January, 1960.

[30] W. S. Chang, "Spin-lattice relaxation via harmonic coupling," in "Quantum Electronics," C. H. Townes, Ed., Columbia University Press, New York, N. Y.; 1960.

A. Energies and States at Zero Fields

The Hamiltonian is

$$\mathcal{H} = D(S_z^2 - \tfrac{5}{4}) + E(S_x^2 - S_y^2)$$
$$= D(S_z^2 - \tfrac{5}{4}) + \tfrac{1}{2}E(S_+^2 + S_-^2),$$

where $S\pm \equiv S_x \pm iS_y$.

We now write down the matrix of the Hamiltonian in the representation of the eigenstates of S_z, defined by $S_z|M\rangle = M|M\rangle$. Since S for Cr^{3+} is 3/2, M can take the values $\pm 1/2$, $\pm 3/2$. Proceeding by the methods shown in Bowers and Owen,[31] for example, we obtain for the matrix of $\mathcal{H}$:

$$\begin{array}{c|cccc|} & |\tfrac{3}{2}\rangle & |\tfrac{1}{2}\rangle & |-\tfrac{1}{2}\rangle & |-\tfrac{3}{2}\rangle \\ |\tfrac{3}{2}\rangle & D & 0 & E\sqrt{3} & 0 \\ |\tfrac{1}{2}\rangle & 0 & -D & 0 & E\sqrt{3} \\ |-\tfrac{1}{2}\rangle & E\sqrt{3} & 0 & -D & 0 \\ |-\tfrac{3}{2}\rangle & 0 & E\sqrt{3} & 0 & D \end{array}, \qquad (28)$$

which can be reduced, by rearrangement of rows and columns, to the following two submatrices:

$$\begin{array}{c|cc|} & |\tfrac{3}{2}\rangle & |-\tfrac{1}{2}\rangle \\ |\tfrac{3}{2}\rangle & D & E\sqrt{3} \\ |-\tfrac{1}{2}\rangle & E\sqrt{3} & -D \end{array} \quad \text{and} \quad \begin{array}{c|cc|} & |-\tfrac{3}{2}\rangle & |\tfrac{1}{2}\rangle \\ |-\tfrac{3}{2}\rangle & D & E\sqrt{3} \\ |\tfrac{1}{2}\rangle & E\sqrt{3} & -D \end{array}.$$

The identity of the two submatrices shows that results from the $|\tfrac{3}{2}\rangle$, $|-\tfrac{1}{2}\rangle$ manifold can be carried over to the $|-\tfrac{3}{2}\rangle$, $|+\tfrac{1}{2}\rangle$ simply by substituting $|-M\rangle$ for $|M\rangle$.

The secular equation for the energy for either manifold is, in determinantal form,

$$\begin{vmatrix} D - W & E\sqrt{3} \\ E\sqrt{3} & -D - W \end{vmatrix} = 0,$$

whence $W = \pm(D^2+3E^2)^{1/2}$, as already stated in Bowers and Owen.[2]

If $E=0$ it can be seen by inspection of the matrix (28) that the eigenstates are $|\pm\tfrac{3}{2}\rangle$ at energy D and $|\pm\tfrac{1}{2}\rangle$ at $-D$. In defining the states for $E \neq 0$, some attention is needed to the influence of the sign of D, which has been obscured in the expression $(D^2+3E^2)^{1/2}$. Let $\lambda = D/|D|$; then $|\tfrac{3}{2}'\rangle$ must be defined as the state at energy $\lambda(D^2+3E^2)^{1/2}$. Then, as $E \to 0$, $|\tfrac{3}{2}'\rangle \to |\tfrac{3}{2}\rangle$, and the energy approaches its correct value of $\lambda|D|$. Bearing in mind the requirements of normalization and orthogonality, it is evident that the eigenstates of the $|\tfrac{3}{2}\rangle$, $|-\tfrac{1}{2}\rangle$ submatrix may be written as

$$|\tfrac{3}{2}'\rangle = \cos\alpha\,|\tfrac{3}{2}\rangle + \sin\alpha\,|-\tfrac{1}{2}\rangle \text{ at } \lambda(D^2+3E^2)^{1/2}$$
$$|\tfrac{1}{2}'\rangle = \cos\alpha\,|-\tfrac{1}{2}\rangle - \sin\alpha\,|\tfrac{3}{2}\rangle \text{ at } -\lambda(D^2+3E^2)^{1/2}.$$

[31] Bowers and Owen, *op. cit.*, pp. 319–321.

Here α is to be found from the eigenvalue equation,

$$\mathcal{H}|\tfrac{3}{2}'\rangle = W_{3/2}'|\tfrac{3}{2}'\rangle = \lambda(D^2+3E^2)^{1/2}|\tfrac{3}{2}'\rangle,$$

that is

$$\begin{bmatrix} D & E\sqrt{3} \\ E\sqrt{3} & -D \end{bmatrix}\begin{bmatrix}\cos\alpha \\ \sin\alpha\end{bmatrix} = \lambda(D^2+3E^2)^{1/2}\begin{bmatrix}\cos\alpha \\ \sin\alpha\end{bmatrix};$$

or, using the second row of the matrix,

$$E\sqrt{3}\cos\alpha - D\sin\alpha = \lambda(D^2+3E^2)^{1/2}\sin\alpha,$$

whence

$$\tan\alpha = \frac{E\sqrt{3}}{D + \lambda(D^2+3E^2)^{1/2}}. \qquad (29)$$

B. Effect of a Small Magnetic Field

We take as unperturbed states the results of Section A above, namely

$$|\pm\tfrac{3}{2}'\rangle = \cos\alpha\,|\pm\tfrac{3}{2}\rangle + \sin\alpha\,|\mp\tfrac{1}{2}\rangle$$
$$\text{at energy } \lambda(D^2+3E^2)^{1/2}$$

and

$$|\pm\tfrac{1}{2}'\rangle = \cos\alpha\,|\pm\tfrac{1}{2}\rangle - \sin\alpha\,|\mp\tfrac{3}{2}\rangle$$
$$\text{at energy } -\lambda(D^2+3E^2)^{1/2}.$$

The effect of an applied magnetic field B may now be derived by a perturbation treatment,[32] yielding first-order perturbations of order $g\beta B$ and second-order perturbations of order $(g\beta B)^2/(D^2+3E^2)^{1/2}$. The latter, however, are very complicated and we shall be content here with the first-order effect except for the simpler case where $E=0$ in the Hamiltonian (part C). The first-order treatment is applicable with sufficient accuracy to Cr^{3+} in rutile used as an L-band maser, because the zero-field splitting $2(D^2+3E^2)^{1/2}$ is so high.

To obtain the first-order perturbation of energy for the doublet $|\pm\tfrac{1}{2}'\rangle$ one has to write the matrix of the perturbation operator V in the representation of $|+\tfrac{1}{2}'\rangle$ and $|-\tfrac{1}{2}'\rangle$, and solve for its characteristic values.[32]

The perturbation V is expressible in a convenient form by writing

$$V = g\beta B\cdot S = G\cdot S = G_zS_z + \tfrac{1}{2}(G_+S_- + G_-S_+),$$

where

$$G_z = g\beta B_z = g\beta B\cos\theta = G\cos\theta$$
$$G_\pm = g\beta(B_x \pm iB_y) = G\sin\theta e^{\pm i\phi}$$
$$G = g\beta B;$$

then the matrix of V takes the form

[32] E. U. Condon and G. H. Shortley, "The Theory of Atomic Spectra," Cambridge University Press, Cambridge, Eng., pp. 30 ff.; 1951.

$$\begin{array}{c} \\ |\tfrac{1}{2}'\rangle \\ \\ |-\tfrac{1}{2}'\rangle \end{array}\begin{array}{c} |\tfrac{1}{2}'\rangle \qquad\qquad\qquad\qquad |-\tfrac{1}{2}'\rangle \\ \begin{bmatrix} G_z(\tfrac{1}{2}\cos^2\alpha-\tfrac{3}{2}\sin^2\alpha) & G_-\cos^2\alpha-G_+\sqrt{3}\sin\alpha\cos\alpha \\ G_+\cos^2\alpha-G_-\sqrt{3}\sin\alpha\cos\alpha & G_z(-\tfrac{1}{2}\cos^2\alpha+\tfrac{3}{2}\sin^2\alpha) \end{bmatrix}, \end{array}$$

and its characteristic values are $+W_{1/2}''$, corresponding to the state $|\tfrac{1}{2}''\rangle$ (which approaches $|\tfrac{1}{2}'\rangle$ as $\theta\to 0$); and $-W_{1/2}''$, corresponding to the state $|-\tfrac{1}{2}''\rangle$, with

$$W_{1/2}'' = \tfrac{1}{2}G\left[\cos^2\theta(1-4\sin^2\alpha)^2+\sin^2\theta(4\cos^4\alpha + 3\sin^2 2\alpha - 4\sqrt{3}\cos^2\alpha\sin 2\alpha\cos 2\phi)\right]^{1/2}. \quad (30)$$

The perturbations of the $|\pm\tfrac{3}{2}'\rangle$ states, found similarly, are $W_{3/2}''$, corresponding to $|\tfrac{3}{2}''\rangle$ (which approaches $|\tfrac{3}{2}'\rangle$ when $\theta\to 0$); and $-W_{3/2}''$, corresponding to $|-\tfrac{3}{2}''\rangle$, with

$$W_{3/2}'' = \tfrac{3}{2}G\left[\cos^2\theta(1-\tfrac{4}{3}\sin^2\alpha)^2 + \tfrac{4}{9}\sin^2\theta\sin^2\alpha(1+2\cos^2\alpha+\sqrt{3}\sin 2\alpha\cos 2\phi)\right]^{1/2}. \quad (31)$$

The angle α which enters (30) and (31) is defined in (29).

Collecting results, the total energies are:

$$\begin{aligned} W(\pm\tfrac{3}{2}) &= \lambda(D^2+3E^2)^{1/2} \pm W_{3/2}'' \quad \text{for } |\pm\tfrac{3}{2}''\rangle \\ W(\pm\tfrac{1}{2}) &= -\lambda(D^2+3E^2)^{1/2} \pm W_{1/2}'' \quad \text{for } |\pm\tfrac{1}{2}''\rangle. \end{aligned} \quad (32)$$

The second-order perturbations will not be given here explicitly for the general case; it would be necessary to solve for the composition of $|\tfrac{3}{2}''\rangle$, $|\tfrac{1}{2}''\rangle$, etc. in the same way as for $|\tfrac{3}{2}'\rangle$, $|\tfrac{1}{2}'\rangle$, etc. in Section A. The second-order perturbation of the energy of $|\tfrac{1}{2}''\rangle$, for example, is[32]

$$\frac{-|\langle\tfrac{1}{2}''|V|\tfrac{3}{2}''\rangle|^2 - |\langle\tfrac{1}{2}''|V|-\tfrac{3}{2}''\rangle|^2}{2\lambda(D^2+3E^2)^{1/2}}, \quad (33)$$

which is a complicated function of α, θ and ϕ of order $(g\beta B)^2/2(D^2+3E^2)^{1/2}$. In the case of rutile operating as an L-band maser at low fields, the frequency-equivalent of this correction is only about $(1400)^2/43{,}000$ or 50 Mc, which should be within the scope of tuning adjustments.

C. Case of the Simpler Hamiltonian $g\beta B\cdot S+D(S_z^2-5/4)$

It is now relatively simple to solve for the states $|\tfrac{3}{2}''\rangle$, $|\tfrac{1}{2}''\rangle$, etc., and the second-order term (33) is found to take the form

$$-3\sin^2\theta(g\beta B)^2/8D. \quad (34)$$

This applies to both $|\tfrac{1}{2}''\rangle$ and $|-\tfrac{1}{2}''\rangle$, while the term for $|\pm\tfrac{3}{2}''\rangle$ has the opposite sign.

Collecting terms from (30), (32) and (34), the energies, up to second order, are found to be:

$$\begin{aligned} W(\pm\tfrac{3}{2}) &= D \pm \tfrac{3}{2}g\beta B\cos\theta + 3\sin^2\theta(g\beta B)^2/8D \\ W(\pm\tfrac{1}{2}) &= -D \pm \tfrac{1}{2}g\beta B(1+3\sin^2\theta)^{1/2} \\ &\quad - 3\sin^2\theta(g\beta B)^2/8D. \end{aligned} \quad (35)$$

These are rewritten in (9) in such a way as to maintain a consecutive order of energies whatever the sign of D.

Appendix II

Conditions for Cross-Relaxation-Assisted Maser Action in the "High-Field Mode"

A. Calculation of the Energy Levels

When the spin Hamiltonian has its most general form for Cr^{3+}, namely

$$\mathcal{H} = \beta B\cdot g\cdot S + D(S_z^2-\tfrac{5}{4}) + E(S_x^2-S_y^2), \quad (36)$$

the energy levels can be obtained exactly provided that the applied field is along the x, y or z axes.[8]

For the z-direction of field the energy levels are,[33]

$$\begin{aligned} W_{d,b} &= \tfrac{1}{2}G \pm [(D+G)^2+3E^2]^{1/2} \\ &= \tfrac{1}{2}G \pm (Z^2+G^2+2DG)^{1/2} \\ W_{c,a} &= -\tfrac{1}{2}G \pm [(D-G)^2+3E^2]^{1/2} \\ &= -\tfrac{1}{2}G \pm (Z^2+G^2-2DG)^{1/2}, \end{aligned} \quad (37)$$

where $G=g_z\beta B$ and $2Z$ is the zero-field splitting $2(D^2+3E^2)^{1/2}$. It may be seen by inspection that at very high fields the energy levels ascend in the order a, b, c, d. In Fig. 4(a) these levels are sketched on the assumption that D is positive and $E=\tfrac{1}{2}D$. The figure is therefore closely applicable to rutile, where $D=0.55$ and $E=0.27\ \text{cm}^{-1}$.

The energy levels for the x- and y-directions may be obtained from (37) by a simple transformation which is given in Bowers and Owen.[34] For field in the x-direction the rule is to replace g_z by g_x, D by $\tfrac{1}{2}(3E-D)$, and E by $-\tfrac{1}{2}(D+E)$. Naturally, the zero-field splitting $2Z=2(D^2+3E^2)^{1/2}$ is invariant under this transformation. The energies become

$$\begin{aligned} W_{d,b} &= \tfrac{1}{2}G \pm [Z^2+G^2+(3E-D)G]^{1/2} \\ W_{c,a} &= -\tfrac{1}{2}G \pm [Z^2+G^2-(3E-D)G]^{1/2}, \end{aligned} \quad (38)$$

where $G=g_x\beta B$. They are sketched in Fig. 4(b).

For field in the y-direction the rule is to replace g_z by g_y, D by $-\tfrac{1}{2}(D+3E)$ and E by $\tfrac{1}{2}(D-E)$, which yields

$$\begin{aligned} W_{d,b} &= \tfrac{1}{2}G \pm [Z^2+G^2-(3E+D)G]^{1/2} \\ W_{c,a} &= -\tfrac{1}{2}G \pm [Z^2+G^2+(3E+D)G]^{1/2}. \end{aligned} \quad (39)$$

These are sketched in Fig. 4(c).

In the important case $E=0$, both (38) and (39) reduce to

$$\begin{aligned} W_{d,b} &= \tfrac{1}{2}G \pm (D^2+G^2-DG)^{1/2} \\ W_{c,a} &= -\tfrac{1}{2}G \pm (D^2+G^2+DG)^{1/2}, \end{aligned} \quad (40)$$

with $G=g_\perp\beta B$. For ruby, where D is negative, the identity of the above levels with those of Fig. 2 is secured by associating a, b, c, d with 1, 2, 3, 4, respectively.

Eq. (40) and Fig. 2 will now be used to discuss cross-relaxation-assisted maser action in ruby in the high-field L-band mode, and analogous action in other materials.

[33] Bowers and Owen, *op. cit.*, p. 335.
[34] *Ibid.*, p. 321.

B. Condition for Cross-Relaxation-Assisted Maser Action in High Fields with Materials Like Ruby

This mode of maser action is exemplified by ruby acting as an L-band amplifier in a perpendicular field of about 2000 gauss (Fig. 2). The results of the following discussion would be the same whatever the sign of D, but for clarity it seems preferable to work in terms of negative D as for ruby (Fig. 2). The energy levels are then, from (40),

$$W_{4,2} = \tfrac{1}{2}G \pm (D^2 + G^2 + |D|G)^{1/2}$$
$$W_{3,1} = -\tfrac{1}{2}G \pm (D^2 + G^2 - |D|G)^{1/2}, \qquad (41)$$

the labels according with Fig. 2.

It has been shown in the text that the cross-relaxation process which benefits the ruby L-band maser requires that $W_4 - W_3 = W_3 - W_2$. This is easily shown from (41) to lead to

$$G = |D|. \qquad (42)$$

In other words, the magnetic field energy is equivalent to half the zero-field splitting. We now calculate the pumping and amplifying frequencies when $G = |D|$. The pumping transition is between the lowest and second-to-highest level, *i.e.*,

$$h\nu_p = W_3 - W_1 = 2(D^2 + G^2 - |D|G)^{1/2} = 2|D|, \qquad (43)$$

which means that the pumping frequency is identical with the zero-field splitting frequency. The amplifying transition is between the two lowest levels, *i.e.*,

$$h\nu_s = W_2 - W_1 = G - (D^2 + G^2 + |D|G)^{1/2} + (D^2 + G^2 - |D|G)^{1/2}$$
$$= |D| - \sqrt{3}|D| + |D| = |D|(2 - \sqrt{3}). \qquad (44)$$

Thus the amplifying frequency is $(1 - \sqrt{3}/2)$, or 0.134, times the zero-field frequency.

C. High-Field Cross-Relaxation Maser Action with Materials Like Rutile

It is shown in the text that cross-relaxation modes are possible with field along the z-, x- and y-axes [Figs. 4(a), (b) and (c)].

1) *Field in the z-direction:* The pumping transition is from level b to c [Fig. 4(a)] and the amplifying from a to b. The cross-relaxation process requires that $W_c = \tfrac{1}{2}(W_a + W_d)$. Using (37) this condition may be expressed as

$$-G + 3(Z^2 + G^2 - 2DG)^{1/2} = (Z^2 + G^2 + 2DG)^{1/2}, \qquad (45)$$

where $G = g_z\beta B$. Unfortunately this equation is of fourth degree in G, and no analytic solution can be given. If E were small compared with D, which is not the case in rutile, the following solutions would be useful:

$$G = \tfrac{2}{5} D(1 + 45E^2/14D^2 + \cdots) \qquad (46)$$
$$h\nu_{ab} = h\nu_s = 2D(1/5 - E^2/14D^2 + \cdots) \qquad (47)$$
$$h\nu_{cb} = h\nu_p = 2D(4/5 + 8E^2/7D^2 + \cdots), \qquad (48)$$

subsequent terms in the brackets being of order E^4/D^4.

2) *Field in the x-direction:* Two cases occur, one for $E > \tfrac{1}{3}D$ and the other for $E < \tfrac{1}{3}D$. In the first case, exemplified by rutile [Fig. 4(b)] the cross-relaxation condition occurs at a very high field, at which the average of W_b and W_d intersects W_c. The pumping transition is from a to c and the amplifying from b to a. The condition for the intersection is, from (38),

$$G = [Z^2 + G^2 - G(3E - D)]^{1/2}, \qquad (49)$$

where $G = g_x\beta B$. It may be noted that G in this equation must be positive. This reduces to

$$G = (D^2 + 3E^2)/(3E - D), \qquad (50)$$

which can only be satisfied if $E > D/3$.

The pumping and amplifying frequencies may be worked out from (38), but we do not quote them here because not only is the required field inconveniently high, but also the ratio of pumping to amplifying frequency is relatively low, and the mode is unsuitable for maser work.

When $E < \tfrac{1}{3}D$, different levels come into play: the average of W_a and W_c now intersects W_b, and the pumping and amplifying transitions are between b and d, and c and d, respectively. The field required is

$$G = (D^2 + 3E^2)/(D - 3E), \qquad (51)$$

and, as before, only a positive G is meaningful, so that this mode is only possible when $E < \tfrac{1}{3}D$. When $E \to 0$ this mode approaches that typified by ruby in the 2000 gauss L-band mode, and (51) becomes identical with (42). The amplifying and pumping frequencies are given by

$$h\nu_{dc} = h\nu_s = D[2 - \sqrt{3} + (6 - \sqrt{3})E/D + (24 - 6\sqrt{3})E^2/D^2 + \cdots] \qquad (52)$$
$$h\nu_{db} = h\nu_p = 2Z^2/(D - 3E). \qquad (53)$$

This mode would have practical application only when $E \ll (\tfrac{1}{3})D$; otherwise the field required would be very high.

3) *Field in the y-direction:* As Fig. 4(c) shows, the average of W_a and W_d intersects W_b at a field somewhat below $G = D$. The pumping transition is from b to c and the amplifying transition from c to d. The condition for the intersection is

$$-G + 3[Z^2 + G^2 - G(3E + D)]^{1/2} = [Z^2 + G^2 + G(3E + D)]^{1/2}, \qquad (54)$$

where $G = g_y\beta B$. Just as for the z-direction, this equation is of the fourth degree in G. To get an approximate treatment the best course is to abandon (54), and to describe the energy levels in terms of a different spin Hamiltonian. It follows from the transformation[34] already used in obtaining (39) that the energy levels for the y-direction of field, that is, the eigenvalues of

$$\mathcal{H} = g_y\beta BS_y + D(S_z^2 - \tfrac{5}{4}) + E(S_x^2 - S_y^2),$$

are identical with the eigenvalues of another Hamiltonian

$$\mathcal{H}' = g_z'\beta B S_z' + D'(S_z'^2 - \tfrac{5}{4}) + E'(S_x'^2 - S_y'^2),$$

where $g_z' = g_{/\!/}$, $D' = -\frac{1}{2}(D+3E)$ and $E' = \frac{1}{2}(D-E)$. For example, the y-direction energy levels [Fig. 4(c)] of rutile, the published parameters of which are $g_{x/y\,z} = 1.97$, $D = 0.55$ and $E = 0.27$ cm^{-1}, could equally well have been calculated as the z-direction levels of a Hamiltonian $\mathcal{H}'$ in which $g_z' = 1.97$, $D' = -0.68$ cm^{-1} and $E' = 0.14$ cm^{-1}. A glance at Figs. 4(a) and 4(c) shows their similarity.

Thus the field requirement and pumping and signal frequencies in the y-direction can be calculated using (46), (47), and (48) already worked out for the z-direction. One more transformation is needed, however: D' has to be replaced by $D'' = -D'$. Then, as a consideration of (37) shows, the energies are reversed in sign and their labeling is brought into correspondence with Fig. 4(a), as is necessary if (46), (47), and (48) are to be applied. After this transformation, of course, the energies are the reverse of the actual y-direction energies; but this does not affect maser considerations.

The equations for the y-direction are thus

$$G = \tfrac{2}{5}D''(1 + 45E'^2/14D''^2 + \cdots) \quad (55)$$

$$h\nu_s = 2D''(1/5 - E'^2/14D''^2 + \cdots) \quad (56)$$

$$h\nu_p = 2D''(4/5 + 8E'^2/7D''^2 + \cdots), \quad (57)$$

where $G = g_{/\!/}\beta B$, $D'' = \frac{1}{2}(D+3E)$ and $E' = \frac{1}{2}(D-E)$.

Correction

T. J. Rey, author of "Automatic Phase Control: Theory and Design," which appeared on pages 1760–1771 of the October, 1960 issue of PROCEEDINGS, has called the following to the attention of the *Editor*.

Page	*Column*	*Line*	*For*	*Read*
1762	1	14 from top	ϕ	ϕ_x
1762	1	6 from bottom	$<2(\pi-\phi_x)$	$<(\pi \pm 2\phi_x)$
1764	1	7 from top	unit bandwidth	bandwidth $\delta\nu$
1765	2	18 from top	$-\ddot{\varphi}+\Omega_s$	$-\dot{\varphi}+\Omega_s$
1765	2	26 from top	$\dot{\varphi}-\dot{\omega}_s$	$\ddot{\varphi}-\dot{\omega}_s$
1765	2	11 from bottom	φ	$\epsilon-\varphi$
1766	1	6 from top	1 and 3	2 and 3
1766	1	13 from bottom	$a\tau V$	$a\tau\dot{V}$
1766	2	6 from top	$2\omega_n\dot{\phi}$	$2\zeta\omega_n\dot{\phi}$
1766	1	7 from bottom	sin	$\sin^{-1}$
1767	2	10 from top	$\cos\psi_i$	$, \cos\psi_v$
1767	2	last	$\lvert\;\rvert$	$\lvert\;\rvert^{1/2}$
1768	2	5 from bottom	ϕ_K	ψ_K
1770	1	Fig. 14	Eq. 29	Eq. 34

Traveling-Wave Parametric Amplifier Analysis Using Difference Equations*

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Summary—A second-order difference equation is derived for both periodically and uniformly distributed parametric amplifiers. Using a two-frequency approximation the gain and the voltage output of the amplifier are computed. The results are specifically applied to an LC-distributed parametric amplifier and the gain computed for a capacity modulation index of 0.5, and for different normalized pump frequencies.

I. Introduction

Parametric amplifiers have recently received considerable attention both theoretically and experimentally. (An extensive bibliography on the subject has been presented by Mumford.[1]) This paper is primarily concerned with the analysis of periodically-distributed parametric amplifiers. The main advantage of such an amplifier is the much wider bandwidth that can be obtained[2,3] in comparison to the single-tuned parametric amplifier. Previous analyses[4–8] of both uniformly- and periodically-distributed parametric amplifiers have been based on the initial approximation that only two frequencies, namely, the signal and idler frequencies, are of large enough magnitude to be considered. Roe and Boyd have shown[9] that, for the uniform transmission-line parametric amplifier, the solution obtained by considering two frequencies only is inadequate since the higher generated frequencies may not be neglected, and consequently, they have presented an alternate approximation method. Simon treated the uniformly distributed parametric amplifier in terms of difference equations.[10] Application of the method described herein to the uniformly distributed parametric amplifier led to an independent derivation of the difference equation obtained by Simon. This equation is also derived here for completeness.

The difference equation has been obtained by considering all the frequencies present in a parametric amplifier in steady state. The difference equation is of second order with variable coefficients for both types. The difference equation applies to both a forward and backward traveling-wave parametric amplifier. Though a closed form solution to a second-order difference equation for an arbitrary dependence of the coefficients is not available, for specific applications, the difference equation presents a means to obtain a solution with a high degree of accuracy by reducing the difference equation to a finite number of algebraic equations, the number depending on the number of frequencies which need to be considered. Furthermore, the theory of difference equations may be applied to the problem considered, in order to deduce some general amplifier properties, though this has not been attempted in this work.

As an application of the difference equation, an approximate solution is derived for a forward traveling-wave periodically-distributed parametric amplifier consisting of arbitrary symmetrical networks periodically loaded with parametric capacitances. For simplification and comparison purposes the assumption that only two frequencies of importance exist was also used here. In many applications by proper design of the networks the higher frequencies will be attenuated. In addition, it was assumed that the amplifier is terminated with its image impedance for the growing waves at both frequencies; hence, when the gain per section is small, all reflected waves are eliminated. The expression obtained for the gain per section reduces to the expressions obtained by others[5,7,8] depending on the particular assumption made.

Specifically, the results are applied to an LC periodically-distributed parametric amplifier and the gain obtainable in such an amplifier for different normalized pump frequencies has been computed. An LC parametric amplifier could serve as a means for experimental verification of the validity of the assumptions made in the two frequency derivations.

* Received by the IRE, June 27, 1960; revised manuscript received, November 7, 1960. The work described was performed under the sponsorship of the U. S. Army Signal Engrg. Labs., Fort Monmouth, N. J., under Contract No. DA-36-039-SC-78269.

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II. Derivation of the Difference Equation

A. Periodically Distributed Parametric Amplifier

The parametric amplifier considered is shown in Fig. 1. The networks are assumed to be linear, symmetrical and identical. The capacity variation for the kth network is assumed to be

$$C_k = C_0 + C_1 \cos(\omega t - \gamma k), \tag{1}$$

where

ω = pump frequency,

γ = propagation constant for the pump frequency, which is positive for a forward, and negative for a backward traveling-wave parametric amplifier.

(The above dependence of the capacity assumes no reflection of the pump signal.)

The symmetrical networks are replaced by equivalent π networks. The π equivalent for the kth network is shown in Fig. 2.

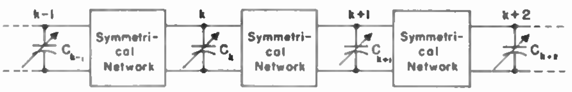

Fig. 1—Symmetrical networks and variable capacitors in cascade. $C_k = C_0 + C_1 \cos(\omega t - \gamma k)$.

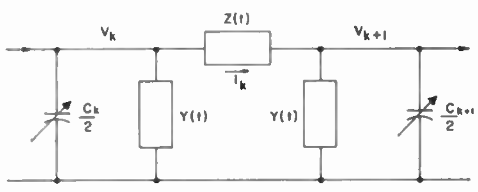

Fig. 2—Equivalent circuit of kth section.

The loop equations for the kth and $(k+1)$th network are

$$V_k - V_{k+1} = Z(t) I_k \tag{2}$$

$$V_{k+1} - V_{k+2} = Z(t) I_{k+1}. \tag{3}$$

The node equation for $(k+1)$th junction is

$$I_k - I_{k+1} = \frac{d}{dt}(C_{k+1} V_{k+1}) + Y(t) V_{k+1}, \tag{4}$$

where $Z(t)$ and $Y(t)$ are linear operators with properties that

$$Z(t) e^{j\omega t} = Z(j\omega)^{j\omega t} \tag{5}$$

$$Y(t) e^{j\omega t} = Y(j\omega) e^{j\omega t}, \tag{6}$$

where $Z(j\omega)$ and $Y(j\omega)$ being the series impedance and the shunt admittance, respectively, of the equivalent network for any circular frequency ω.

Substracting (3) from (2), and substituting (4) results in

$$V_k - 2V_{k+1} + V_{k+2} = Z(t) \frac{d}{dt}(C_{k+1} V_{k+1}) + Z(t) Y(t) V_{k+1}. \tag{7}$$

Assuming that the amplifier is stable, the steady-state voltage at the kth terminal can be expanded in a harmonic series given by

$$V_k = \sum_{n=-\infty}^{\infty} \left[A_{nk} e^{j(\omega_1 + n\omega)t} + A_{nk}^* e^{-j(\omega_1 + n\omega)t} \right], \tag{8}$$

where

ω_1 = signal frequency.

Substituting (8) into (7) and using the properties of the differential operators given by (5) and (6), the following partial difference equation is obtained by comparing terms with the same time dependence:

$$\begin{aligned} &A_{nk} - A_{n,k+1}[2 + Z(\omega_1 + n\omega) Y(\omega_1 + n\omega) \\ &+ j(\omega_1 + n\omega) C_0 Z(\omega_1 + n\omega)] \\ &+ A_{n,k+2} - Z(\omega_1 + n\omega) j(\omega_1 + n\omega) \frac{C_1}{2} [A_{n-1,k+1} e^{-j\gamma(k+1)} \\ &+ A_{n+1,k+1} e^{j\gamma(k+1)}] = 0. \end{aligned} \tag{9}$$

The difference equation for A_{nk}^* is the conjugate of (9).

The partial difference equation (9) has coefficients which are dependent on both n and k. The dependence on k can be eliminated by the following substitution if one lets

$$A_{nk} = B_{nk} e^{-j\gamma nk}. \tag{10}$$

Substituting (10) into (9) yields

$$\begin{aligned} &B_{n,k} e^{j\gamma n} - B_{n,k+1}[2 + Z(\omega_1 + n\omega) Y(\omega_1 + n\omega) \\ &+ j(\omega_1 + n\omega) C_0 Z(\omega_1 + n\omega)] + B_{n,k+2} e^{-j\gamma n} \\ &- Z(\omega_1 + n\omega) j(\omega_1 + n\omega) \frac{C_1}{2} [B_{n-1,k+1} + B_{n+1,k+1}] = 0. \end{aligned} \tag{11}$$

The partial difference equation (11) has constant coefficients in k. Therefore, the solution to that equation is given by

$$B_{nk} = D_n e^{\Gamma k}. \tag{12}$$

Substituting (12) into (11) gives

$$\begin{aligned} &D_n e^{j\gamma n} - e^{\Gamma} D_n[2 + Z(\omega_1 + n\omega) Y(\omega_1 + n\omega) \\ &+ j(\omega_1 + n\omega) C_0 Z(\omega_1 + n\omega)] + D_n e^{-j\gamma n} e^{2\Gamma} \\ &- Z(\omega_1 + n\omega) j(\omega_1 + n\omega) \frac{C_1}{2} [D_{n-1} + D_{n+1}] e^{\Gamma} = 0. \end{aligned} \tag{13}$$

The difference equation (13) reduces to a simpler form by noticing that the propagation constant γ_{nn} for the unpumped recurrent network at a frequency $\omega_1+n\omega$ is given by

$$\cos\gamma_{0n} = 1 + \frac{Z(\omega_1+n\omega)}{2}\left[Y(\omega_1+n\omega)+j(\omega_1+n\omega)C_0\right]. \quad (14)$$

Using (14) the difference equation (13) reduces, after some manipulation, to the following form:

$$D_n[\cosh(\Gamma - j\gamma n) - \cos\gamma_{0n}] - j(\omega_1+n\omega)\frac{C_1}{4}Z(\omega_1+n\omega)(D_{n-1}+D_{n+1}) = 0. \quad (15)$$

The difference equation (15) represents an infinite number of algebraic equations which contain the unknown propagation constant Γ. The propagation constant Γ can, in principle, be determined from the condition that the infinite-order determinant of the difference equation has to be equal to zero. By considering a finite number of harmonics N, the determinant of the difference equation will yield $2N$ discrete values of Γ, and, therefore, there will be $2N$ constants of integration. These $2N$ constants of integration can be determined from the two terminal conditions for each of the N harmonics, one at the sending and the other at the receiving end of the parametric amplifier.

B. Uniformly-Distributed Parametric Amplifier

A uniformly-distributed parametric amplifier is shown in Fig. 3.

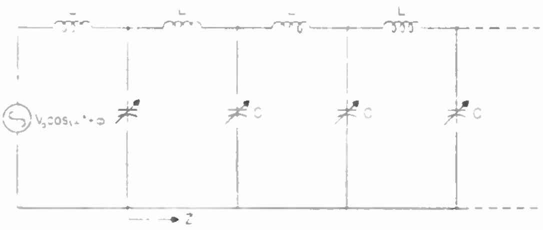

Fig. 3—Distributed-parameter parametric amplifier. $C=C_0+C_1\cos(\omega t-\beta_z)$.

The transmission line equations are given by

$$\frac{\partial V}{\partial z} = -L\frac{\partial I}{\partial t} \quad (16)$$

and

$$\frac{\partial I}{\partial z} = -\frac{\partial}{\partial t}(CV), \quad (17)$$

where

V = voltage,
I = current,
L = inductance per unit length,
C = capacity per unit length.

The dependence of C on time and distance is assumed to be

$$C = C_0 + C_1\cos(\omega t - \beta z) \quad (18)$$

where

ω = pump frequency
β = propagation constant for the pump.

Differentiating (16) with respect to z and substituting (17) results in

$$\frac{\partial^2 V}{\partial z^2} = L\frac{\partial^2}{\partial t^2}(CV). \quad (19)$$

Assuming that the amplifier is stable, the steady-state solution for V is given by

$$V(z,t) = \sum_{n=-\infty}^{\infty}\left[V_n(z)e^{j(\omega_1+n\omega)t} + V_n^*(z)e^{-j(\omega_1+n\omega)t}\right], \quad (20)$$

where ω_1 = signal frequency.

Substituting (18) and (20) into (19), and comparing terms with the same time dependence, results in the following differential difference equation:

$$\frac{\partial^2 V_n}{\partial z^2} + LC_0(\omega_1+n\omega)^2V_n + \frac{LC_1}{2}(\omega_1+n\omega)^2\left[V_{n-1}e^{-j\beta z}+V_{n+1}e^{j\beta z}\right] = 0. \quad (21)$$

The dependence of the coefficients in z in (21) can be eliminated by the following substitution if one lets

$$V_n(z) = A_n(z)e^{-j\beta_n z} \quad (22)$$

where

$$\beta_n = \sqrt{LC_0}(\omega_1+n\omega).^{11} \quad (23)$$

Substituting (22) and (23) into (21) results in the following differential difference equation:

$$\frac{d^2A_n}{dz^2} - 2j\beta_n\frac{dA_n}{dz} + \frac{C_1}{2C_0}\beta_n^2[A_{n-1}+A_{n+1}] = 0. \quad (24)$$

The z dependence in (24) can be eliminated by using Laplace transforms, or by the substitution

$$A_n(z) = B_ne^{j\beta_0 z}. \quad (25)$$

Substituting for (25) results in the following difference equation which is independent of z:

$$B_n\frac{\beta_0}{\beta_n}\left[2-\frac{\beta_0}{\beta_n}\right] + \frac{C_1}{2C_0}[B_{n-1}+B_{n+1}] = 0. \quad (26)$$

Eq. (26) is a difference equation with variable coefficients in n, which contain the unknown propagation constant β_0. The propagation constant is to be determined from the condition that the determinant of the difference equation has to vanish.

[11] It has been assumed that the propagation constant for the pump $\beta=\sqrt{LC_0}\omega$.

III. Approximate Solution to the Difference Equation for the Periodically-Distributed Parametric Amplifier

A. Roots of the Conditional Equation

A closed form solution to the difference equation (15) is not available. For the periodically-distributed parametric amplifier under certain conditions, it can be assumed that only two signal frequencies, corresponding to $n=0$ and $n=-1$ (signal and idler), will be present. Signals at other frequencies may fall in the stop bands of the amplifier and therefore will be attenuated.

Assuming that only two frequencies are present, corresponding to $n=0$ and $n=-1$, the difference equation (15) reduces to two equations

$$D_0(\cosh\Gamma - \cos\gamma_{00}) - j\omega_1 \frac{C_1}{4} Z(\omega_1)\, D_{-1} = 0; \tag{27}$$

$$D_{-1}[\cosh(\Gamma + j\gamma) - \cos\gamma_{0-1}] - j(\omega_1 - \omega)\frac{C_1}{4} Z(\omega_1 - \omega) D_0 = 0. \tag{28}$$

The conditional equation for Γ is obtained from (27) and (28) and is given by

$$(\cosh\Gamma - \cos\gamma_{00})[\cosh(\Gamma + j\gamma) - \cos\gamma_{0-1}] + \omega_1(\omega_1 - \omega)\left(\frac{C_1}{4}\right)^2 Z(\omega_1) Z(\omega_1 - \omega) = 0. \tag{29}$$

The conditional equation (29) can be expressed, in terms of propagation constants only, by introducing the propagation constants for the unloaded network. It follows from (14) that the propagation constant of the unpumped network can be expressed as

$$\cos\gamma_{0n} = \cos\beta_{0n} + j(\omega_1 + n\omega)\frac{C_0}{2} Z(\omega_1 + n\omega), \tag{30}$$

where β_{0n} = propagation constant of the recurrent network without capacitive loading. Eq. (29) is therefore given by:

$$(\cosh\Gamma - \cos\gamma_{00})[\cosh(\Gamma + j\gamma) - \cos\gamma_{0-1}] = \left(\frac{C_1}{2C_0}\right)^2 (\cos\gamma_{00} - \cos\beta_{00})(\cos\gamma_{0-1} - \cos\beta_{0-1}). \tag{31}$$

The conditional equation (31) is of the fourth order in e^{Γ}. An approximate solution for the roots of (31) is given in Appendix I under the assumption that the right hand side is small. The roots of the conditional equation are approximately given by

$$\Gamma_1 = -j(\gamma_{00} - \delta_1 + j\alpha) \tag{32}$$

$$\Gamma_2 = -j(\gamma_{00} - \delta_1 - j\alpha) \tag{33}$$

$$\Gamma_3 = j(\gamma_{00} + \delta_3) \tag{34}$$

$$\Gamma_4 = -j(\gamma + \gamma_{0-1} + \delta_4) \tag{35}$$

where

$$\sin(\delta_1 \pm j\alpha) = \frac{\cos(\gamma - \gamma_{00}) - \cos\gamma_{0-1}}{2\sin(\gamma - \gamma_{00})} \pm \sqrt{\left[\frac{\cos(\gamma - \gamma_{00}) - \cos\gamma_{0-1}}{2\sin(\gamma - \gamma_{00})}\right]^2 - \left(\frac{C_1}{2C_0}\right)^2 \frac{(\cos\gamma_{00} - \cos\beta_{00})(\cos\gamma_{0-1} - \cos\beta_{0-1})}{\sin\gamma_{00}\sin(\gamma - \gamma_{00})}} \tag{36}$$

$$\sin\delta_3 = \left(\frac{C_1}{2C_0}\right)^2 \frac{(\cos\gamma_{00} - \cos\beta_{00})(\cos\gamma_{0-1} - \cos\beta_{0-1})}{\sin\gamma_{00}[\cos\gamma_{0-1} - \cos(\gamma_{00} + \gamma)]} \tag{37}$$

$$\sin\delta_4 = \left(\frac{C_1}{2C_0}\right)^2 \frac{(\cos\gamma_{00} - \cos\beta_{00})(\cos\gamma_{0-1} - \cos\beta_{0-1})}{\sin\gamma_{0-1}[\cos(\gamma_{0-1} + \gamma) - \cos\gamma_{00}]}. \tag{38}$$

Eq. (32) shows that the amplifier will have exponential gain provided that the quantity under the root in (36) is negative. It also follows from (36) that maximum gain will be obtained when the known phase relationship[4] between the propagation constant for the pump signal and idler is satisfied, namely:

$$\gamma - \gamma_{00} = \gamma_{0-1}. \tag{39}$$

Under these conditions, $\delta_1 = 0$, and

$$\sinh\alpha = \frac{C_1}{2C_0}\sqrt{\frac{(\cos\gamma_{00} - \cos\beta_{00})[\cos(\gamma - \gamma_{00}) - \cos\beta_{0-1}]}{\sin\gamma_{00}\sin(\gamma - \gamma_{00})}}. \tag{40}$$

B. The Constants of Integration

To complete the solution for the conditions that only the signal and idler are propagating, the constants of integration D_0 and D_{-1} in (27) and (28) will be evaluated. Since D_0 and D_{-1} are related by (27) and (28), it will be sufficient to evaluate either of them. Due to the four roots of (31), four values of D_0 and D_{-1} will exist. These values will be determined from the terminal conditions at the sending and receiving end of the amplifier.

The signal and the idler voltage at the output terminals V_{0L} and V_{-1L} are

$$V_{0L} = V_{0m} \cosh \alpha K \cos \left[(\delta_1 - \gamma_{00})K + \omega_1 t + \phi\right] \quad (46)$$

and

$$V_{-1L} = \frac{2V_{0m} \sinh \alpha \sinh \alpha(K + \frac{1}{2}) \sin (\gamma_{00} - \delta_1) \cos \dfrac{(\gamma + \delta_1 - \gamma_{00})}{2}}{(\cos \gamma_{00} - \cos \beta_{00}) \cos \dfrac{\gamma_{00} - \delta_1}{2}} \frac{C_0}{C_1}$$

$$\cdot \sin \left[(\gamma + \delta_1 - \gamma_{00})K + \frac{\gamma}{2} + (\omega_1 - \omega)t + \phi\right] \quad (47)$$

At the sending end it is assumed that the signal voltage V_0 is

$$V_0 = V_{0m} \cos (\omega_1 t + \phi) = \frac{v_{0m}}{2} e^{j\omega_1 t} + \frac{v_{0m}^*}{2} e^{-j\omega_1 t}. \quad (41)$$

where K is the total number of T sections. The voltage gain at the signal and the idler frequency is therefore

$$G_{0V} = \cosh \alpha K \quad (48)$$

and

$$G_{-1V} = \frac{2 \sinh \alpha \sinh \alpha(K + \frac{1}{2}) \sin \dfrac{\gamma_{00} - \delta_1}{2} \cos \dfrac{\gamma + \delta_1 - \gamma_{00}}{2}}{(\cos \gamma_{00} - \cos \beta_{00}) \cos \gamma_{00} - \delta_1} \frac{C_0}{C_1}. \quad (49)$$

At the receiving end it is assumed that the amplifier is terminated with the impedances Z_0 and Z_{-1} for signal and idler frequency, respectively. It is also assumed that the terminating impedances are chosen to match the amplifier and are given by

$$Z_0 = -\frac{Z(\omega_1)}{2} \operatorname{ctgh} \frac{\Gamma_1}{2} \quad (42)$$

and

$$Z_{-1} = -\frac{Z(\omega_1 - \omega)}{2} \operatorname{ctgh} \frac{\Gamma_1 + j\gamma}{2}. \quad (43)$$

In Appendix II the constants of integration are evaluated under the above conditions and it is shown that two constants of integration vanish.

The remaining constants of integration are approximately given by

$$D_{01} = D_{02} = \frac{v_{0m}}{4e \dfrac{\Gamma_1}{2} \cosh \dfrac{\Gamma_1}{2}} \quad (44)$$

and

$$D_{-11} = -D_{-12} = 2D_{01} \frac{\cosh \Gamma_1 - \cos \gamma_{00}}{\cos \gamma_{00} - \cos \beta_{00}} \frac{C_0}{C_1}. \quad (45)$$

IV. Application to a Pumped LC Parametric Amplifier

As an example, the above derivations are applied to a recurrent LC parametric amplifier, shown in Fig. 4.

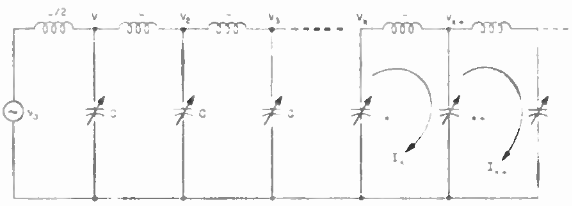

Fig. 4—Low-pass-filter parametric amplifier. $V_0 = \cos (\omega t + \phi)$; $C_k = C_0 + C_1 \cos |\omega t - \gamma k|$.

From (15), the partial difference equation for that amplifier is, given by

$$D_n\left[\cosh (\Gamma - j\gamma_n) - \cos \gamma_{0n}\right] + \left(\frac{\omega_1 + n\omega}{\omega_0}\right)^2 \frac{C_1}{4C_0} (D_{n-1} + D_{n+1}) = 0 \quad (50)$$

where from (14),

$$\cos \gamma_{0n} = 1 - \frac{1}{2}\left(\frac{\omega_1 + n\omega}{\omega_0}\right)^2 \quad (51)$$

and

$$\omega_0 = \frac{1}{\sqrt{LC_0}} \tag{52}$$

Assuming that only the signal and idler frequency propagate, the conditional equation is given, from (29),

$$(\cosh \Gamma - \cos \gamma_{00})[\cosh (\Gamma + j\gamma) - \cos \gamma_{0-1}]$$
$$= \left(\frac{C_1}{4C_0}\right)^2 \left(\frac{\omega_1}{\omega_0}\right)^2 \left(\frac{\omega_1 - \omega}{\omega_0}\right)^2. \tag{53}$$

From (36), the gain of the amplifier is determined by

$$\sin (\delta_1 + j\alpha) = \delta_1 + j\alpha = \frac{\cos (\gamma - \gamma_{00}) - \cos \gamma_{0-1}}{2 \sin (\gamma - \gamma_{00})}$$
$$\pm \sqrt{\left(\frac{\cos (\gamma - \gamma_{00}) - \cos \gamma_{0-1}}{2 \sin (\gamma - \gamma_{00})}\right)^2 - 4\left(\frac{C_1}{C_0}\right)^2 \frac{\sin (\gamma - \gamma_{00})}{\sin \gamma_{00}} \sin^2 \frac{\gamma_{00}}{2} \sin \frac{\gamma_{0-1}}{2}}. \tag{54}$$

The conditional equation (53) has been solved with the aid of a computer for $C_1/C_0 = \frac{1}{2}$ and for different values of the pump propagation constant γ. The propagation constant has been assumed to be related to the pump frequency by (51), namely,

$$\cos \gamma = 1 - \frac{1}{2}\left(\frac{\omega}{\omega_0}\right)^2. \tag{55}$$

The values obtained for α are shown graphically in Fig. 5. The values for α have also been computed using

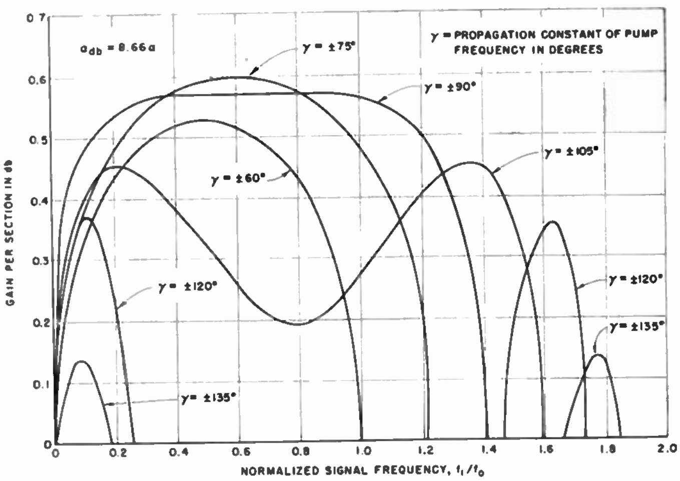

Fig. 5—Parametric amplifier gain characteristics.

(54) for $\gamma = 60°$ and very good agreement has been obtained.

It follows from Fig. 5 that considerable bandwidth can be obtained from such an amplifier. However, under matched conditions the gain per section is small. The low gain is partially due to the fact that the phase relationship between pump signal and idler frequency is not fulfilled. With the optimum phase relationship, the gain per section, α, would be

$$\sinh \alpha = \frac{C_1}{2C_0}\sqrt{\tan \frac{\gamma_{00}}{2} \tan \frac{\gamma_{0-1}}{2}}. \tag{56}$$

For the value of C_1/C_0 used in the computation and $\gamma_{00} = \gamma_{0-1}, = 45°$, 1.57 times the gain per section would be obtained.

V. Conclusion

It has been shown that the steady-state analysis of traveling-wave parametric amplifiers, consisting of arbitrary symmetrical networks periodically loaded with parametric capacitances, can be formulated in terms of a second-order difference equation with variable coefficients. An approximate solution can be obtained by reducing the difference equation to a finite number of algebraic equations. The number of equations equals the number of frequencies considered. The theory of difference equations may also be applied to determine some general properties of the amplifier.

Using a two-frequency approximation, the gain of a periodically-distributed parametric amplifier consisting of arbitrary symmetrical networks periodically loaded with parametric capacitances, and terminated with its image impedance at both frequencies, has been obtained.

Appendix I

Roots of the Conditional Equation

The conditional equation (31) is given by:

$$(\cosh \Gamma - \cos \gamma_{00})[\cosh (\Gamma + j\gamma) - \cos \gamma_{0-1}]$$
$$= \left(\frac{C_1}{2C_0}\right)^2 (\cos \gamma_{00} - \cos \beta_{00})(\cos \gamma_{0-1} - \cos \beta_{0-1}). \tag{57}$$

When the right hand side of (57) is zero, the roots are

$$\Gamma_1' = -j\gamma_{00} \tag{58}$$
$$\Gamma_2' = +j(\gamma_{0-1} - \gamma) \tag{59}$$
$$\Gamma_3' = j\gamma_{00} \tag{60}$$
$$\Gamma_4' = -j(\gamma_{0-1} + \gamma). \tag{61}$$

When the right hand side of (57) is small, the roots (58)–(61) will differ only by a small amount. Furthermore, the roots (58) and (59) are very close together and would be identical if a linear relationship between the propagation constant and frequency were to exist. Let, therefore,

$$\Gamma_1 = -j(\gamma_{00} - \Delta_1). \tag{62}$$

Substituting (62) and considering that Δ_1 will be small, results in

$$\sin \gamma_{00} \sin \Delta_1 [\cos (\gamma - \gamma_{00}) - \cos \gamma_{0-1} - \sin (\gamma - \gamma_{00}) \sin \Delta_1] = \left(\frac{C_1}{2C_0}\right)^2 (\cos \gamma_{00} - \cos \beta_{00})(\cos \gamma_{0-1} - \cos \beta_{0-1}). \tag{63}$$

Solving (63) gives (36).

Similarly, let

$$\Gamma_3 = +j(\gamma_{00} + \delta_3) \tag{64}$$

and

$$\Gamma_4 = -j(\gamma_{0-1} + \delta_4). \tag{65}$$

Substituting (64) and (65) into (57), and considering that δ_3 and δ_4 are small, results in (37) and (38).

Appendix II

The Constants of Integration

The voltage at the kth node is given, from (8), (10), and (12), by

$$V_k = D_0 e^{(\Gamma k + j\omega_1 t)} + D_{-1} e^{(\Gamma + j\gamma)k + j(\omega_1 - \omega)t}, \tag{66}$$

and from (2) the kth mesh current is

$$I_k = \frac{D_0}{Z(\omega_1)} e^{\Gamma k + j\omega_1 t}(1 - e^{\Gamma}) + \frac{D_{-1}}{Z(\omega_1 - \omega)} e^{\Gamma k + j\gamma k + (\omega_1 - \omega)t}(1 - e^{\Gamma + j\gamma}). \tag{67}$$

From (27) D_0 is related to D_{-1} by

$$D_0 = \frac{j\omega_1 \frac{C_1}{4} Z(\omega_1)}{\cosh \Gamma - \cos \gamma_{00}} D_{-1}. \tag{68}$$

With the specified terminal condition at the input given by (41) and the terminating impedances Z_0 and Z_{-1} at the output, the following four equations are obtained by comparing terms with the same time dependence:

$$\frac{v_{0m}}{2} e^{j\omega_1 t} = I_{00} Z\left(\frac{\omega_1}{2}\right) + V_{01} \tag{69}$$

$$0 = I_{-10} \frac{Z(\omega_1 - \omega)}{2} + V_{-11} \tag{70}$$

$$0 = V_{0K} - I_{0K}\left[\frac{Z(\omega_1)}{2} + Z_0\right] \tag{71}$$

$$0 = V_{-1K} - I_{-1K}\left[\frac{Z(\omega_1 - \omega)}{2} + Z_{-1}\right]. \tag{72}$$

In the above notation

$$I_k = I_{0k} + I_{-1k} \tag{73}$$

$$V_k = V_{0k} + V_{-1k}. \tag{74}$$

Substituting (66) and (67) into (69)–(72) results in the following equations for the constants of integration:

$$v_{0m} = D_0(1 + e^{\Gamma}) \tag{75}$$

$$0 = D_{-1}(1 + e^{\Gamma + j\gamma}) \tag{76}$$

$$0 = D_0 e^{\Gamma(K+1/2)} \cosh \frac{\Gamma}{2}\left[1 + \frac{2Z_0}{Z(\omega_1)} \tanh \frac{\Gamma}{2}\right] \tag{77}$$

$$0 = D_{-1} e^{(\Gamma + j\gamma)(K+1/2)} \cosh \frac{\Gamma + j\gamma}{2} \cdot \left[1 + \frac{2Z_{-1}}{Z(\omega_1 - \omega)} \tanh \frac{\Gamma + j\gamma}{2}\right]. \tag{78}$$

In (75)–(77), D_0 and D_{-1} have four values corresponding to the four different values of Γ. To simplify the evaluation of the constants, it will be assumed that the amplifier is matched for both signal and idler frequencies; under these conditions, two constants of integration will vanish.

Let, therefore,

$$Z_0 = -\frac{Z(\omega_1)}{2} \operatorname{ctgh} \frac{\Gamma_1}{2} \tag{79}$$

and

$$Z_{-1} = -\frac{Z(\omega_1 - \omega)}{2} \operatorname{ctgh} \frac{\Gamma_1 + j\gamma}{2} \tag{80}$$

Since Γ_2 differs from Γ_1 only by 2α, which is assumed to be small, two constants of integration vanish. Under these conditions (75)–(78) reduce to

$$v_{0m} = D_{01}(1 + e^{\Gamma_1}) + D_{02}(1 + e^{\Gamma_2}) \tag{81}$$

$$0 = D_{-11}(1 + e^{\Gamma_1 + j\gamma}) + D_{-12}(1 + e^{\Gamma_2 + j\gamma}). \tag{82}$$

Considering that α is small, (82) yields:

$$D_{-11} = -D_{-12}. \tag{83}$$

From (68)

$$\frac{D_{01}}{D_{02}} = \frac{\cosh \Gamma_2 - \cos \gamma_{00}}{\cosh \Gamma_1 - \cos \gamma_{00}} \frac{D_{-11}}{D_{-12}} \approx 1. \tag{83a}$$

Therefore, from (81),

$$D_{01} = D_{02} = \frac{v_{0m}}{4e^{\frac{\Gamma_1}{2}} \cosh \frac{\Gamma_1}{2}} \tag{84}$$

and

$$D_{-11} = -D_{-12} = \frac{\cosh \Gamma_1 - \cos \gamma_{00}}{j\omega_1 C_1 Z(\omega_1)} \frac{v_{0m}}{e^{\frac{\Gamma_1}{2}} \cosh \frac{\Gamma_1}{2}}. \tag{85}$$

Using (30) results in

$$D_{-11} = -D_{-12}$$
$$= \frac{\sinh \alpha \sin (\gamma_{00} - \delta)}{2j(\cos \gamma_{00} - \cos \beta_{00})} \frac{v_{0m}}{e^{\frac{\Gamma_1}{2}} \cosh \frac{\Gamma_1}{2}} \frac{C_0}{C_1}. \tag{86}$$

From (77), the output voltage at the signal frequency is given by

$$v_{0L} = \frac{v_{0m}}{2} e^{j(-\gamma_{00}+\delta_1)K} \cosh \alpha K. \tag{87}$$

The instantaneous output voltage at signal frequency is approximately given by

$$v_{0L} = v_{0L} e^{j\omega_1 t} + v_{0L}{}^* e^{-j\omega_1 t}$$
$$= V_{0m} \cosh \alpha K \cos \left[(-\gamma_{00} + \delta_1)K + \omega_1 t + \phi\right]. \tag{88}$$

Similarly, the output voltage at the idler frequency is approximately

$$V_{-1L} = \frac{v_{0m} \sinh \alpha \sin (\gamma_{00} - \delta_1)}{j(\cos \gamma_{00} - \cos \beta_{00}) \cos \frac{\gamma_{00} - \delta_1}{2}} \frac{C_0}{C_1}$$
$$\cdot \cos \left(\frac{\gamma + \delta_1 - \gamma_{00}}{2}\right) \sinh \alpha (K + \tfrac{1}{2})$$
$$\cdot e^{j[(\gamma+\delta_1-\gamma_{00})K+\gamma/2]} \tag{89}$$

and the instantaneous output voltage at the idler frequency is

$$V_{-1L} = 2V_{0m} \frac{\sinh \alpha \sin (\gamma_{00} - \delta_1)}{\cos \gamma_{00} - \cos \beta_{00}}$$
$$\cdot \frac{\cos \frac{\gamma + \delta_1 - \gamma_{00}}{2}}{\cos \frac{\gamma_{00} - \delta_1}{2}} \sinh \alpha (K + \tfrac{1}{2})$$
$$\cdot \sin \left[(\gamma + \delta_1 - \gamma_{00})K + \frac{\gamma}{2} + (\omega_1 - \omega)t + \phi\right]. \tag{90}$$

The gain for signal and idler frequencies is therefore given by (48) and (49), respectively.

IRE Standards on Video Techniques: Measurement of Resolution of Camera Systems, 1961*

(60 IRE 2352)

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* Approved by the IRE Standards Committee, September 8, 1960. Reprints of IRE Standard 60 IRE 23.S2 may be purchased while available from the Institute of Radio Engineers, 1 East 79th Street, New York, N. Y., at $0.50 per copy. A 20 per cent discount will be allowed for 100 or more copies mailed to one address.

I. Introduction

This standard is a revision of Part II of 50 IRE 23.S1, and replaces it in all respects.

One of the major characteristics of a television system affecting over-all picture quality is the ability of the system to reproduce fine detail found in the original image. This ability to resolve detail is determined by a number of factors, such as the number of scanning lines employed, the frame repetition rate, and the over-all response of the electrical circuits, which is usually specified in terms of the frequency-response characteristics. Performance of the optical imaging device, the camera tube, and the reproducing device also has considerable influence on the ability of the system to resolve detail.

A. General Description

The fundamental basis for making a measurement of resolution of a camera system is to televise a suitable test chart with the equipment under test. This test chart must include a pattern which will have a sufficient amount of fine detail, so that a quantitative observation can be made of the amount of this detail in the reproduced picture. This is usually done by incorporating in the chart a series of lines having graduated widths. The reproduced image of this test chart is then observed on a picture tube or other suitable reproducing device. The point in the reproduced picture where the lines are no longer visible as separately defined images gives a measure of the system performance with respect to resolution.

A quantitative method of measuring the horizontal resolution of a camera system is based upon the oscilloscopic display of the camera output voltage obtained from any single line scan across the vertical wedges of the resolution chart image. By choosing lines which occur at suitable times, the amplitude of the resulting signal can be plotted as a function of the line number of the chart.[1]

B. Definitions

Resolution. In television, a measure of ability to delineate picture detail.

Limiting Resolution. In television, a measure of resolution usually expressed in terms of the maximum number of lines per picture height discriminated on a test chart.

Note: For a number of lines N (alternate black and white lines) the width of each line is $1/N$ times the picture height.

Resolution Response. In television, the ratio of 1) the peak-to-peak signal amplitude, given by a test pattern consisting of alternate black and white bars of equal widths corresponding to a specified line number, to 2) the peak-to-peak signal amplitude, given by large area blacks and large area whites having the same luminance as the black and white bars in the test pattern.

Line Number, Television. In measuring resolution, the ratio of the frame height to the width of each bar of a test pattern composed of alternate equal width black and white bars, as projected on the frame.

II. Test and Measuring Equipment

A. Test Chart

The essential tool for this measurement is a suitable test chart. The RETMA Resolution Chart 1956, shown in Fig. 1, is recommended for this purpose. This chart may be used directly for measurement of direct pickup studio and field cameras.[2] For checking gray scale reproduction, the Electronic Industries Association (EIA) also has available 18-inch × 24-inch opaque charts: these are available both in linear and in logarithmic steps. Gray scale strips having logarithmic steps are also available for pasting directly onto the 18-inch × 24-inch opaque resolution charts. Due to the extreme difficulty of accurately reproducing these original charts in either opaque or transparency form, any such reproduction should be checked for compliance with the forthcoming American Standards before being used to make measurements in accordance with this IRE standard.[3]

In addition to being used for the measurement of resolution, the RETMA Resolution Chart may be employed as an aid in checking scanning linearity, aspect ratio, interlacing, shading, streaking, and ringing.

B. Picture Monitor

When a picture monitor is used to measure the resolution of a camera system, the monitor should have a resolution capability exceeding that of the camera system. This requires that the bandwidth of its video amplifier be greater than that of the camera system, and that it have a suitably fine scanning spot.

C. Oscilloscope

For the measurement of the resolution response of a camera system, an oscilloscope having a vertical amplifier of sufficiently wide bandwidth to avoid measurement error is required. In order to realize the full capabilities of the resolution chart when scanned with a camera operating on United States broadcast TV standards, the bandwidth and transient response of the vertical amplifier should be such as to introduce negligible display errors at any frequency up to at least 10 megacycles.

The oscilloscope should be fitted with a line selector, which will permit the selection, display, and identifica-

[1] An extensive discussion of the subject of resolution, especially in terms of the oscilloscopic method of measurement, is given by O. H. Shade, "Image gradation, graininess and sharpness in television and motion picture systems," *J. SMPTE*, vol. 56, pp. 131–171, February, 1952; vol. 58, pp. 181–222, March, 1952; vol. 61, pp. 97–164, August, 1953; vol. 64, pp. 593–617, November, 1955.

[2] The 18-inch × 24-inch opaque charts may be obtained from the EIA Engineering Department, 11 West 42nd Street, New York 36, N. Y.

[3] For the purpose of testing slide and film cameras, the Society of Motion Picture and Television Engineers is preparing Standards, to be submitted as American Standards, for transparency charts in sizes of 8 inches × 10 inches and 2 inches × 2 inches. Transparencies made according to these Standards will ultimately be available from the Society of Motion Picture and Television Engineers, 55 West 42nd Street, New York 36, N. Y.

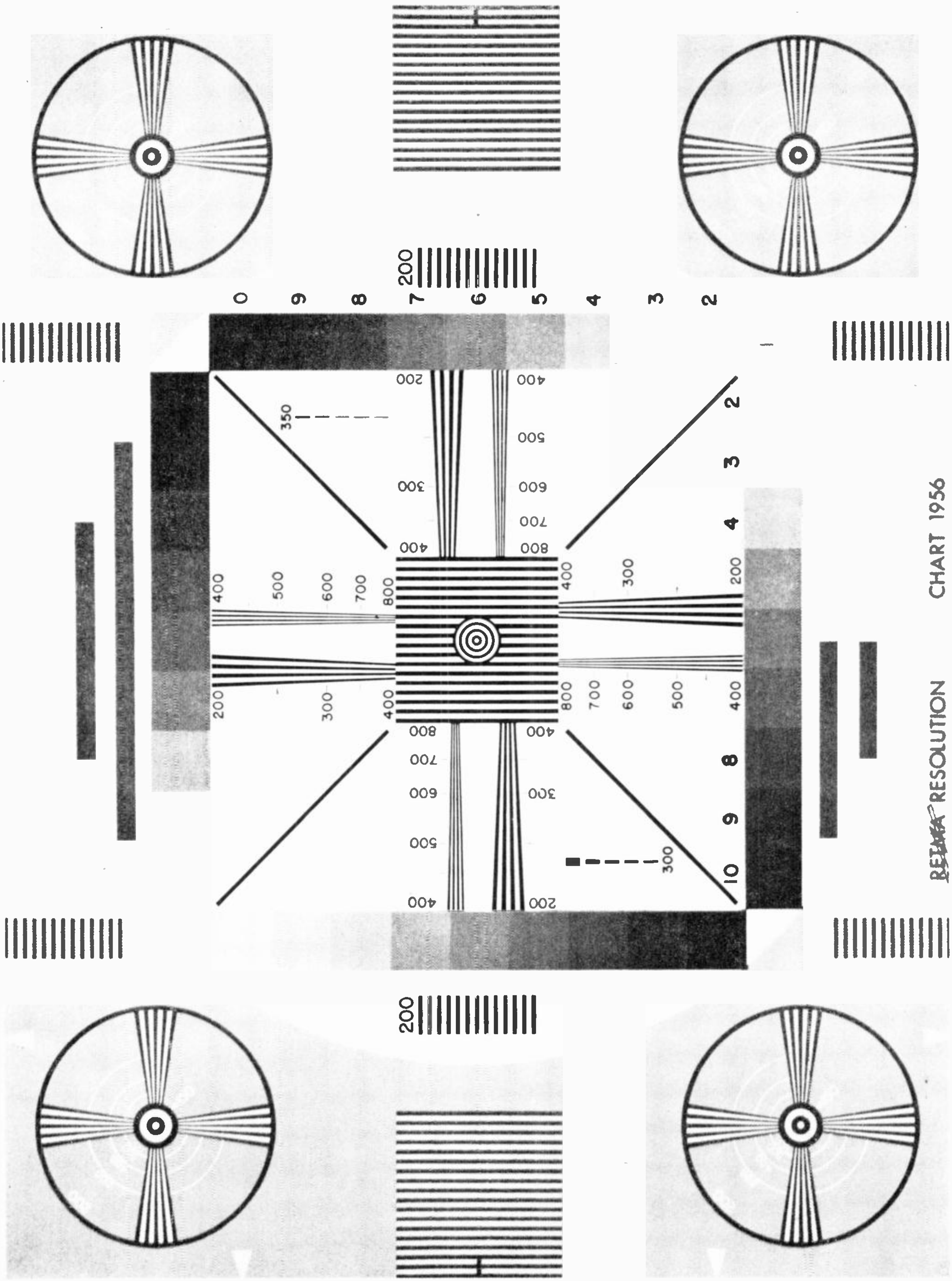

Fig. 1.

tion of any desired horizontal scan interval once each frame time.

III. Procedure

A. Conditions

Before a significant measurement of resolution is made, it is essential that both the pickup and reproducing equipment be in proper adjustment. After the test pattern has been properly oriented with respect to the camera tube, the following items are among those which must be given attention:

1. *Scanning and Interlace:* Care should be taken to check and adjust for proper scanning size, scanning linearity, aspect ratio, and interlace. For measurement and adjustment of scanning size and linearity and aspect ratio, it is suggested that reference be made to 54 IRE 23.S1, Standard on Measurement of Aspect Ratio and Geometric Distortion.

Interlace will affect vertical resolution; hence, any adjustments in the system which influence interlace should be optimized.

2. *Shading and Compression:* If the camera equipment employs signals for camera-shading correction, two methods for proper adjustment are suggested: a) visual inspection of the picture monitor to determine if the background is an even gray, and b) use of the waveform monitor to determine whether the average picture signal axis is parallel to the black level line, both at line and field frequencies.

Abnormal white or black compression must be avoided in order to assure significant resolution readings. This may be achieved by adjustments which yield the maximum number of gray scale steps, through the use of the gray scale slides or charts described in Section A.

3. *Streaking and Ringing:* Streaking following any one of the horizontal black bars at the top or bottom of the large circle is an indication of low-frequency distortion in the signal circuits. The black bars are also useful for adjusting peaking circuits.

Ringing, or multiple echoes following the single line widths, located in the upper right and lower left quadrants, is a function of the high-frequency response of the system. These echoes may be confused with the multiple lines of the resolution wedge and hence lead to an inaccurate determination of resolution.

4. *Focus:* All optical and electrical focusing at both the camera and display device should be optimized.

5. *Light Level:* Since resolution readings depend upon light level, the luminance of the resolution chart should be uniform and at the desired value.

B. Measurement Technique

1. *Measurement of Limiting Resolution:* After the above adjustments have been made, the picture monitor should be observed. The limiting horizontal and vertical resolution of the television camera chain and picture display combination is determined by observing the point at which the individual lines of the graduated wedges are no longer distinguishable as separately defined images. The resolution readings of both horizontal and vertical wedges will indicate the system performance under the conditions of the test.

Pictures may have different values of limiting resolution in different areas, as indicated by the wedges in the corner circles. Unless otherwise specified, the resolution cited is presumed to apply to the central portion of the picture.

2. *Measurement of Horizontal Resolution Response of Camera Systems:* The oscilloscope should be connected to the output of the camera system to be measured. As the scanning beam at the camera crosses the vertical wedges which are used to measure horizontal resolution, there will be a burst of four cycles in the video signal. The duration of the sweep of the oscilloscope should, therefore, be adjusted so as to permit ready observation of these bursts. Lines should be selected corresponding to numbers, from the minimum on the chart (200) to the maximum for which the bursts are still discernible. The relative peak-to-peak amplitude of the bursts should be noted for enough different lines to give complete information of amplitude vs chart line-number. In addition, a reference reading should be obtained by noting the amplitude of the video signal for the transition between the horizontal black bars and the white background.

It should be noted that this method is inherently subject to a small error, due to the fact that the resolution wedges of the chart produce an optical square wave, rather than a sine wave. This means that the reading of resolution response at a given line number will be influenced by the response of the system being measured to the higher harmonics of the square wave.

C. Presentation of Data

The following data should be recorded:

Using the picture monitor: limiting horizontal resolution, and limiting vertical resolution;

Using the oscilloscope: the relative peak-to-peak amplitudes of the burst vs the chart line numbers.

This information may be plotted to display the horizontal resolution-response characteristic. From this curve, a reading may be taken of one or more of the following significant points, as appropriate:

1) The chart line number for which the horizontal resolution response is half its reference value. (This is the half-amplitude response.)
2) The chart line number at which the horizontal resolution-response characteristic approaches zero. (This corresponds roughly to the limiting resolution.)
3) The value of the horizontal resolution response corresponding to a chart-line number of 350 lines. (This corresponds to the approximate maximum video frequency which may be transmitted under United States broadcasting standards for monochrome television.)

For reference purposes, light level and lens settings (f numbers) should be recorded.

Effects of Electrons and Holes on the Transition Layer Characteristics of Linearly Graded *P-N* Junctions*

C. T. SAH†, MEMBER, IRE

Summary—**The dc theory of *p-n* junctions has been extended, taking into account the mobile carriers or electrons and holes in the transition region. The linearized Poisson-Boltzmann equation is solved by using a linearization parameter α, which is a measure of the relative importance of the fixed, ionized impurity space charge compared with the mobile carrier or electron and hole charges in the transition region of the *p-n* junction. It is found that both the transition layer width and the transition carrier capacitance associated with the electrons and holes in the transition region increase exponentially with applied voltage under forward bias condition. A calculation of the recombination-generation current at a forward bias beyond the built-in or diffusion voltage is now possible with the present theory. The dc theory of junction capacitance compares favorably with experimental measurements of a wide variety of nearly linear-graded diffused silicon junctions.**

I. Introduction

The characteristics of *p-n* junctions have been investigated by many authors. Some of the important transistor characteristics can be more readily understood by studying only one junction. For example, the junction capacitance affects the high-frequency transistor current gain, the recombination-generation current in the transition region greatly reduces the low-level transistor current gain, and the charge stored in the junction capacitance affects the recovery time or the speed with which a transistor or a diode can be switched.

In the space charge approximation for *p-n* junctions, the effect of the free electron and hole charges in the *p-n* junction transition region is neglected.[1] This approximation is justified when the electron and hole concentrations in the transition layer are small compared with the density of the fixed space charge from ionized impurities. Such a condition exists only in reversely biased junctions. The electron and hole densities cannot be neglected when a junction is forward biased. If the results of the simplified approximation are extrapolated into the forward bias condition, the correct answers are not obtained. For example, the junction capacitance of a linearly graded junction follows the (diffusion voltage − applied voltage)$^{-1/3}$ voltage-dependence according to the space-charge approximation, but an exponential voltage dependence is generally observed when sufficient forward bias is applied to the junction. The observed magnitude and exponential voltage-dependence of the junction capacitance follow neither the diffusion capacitance formula of the space-charge approximation, nor the capacitance of the neutral approximation which assumes complete electrical neutrality.[1] Furthermore, the recombination-generation current calculated, using the potential distribution of the space-charge approximation, has been usually smaller than the measured value at moderate forward bias voltage,[2-4] although the difference is small and may not be significant due to other effects such as surface channel leakage.

In the past, analyses of the transition layer characteristics for the step junction[5] in which the free electron and hole densities[6-13] have been included, have been carried out by many authors. The results of these calculations can be put into a closed integral form if the boundary conditions based on a definable transition layer width are used. Both asymptotic forms and numerical evaluations of the integral have been obtained. However, it is

* Received by the IRE, August 8, 1960; revised manuscript received, October 27, 1960. A portion of this paper was presented at the AIEE-IRE Solid-State Device Res. Conf., June 13–15, 1960, Carnegie Inst. of Tech., Pittsburgh, Pa.

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[1] W. Shockley, "Theory of *p-n* junctions in semiconductors and *p-n* junction transistors," *Bell Sys. Tech. J.*, vol. 28, pp. 436–489; July, 1949.

[2] C. T. Sah, R. N. Noyce, and W. Shockley, "Carrier generation and recombination in *p-n* junctions and *p-n* junction characteristics," Proc. IRE, vol. 45, pp. 1228–1243; September, 1957.

[3] D. J. Sandiford, "Heat treatment centers and bulk currents in silicon *p-n* junctions," *J. Appl. Phys.*, vol. 30, pp. 1981–1986; December, 1959.

[4] A. E. Bakanowski and J. H. Forster, "Electrical properties of gold-doped diffused silicon computor diode," *Bell Sys. Tech. J.*, vol. 39, pp. 87–103; January, 1960.

[5] Step junction is defined as a *p-n* junction with ionized impurity concentration being N_A and space constant on the *p*-type side, and N_D and space constant on the *n*-type side.

[6] K. B. Tolpygo, "Emission capability of an abrupt *p-n*-transition and its effect upon the conductivity of a semiconductor," *Soviet J. Tech. Phys.* (translation), vol. 1, pp. 287–305; 1956.

[7] A. Herlet, "Das verhalten von *p-n*-gleichrichtern bei hohen durchlassbelastungen," *Z. Naturforsch*, vol. 11A, pp. 498–510; June, 1956.

[8] E. I. Adirovich, Iu. S. Riabinkin, and K. V. Temko, "Equilibrium distribution of potential, field and concentration of current carriers in fused junctions," *Soviet J. Tech. Phys.* (translation), vol. 3, pp. 49–59; January, 1958.

[9] A. K. Jonscher, "Analysis of current flow in a planar junction diode at a high forward bias," *J. Electronics and Control*, vol. 5, pp. 1–14; July, 1958.

[10] P. Ehrenberg, "Electric Conduction in Semiconductors and Metals," Oxford University Press, New York, N. Y., p. 278; 1958.

[11] P. H. Passau and M. Van Styvendael, "La jonction *p-n* abrupt dans le cas statique," in "Solid-State Physics in Electronics and Tele-Communications," M. Desirant and J. L. Michiels, Eds., Academic Press, New York, N. Y., vol. 1, Semiconductors, pp. 407–421; 1960.

[12] A. D. Chevychelov, "The current-voltage characteristic of *p-n* junction with due regard to the generation and recombination of carriers in the space charge layer," *Soviet Solid State Phys.* (translation), vol. 1, pp. 1102–1108; February, 1960.

[13] A. I. Uvarov, "Effect of the space charge of moving carriers on the electric breakdown of a strongly asymmetric *p-n* junction," *Soviet Solid-State Phys.* (translation), vol. 1, pp. 1336–1338; March, 1960.

difficult to interpret these results on a simple physical basis and to correlate theoretical formulas with experimental measurements.

In the case of graded *p-n* junctions, several authors have obtained approximate solutions using the space-charge approximation by neglecting altogether the free electron and hole carrier charge effects.[14–16] In the classic treatment of Shockley,[1] a very crude estimate of the effect of the free electron and hole was made by calculating the neutral capacitance of a linearly graded junction. The calculations for the neutral case were made by assuming that the junction is nearly at thermodynamic equilibrium (zero bias) and that the electrical neutrality condition prevails over the transition region. However, in practical cases, the neutrality condition rarely exists at equilibrium. In addition, the potential across the transition region V_j which appears in the neutral capacitance formula is not a directly observable quantity and is only a measure of the applied voltage. No explicit relation between the applied voltage and the junction voltage was given by Shockley.[1] In an attempt to understand this problem better, computer solutions of the Poisson equation have been obtained by Smits and Morgan for a linearly graded junction.[17] However, their solution is merely a joining of Shockley's space-charge and neutral approximations and has limited applicability due to the assumption of no current flow in their analysis. In particular, this assumption is invalid at moderate or high forward applied voltage.

In the present approach, the effect of current flow or thermal nonequilibrium is taken into account, approximately. Thus, the results are applicable even under large forward applied voltage. An approximate electrostatic potential function describing the Boltzmann factors for the electron and hole densities in the transition layer is used in order to linearize the Poisson equation. The derivations of several approximate potential functions and appropriate boundary conditions are derived, based on reasonable physical considerations. The ultimate test of the correctness or the goodness of the approximations is made by comparing the end results with experimental measurements.

II. Analysis for Some of the Measurable Electrical Characteristics

There are many *p-n* junction characteristics such as the current-voltage characteristics and the steady-state impedance, which can be electrically measured from the two external leads. These characteristics may also be investigated as a function of temperature or frequency. In this analysis, we shall limit ourselves to an investigation of the low-frequency junction capacitance and the dc current-voltage characteristics. A detailed study of the low-frequency junction capacitance will be made, while only a brief résumé of the dc current-voltage characteristics with a more exact formula for the recombination-generation current is given, since detailed discussions are given by Sah, Noyce and Shockley.[2]

A. The Junction Capacitances

The total low-frequency capacitance of a planar *p-n* junction, measured between the two end leads, may be calculated from the differential change of the charge flow in the external lead per unit change of applied voltage, dQ/dV. With reference to Fig. 1, the capacitance

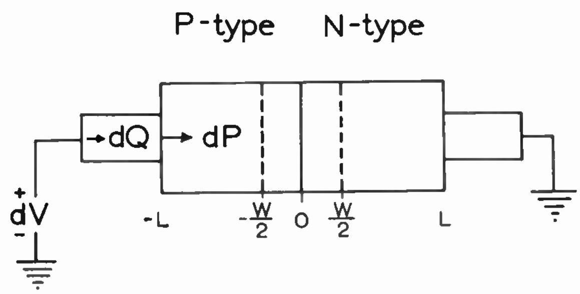


Fig. 1—Schematic of a semiconductor containing a linearly graded *p-n* junction. The transition region extends from $-W/2$ to $W/2$.

may be obtained by the following calculations. (See List of Symbols.)

$$C = \frac{dQ}{dV} = q\frac{dP}{dV} = q\frac{d}{dV}\int_{-L}^{L} pdx$$
$$= q\frac{d}{dV}\left[\int_{-L}^{-W/2} + \int_{-W/2}^{W/2} + \int_{W/2}^{L} pdx\right] \quad (1)$$

where $\pm W/2$ are the edges of the transition layer. Outside of the transition layer, electrical neutrality is assumed. Thus, using the neutrality condition, $n-p = N(x)$, in which the charge due to the recombination centers is neglected, (1) may be rewritten as

$$C = C_d + C_{ti} + C_{tc}, \quad (2)$$

where

$$C_d = q\frac{d}{dV}\left[\int_{-L}^{-W/2} ndx + \int_{W/2}^{L} pdx\right] \quad (3)$$

$$C_{ti} = -q\frac{d}{dV}\int_{-L}^{-W/2} N(x)dx = \frac{K\epsilon_0}{W}\left(-\frac{dw^3}{dv}\right) \quad (4)$$

and

$$C_{tc} = q\frac{d}{dV}\int_{-W/2}^{W/2} pdx. \quad (5)$$

[14] A. Roder and C. T. Sah, "Normalgraphs of the transition layer characteristics of exponentially graded *p-n* junctions," unpublished, 1957.

[15] R. M. Scarlett, "Space-charge width in diffused junctions," IRE Trans. on Electron Devices, vol. ED-6, no. 4, pp. 405–408; October, 1959.

[16] H. Lawrence and R. M. Warner, Jr., "Diffused junction depletion layer calculations," *Bell Sys. Tech. J.*, vol. 39, pp. 389–403; March, 1960.

[17] F. M. Smits and S. P. Morgan, "Potential distribution and capacitance of a graded *p-n* junction," IRE-AIEE Solid State Devices Res. Conf., Cornell Univ., Ithaca, N. Y.; June 17–19, 1959. We are indebted to F. M. Smits for sending us a preprint.

These capacitances are: C_d, the minority carrier diffusion capacitances outside of the transition region; C_{ti}, the transition capacitance due to the change of the total number of ionized impurity space charge in half of the transition layer, which arises from the change of the edge positions of the transition layer with a change of the applied voltage; and C_{tc}, the capacitance due to the change of the total number of free holes in the transition region. We shall call C_{ti} the transition space-charge capacitance and C_{tc} the transition carrier capacitance.

The explicit expression of the diffusion capacitance may be obtained by integrating (3), using the solution of the electron and hole densities obtained by Bakanowski and Forster[4] for a linearly graded junction. Their solution was obtained by assuming electrical neutrality and negligible majority carrier current outside of the transition region. Thus, the electric field outside the transition region is just that given by the built-in field, $E=-kT/qx$, due to nonuniform impurity distribution. The differential equation for hole flow in the n-type region is

$$\frac{d^2p}{dz^2}+\frac{1}{z}\frac{dp}{dz}-\left(1+\frac{1}{z^2}\right)p = p_n,$$

where $z=x/L_p$, and the solution may be obtained in terms of Bessel functions. For example, the diffusion capacitance due to hole flow in the n-type region is given by

$$C_{dp} = q\frac{d}{dV}\int_{W/2}^{L} p\,dx = q\frac{n_i^2}{a}\frac{q}{kT}\frac{d}{dv}\left[\frac{e^v}{z_W}\frac{K_0(z_W)}{K_1(z_W)}\right]. \quad (6)$$

if it is assumed that the semiconductor is thick compared with the hole diffusion length, *i.e.*, $L \gg L_p$; and if the low-level boundary conditions for the hole density at the edge of the transition region, $p(W/2)=(2n_i^2/aW)\exp(qV/kT)$, is used. Similar results may be obtained for electrons in the p-type region. If the minority-carrier diffusion length is much less than the width of the transition region, (6) reduces to

$$C_{dp} \doteq C_{dn} \doteq q\frac{n_i^2}{a}\frac{q}{kT}\exp(qV/kT) \quad L_p \ll W. \quad (7)$$

If the diffusion length is large compared with the width of the transition region, (6) may be simplified to

$$C_{dp} = q\frac{n_i^2}{a}\frac{q}{kT}\frac{2L_p}{W}\exp(qV/kT) \quad L_p \gg W. \quad (8)$$

The explicit form of the transition space-charge capacitance C_{ti} given in (4) is obtained by straightforward calculation of the integral. The last form of (4) reduces to the usual formula for a parallel plate condenser, if the normalized transition layer width, w, is proportional to $(v_D-v)^{1/3}$, such as in the case of the space-charge approximation. The factor, $(-dw^3/dv)$, is usually less than unity if carrier charges are taken into account.

The calculation of the transition carrier capacitance C_{tc}, due to free electron and hole charges, is complicated, since the electron and hole densities in the transition region are not space constant and are also dependent on the applied voltage. However, a rather simple and accurate estimate can be made by assuming that the electron and hole densities are constant in the transition region and are given by $p=n_i\exp(v/2)=n_i^2/n$. With this approximation, (5) reduces to

$$C_{tc} \doteq \frac{qn_i}{2}\frac{q}{kT}W\left[1+2\frac{d\ln w}{dv}\right]\exp(qV/2kT). \quad (9)$$

This formula gives the correct asymptotic capacitance at large forward bias voltage. Let us use the $(v_D-v)^{1/3}$ dependence for the transition layer width (space-charge approximation) as a rough approximation; then, (9) may be written as

$$C_{tc} \doteq \frac{qn_i}{6}\frac{q}{kT}W\exp(qV/2kT). \quad (10)$$

The approximate result obtained here is 4/15 times that of the more accurate calculations which will be discussed in a later section.

Under moderate and large forward applied voltage, the transition capacitance C_{ti} is small compared with C_{tc}, and the ratio of the total transition capacitance to the diffusion capacitance obtained by using (7) or (8) and (10) are

$$\frac{C_t}{C_d} \doteq \frac{C_{tc}}{C_d} \doteq \frac{1}{12}\frac{aW}{n_i}\exp(-qV/2kT) \quad L_p, L_n \ll W \quad (11)$$

and

$$\frac{C_t}{C_d} \doteq \frac{C_{tc}}{C_d} \doteq \frac{1}{12}\frac{aW}{n_i}\frac{W}{L_p+L_n}\exp(-qV/2kT) \quad L_p, L_n \gg W. \quad (12)$$

Thus, in a graded junction, the transition carrier capacitance due to electrons and holes dominates in semiconductor materials with large energy gap or small intrinsic carrier concentration n_i, low minority carrier lifetime and large concentration gradient at the junction. In a diffused junction, large concentration gradient implies high bulk concentration or low resistivity. It would also be the dominant capacitance for materials with not too large an energy gap, but at low temperatures. These conclusions for a strictly linear-graded junction are similar to those made for the recombination-generation current and diffusion current of a hybrid junction with linear gradient in the transition region, and uniform impurity concentration outside of the transition region.[2]

An advantage of investigating the junction capacitance over the recombination-generation current is immediately evident from (9) and (10). The capacitance is independent of the minority carrier lifetime over a large forward bias voltage range so that the only device parameter required for a theoretical calculation is the impurity concentration gradient and no other adjustable parameters, such as the minority carrier lifetime or the capture cross sections for holes and electrons and the energy level of the recombination centers, are needed. Thus, a correlation of the calculated junction capacitance with experimental data is unambiguous.

B. The Recombination-Generation Current

A detailed discussion and calculation of the recombination-generation current was made by Sah, Noyce and Shockley.[2] We shall consider the more exact result which takes into account the free electron and hole in the transition region.

In the calculation of the recombination-generation current given by Sah, Noyce and Shockley in their equation (27), a specific assumption about the electric field was made in order to take into account the electron and hole recombination rate in the transition region. The integral of the recombination-generation rate was evaluated using infinities as limits. A more general result may be obtained by using finite limits corresponding to the edges of the transition region and by assuming a potential of the form, αy for $u_0 = [\psi - (\phi_p + \phi_n)/2]q/kT$, where α is a measure of the injection level, the electrical neutrality condition, or the relative importance of the fixed impurity space charge and the free carrier charges, and is independent of the position in the junction. The explicit forms of α will be the subject of a detailed discussion in the next section. By carrying out the integration of $J_{rg} = q\int U dx$ with finite limits corresponding to the boundaries of the transition layer, the more general form of the recombination-generation current can be obtained, and is given by

$$J_{rg} = \frac{qn_iW_0}{\sqrt{\tau_{p0}\tau_{n0}}}\frac{w}{\alpha}f(b)\sinh\frac{qV}{2kT}, \tag{13}$$

where the function $f(b)$ is given by

$$f(b) = \frac{1}{\sqrt{1-b^2}} \cdot \arctan\left[\frac{2\sqrt{1-b^2}\sinh\alpha}{\sqrt{\tau_{p0}/\tau_{n0}} + \sqrt{\tau_{n0}/\tau_{p0}} + 2b\cosh\alpha}\right] \tag{14}$$

and

$$b = \exp(-qV/2kT) \cdot \cosh q[(E_t - E_i)/kT + \ln\sqrt{\tau_{p0}/\tau_{n0}}]. \tag{15}$$

These results are particularly convenient for discussion at large forward bias where an asymptotic formula can be obtained. As $v \gg 0$, $b \doteq 0$, and the parameter α can be chosen to go to zero. Thus, (14) becomes

$$f(b) = \frac{2\alpha}{\sqrt{\tau_{p0}/\tau_{n0}} + \sqrt{\tau_{n0}/\tau_{p0}}} \tag{16}$$

and the recombination-generation current reduces to

$$J_{rg} \doteq \frac{qn_iW}{\tau_{p0}+\tau_{n0}}\exp\left(\frac{qV}{2kT}\right). \tag{17}$$

In (17) it is evident that if the transition layer width goes to zero faster than $\exp(-v/2)$ at large forward bias, an S-type negative resistance region might be obtained if the diode has negligible diffusion current at this bias level. In the analysis dealt with in the next section, it is shown that the transition layer width actually reaches a minimum and starts to increase at moderate forward bias. Thus, the negative resistance does not occur.

III. Approximate Solution of the Transition Layer Potential Distribution and Related Characteristics

In the calculations made in the preceding section, there are several parameters which need to be obtained explicitly in order to predict the dc capacitance and voltage-current characteristics. Some of these parameters are: the voltage dependence of the transition layer width; the potential distribution in the transition region; the potential function, $u_0 = [\psi - (\phi_p + \phi_n)/2]q/kT$ which is related to the electron and hole densities in the transition region through $p = n_i \exp(u_p - u)$ and $n = n_i \cdot \exp(u - u_n)$; the diffusion or the built-in voltage V_D; and the electrical neutrality parameter α. The exact solution of these parameters may be obtained by solving the three nonlinear coupled differential equations described by Shockley,[1] if the appropriate boundary conditions are used. Several authors have attempted to obtain solutions for the three differential equations for the step junction impurity distribution by assuming very narrow transition layer width. The numerical solutions are difficult to interpret and could provide no information about the transition layer characteristics. For linearly graded junctions, there have been no published solutions of the three coupled differential equations. The calculations made by Shockley,[1] Scarlett,[15] Lawrence and Warner,[16] and Roder and Sah[14] neglect the effect of the electron and hole densities in the transition region (the space-charge approximation) so that only the Poisson equation is necessary to obtain the solution. Therefore, these results are valid only at large reverse bias. Smits and Morgan[17] have also analyzed the case of the linearly graded junction by numerical integration of the Poisson equation, in which they included the electron and hole densities. They assumed as in the Shockley treatment[1] that the carrier densities are related to the electrostatic potential through the Boltzmann factor, and that the potential u_0 is equal to the true electrostatic potential u. Numerical solutions of the nonlinear Poisson equation were obtained through the use of the high-speed computer. Explicit asymptotic formulae, however, could not be obtained.

In the approach undertaken here, we shall follow the procedure used by Shockley, Smits and Morgan. However, instead of obtaining numerical solutions, we shall use approximate potentials for u_0 to describe the electron and hole densities, so that the Poisson equation is linearized. The solutions can then be derived readily with the use of boundary conditions which are obtained by physical considerations and by requiring the asymptotic form of the solution to be in agreement with the known results of the linearly graded junction in the space-charge approximation. The advantage of this approach is that it provides explicit solutions which may be compared with experimental results. In addition, these solutions can be studied in detail to provide physical understanding of the situation within and at the boundary of the transition region where direct physical measurements are not possible.

A. Assumptions on the Boundary Conditions

In order to simplify the notations (see List of Symbols), we shall use normalized parameters. Poisson's equation in the planar geometry for a linearly graded impurity distribution, $N(x)=ax$, is

$$\frac{d^2\psi}{dx^2} = -\frac{q}{K\epsilon_0}(p - n + ax). \tag{18}$$

In this equation we have assumed that the recombination center density is small so that the charge on the ionized centers may be neglected. Using the Boltzmann approximation for the electron and hole densities, (18) may be written in the normalized form

$$u'' = \frac{3}{2}w^3\left[\frac{4n_i}{aW}\exp\left(\frac{u_p - u_n}{2}\right)\sinh u_0 - y\right]. \tag{19}$$

The transition layer is bounded by the two planes, $x=\pm W/2$, on the opposite side of the junction, as shown in Fig. 1. The distance is normalized to $W/2$: $y=2x/W$. The edges of the transition layer at $y=2x/W=\pm 1$ are defined by the following boundary conditions:

$$\begin{aligned} u''(\pm 1) &= 0 & |y| &\geq 1 & (20)\\ u'(\pm 1) &= 0 & |y| &= 1 & (21)\\ u(0) &= 0 & y &= 0 & (22)\\ u(\pm 1) &= \pm\,\xi_j/2 = \pm\,(v_D - v_j)/2 & |y| &= 1. & (23)\end{aligned}$$

These are four of the seven assumptions we shall make.

The first boundary condition (20) states that the charge density at the edges and outside of the transition layer is zero, *i.e.*, electrical neutrality. The second boundary condition, (21), assumes zero electric field at the edge of the transition region. This condition is only an approximate one, since, from the discussion preceding (6), the electric field due to the built-in field at the edges of the transition region is $E_I=-2kT/qW$, or $u'(\pm 1)=1$. At small forward bias and reverse bias, the value of $u'(\pm 1)=1$ is much smaller than the maximum electric field $u'(0)$, so that the assumption of $u'(\pm 1)=0$ is good. At high forward bias the assumptions made leading to $u'(\pm 1)=1$ are no longer valid, since the electric field due to majority carrier flow, which is in the opposite direction of the built-in field, becomes comparable to the built-in field. Thus, at large forward bias, $u'(\pm 1)=0$ becomes again a good approximation. The condition given by (22) sets the zero reference for the junction potential.

The last boundary condition, (23), is the most important difference between our analysis and previously published works; it allows a difference between the voltage applied to the end leads of the diode, v, and the actual voltage drop across the transition layer v_j. This situation is closely related to the built-in field due to nonuniform impurity distribution and the majority carrier current flow outside of the transition region. To understand that in general $v\neq v_j$, we may consider the case of a step junction where only the electric field due to majority current flow is present outside of the transition region. The potential distribution shown in Fig. 2(a) corresponds to that in a step junction at thermodynamic equilibrium or zero-applied bias. The electrostatic potential barrier is built up because holes flow from the high concentration p-type side to the low concentration n-type side by diffusion, and thus charge up

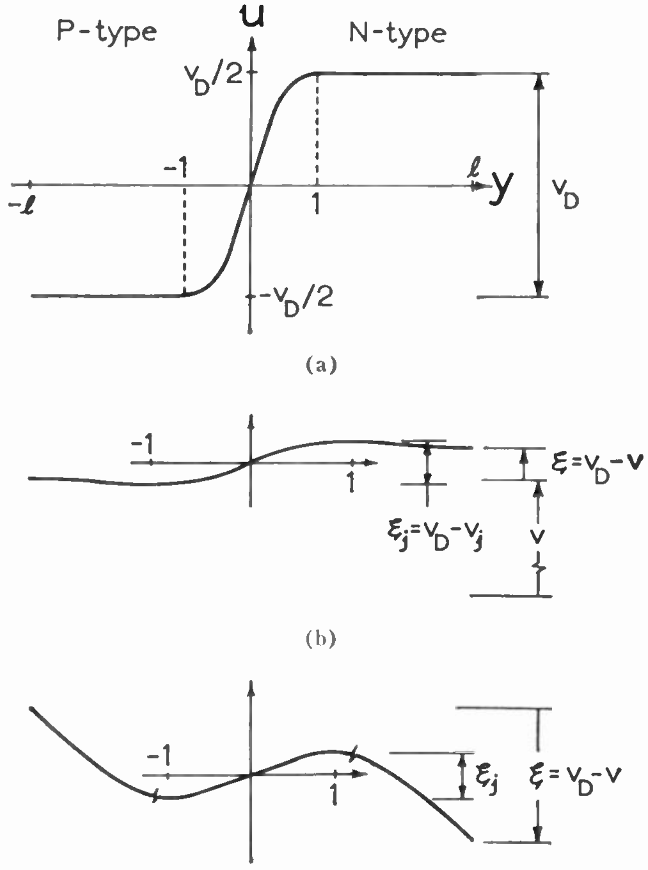


Fig. 2—The variation of the normalized electrostatic potential, $u=q\psi/kT$, with distance $y=2x/W$, in a linearly graded p-n junction under several forward applied voltages: (a) zero bias, (b) $v=0.9\ v_D$ and (c) $v=1.2\ v_D$. The distance axis is not linearly scaled.

the n-type region positively. In order to maintain equilibrium, an equal number of holes must drift in the reverse direction under the influence of the electric field. A similar situation applies to the electrons in the n-type region. Thus, an electric field is built up in the transition layer which corresponds to a voltage drop of v_D (usually called the diffusion voltage) from $y=-1$ to $y=1$.

As a positive voltage, nearly equal to the built-in voltage, is applied to the end leads of the p-n junction, the electrostatic potential distribution becomes that shown in Fig. 2(b). The voltage across the junction, v_j, is now slightly less than the applied voltage v or $\xi_j > \xi$. (The ξ's are called the electrostatic potential differences.) The small voltage difference accounts for the electric field that must build up outside of the transition layer from the large majority carrier flow from the p-side to the n-side of the semiconductor. This condition may be derived more exactly from

$$J_p = qD_p\left(\frac{qE}{kT}p - \frac{dp}{dx}\right) \tag{24}$$

and

$$J_n = qD_n\left(\frac{qE}{kT}n + \frac{dn}{dx}\right). \tag{25}$$

A rough estimate may be made of the magnitude of the electric field due to the majority carrier current outside of the transition layer by considering these current equations for the majority carrier. For example, on the p-type side, we may solve (24) by assuming electrical neutrality and constant impurity concentration from $x=-L$ to $-W/2$. Thus, $p=-N_A$ and $E_J=(kT/q)/(qN_AD_p/J)$, since in this region the total current density is approximately equal to the hole current density, $J=J_p$. A similar estimate may be made for the n-type side of the semiconductor. As the junction is forward-biased, $J>0$, and a positive electric field is built up outside of the transition region due to majority carrier flow which corresponds to the situation shown in Fig. 2(b). Thus, in a step junction, $V_j < V$, and it is also true at reverse bias that $V<0$, since $J<0$.

The situation for linearly graded junction is not quite the same, since there is the additional built-in electric field, E_I, due to nonuniform impurity distribution outside the transition region. This built-in field, which is in the negative direction for the impurity distribution, $N(x)=ax$, tends to compensate for the electric field due to majority carrier flow. At small forward bias and reverse bias when the total current density J is small, $E_J < E_I$, which causes the junction voltage to be higher than the applied voltage, $V_j > V$. At large forward bias, $E_J > E_I$ and $V_j < V$, which is then similar to the condition in a step junction.

The inequality $v \neq v_j$ is more evident when the applied voltage is greater than v_D, such as that shown in Fig. 2(c). The junction potential ξ_j would approach zero as a limit, since if ξ_j could become negative, we would have the impossible situation that the hole density on the n-type side is greater than the hole concentration on the p-type side. Therefore, as $v \gg v_D$ and $\xi_j \to 0$, the correct limit is that the hole and the electron concentrations become constant everywhere. In this situation, the current flow in the semiconductor is limited by the total integrated ohmic resistance across the slab and the transition region offers no additional resistance. These physical considerations are further verified in the more exact calculations to follow.

B. Assumptions on the Imrefs and the Potential Function, u_0

In addition to the four boundary conditions assumed in (20) to (23), two other assumptions are made and are given by

$$u_p - u_n = v \qquad |y| \leq 1 \tag{26}$$

and

$$u_0 = \alpha y \qquad |y| \leq 1. \tag{27}$$

The relation given by (26) assumes that the quasi-Fermi levels or imrefs for electrons and holes are constant across the transition region and the difference between the two imrefs in the transition region is equal to the applied voltage. The fact that the imrefs do not change appreciably across the transition region has been proved.[1,2,12] It was also established that the imrefs must be monotonically increasing or decreasing functions of distance. Thus, these conditions establish the form of the potential and the imref variations shown in Fig. 3.

The exact form of the variation of u_0 with distance is very nearly the same as u within the transition region

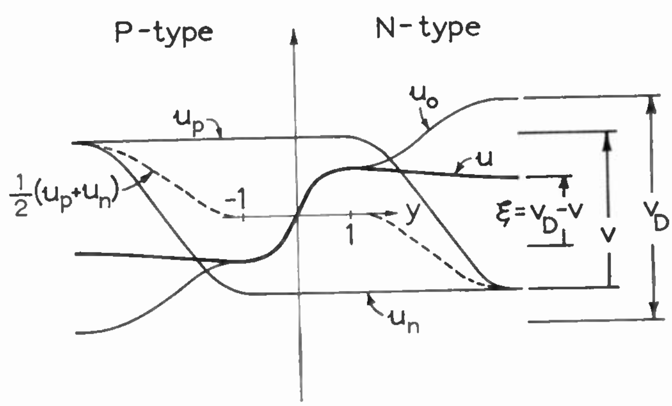


Fig. 3—The variation of the normalized quasi-Fermi level for electrons and holes, $u_n=q\phi_n/kT$ and $u_p=q\phi_p/kT$, and the electrostatic potential function, $u_0=(q/kT)[\psi-(\phi_p+\phi_n)/2]$ with distance in a linearly graded p-n junction for an applied voltage of $v=0.3\ v_D$.

as shown in Fig. 3. This result is a direct consequence of the assumptions made on the imrefs in the preceding discussions. However, if $u_0 = u$ is used, (19) becomes nonlinear and its solution becomes difficult to find. Thus, we shall employ the approximation given by (27), using α as a parameter which is assumed to be independent of distance and is a function of the electric field at the center of the junction.

C. The Physical Meaning of α and Its Effect on the Total Charge, the Electric Field, and the Potential Variation in the Transition Region

Before considering the solutions of the Poisson equation for specific forms of α, we shall consider first the general characteristics and physical meanings of α using the linearized Poisson equation

$$u'' = -\frac{3}{2} w^3 \left[y - \frac{\sinh \alpha y}{\sinh \alpha} \right]. \tag{28}$$

which is obtained by using (26), (27) and the boundary condition (20) of electrical neutrality. The use of the boundary condition (20) results in one of the three important relationships between the material properties and the junction characteristics, *viz.*,

$$\frac{4n_i}{aW_0} = \frac{w \exp(-v/2)}{\sinh \alpha}. \tag{29}$$

By straightforward integration of (28) using the boundary conditions (21) and (22), the electric field and electrostatic potential are obtained as

$$u' = \frac{3}{4} w^3 \left[(1 - y^2) - 2 \frac{\cosh \alpha - \cosh \alpha y}{\alpha \sinh \alpha} \right] \tag{30}$$

and

$$u = \frac{w^3}{2} \left[\frac{3}{2} \left(y - \frac{y^3}{3} \right) - y \frac{3}{\alpha^2} \left(\alpha \operatorname{ctnh} \alpha - \frac{\alpha}{\sinh \alpha} \frac{\sinh \alpha y}{\alpha y} \right) \right]. \tag{31}$$

The maximum field at the center of the junction is

$$u'(0) = \frac{3}{4} w^3 \left[1 - \frac{\tanh(\alpha/2)}{(\alpha/2)} \right]. \tag{32}$$

A second important relationship which relates the junction width, the applied bias and the junction potential, v_j, may be obtained by applying the boundary condition (23) to (31). This relation is

$$\xi_j = w^3 S(\alpha) \tag{33}$$

where

$$S(\alpha) = 1 - 3(\alpha \operatorname{ctnh} \alpha - 1)/\alpha^2. \tag{34}$$

The asymptotic forms of the function $S(\alpha)$ are

$$S(\alpha) \doteq \frac{\alpha^2}{15}\left(1 - \frac{2}{21}\alpha^2\right) \qquad \alpha \leq 1 \tag{35}$$

and

$$S(\alpha) \doteq 1 - 3\frac{\alpha - 1}{\alpha^2} \qquad \alpha \geq 2. \tag{36}$$

A plot of $S(\alpha)$ and $1 - S(\alpha)$ vs α is given in Fig. 4. The modifications of the results of (28) to (33) due to the built-in field E_I are given in Appendix I.

The dependence of α on the applied voltage can be obtained from (29) and (33). At very large negative applied voltage, the junction voltage is nearly the same as the applied voltage. Since the transition layer width is proportional to the one-third power of the applied voltage, from (33) we may conclude that as v approaches large negative value, α must be very large and positive, so that $S(\alpha)$ approaches 1 as indicated in (36). At large forward applied voltage, (29) requires that $\sinh \alpha$ or α be small, and $S(\alpha)$ can be approximated by (35). Thus, the parameter α, which is a measure of the electric field in the junction, is also a measure of the applied voltage to the junction and the condition of electrical neutrality in the transition region. At large forward bias, α is small and the junction region approaches electrical neutrality as indicated by $u'' \to 0$ from (28), while for large reverse bias, α is large and there is an uncompensated space-charge layer in the transition region. The latter is the space-charge approximation mentioned previously. A comparison of α with the neutrality parameter $K = L_D/2L_a$ given by Shockley[1] requires an explicit form for α, so that the discussion will be postponed.

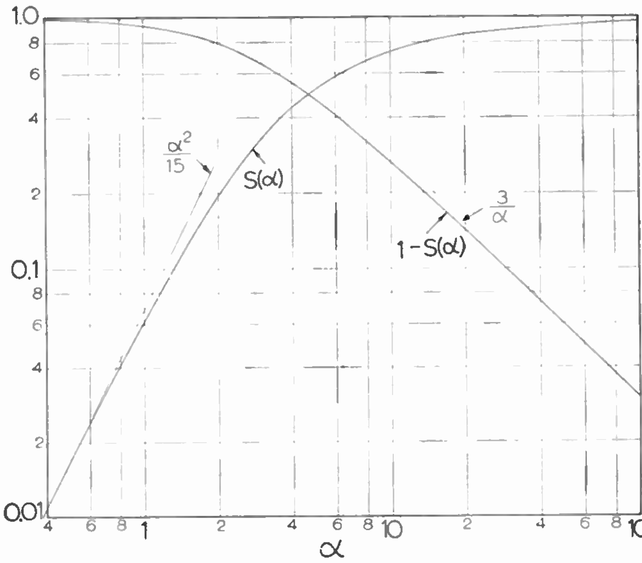


Fig. 4—The functions $S(\alpha)$ and $1 - S(\alpha)$.

From the interpretation of the electrical neutrality parameter α, we may proceed to obtain the effect of the electron and hole densities on the charge, the potential and electric field distribution in the transition region. This is best done by plotting out the expressions given by (28), (30) and (31) as a function of distance using α as a parameter. The results are shown in Fig. 5(a)–5(f).

The total charge distribution, and the ratio of the carrier-charge density to the ionized impurity density are presented in Fig. 5(a) and 5(b) respectively. It is seen that as α becomes infinite, the electrons and holes are depleted in the transition region and the total charge is just that of the ionized impurity which has the linear distribution $N(x)=ax$. As α becomes small, the total charge density in the transition region becomes small and the electrical neutrality condition is approached. The limiting shape of the charge variation as $\alpha \to 0$ is given by $(\alpha^2/6)y(1-y^2)$, and the factor $y(1-y^2)$ is shown as a dashed curve in Fig. 5(a).

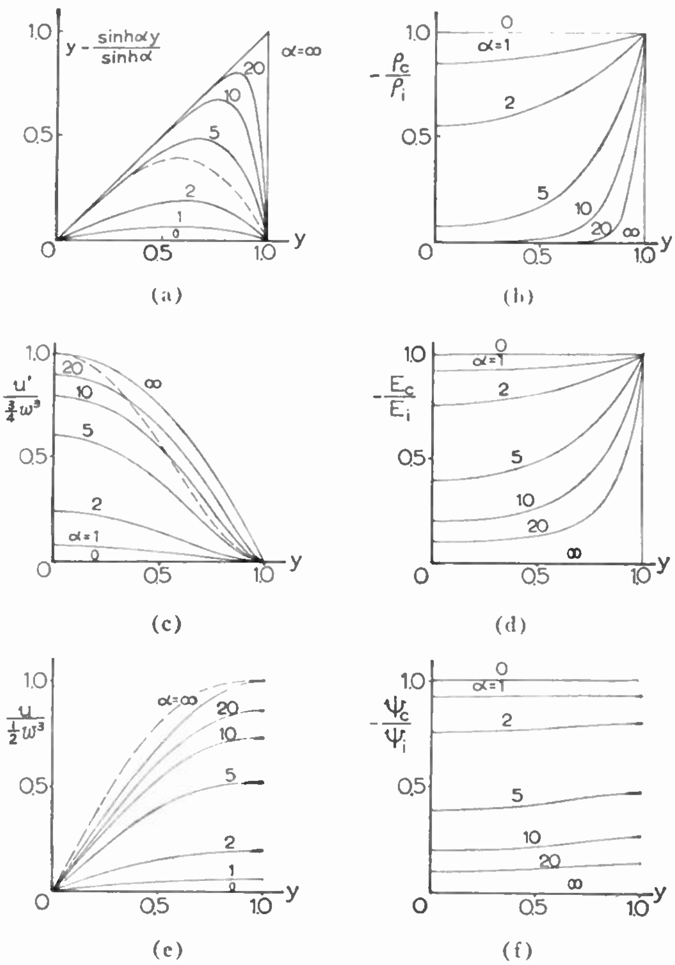


Fig. 5—The effects of the electrical neutrality parameter α on the internal characteristics of a linearly graded *p-n* junction. Only the *n*-type half of the junction region is shown. (a) The normalized total charge variation. (b) The ratio of the carrier charge to the fixed and ionized impurity space charge. (c) The normalized electric field variation. (d) The ratio of the electric field due to the carrier charge to that due to the fixed and ionized impurity space charge. (e) The normalized electrostatic potential variation. (f) The ratio of the electrostatic potential due to the carrier charge to that due to the fixed and ionized impurity space charge.

The electric field, and the ratio of the electric field due to electrons and holes to that caused by the ionized impurities are plotted in Fig. 5(c) and 5(d). At large reverse bias, $\alpha \to \infty$, the field variation is in the usual parabolic form. At large forward bias, $\alpha \to 0$, the field in the transition region approaches zero. The limiting shape of the field variation in the junction is given by $(\alpha^2/12)(1-y^2)^2$, and the factor $(1-y^2)^2$ is shown as a dashed curve in Fig. 5(c).

In Fig. 5(e) and 5(f) the potential variation in the transition region is plotted. The effect of the electron and hole on the shape of the potential is most readily seen in Fig. 5(e), where the dashed curve represents the limiting shape of the potential variation for nearly electrical neutral condition and is given by $(8/15)y(1-2y^2/3+y^4/5)$. It is seen that large electron and hole concentrations cause a greater curvature of the potential variation. A comparison of the electrostatic potential due to electrons and holes with that due to the ionized impurities is made in Fig. 5(f). It is seen again that the effect of the electrons and holes is small at large reverse bias or large α and becomes important at small α. Thus, we may finally give the following definition for α. "α" is a measure of the relative importance of the fixed impurity space charge compared with the free electron and hole or mobile carrier charges in the transition region.

IV. Calculation of the Junction Characteristics

The calculation of the junction capacitance, resistance and current-voltage characteristics from (1) and (13) can be made by using (29) and (33) with an additional relation for α (the seventh and last assumption). From the considerations made in the previous sections, it is evident that α must be a function of the electric field in the junction. We shall consider two approximations: 1) $\alpha=\xi_j/2$, and 2) $\alpha=(2/3)u'(0)$. Both of these are constant field approximations using the electric field appropriate to the case of appreciable electron and hole densities. The first approximation is simply that of taking the potential appearing across the junction divided by the junction width, which is equivalent to using the average electric field over the transition region. It is identical to the potential function used by Sah, Noyce, and Shockley[2] for the calculations of the recombination-generation current if $v_j=v$. The second potential is probably a more reasonable one, since it corresponds to a zeroth order self-consistent approximation. The factor (2/3) comes from the requirement that the final result at large reverse bias approaches that given by the negligible electron and hole density approximation.

A. Approximate Solutions

Approximation 1: For this case we assume that

$$\alpha = \xi_j/2. \tag{37}$$

The complete solution can be obtained from (37), (29) and (33), with the aid of the $S(\alpha)$ function given by (34). For the convenience of discussion, we shall repeat (29) and (33) here:

$$\frac{4n_i}{aW_0} = \frac{w \exp(-v/2)}{\sinh \alpha} = w_D/\sinh \alpha_D \qquad (38)$$

$$\xi_j = v_D - v_j = w^3 S(\alpha) \qquad (39)$$

where the last form of (38) with subscript D denotes the zero bias condition. The solution for w and α may be obtained from (37) to (39) for a given material and junction property, $4n_i/aW_0$, and an applied voltage, v. The diffusion or built-in voltage, v_D, is defined in Fig. 2(a), and may be obtained by setting both v and v_j equal to zero. The result of the calculation for the diffusion voltage using

$$a = 5.62 \times 10^{27}(v_D)^{-1/2} \exp\left[\tfrac{3}{4}(v_D - 46.615)\right] \cdot \exp\left[\tfrac{3}{4}(46.615 - v_{g0})\right]\left(\frac{T}{300}\right)^{9/4} \text{cm}^{-4}$$

is plotted in Fig. 6 as a function of the concentration gradient with junction temperature as a parameter for linearly graded silicon junctions. The intrinsic carrier concentration and the energy gap for silicon are taken from the work of Morin and Maita[18] and MacFarlane, *et al.*[19]

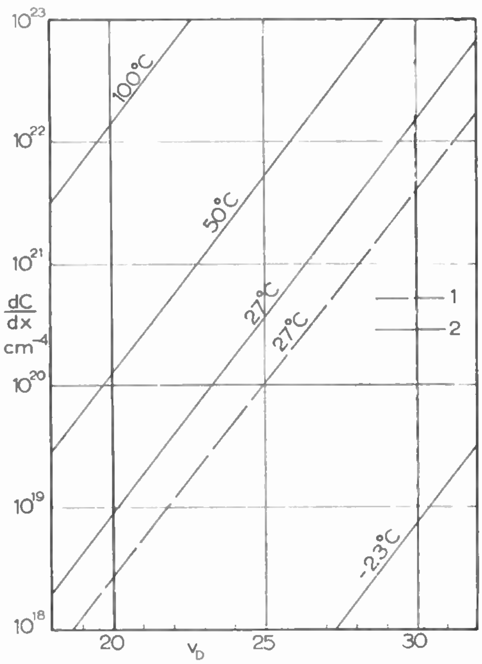


Fig. 6—The normalized diffusion or built-in voltage $v_D = qV_D/kT$, in a linearly graded silicon p-n junction at various junction temperatures vs the ionized impurity concentration gradient dC/dx for both Approximation 1 and Approximation 2.

[18] F. J. Morin and J. P. Maita, "Electrical properties of silicon containing arsenic and boron," *Phys. Rev.*, vol. 96, pp. 28–35; October, 1, 1954.

[19] G. G. MacFarlane, T. P. McLean, J. E. Quarrington, and V. Roberts, "Fine structure in the absorption-edge spectrum of silicon," *Phys. Rev.*, vol. 111, pp. 1245–1254; September 1, 1958.

The capacitances can be obtained from (62), (63), (37) to (39). They are given by

$$\frac{C_{tc}}{C_0} = \frac{1}{\alpha w S}\left(1 + 2\frac{d \ln S}{d \ln \alpha}\right)\frac{dv_j}{dv} \qquad (40)$$

and

$$\frac{C_{ti}}{C_0} = \frac{1}{wS}\left(1 - \frac{d \ln S}{d \ln \alpha}\right)\frac{dv_j}{dv} \qquad (41)$$

where

$$\frac{dv_j}{dv} = 3\alpha\left(\frac{d \ln S}{d \ln \alpha} - 1 + 3\alpha \operatorname{ctnh} \alpha\right)^{-1}. \qquad (42)$$

Approximation 2: For this case, we assume that

$$\alpha = \frac{2}{3}u'(0) = \frac{w^3}{2}\left[1 - \frac{\tanh(\alpha/2)}{(\alpha/2)}\right]. \qquad (43)$$

The last form of (43) is obtained by using (32). The capacitances are obtained from (62) and (63) (in Appendix II), (38), (39) and (43). They are given by

$$\frac{C_{tc}}{C_0} = \frac{3}{\alpha} w^2 \frac{d \ln \alpha}{dv}\left[\frac{2}{3}\frac{d \ln w^3}{d \ln \alpha} - 1\right] \qquad (44)$$

and

$$\frac{C_{ti}}{C_0} = -w^2 \frac{d \ln \alpha}{dv}\frac{d \ln w^3}{d \ln \alpha}. \qquad (45)$$

where

$$\frac{d \ln w^3}{d \ln \alpha} = 2 - \tanh^2(\alpha/2)\left[1 - \frac{\tanh(\alpha/2)}{(\alpha/2)}\right]^{-1} \qquad (46)$$

and

$$\frac{d \ln \alpha}{dv} = \frac{3}{2}\left(\frac{d \ln w^3}{d \ln \alpha} - 3\alpha \operatorname{ctnh} \alpha\right)^{-1}. \qquad (47)$$

Numerical solution for the built-in or diffusion voltage is again obtained and is also plotted in Fig. 6. The diffusion voltage for this approximation is smaller than that of Approximation 1 for a given concentration gradient dC/dx.

B. Asymptotic Solutions

1) *Large Reverse Bias, $v \ll 0$ and $\alpha \gg 0$:* Under this condition, the transition layer width is proportional to the one-third power of the applied bias, and the transition capacitance due to ionized impurity predominates. The percentage difference between the junction voltage v_j, and the applied voltage v, approaches zero. The results are identical for the two approximations of α, and are given by

$$v_D - v_j \doteq w^3 \qquad (48)$$

$$C_{ti}/C_0 = 1/w \qquad (49)$$

and

$$J_{rg}/J_{rg0} = w \tag{50}$$

where

$$J_{rg0} = \frac{qn_iW_0}{2\sqrt{\tau_{p0}\tau_{n0}}}. \tag{51}$$

2) *Large Forward Bias, $v \sim v_D$ and $\alpha \to 0$:* Under this condition, the transition layer width, the transition carrier capacitance which predominates and the recombination-generation current are all exponentially dependent upon the applied voltage. The junction width of the two approximations are slightly different:

Approximation 1: $\alpha = \xi_j/2$

$$w = \left(\frac{30}{\alpha}\right)^{1/3} = \left(30\frac{w_D}{\sinh \alpha_D}\right)^{1/4} \exp\left(\frac{v}{8}\right)$$
$$= \left(\frac{120n_i}{aW_0}\right)^{1/4} \exp\left(\frac{v}{8}\right). \tag{52}$$

Approximation 2: $\alpha = (2/3)\ u'(0)$

$$w = \left(\frac{24}{\alpha}\right)^{1/3} = \left(24\frac{w_D}{\sinh \alpha_D}\right)^{1/4} \exp\left(\frac{v}{8}\right)$$
$$= \left(\frac{96n_i}{aW_0}\right)^{1/4} \exp\left(\frac{v}{8}\right). \tag{53}$$

The capacitance C_{tc}, and the recombination-generation current may be obtained by using the transition layer width obtained above and the asymptotic reults given by (9) and (17). The results may be written into the following normalized forms:

$$\frac{C_{tc}}{C_0} = \frac{15}{8}\frac{w_D}{\sinh \alpha_D} w \exp\left(\frac{v}{2}\right) = \frac{15n_i}{2aW_0} w \exp\left(\frac{v}{2}\right) \tag{54}$$

$$\frac{J_{rg}}{J_{rg0}} = \frac{2\sqrt{\tau_{p0}\tau_{n0}}}{\tau_{p0}+\tau_{n0}} w \exp\left(\frac{v}{2}\right). \tag{55}$$

The numerical difference between the two approximations is rather small. For a given material and junction property, the junction width ratio of Approximation 1 to Approximation 2 is only $(120/96)^{1/4} = 1.056$; thus, it is difficult to distinguish these two approximations experimentally.

The relationship between the electrical neutrality parameter α, and the factor K considered by Shockley[1] as a measure of electrical neutrality can be compared by extending his definition of K to the nonequilibrium case, using $n_i \exp(qV/2kT)$ instead of n_i. Thus,

$$K = K_0 \exp\left(-\frac{3}{4}v\right) = \left[\frac{2}{3}\frac{\sinh^3 \alpha}{w^3}\right]^{1/2}, \tag{56}$$

where

$$K_0 = \frac{2}{3}\left(\frac{aW_0}{4n_i}\right)^{3/2} = \frac{L_D}{2L_a}. \tag{57}$$

The last form given in (56) is particularly useful for a comparison of K and α at small α or high forward bias. Using the asymptotic results from (52) and (53), the relationship between K and α for the two approximations are

$$\text{Approximation 1:} \quad K = \sqrt{\frac{4}{5}}\frac{\alpha^2}{6} \tag{58}$$

and

$$\text{Approximation 2:} \quad K = \frac{\alpha^2}{6}. \tag{59}$$

Thus, from the discussions given in Section III, C, and (58) or (59), the asymptotic values of the total charge, the electric field and the junction potential across the transition region are all proportional to the factor K as α and K become small and electrical neutrality is approached.

C. Numerical Calculations for $V_D = 30kT/q$

To illustrate the general behavior of the capacitance-voltage and current-voltage characteristics, numerical calculations are made for the two approximations, using (13) and (37) to (47). The results are presented in Figs. 7 to 10, using $v_D = 30$ for both Approximations 1 and 2. The curves for the case of negligible electron and hole density approximations are also included for comparison. Since Fig. 6 shows that for a given v_D, the values of $a = dC/dx$ would be different for the two approximations, the calculations based on $V_D = 30kT/q$ for the two approximations actually represent two physical cases with different impurity concentration gradients. However, as discussed in the preceding section, the differences between the two approximations at large reverse or forward bias would be indistinguishable if a given dC/dx is used. Thus, in several graphs, only the results of Approximation 1 are presented for clarity.

In Fig. 7, the normalized transition layer width is plotted against the junction electrostatic potential, $v_D - v_j$. The line for the negligible electron and hole density approximation is also shown. The transition layer is wider as a result of large electron and hole density in this region. In addition, it has a minimum value at an intermediate forward bias, and increases at large forward bias.

In Fig. 8(a) and 8(b) the transition layer capacitances of Approximation 1 are presented as a function of the electrostatic potential $v_D - v_j$ and the applied voltage v. The total transition capacitance is also plotted. Although the transition width passes through the minimum shown in Fig. 7, the transition carrier capacitance C_{tc} becomes so large at this forward bias voltage that the negative capacitance due to C_{ti} would not be observable.

The transition capacitance calculated using the transition layer width of the negligible electron and hole or space-charge approximation is also plotted in Fig. 8(a). Because of the result that the transition layer width

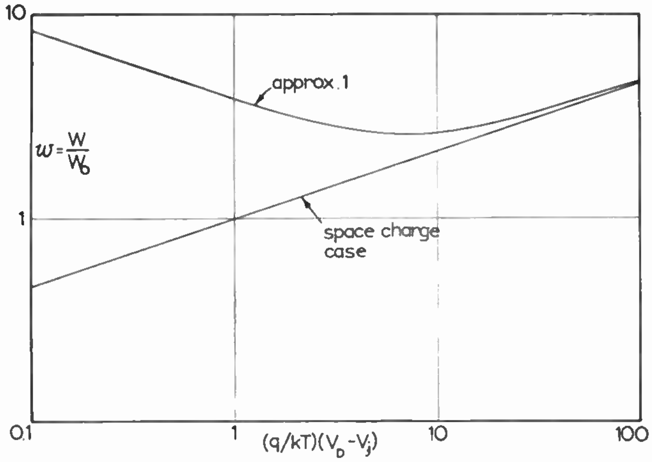
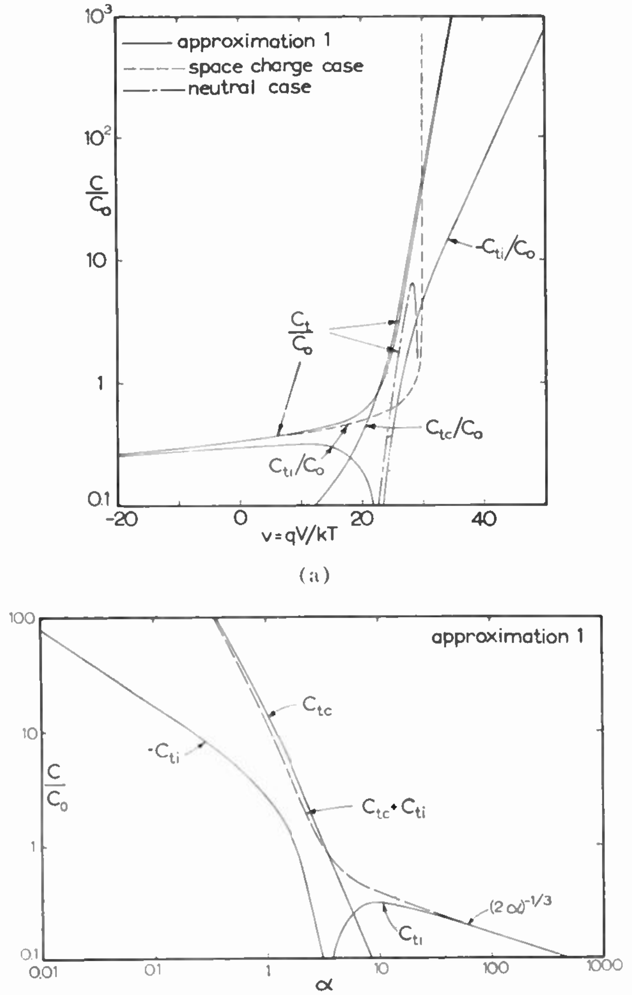


Fig. 7—The transition layer width W, normalized to W_0 (W_0 is the extrapolated space-charge layer width of the space-charge approximation at $V_D-V=kT/q$) vs the junction electrostatic potential $\xi_j=(q/kT)(V_D-V_j)$ for Approximation 1 and for the space-charge approximation.



(a)

(b)

Fig. 8—The junction capacitance, normalized to C_0 ($C_0=K\epsilon_0/W_0$) vs applied voltage, $v=qV/kT$. (a) The transition carrier capacitance C_{tc}, the transition space-charge capacitance C_{ti} and the total transition capacitance C_t+C_{ti}, of Approximation 1, are compared with the capacitance of the space-charge approximation and the capacitance of the neutral approximation. (b) The capacitance of Approximation 1 is plotted as a function of α, or half of the junction-electrostatic potential, $\alpha=\xi_j/2$.

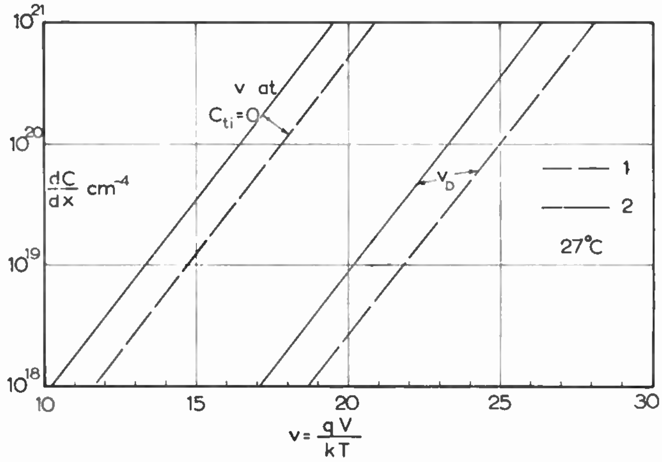


Fig. 9—The voltage at $C_{ti}=0$, $v(C_{ti}=0)$, for a linearly graded *p-n* junction at room temperature (27°C) vs the ionized impurity concentration gradient dC/dx, for both Approximations 1 and 2. The diffusion voltage v_D from Fig. 6 is also shown for comparison. The voltage $v(C_{ti}=0)$, may be taken as the lower limit of the forward bias at which the transition carrier capacitance completely predominates over the transition space-charge capacitance.

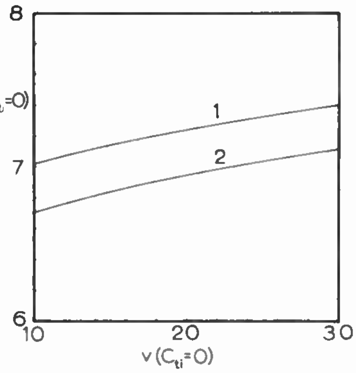


Fig. 10—The difference $v_D-v(C_{ti}=0)$ vs $v(C_{ti}=0)$. This graph is applicable at all temperatures and shows that $v_D-v(C_{ti}=0)$ is approximately 7 for both Approximations 1 and 2.

goes to zero when $v=v_D$ in this approximation, C_{ti} becomes infinite at $v=v_D$. This result is obviously incorrect when $v\to v_D$. The total transition capacity of the neutral case is also shown in Fig. 8(a). As $v\to v_D$, the neutral capacitance reaches a maximum, then drops to zero and becomes negative. This behavior is evidently incorrect, since the calculation is made by assuming $V_j=V$, which is not valid at large forward-bias voltages.

The applied voltage corresponding to $C_{ti}=0$ may be taken as a criterion for estimating the importance of the transition carrier capacitance C_{tc}. It is evident from Fig. 8(a) that at $v>v(C_{ti}=0)$, the transition carrier capacitance C_{tc} dominates. This condition also corresponds to the point of minimum junction width shown in Fig. 7. The values of the electrical neutrality parameter and the minimum junction widths can be obtained for the two approximations considered. For $C_{ti}=0$,

Approximation 1: $\alpha=3.415$, $K=11.37$, $w=2.62$.

Approximation 2: $\alpha=3.212$, $K=9.16$, $w=2.47$.

These results indicate that the transition carrier capacitance dominates at a bias voltage when the transition region is far from electrical neutrality (electrical neutrality corresponds to $\alpha \ll 1$, or $\alpha \leq 0.1$). In Fig. 9, the impurity concentration gradient, dC/dx, is plotted as a function of the voltage $v(C_{ti}=0)$, at room temperature for silicon. Included is also a plot of the diffusion voltage v_D, from Fig. 6. The difference between v_D and v is nearly constant and is approximately given by $v_D - v \cong 7$ in the range shown in Fig. 10.

In Fig. 11, the difference between the applied voltage and the junction voltage is presented as a function of the applied voltage for both approximations. At large forward bias, the junction voltage v_j is smaller than the applied voltage and approaches v_D when $v > v_D$. The difference may be accounted for by the ohmic drop in the p-type and the n-type region, as discussed in Section III in connection with Fig. 2. However, at small forward bias and reverse bias, Fig. 11 shows that $v < v_j$ with a difference of less than kT/q. The reason for this result was also discussed in Section III. The difference comes from the built-in field outside of the transition region which arises because of the nonuniform (linearly graded for this case) impurity distribution. This effect is not present in a step junction with constant impurity density on both sides of the junction. The results of Fig. 11 are altered if the boundary condition for the electric field is changed from $u'(\pm 1) = 0$, given by (21), to $u'(\pm 1) = 1$, due to the built-in field, E_I, at large reverse bias. However, the general feature of the curve is not changed; only the value of $v - v_j$ is increased by a factor of about 2. At medium and large forward bias, the condition $u'(\pm 1) = 0$ is more accurate, so that the results shown in Fig. 11 are accurate.

In Fig. 12, the recombination-generation current is plotted for the case of $E_t = E_i$ and $\tau_{p0} = \tau_{n0}$. The curve for the case of negligible electron and hole density in the transition region shows smaller current and fictitious negative resistance, which was discussed previously in Section II, B.

V. Comparison with Experimental Measurements

The current-voltage characteristics and the junction capacitance are measured as a function of applied voltage for a large number of diffused silicon diodes which are nearly linear-graded and have the planar geometry shown in Fig. 13. Three groups of diodes with different base resistivities and concentration gradients are made. Each group has several added gold recombination center densities. Since the current-voltage characteristics are sensitive to surface recombination and channel leakage, and since the gold impurity has two recombination levels which contribute about equally to the recombination current in silicon, it would be quite difficult to compare unambiguously the experimental data with the calculation which was based on a single-level recombination center model. However, the comparison with the junction-capacitance calculation should be less

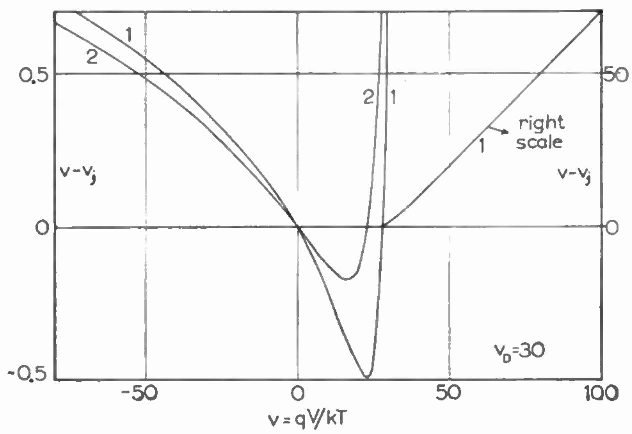


Fig. 11—The normalized ohmic voltage drop, $v - v_j$, vs the applied voltage $v = qV/kT$, for both Approximations 1 and 2.

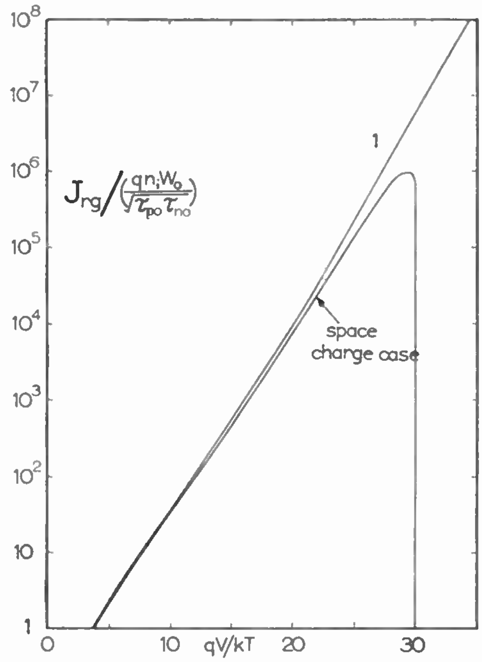


Fig. 12—The normalized carrier recombination current in the transition region vs the forward applied voltage $v = qV/kT$. Approximation 1 (or 2) removes the negative resistance of the space-charge approximation.

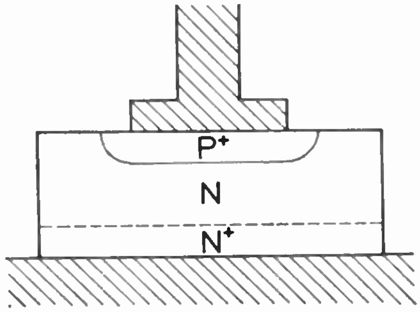
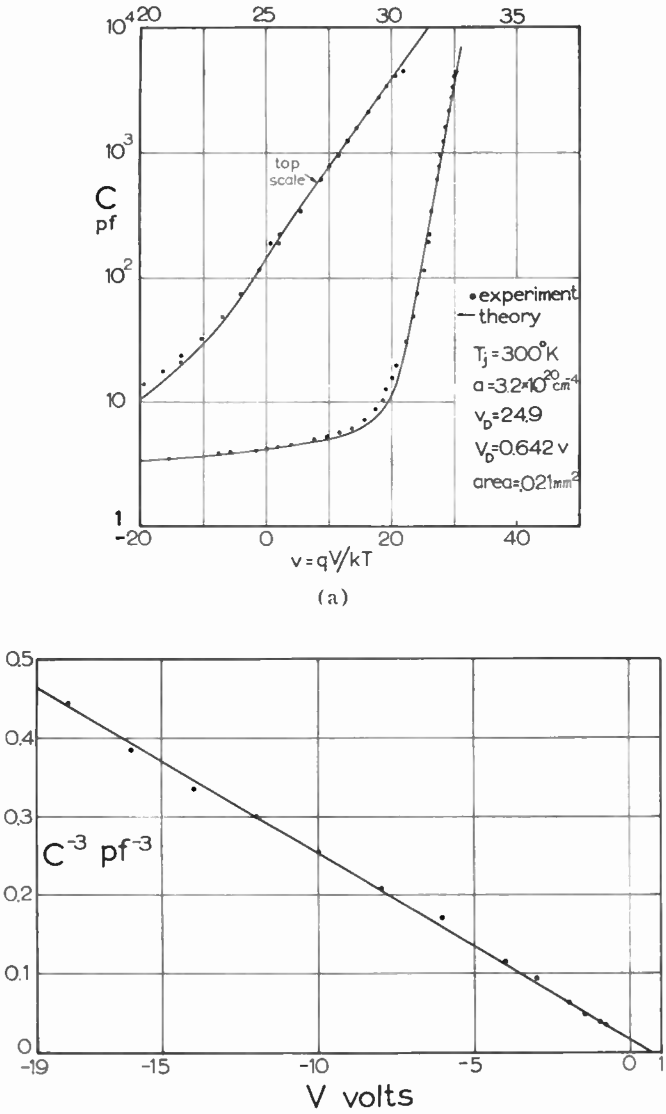


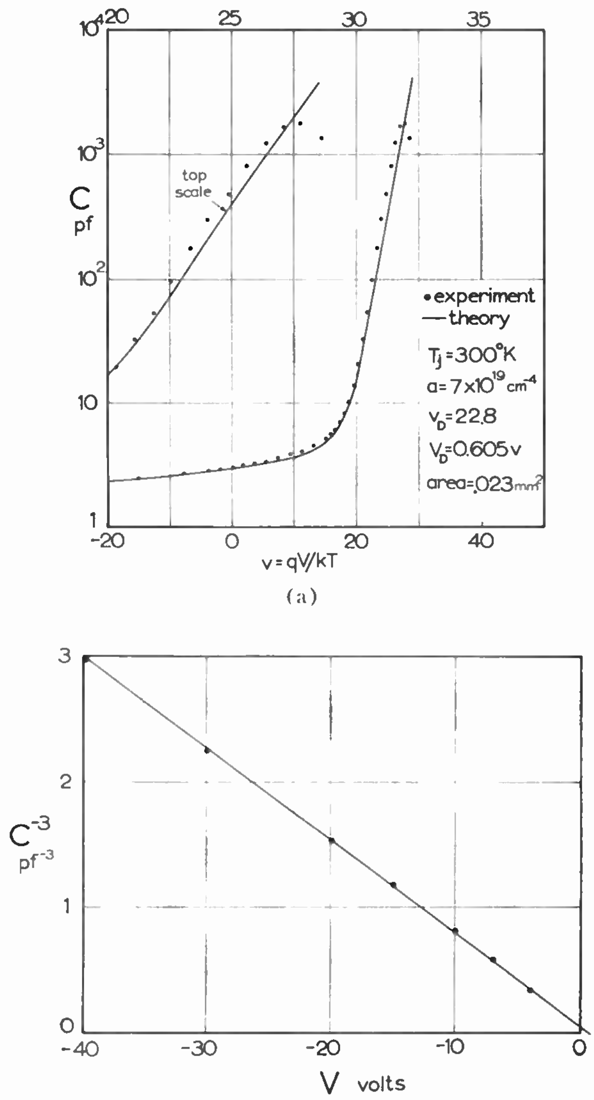
Fig. 13—Schematic of the "planar" diode geometry.



(a)

(b)

Fig. 14—A comparison of the dc theory and experiments of silicon junction capacitance. (a) Forward applied voltage. (b) Reverse bias. The impurity concentration gradient at the junction is very steep.



(a)

(b)

Fig. 15—A comparison of the dc theory and experiments of silicon junction capacitance. (a) Forward bias. (b) Reverse bias. The impurity concentration gradient at the junction is moderately steep.

ambiguous, since the junction capacitance is less dependent upon the minority carrier lifetimes. Precaution in the design of the diode geometry and the diffusion schedule should be taken so that an inductance, which is probably due to the conductivity modulation effect from the minority carrier in the n-type region, is not important.[20,21] The inductance caused by this effect cannot be eliminated completely, but becomes small at low frequencies.

Figs. 14 to 16 show the measured junction capacitance at room temperature using a Wayne-Kerr bridge and a

[20] T. E. Firle and O. E. Hayes, "Investigation of capacitance of forward biased junctions," *Bull. Am. Phys. Soc.*, vol. 3, p. 12, Paper D-1; January 29, 1958.

[21] J. Nishizawa and Y. Watanabe, "Semiconductor inductance diode," Digest of the 1960 Internatl. Solid-State Circuits Conf., Lewis Winner, Inc., New York, N. Y., p. 84; February, 1960.

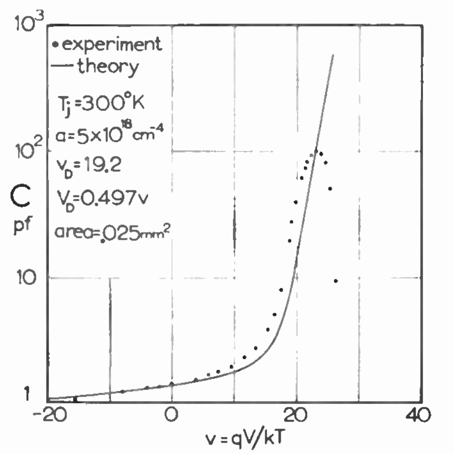


Fig. 16—A comparison of the dc theory and experiments of silicon junction capacitance. The impurity concentration gradient at the junction is rather gentle; the junction injects heavily and becomes a p^+n junction at moderately low forward bias.

Kintel digital voltmeter and the theoretical calculations using Approximation 2. The calculations were made using measured junction area and impurity concentration gradient. The concentration gradients obtained from breakdown voltage, reverse capacitance and diffusion data agree within experimental accuracy. These silicon diodes were picked at random from three groups of different impurity concentration gradients. The variations of the capacitance among the devices in each group are usually less than a few per cent. There were no intentionally added recombination centers in these three groups. The pulse recovery time for equal forward and reverse current at 10 ma is 50 mμsec for all three groups. The agreement between measured and calculated capacitances is good for the diode with the steepest concentration gradient shown in Fig. 14(a). The departure of the experimental data from the calculated values at large forward bias is more evident for diodes with smaller concentration gradient, such as those shown in Figs. 15(a) and 16. The decrease of junction capacitance at large forward bias is probably associated with the conductivity modulation effect in the n-region for these p^+nn^+ diodes. This effect should be less evident in diodes which have a truly graded impurity gradient from one surface of the semiconductor to the opposite surface. The impurity gradients for the two groups of devices shown in Figs. 14(a), 14(b), 15(a) and 15(b) are very nearly linear-graded, as can be seen from Figs. 14(b) and 15(b). The measurements of junction capacitance made on diodes corresponding to the group shown in Fig. 16 showed a capacitance variation between linear grading and step junction from zero to large reverse bias.

The inductance effect is further exemplified by the experimental data shown in Figs. 17 and 18. In Fig. 17 the effect of the minority carrier lifetime on the junction capacitance at high forward bias is evident. The devices shown in Fig. 17 have the same geometry and impurity concentration gradient as those given by Figs. 14(a) and 14(b). However, the recombination center densities (gold) in the three groups shown in Fig. 17 are different. For the heaviest gold doping ($\tau_R = 5$ mμsec), the junction capacitance becomes negative and decreases exponentially with voltage at around 25 $kT/q = 0.63$ volt.

The experimental measurements of the junction capacitance are also made at several frequencies. In Fig. 18, capacitance data at two frequencies are obtained for the device shown in Fig. 14. It is seen that the measurements at these two frequencies are in fairly good agreement with the dc calculations. However, at large forward bias, the inductance effect, which is frequency dependent, becomes important and the junction capacitance starts to drop at lower forward-bias voltage for the 5-Mc measurements than the 1-Mc measurements.

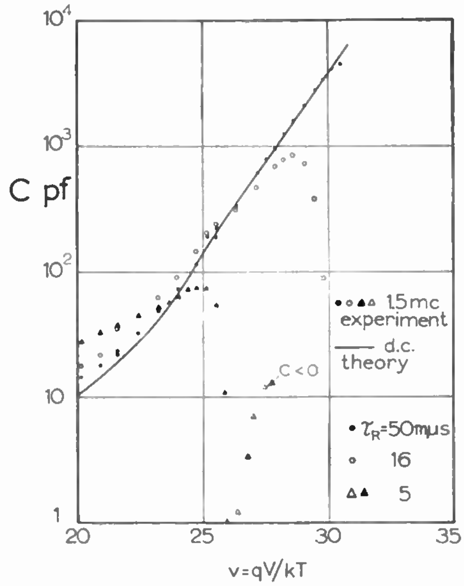


Fig. 17—The effect of minority carrier lifetime or pulse recovery time on the junction capacitance of linearly graded silicon junctions with a very steep impurity concentration gradient.

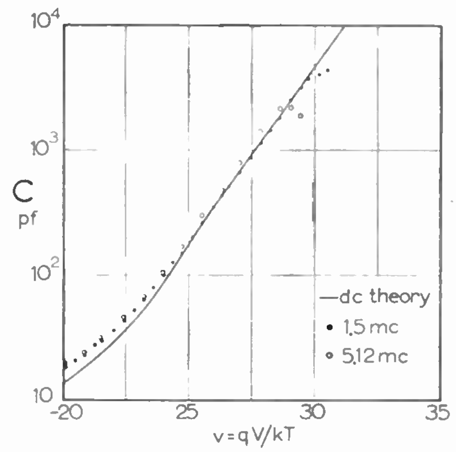


Fig. 18—The frequency effect on the junction capacitance of a linearly graded silicon junction with a very steep impurity concentration gradient.

VI. Concluding Remarks

The calculation of the junction characteristics associated with the transition region is carried out using a linearized Poisson-Boltzmann equation and approximate boundary conditions which are physically reasonable at the edge of the transition region. The potential variation, the electric field, and the total charge density in the transition region are related to the electrical neutrality parameter α, which is a measure of the relative importance of the fixed impurity space charge and the mobile carrier or free electron and hole charges. The following important features of the present analysis are obtained:

1) The transition layer width is wider than that predicted by the space-charge approximation and in-

creases at large forward bias exponentially with applied voltage with an exp $(qV/8kT)$ dependence.

2) The transition space-charge capacitance due to fixed impurity space charge is smaller than that given by the space-charge approximation. In the intermediate forward bias, this capacitance passes through zero and becomes negative at large forward bias. However, in this region, the transition carrier capacitance due to free electrons and holes in the transition region becomes large and dominates with an exp $(5qV/8kT)$ voltage dependence. The point at which the transition space-charge capacitance becomes zero may be used to estimate the relative importance of the two transition capacitances. It corresponds to the point where the transition layer width is a minimum and $\alpha \doteq 3.5$, or $K \doteq 10$. The transition region is far from electrical neutrality at this bias voltage.
3) The inclusion of the electron and hole charges decreases the magnitude of the electric field in the transition region.
4) The recombination-generation current in the transition region is higher than that predicted by the space-charge approximation. At large forward bias, it has an exp $(5qV/8kT)$ voltage dependence.

Although the upper forward voltage limit of the present analysis is not established, experimental results of the junction capacitance measurement are in good agreement with the theoretical calculations in the forward bias region beyond $V > V_D$. Several experiments were made to demonstrate that at high forward-bias level an inductance, probably due to conductivity modulation, is no longer negligible. The high-frequency effects on the junction capacitance, and the loss mechanism associated with the high density of the ionized and neutral recombination centers in the semiconductor and the p-n junction transition region are not considered. These effects would not be important until the frequency of RF measurement signal becomes comparable to the reciprocal lifetime such as that encountered in the parametric application of the junction diodes. Thus, the extension of the present calculation to high frequencies would be of considerable practical importance.

Appendix I

The modifications of the results obtained in (28) to (33), due to the built-in field E_I, when the applied bias is either negative or small, are:

1) $u'(y)$ in (30) is replaced by $u'(y)-1$.
2) $u(y)$ in (31) is replaced by $u(y)-y$.
3) $u'(0)$ in (32) is replaced by $u'(0)-1$.
4) ξ_j in (33) is replaced by ξ_j-2.

These numerical factors of 1 or 2 do not appreciably affect the results obtained in the text.

Appendix II

General Capacitance Formulae

We shall obtain a more explicit expression for the transition carrier capacitance C_{tc} given by (5), using the assumptions of (26) and (27), and the result given by (29). Due to the symmetry of the linear-graded junction, (5) may be written as

$$C_{tc} = q\frac{d}{dV}\int_{-W/2}^{W/2} p\,dx = q\frac{d}{dV}\int_0^{W/2}(p+n)\,dx, \quad (60)$$

which may be further reduced to

$$C_{tc} = qn_i\frac{q}{kT}W_0\frac{d}{dv} \cdot \left[w\left[\exp\tfrac{1}{2}(u_p-u_n)\right]\int_0^1 \cosh u_0 dy\right]. \quad (61)$$

With the aid of (26), (27) and (29), the following simple result is obtained:

$$C_{tc} = C_0 3\frac{d}{dv}\left(\frac{w^2}{\alpha}\right), \quad (62)$$

where $C_0 = K\epsilon_0/W_0$.

Repeating (4),

$$C_{ti} = C_0\frac{1}{w}\left(-\frac{dw^3}{dv}\right), \quad (63)$$

we have in (62) and (63) the general expressions for the two transition capacitances. It can be shown that as $\alpha\to 0$, (62) reduces to (9) if (29) is used.

List of Symbols

a = impurity concentration gradient at the junction, $a = dC/dx$.
α = the electrical neutrality parameter.
α_D = the electrical neutrality parameter at zero applied voltage.
C = the junction capacitance per unit area.
C_d = the minority carrier diffusion capacitance per unit area.
C_{dn}, C_{dp} = the electron and hole diffusion capacitances in the p-region and n-region per unit area.
C_0 = the junction capacitance at $V_D - V = kT/q$ in the space-charge approximation, $C_0 = K\epsilon_0/W_0$.
C_{tc}, C_{ti} = the transition carrier capacitance and the transition space-charge capacitance per unit area.
D_n, D_p = minority carrier diffusion coefficients for electrons and holes.
E = the electric field.
E_i = intrinsic Fermi level $= -q\psi$.
E_t = energy level of the recombination centers.
E_I = the electric field outside of the transition region due to nonuniform impurity distribution.

E_J = the electric field outside of the transition region due to ohmic voltage drop or majority carrier current flow.
ξ_j = the electrostatic potential difference across the transition region normalized to kT/q, $\xi_j = v_D - v_j$.
J_n, J_p = the electron and hole currents per unit area.
J = the total current per unit area.
J_{rg} = the recombination-generation current per unit area in the transition region.
k = the Boltzmann constant.
K = the electrical neutrality parameter of Shockley $= L_D/2L_a$.
K = the dielectric constant of the semiconductor.
ϵ_0 = the permittivity of vacuum, $\epsilon_0 = 0.08854$ pf/cm.
K_0, K_1 = the modified Bessel functions of the second kind.
L = one-half of the length of the semiconductor containing the p-n junction.
L_n, L_p = the electron- and hole-diffusion lengths, $L_n = \sqrt{D_n\tau_{n0}}$ and $L_p = \sqrt{D_p\tau_{p0}}$.
L_a = a length used in Shockley's electrical neutrality parameter K, $L_a = n_i \exp(qV/2kT)/a$.
L_D = the Debye length, $L_D = [K\epsilon_0(kT/q)/2qn_i \exp(qV/2kT)]^{1/2}$.
n, p = density of electron and hole per unit volume in the conduction and valence bands, $n = n_i \exp(u - u_n)$ and $p = n_i \exp(u_p - u)$.
n_i = density of electron or hole per unit volume in an intrinsic specimen.
n_p, p_n = the minority carrier densities per unit volume.
P, N = the total number of electron and holes per unit area.
N_A, N_D = ionized acceptor and donor densities per unit volume.
q = the magnitude of the electronic charge.
Q = the total charge flow per unit area in the semiconductor.
$S(\alpha)$ = see (34).
T = absolute junction temperature in °K.
τ_{n0}, τ_{p0} = electron and hole lifetime in highly p-type or n-type specimen.
u = the electrostatic potential function, $u = q\psi/kT = -E_i/kT$.
u_0 = a potential function, $u_0 = [\psi - (\phi_p + \phi_n)/2]\, q/kT$.
u_n, u_p = the quasi-Fermi potential for electron and hole, $u_n = q\phi_n/kT$ and $u_p = q\phi_p/kT$.
U = the steady-state recombination-generation rate of electrons and holes.
v, V = the applied voltage across the end leads of a p-n junction, $v = qV/kT$.
v_D, V_D = the diffusion or the built-in voltage or the electrostatic potential difference across the transition layer at zero-applied voltage, $v_D = qV_D/kT$.
v_{g0}, V_{g0} = the energy gap at 0°K in volt, $v_{g0} = qV_{g0}/kT$.
v_j, V_j = the voltage across the transition region, $v_j = qV_j/kT$.
w, W = the width of the transition layer, $w = W/W_0$.
w_D, W_D = the width of the transition layer at zero-applied voltage, $w_D = W_D/W_0$.
W_0 = the transition layer width at $V_D - V = kT/q$ in the space-charge approximation, $W_0 = [12K\epsilon_0(kT/q)/aq]^{1/3}$.
x, y, z = distances measured from the center of the transition region, $y = x/(W/2)$ and $z = x/L_p (x > 0)$, or $z = x/L_n (x < 0)$.
z_W = half width of the transition layer normalized to the electron- or hole-diffusion length, $z_W = W/2L_p (x > 0)$, or $W/2L_n (x < 0)$.

VII. Acknowledgment

The author wishes to thank G. E. Moore and J. A. Hoerni for their helpful comments, and O. Hatcher and J. Lessard for fabricating the diodes.

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Definitions

Aerosol Development. *Development* by means of a suspending gas.

Cascade Development. *Development* by means of gravitational forces

Charging (Electrostatography). See **Sensitizing.**

Corona Charging. *Sensitizing* by means of gaseous ions generated by corona ionization.

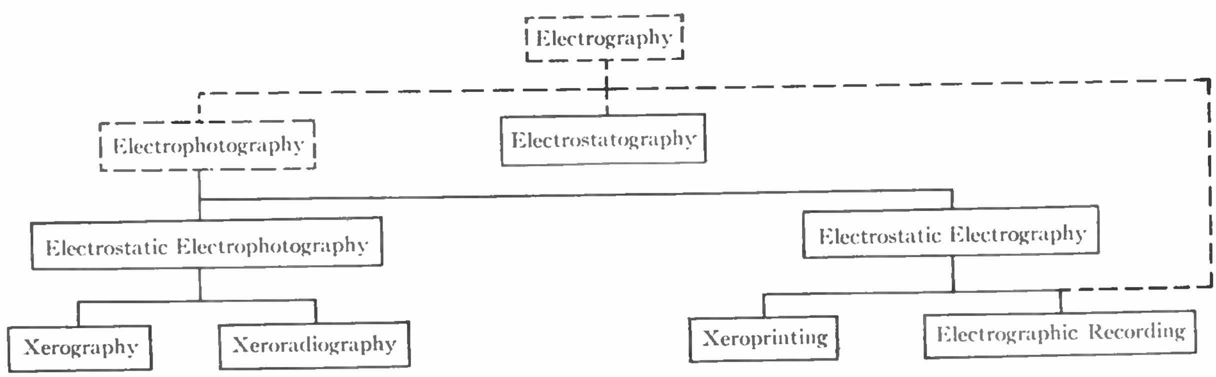
Development (Electrostatography). The act of rendering an electrostatic image visible in which the image-forming material is carried to the field of the electrostatic image, as by a fibrous brush, a suspending liquid, or other means.

Electrographic Recording (Electrostatography). That branch of *electrostatic electrography* which employs a gaseous discharge between two or more electrodes to form directly electrostatic charge patterns on an insulating medium for producing a visible record.

Electrostatic Electrography. That branch of *electrostatography* which employs an insulating medium to form, without the aid of electromagnetic radiation, latent electrostatic charge patterns for producing a visible record.

Electrostatic Electrophotography. That branch of *electrostatography* which employs a photoresponsive medium to form latent electrostatic images with the aid of electromagnetic radiation for producing a visible record.

Classification of Electrical Graphic Arts



Electrostatography. The formation and utilization of latent electrostatic charge patterns for the purpose of recording and reproducing patterns in visible form.

Exposure (Electrostatography). The act of subjecting a photoconductive insulating medium to electromagnetic radiation.

Fixing (Electrostatography). The act of bonding a developed image to a supporting member, as by the use of heat, solvent, or mechanical pressure.

Magnetic Brush Development. Development by means of ferromagnetic particles as carriers under the influence of a magnetic field.

Sensitizing (Electrostatography). The act of establishing an electrostatic surface charge of uniform density on an insulating medium.

Transfer (Electrostatography). The act of moving a developed image, or a portion thereof, from one surface to another without altering its geometric configuration as by electrostatic forces or contacting with an adhesive coated surface.

Xerography. That branch of *electrostatic electrophotography* which employs a photoconductive insulating medium to form latent electrostatic images with the aid of infrared, visible, or ultraviolet radiation for producing a visible record.

Xeroprinting. That branch of *electrostatic electrography* which employs a pattern of insulating material on a conductive medium to form electrostatic charge patterns for duplicating purposes.

Xeroradiography. That branch of *electrostatic electrophotography* which employs a photoconducting insulating medium to form latent electrostatic images with the aid of X rays or gamma rays for producing a visible record.

CORRECTION

Robert H. Dimond, author of "Interplanetary Telemetering," which appeared on pages 679–685 of the April, 1960 issue of PROCEEDINGS, has called the following to the attention of the *Editor*.

If T_A is defined as the noise temperature applied to the network input, and substituted for T_0 in (6), the expression for total noise power becomes:

$$P = (T_A + T_e)KB, \text{ or } P = KT_sB.$$

The substitution of T_A for T_0 is justified whenever T_0 appears, but in equations involving noise figure F, this would be contrary to the definition of F which includes the arbitrary T_0, (290°K).

While (6) was correct as originally presented, the use of T_0 limits its application in the same manner as the application of noise figure is limited, which is to the specific instance when 290°K is assumed for T_A. It was presented in this manner to allow a relationship between T_e and F to be established; however, it is more desirable to use an actual T_A. The fact that this can be done when using noise temperatures represents the advantage to this approach.

The basic error in the analysis was the substitution of a specific value of T_s, in this case 172°K, for T_e in (6) rather than for the term (T_0+T_e). When this is done, the value for P becomes −182 db.

This same situation is reflected in Figs. 3 and 4. As shown for receiver noise level in Fig. 3, the values are based upon T_0. A more useful nomograph would probably be to use T_s rather than T_e and F for the right-hand scale. Receiver noise level would then be referred to actual temperatures. The correct usage of Fig. 3 as it is presented involves correcting the receiver noise level value to the desired T_A. This can be accomplished by subtracting the power ratio T_0/T_A from the receiver noise level scale. Fig. 4 can be used in the same manner. For a T_A of other than 290°K, a corrected value of transmission power required can be obtained by subtracting T_0/T_A in db. The Receiver Noise Level scale of Fig. 3 and the Transmission Power Required scale of Fig. 4 should be shown as *DBW* rather than *DB*.

The Analysis of Transmission Power Requirements section of the paper is corrected as follows after the determination of a T_s of 172°K:

$$P = (172)(1.38 \times 10^{-23})(300) = -182 \text{ db}.$$

Fig. 3 can be used to obtain this value by drawing a line between T_e of 25°K and B of 300 cps. This yields a value of −179 dbw which is corrected by subtracting 3 db $[T_A = 147°\text{K}, (T_s - T_e)$, therefore $T_0/T_A = 3 \text{ db}]$ to obtain −182 dbw.

Receiving system noise level	−182 dbw
Required radiated power	44 db
Required transmitter power	15 dbw (32 watts).

Employing Fig. 4 and correcting the value for transmission power required by 3 db, as above, the following results are obtained.

Basic transmission power required	53 dbw/cps bw
Correction for noise factor (T_e=25°K or F≈0 db)	0 db
Required radiated power	44 dbw.

Correspondence

One-Tunnel-Diode Flip-Flop*

A one-tunnel-diode flip-flop, in comparison with the large number of multi-diode circuits, might appear to be an overly simple component configuration. Yet, with reliability and stability of performance being equal, as the simplicity of a circuit designed to execute one specific function increases, the value of that circuit grows accordingly. In this sense, the one-diode flip-flop has remarkable properties especially worthwhile in today's complex high-speed digital computers.

Take a tunnel diode, preferably of the GaAs type because of its higher voltage swing, although any other type will do the job as well. Connect a series resistor that intersects the static tunnel diode characteristic in two stable points. Finally, add a timing inductor in series with the diode, resistor, and power supply voltage to complete the one-diode flip-flop. Fig. 1 shows the resulting piece of circuitry which, when driven by the particular pulse sequence specified below, functions as a bistable device.

Let us briefly trace the flip-flop action for this circuit. Assume that a trigger current of the shape sketched in Fig. 2 is applied to the diode. Furthermore, let the diode reside initially in its high voltage state, designated Number 1. The arbitrarily large negative trigger excursion throws the diode to its low voltage state. With zero trigger current, the diode will temporarily assume point Number 10, because of the persisting timing inductor current i_1. If the positive going trigger-current excursion is smaller than $(i_p - i_1)$, the diode will remain in the low voltage state to which it has been switched by the trigger pulse. It is evident that the inductor time constant must be made larger than the trigger-pulse duration to prevent the positive pulse excursion from switching the diode back to its high voltage state. As the current through the inductor increases, the operating point approaches the statically stable point designated Number 0. This increases the current through the timing inductor to i_0.

With a subsequent trigger pulse applied, the negative trigger current will not affect the diode state. After all, the diode already resides in its low voltage state. However, the positive going trigger pulse will throw the diode to its high voltage state, provided the magnitude of the positive pulse portion is larger than $(i_p - i_0)$, causing the total diode current temporarily to exceed i_p. Only after the current through the inductor has relaxed to the quiescent value i_1 can another trigger pulse again stably switch the diode to its low voltage state. This readies the flip-flop for a subsequent performance cycle.

The one-diode flip-flop circuit is advantageously used whenever pulses are available that can be shaped by simple pseudo-differentiation to meet the trigger pulse requirements implied above. In most applications, such pulses can be derived conveniently with the aid of an uncomplicated coupling network which can be resonant or aperiodic in nature. This quick and easy-to-assemble circuit is used successfully in conjunction with transistors and should be employed rather for its simplicity than for speed capabilities. In so doing, unilateral flow of information is insured, large fan-out is made possible, and reliabi ity is improved.

This note is not an attempt to formulate profoundly the circuit functior theoretically. Yet, the flip-flop action is so straightforward that the arm-chair analysis appears entirely sufficient to soundly predict circuit performance for all practical applications.

R. A. Kaenel
Bell Telephone Labs., Inc.
Murray Hill, N.J.

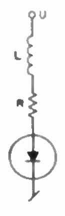


Fig. 1.

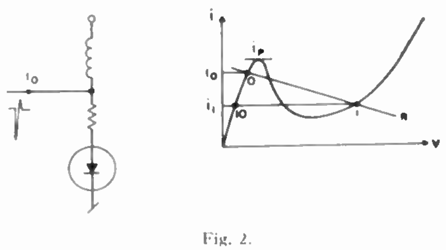


Fig. 2.

* Received by the IRE, November 21, 1960.

Shot Noise in Tunnel Diode Amplifiers*

In the above paper in these Proceedings, J. J. Tiemann[1] refers to a note by K. K. N. Chang[2] and then comments that "Because of some errors in analysis and interpretation, some of the conclusions in this letter are incorrect." He does not amplify his allegation nor make further reference to it. This is regrettable. Those who know Mr. Tiemann and his contributions to the field may be able to discern and evaluate the corrections he implies that he has made. The general reader is not so fortunate.

I presume that the implicit criticism of the Board of Editors of the Proceedings, who accepted his paper as well as Chang's, is unwitting. It is certainly unjustified.

L. S. Nergaard
RCA Labs.
Princeton, N. J.

* Reprinted from Proc. IRE, p. 350; January, 1961.

[1] J. J. Tiemann, "Shot noise in tunnel diode amplifiers," Proc. IRE, vol. 48, pp. 1418 1423; August, 1960.

[2] K. K. N. Chang, "The optimum noise performance of tunnel-diode amplifiers," Proc. IRE, vol. 48, pp. 107 108; January, 1960.

Author's Reply[3]

I agree with Mr. Nergaard that further comment on my part was called for and apologize for not having a letter in the correspondence of the issue in which my paper appeared. By not amplifying my remark, I tacitly implied that the errors in Chang's letter were easy to recognize. Since his analysis is lengthy and contains several typographical errors, quite the opposite is the case. Unfortunately, my objections are too broad to have been included as a footnote in my article. This separate communication is therefore furnished to help clarify the matter.

I would also like to say that no criticisms of the Board of Editors of the Proceedings, either implicit or otherwise, was intended. I assumed that the letter was not refereed.

My reference to Chang's letter referred to the way he relates the IR product of an I-V characteristic to the noise performance of a tunnel diode amplifier. (It also concerns statements made by him about the relationship of the IR product to various other properties of the characteristic. By presenting a simple method for obtaining the the IR product directly from any I-V characteristic, my article provides a basis for understanding the nature of this relationship. In a sense, then, my article attempted to correct these points too.)

To be specific, the implication that the second derivative of the I-V characteristic affects the minimum IR product is not correct; neither is the statement that a low value of I_m is needed to assure a low $(IR)_{min}$. Furthermore, the conclusion about the properties of an ideal characteristic for lowest possible IR product are incorrect and misleading.

The basic trouble seems to be that several arbitrary assumptions about the tunnel diode characteristics have been made and conclusions based on the *details* of these assumptions have been drawn. With regard to these details, the assumptions are in contradiction with experiment. We may consider two examples, as follows:

Example 1

The curves of Chang's Fig. 1 are only sketches, and although they have some

[3] Received by the IRE, November 14, 1960.

similarity to tunnel-diode characteristics, they are not typical of any Ge, GaAs, GaSb, or Si tunnel diodes we have seen. Sketches which more accurately portray the actual case are shown here in Fig. 1. His sketch of d^2I/dV^2 is seriously at variance with experiment, and his curve of d^3I/dV^3 *may be of the opposite sign in the region of interest.* Thus, inequality (16) may be erroneous. In the paragraph following (16) is the statement: "In fact, for the I-V characteristic of the tunnel diode it can be shown graphically that the numerator of (14) is always negative and hence the second derivative of IR is always positive. Therefore, the absolute value of IR given by (13) is a minimum, and a minimum value of $A(F-1)$ does exist."

It is more accurate to say that *for the sketch shown* . . . the preceding statements could be made. There is, therefore, nothing general about these assertions; and, in fact, it is possible to draw a freehand sketch for which the assertions are false. Such a curve is shown in Fig. 2. Typical G-V characteristics for actual tunnel diodes are shown in Fig. 3. Note the reverse curvature that appears in the regions of negative conductance.

Example 2

In the section labelled "Example," a sine curve is fit to the tunnel-diode characteristic at the inflection point. Only the value and the slope are fit, and, although there is an infinite family of sine curves which pass through a given point with a given slope, no basis is given for the choice of the particular curve shown. The analysis reduces to the statement that the closer the sine wave dips to the $I=0$ axis, the better the noise-gain performance[4] of the diode. This relation is expressed in terms of a dimensionless parameter V_0G_0/I_0, and it is stated that IR can be made small by making $(V_0)^2(G_0)^2/I_0^2$ approach unity. In the case of the tunnel diode, the quantity V_0G_0/I_0 has little to do with noise performance, and, in particular, $V_0G_0/I_0=1$ has no special significance. (Even if this parameter were significant, the approach here is faulty. An analytic expression has been fit to the I-V characteristic *at the inflection point*, and this expression has been used to determine P_m. The trouble is that the properties of the characteristic in the neighborhood of P_m are unrelated to the properties of the characteristic near the inflection point.

The final conclusions of the letter are in error because in (13) it assumes that the simultaneous occurrence of a small first derivative together with a large second derivative is enough to guarantee a small minimum IR product. Unfortunately, this situation has to apply at V_m, and one does not have the liberty to choose V_m. This is why the second derivative of the I-V characteristic is actually unimportant. Let us consider two cases of I-V characteristics which differ from each other in the negative-resistance region only by a constant added

[4] I cannot agree that the quantity $A(F-1)$ is a measure of amplifier performance. The quantity A does not depend on gain as stated; and if it did, $A(F-1)$ would not be uniquely related to any measurable property of an amplifier.

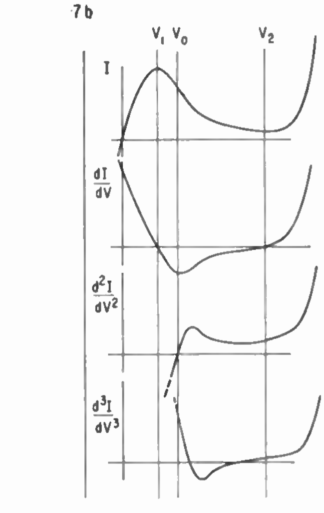


Fig. 1—Sketches of tunnel-diode characteristics.

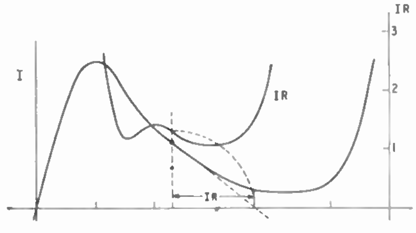


Fig. 2—Tunnel-diode characteristic with a maximum in the IR product.

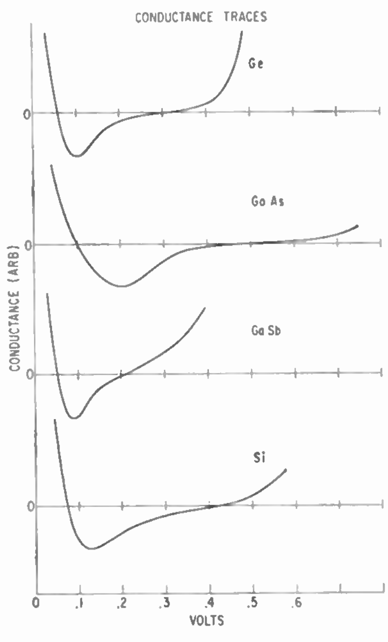


Fig. 3—G-V traces of typical tunnel diodes.

current. Although these two curves have identical f' and f'', the values of IR are different for the two curves. (See Fig. 4.)

A further example of misleading use of (13) occurs in Fig. 2 of Chang's letter. A point is placed in a region of small slope and high second derivative and is labelled P_m.

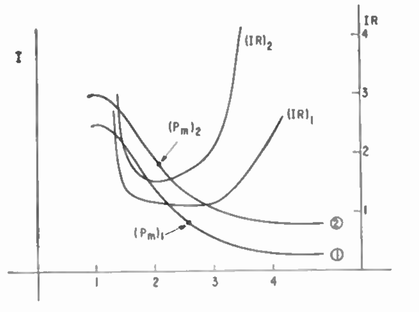


Fig. 4—Curves 1 and 2 have identical derivatives. Note: $(IR)_1 \neq (IR)_2$.

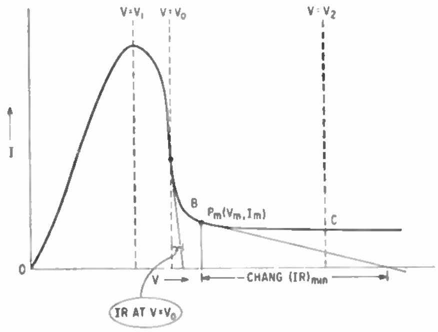


Fig. 5—Chang's "ideal characteristic" (copied from his Fig. 2).

The true P_m (minimum IR point) on the characteristic shown is, however, not near this labelled point. It is considerably closer to inflection point and has an IR product about 15 or 20 times lower than the labelled point. (See Fig. 5.)

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Effect of Higher Harmonic Components on the Performance of the Traveling-Wave Parametric Amplifier*

It has been known that spurious higher harmonic components generated by the coupling between the signal and pumping waves might deteriorate the performance, such as the noise figure and the amplification of the traveling-wave parametric amplifier. The purpose of this note is to show that the mode-coupling equations for the parametrically excited uniform transmission line can be easily transformed to the well-known mode-coupling equations for the ordinary transmission line by introducing the concept of the apparent propagation constants. It becomes evident that from

* Received by the IRE, March 15, 1960.

these new equations the effect of higher harmonic components on the amplification, and the noise figure of the traveling-wave parametric amplifier, can be calculated by the ordinary method.

It is assumed that 1) the signal (ω_1) and all its higher harmonics ($\omega_2, \omega_3, \cdots$) are so small that the small signal theory can be applied, 2) the pumping wave (ω) which propagates from $-z$ to $+z$ with the propagation constant, β, is large enough compared with the signal and its harmonics, but so small that the second order coupling between the signal and the pumping waves can be neglected, 3) all the propagating modes ($\omega, \omega_1, \omega_2, \cdots$) carry the positive power, and 4) the continuously-coupled transmission line is lossless. The mode-coupling equations for the parametrically excited transmission line can be given after some modifications of Haus' formula[1] as follows:

$$\left.\begin{aligned}
\frac{d}{dz}a_1 &= -j\beta_1 a_1 + \omega_1 k_{12} e^{-j\beta z} a_2^* + \omega_1 k_{31}^* e^{j\beta z} a_3\\
\frac{d}{dz}a_2^* &= \omega_2 k_{12}^* e^{j\beta z} a_1 + j\beta_2 a_2^* + \omega_2 k_{42} e^{-j\beta z} a_4^*\\
\frac{d}{dz}a_3 &= -\omega_3 k_{31} e^{-j\beta z} a_1 - j\beta_3 a_3\\
\frac{d}{dz}a_4^* &= -\omega_4 k_{42}^* e^{j\beta z} a_2^* + j\beta_4 a_4^*
\end{aligned}\right\} \quad (1)$$

where, a_1, a_3 are the normalized amplitudes of the signal and its first upper sideband mode ($\omega_3 = \omega_1 + \omega$), respectively; a_2^* and a_4^* are the complex conjugate of the normalized amplitudes of the idler ($\omega_2 = \omega - \omega_1$) and the second lower sideband mode ($\omega_4 = 2\omega - \omega_1$) respectively. β_1, β_2, β_3 and β_4 are the propagation constants for ω_1, ω_2, ω_3 and ω_4, respectively, in absence of coupling, and k_{12}, k_{31} etc. are the modified coupling factors between ω_1, and ω_2 modes, and ω_3 and ω_1 modes etc. respectively. (It should be noted that some coupling factors are missing because of neglecting the higher order nonlinearity of the parametric exitation.) Although (1) involves only ω_1, ω_2, ω_3 and ω_4 modes, it is easily extended to these for the infinite series of the higher harmonic modes. It can easily be shown that (1) satisfys the "Manley-Rowe" power relationship.

The mode-coupling equation (1) is different from the ordinary ones in two points; (1) $C_{mn} \neq -C_{nm}^*$ (C_{mn} is the coupling coefficient of the m-mode to n-mode), and 2) k_{mn} in (1) is always accompanied by $e^{-j\beta z}$. The latter comes out of the fact that the coupling between the modes is caused by the pumping wave propagating with $e^{-j\beta z}$. By introducing the following new variables $a_2'^*$, a_3' and $a_4'^*$,

$$\left.\begin{aligned}
a_2'^* &= e^{-j\beta z} a_2^*\\
a_3' &= e^{j\beta z} a_3\\
a_4'^* &= e^{-j2\beta z} a_4^*
\end{aligned}\right\}, \quad (2)$$

Eq. (1) can be given as follows:

$$\left.\begin{aligned}
\frac{d}{dz}a_1 &= -j\beta_1 a_1 + \omega_1 k_{12} a_2'^* + \omega_1 k_{31}^* a_3'\\
\frac{d}{dz}a_2'^* &= \omega_2 k_{12}^* a_1 - j\beta_2' a_2'^* + \omega_2 k_{42} a_4'^*\\
\frac{d}{dz}a_3' &= -\omega_3 k_{31} a_1 - j\beta_3' a_3'\\
\frac{d}{dz}a_4'^* &= -\omega_4 k_{42}^* a_2'^* - j\beta_4' a_4'^*
\end{aligned}\right\}, \quad (3)$$

where β_2', β_3' and β_4' are the apparent propagation constants of ω_2, ω_3 and ω_4 modes, respectively, seen from the signal mode.

$$\left.\begin{aligned}
\beta_2' &= \beta - \beta_2\\
\beta_3' &= \beta_3 - \beta\\
\beta_4' &= 2\beta - \beta_4
\end{aligned}\right\}. \quad (4)$$

Eq. (3) is just the same as the mode-coupling equations for the ordinary continuously-coupled transmission line except the one point $C_{mn} \neq -C_{nm}^*$ that results in the amplification of the parametric amplifier. Here, $a_2'^*$, a_3' and $a_4'^*$ can be understood to be the apparent amplitudes of ω_2, ω_3, and ω_4 modes seen from the signal mode. Eq. (3) can be solved by the well-known method. By assuming that

$$a_i' = A_i e^{-\Gamma z} \quad (i = 1, 2, 3, 4), \quad (5)$$

the propagation constant, Γ, of the coupled modes can be determined from the following equation.

$$\begin{aligned}
&(\Gamma - j\beta_1)(\Gamma - j\beta_2')(\Gamma - j\beta_3')(\Gamma - j\beta_4')\\
&\quad - \omega_1\omega_2 |k_{12}|^2 (\Gamma - j\beta_3')(\Gamma - j\beta_4')\\
&\quad + \omega_1\omega_3 |k_{31}|^2 (\Gamma - j\beta_2')(\Gamma - j\beta_4')\\
&\quad + \omega_2\omega_4 |k_{42}|^2 (\Gamma - j\beta_1)(\Gamma - j\beta_3')\\
&\quad + \omega_1\omega_2\omega_3\omega_4 |k_{31}|^2 |k_{42}|^2 = 0.
\end{aligned} \quad (6)$$

Let us take some simple examples for understanding the effect of higher harmonics. For the first example, consider an only two mode-coupled (ω_1 and ω_2, or ω_1 and ω_3) parametric transmission. The propagation constant, Γ, is given as follows:

$$\Gamma = \frac{j(\beta_1 + \beta_{2,3}')}{2} \pm j\sqrt{\left(\frac{\beta_1 - \beta_{2,3}'}{2}\right)^2 \mp \omega_1\omega_{2,3} |k_{12,3}|^2}. \quad (7)$$

This is just the same as that given by Tien[2] by a different method. If the two modes, ω_1 and ω_2, are perfectly synchronized; namely $\beta_1 = \beta_2' (\equiv \beta - \beta_1)$,

$$\Gamma = j\beta_1 \pm \sqrt{\omega_1\omega_2}\, |k_{12}|, \quad (8)$$

which implies the growing and attenuating modes. Next consider a three mode-coupled (ω_1, ω_2 and ω_3) line. Γ is given as follows:

$$\begin{aligned}
&(\Gamma - j\beta_1)(\Gamma - j\beta_2')(\Gamma - j\beta_3')\\
&\quad - \omega_1\omega_2 |k_{12}|^2 (\Gamma - j\beta_3')\\
&\quad + \omega_1\omega_3 |k_{31}|^2 (\Gamma - j\beta_2') = 0.
\end{aligned} \quad (9)$$

If the three modes are perfectly synchronized, $\beta_1 = \beta_2' = \beta_3'$,

$$\left.\begin{aligned}
\Gamma &= j\beta_1, \text{ and}\\
&= j\beta_1 \pm j\sqrt{\omega_1\omega_3 |k_{31}|^2 - \omega_1\omega_2 |k_{12}|^2}
\end{aligned}\right\}. \quad (10)$$

It is noted that all the coupled modes are neither growing nor attenuating in this case, because $|k_{12}| = |k_{31}|$ for the non-dispersive transmission line. However, the growing and attenuating waves are generated in the four mode-coupled line for $\beta_1 = \beta_2' = \beta_3' = \beta_4'$.

Once the propagation constant, Γ, of the coupled transmission line is determined, all the normalized amplitudes, a_1, a_2^* etc. can be obtained as the function of the initial values, and then the amplification and the noise figure of the traveling-wave parametric amplifier can be easily calculated. The writer has done the numerical calculation of the amplification and the noise figure of the longitudinal beam-type parametric amplifier, and its detail will be reported elsewhere.[3]

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[1] H. A. Haus, "The kinetic power theorem for parametric, longitudinal electron-beam amplifiers," IRE TRANS. ON ELECTRONIC DEVICES, vol. ED-5, pp. 225–232; October, 1958.

[2] P. K. Tien, "Parametric amplification and frequency mixing in propagating circuits," *J. Appl. Phys.*, vol. 29, pp. 1347–1357; September, 1958.

[3] To be published in the *J. Elec. Comm. Engrs. of Japan*.

The Reactance Tube as a Parametric Frequency Divider and Amplifier*

An examination of parametric-amplifier theory for the case where the pump frequency, ω_p, is twice the signal frequency, shows that oscillations at the signal frequency, ω_s, can be established in the signal circuit with only the pump source applied. This is a parametric oscillator, but it can also be viewed as a frequency divider since the output is a subharmonic of the input (pump). At the lower radio and audio frequencies the reactance tube can be used as a parametric element, *i.e.*, a time-varying inductor or capacitor.

An inductance can be obtained from the reactance tube circuit of Fig. 1, where the magnitude of the inductance is a function of the transconductance, g_m, which is also a function of e_p. When g_m can be treated as a constant, the equivalent circuit is a linear inductance. However, when g_m cannot be treated as a constant, *i.e.*, if g_m is varied at ω_p which is twice ω_s, additional circuit elements appear in the equivalent circuit.

A derivation of the equivalent circuit for this second case where g_m is $(KV_a + G_m)$, $\omega_p = 2\omega_s$ and $1/RC$ is less than ω_s, shows

* Received by the IRE, September 19, 1960; revised manuscript received, September 29, 1960.

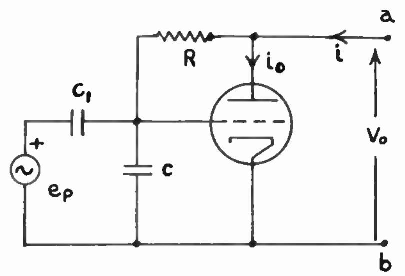

Fig. 1—Basic reactance-tube circuit. The voltage source e_p is used to vary the transconductance. (Bias voltages are not included.)

that the ac component of the plate current is

$$i_0 = \left\{\frac{\alpha K e_p + G_m}{RC}\int V_0 dt + \alpha G_m e_p \right.$$

$$\left. + \frac{K}{2(RC)^2}\left[\int V_0 dt\right]^2 + \frac{K}{2}\alpha^2 e_p^2\right\}, \quad (1)$$

where $\alpha = C_1/(C_1+C)$, $e_p = e \sin \omega_p t$ and the plate resistance, r_p, is assumed to be very large. The first term of (1) is the current in a time varying inductance and the remaining terms represent current sources at frequencies of ω_p, $2\omega_s$ and $2\omega_p$. If $K\alpha^2/2 < 1$, the equivalent circuit is a linear time varying inductance given by

$$L(t) \approx \frac{RC}{G_m}\left[1 - \frac{K\alpha}{G_m}e_p\right] \quad (2)$$

and a current source

$$i(\omega_p) = \alpha G_m e_p + \frac{K}{2(RC)^2}\left[\int V_0 dt\right]^2 \quad (3)$$

in parallel with the inductance. To eliminate the effects of $i(\omega_p)$, a series resonant circuit tuned to ω_p is shunted across the output of the reactance tube. The resulting current at ω_p is then forced to circulate in a closed loop through this filter.

The equivalent circuit of the reactance tube parametric amplifier is shown in Fig. 2, where the filter comprising L_p and C_p is resonant at ω_p; the series-parallel combination of L_s, C_s, L_p, C_p, and RC/G_m is resonant at ω_s; and the load is R_L. If $0 < \omega_s \delta e/2R_L < 1$ where $\delta = RCK\alpha/G_m^2$, the power dissipated in R_L is greater than the power supplied by v_s and the circuit is an amplifier.

If the signal source, v_s, is removed from the circuit (dashed connection in Fig. 2) and $\omega_s \delta e/2R_L \geq 1$, a current at ω_s will flow in the load. The circuit then operates as a parametric frequency divider where the input is e_p and the output is the subharmonic voltage, $i_s R_L$. The experimental output of the divider as a function of ω_p is shown in Fig. 3.

A distinct advantage of this parametric device is that no power is required from the pump source, e_p, since e_p merely controls the times at which energy is transferred from the plate supply to the load. In addition to providing a convenient means for subharmonic generation, the device described can

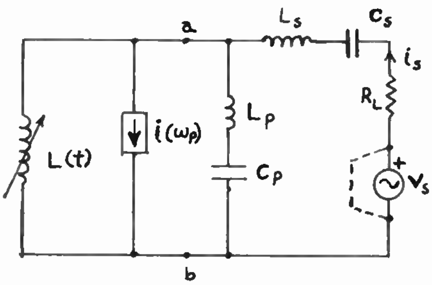

Fig. 2—Schematic representation of the reactance-tube parametric amplifier where the reactance tube is represented by its equivalent circuit.

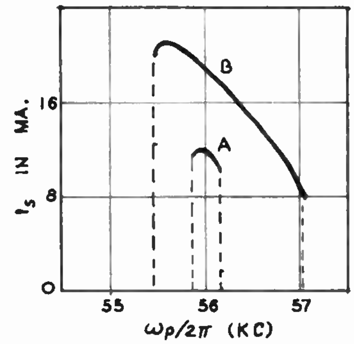

Fig. 3—The output current of the parametric frequency divider ($\omega_s = \omega_p/2$) as a function of ω_p for $e = 6.6$ volts (A) and $e = 7.0$ volts (B).

be used as an educational aid for the demonstration of parametric-amplifier theory.

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Cavity Modes in an Optical Maser*

In a recent note, Fox and Li[1] have considered the problem of the modes that can exist in a Fabry Perot interferometer. They imagine that a plane wave is launched between the plates and, by a Huygens construction, follows its course through many reflections by the plates. The field distribution that ultimately results resembles reasonably closely the field pattern for one of the lowest modes of a cylindrical resonator. Because of the recent success in demonstrating optical maser action,[2,3] we have considered the detailed theory of quantum oscillators in a multimode cavity and find in the *ideal* case that above a certain threshold of pumping power the system breaks into oscillation in the lowest mode. We envisage a maser oscillator utilizing a fluorescent solid, and thus consider as an atomic model a three-level system. The atoms are pumped from the bottom to the top level by the input radiation, whereupon they make a very rapid nonradiative transition to the second level. The connection between the present work and the calculation of Fox and Li[1] becomes evident when we remember that the plane wave inside the cavity can be represented by a suitable sum of cavity modes. Each of these will have its characteristic loss rate, and after passage of time only the modes with the lowest loss rates will have significant excitation. We present here a brief account of our results, which deal with oscillations in only a few of an enormous number of modes.

The spectrum of power radiated by an optical maser is obtained by considering each atomic system to be a source of the randomly fluctuating dipole moment which drives every mode of the cavity. The nonlinear behavior of the system is treated, allowing for a detailed examination of the distribution of power in the various modes. After evaluating the spontaneous and induced transition rates and integrating over frequency, we obtain for the power output $N_1 w$, in units of $\hbar\omega_a A_{12}$, where A_{12} is the rate of spontaneous emission into free space:

$$N_1 w = \frac{N_2 \pi c^3 T}{V\omega_a^3}\sum_m \frac{1}{1 - K_m Q_m + T^2(\omega_m - \omega_a)^2}, \quad (1)$$

Here ω_a is the atomic resonance frequency, $2/T$ is the width of the resonance, V is the volume of the cavity, $-K_m^{-1}$ is the material Q for the mth mode and is proportional to $N_2 - N_1$, Q_m is the mode Q without material, ω_m is the resonance frequency of the mth mode, N_1 and N_2 are the number of atoms in the first and second levels, respectively, and c is the velocity of light in the dielectric.

This equation determines $N_2 - N_1$ as a function of w. Given any spectrum of modes with arbitrary decay rates, one could perform the sum on a machine, and plot w vs $N_2 - N_1$. For the optical case, however, it is sufficient to treat the modes as belonging to a continuum (*i.e.*, approximate the sum by a set of integrals), except possibly for a few modes having frequencies near resonance and low loss rates.

Treating the modes in this way, (1) reduces to

$$\frac{N_1}{N_2} w = \frac{\epsilon}{1 - s} + \int_0^1 \frac{dx}{\sqrt{1 - sf(x)}}, \quad (2)$$

where ϵ is the number of axial modes at resonance divided by the total number of modes in the line width $2/T$, s is the ratio of the cavity Q for the most favored mode to the material Q, x is a variable designating the modes in the continuum, and $f(x)$ expresses the way in which $K_m Q_m$ varies with x. The first term is due to the most favored mode or modes, and the integral closely approximates the contribution of all

* Received by the IRE, December 12, 1960.

[1] A. G. Fox and T. Li, "Resonant modes in an optical maser," Proc. IRE, vol. 48, pp. 1904–1905; November, 1960.

[2] T. H. Maiman, "Optical and microwave-optical experiments in ruby," *Phys. Rev. Lett.*, vol. 4, pp. 564–566; June 1, 1960. "Stimulated optical radiation in ruby," *Nature*, vol. 187, pp. 493–494; August 6, 1960. "Optical maser action in ruby," *Brit. Commun. and Electronics*, vol. 7, pp. 674–675; September, 1960.

[3] R. J. Collins, *et al.*, "Coherence, narrowing, directionality and relaxation oscillations in the light emission from ruby," *Phys. Rev. Lett.*, vol. 5, p. 300 1960.

the other modes. On obtaining a suitable function for $f(x)$, its exact nature being unimportant for the conclusions which follow, we find from (2) that all the modes, (of the order of 10^{11}) other than the several axial modes, deliver a power output which is substantially independent of the pumping power. This power output has a broad spectrum with a width essentially $2/T$. Above a threshold value for the pumping power there is a sharp spike in the output spectrum at the resonant frequency due to the axial mode or modes. The width of the spike in the ideal case, *i.e.*, neglecting scattering by inhomogeneities in the crystal, is exceedingly narrow. The width is given by $(\omega_a/Q)(N_1/N_2)(P_s/P)$, where P_s is the power output due to spontaneous emission in the given mode in the absence of regeneration, and P is the power output due to the same mode when $N_2>N_1$.

A complete exposition of a theory of multimode quantum resonators, and investigations of various mode-loss spectra, will be contained in a paper to be submitted for publication.

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A Proposed Doppler-Helitron Oscillator*

In this device, the cyclotron frequency of a helical beam is magnified twenty to a hundred times by utilizing a Doppler frequency shift. The performance is based on the following considerations. A hollow electron beam injected along the axis of a waveguide immersed in a longitudinal magnetic field B can execute angular rotation at a frequency f_0 corresponding to the cyclotron frequency. The frequencies of the modes which this beam can excite in the waveguide are

$$f = nf_0/(1 \mp \dot{z}_0/v_p) \tag{1}$$

where $\dot{z}_0$ is the axial beam velocity; v_p is the phase velocity of the structure; the plus and minus signs apply to the backward and forward waves, respectively; and finally n is an integer which depends on the mode index. The ordinary Helitron oscillator utilizes the backward wave action in a fast-wave guiding structure where $(\dot{z}_0/v_p)\ll 1$ and $f\approx f_0$ for $n=1$ as in rectangular and circular waveguides.[1] For the generation of electromagnetic power in the low millimeter range, this would necessitate the use of a magnetic field intensity of about 10^5 Gauss, a prohibitively large value except for pulsed schemes. The Doppler frequency shift indicated in (1) can be used to reduce the required magnetic field intensity by more than an order of magnitude; for instance, consider coupling to the forward wave in a slow-wave structure in which $(\dot{z}_0/v_p)\approx 0.95$ such that the frequency of the fields excited is

$$f \approx 20nf_0.$$

It is seen that for the same frequency of output electromagnetic power the magnetic field intensity can be reduced by 20 times.

Thus the main problem which the Helitron oscillator had tried to avoid[2] has become prominent again, namely the slow-wave structure. Such structures have already received exhaustive treatment in literature, except that now the mode of operation has variation in the azimuthal direction. One such structure amenable to this kind of operation is the helix waveguide operating in a hybrid HEM_{nm} mode.[3] For such modes the circuit impedance should be comparable to that which has circular symmetry. Another possible slow-wave structure is a dielectric tube waveguide of inner and outer radii a and b, respectively, and dielectric constant κ. Contrary to common belief such a dielectric tube waveguide can have a circuit impedance which is superior to that of the helix waveguide; however, at low phase velocities and in the low millimeter range the physical dimensions of such a waveguide would become vanishingly small before it becomes electrically competitive with the helix waveguide.

As for the field configuration in a helix waveguide operating in a nonsymmetrical mode, the E_Z and H_Z dependance for $r<a$ is a modified Bessel function of the first kind. Thus for one cyclic variation in the azimuthal direction the E_ϕ field component at the origin has a finite nonzero value, and for $0<r<a$ is a monotonically increasing function. For two or more cyclic variations in the ϕ-direction, $E\phi$ goes to zero at the origin. Hence, it would seem that operation is restricted to the HEM_{1n} modes, since for ordinary electron beam energies and cyclotron frequencies of the order of 10 kMc or more, the radius of curvature of the spinning beam is of the order of 0.03 mm or less. This is not a serious drawback since the operation of waveguides in those modes which have more than one cyclic variation in the ϕ-direction becomes difficult in the low millimeter region.

Feedback in this forward wave oscillator can be performed either externally or internally. For the low millimeter range internal feedback is preferable and is obtained by a double reflection from the guide ends (once from the collector and again from the gun end); here the backward wave does not contribute to the bunching because of its lack of synchronism with the beam.

Some problems may be encountered with mode stability, but the bandwidth of the device should be appreciable. Since the efficiency is higher than in backward wave oscillators the starting current should be lower. This might be of singular importance in the low millimeter range.

Finally, it may be asked whether such a sophisticated scheme is warranted in view of the fact that a TWT incorporating the same structure can operate with a much simpler axial beam, as in an ordinary BWO. The question reduces to which interaction is stronger and which can be pushed up to a higher frequency. However, the gist of the scheme is to point out that devices which incorporate cyclotron motion of charged particles can still be useful at very high frequencies if this cyclotron frequency is magnified through a Doppler shift.

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* Received by the IRE, September 9, 1960. This work was supported by the U. S. Atomic Energy Commission under Contract AT (11-1)-392.

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[3] S. Sensiper, "Electromagnetic wave propagation on helical structures (a review and survey of recent progress)," PROC. IRE, vol. 43, pp. 149–161; February, 1955.

Noise Considerations for Hybrid Coupled Negative-Resistance Amplifiers*

Several authors[1–3] have proposed the use of a hybrid network and two matched negative resistance amplifiers to simulate the properties of one negative resistance amplifier and a circulator, the hope being that the narrow-band properties (or unavailability) of useful circulators can thus be circumvented by using available broad-band hybrids. However, even with an ideal hybrid network and matched amplifiers, this device has a reciprocal transmission characteristic between input and output ports resulting in 1) an increasingly stringent requirement for well-matched terminating impedances if stable operation is to be obtained as the gain of the device is increased, and 2) an even more stringent requirement for a well-matched signal source impedance if low-noise high-gain amplifiers are used and their noise performance is not to be significantly degraded by the presence of a conventional second-stage. The importance of this latter condition was recognized by Autler.[1] Sie[2] presents experimental noise figure data, presumably taken with a matched source impedance; he also presents stability data taken as the source impedance is mismatched, but does not consider the simultaneous effect on noise performance. The

* Received by the IRE, September 19, 1960. The work reported here was conducted under Contract AF30(602)-1854 with the Air Res. and Dev. Command, Rome Air Development Center, Griffiss Air Force Base, N. Y.

[1] S. H. Autler, "Proposal for a maser-amplifier system without nonreciprocal elements," PROC. IRE, vol. 46, pp. 1880–1881; November, 1958.

[2] J. J. Sie, "Absolutely stable hybrid coupled tunnel-diode amplifier," PROC. IRE, vol. 48, p. 1321; July, 1960.

[3] J. C. Greene, *et al.*, "Eighth Quarterly Progress Report on Application of Semiconductor Diodes to Low-Noise Amplifiers, Harmonic Generators, and Fast-Acting TR Switches," Airborne Instruments Lab., Melville, N. Y., Rept. No. 4589-I-8; June, 1960.

source impedance in practical systems is that of an antenna, which tends to vary significantly over only moderately large frequency ranges or with antenna rotation; consequently, both stability and noise performance under mismatched source impedance conditions are of primary interest.

The noise performance of the hybrid coupled amplifier has been analyzed in detail and the degradation in amplifier noise performance with source impedance mismatch verified experimentally.[3] The pertinent equation from the report by Greene *et al.*[3] is

$$\frac{T}{T_m} \approx 1 + |\rho_1|^2 \rho^2 \left[1 + \frac{T_L}{T_m}\right] \qquad (1)$$

where

T = effective input noise temperature of the hybrid coupled amplifier

T_m = minimum effective input noise temperature of the amplifier(s) proper

T_L = available noise temperature at the second-stage input port

ρ_1 = voltage reflection coefficient of the signal source impedance

ρ_2 = power gain of the amplifier(s) under matched conditions.

Eq. 1 is plotted in Fig. 1.

For Sie's amplifier, $\rho^2 \approx 6.3$ (gain ≈ 8 db) and $T_m \approx 162°$K ($F = 1.93$ db). Then, assuming an available second-stage noise temperature, T_L, of 290°K, which is representative of the value for an isolator or a crystal mixer operated at room temperature, (1) yields the noise performance shown in Table I for Sie's hybrid coupled amplifier under varying degrees of source impedance mismatch. For the frequency range covered by Sie's amplifier, it is likely that the VSWR of an antenna would have peak values as high as 3.0, resulting in an amplifier noise figure as high as 6 db in some parts of the pass band. Furthermore, the low gain of this amplifier will result in a large noise contribution from a conventional second-stage receiver; if the gain is increased to overcome this difficulty, the resulting degradation in noise performance with source impedance mismatch will become even more pronounced, and the device may also become unstable.

Although it can be argued that the use of an isolator between the antenna and the amplifier input port would minimize these problems, 1) the forward loss of the isolator would degrade T_m; 2) the maximum VSWR of a broad-band isolator would still be significant; 3) the nonreciprocal isolator element could most likely be used to provide a broad-band circulator, which would provide superior performance with only one amplifier; and 4) in a practical case, the hybrid network will not be ideal nor the two amplifiers perfectly matched, resulting in some additional degradation in amplifier performance even with an ideal isolator.

An analysis of the hybrid coupled amplifier together with supporting experimental data will be published shortly,[4] wherein it is shown that this device is not generally practical for broad-band applications.

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Melville, N. Y.

[4] P. P. Lombardo, S. Okwit, and E. W. Sard, "Performance of Hybrid Coupled Negative Resistance Amplifiers," to be published.

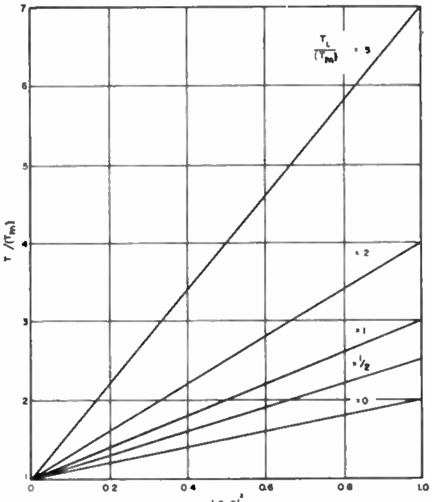

Fig. 1—Degradation in effective input noise temperature as a function of input mismatch.

TABLE I

ρ_1	Signal Source VSWR	Effective Input Noise Temperature of Hybrid Coupled Amplifier, °K
	1.0	162
0.1	1.22	190
0.3	1.86	417
0.5	3.0	875

A New Exact Method of Nonuniform Transmission Lines*

This correspondence aims to present a new method to obtain exact solutions for problems of nonuniform transmission lines. Although there are numerous published papers[1] that deal with approximate solutions, very few papers exist which are devoted to exact solutions for nonuniform transmission lines. The basic idea described here utilizes two newly discovered transforms[2] for a generalized Riccati's nonlinear differential equation (NDE). The fundamental principle set forth in this correspondence is widely applicable to any homogeneous, second-order, linear differential equation (LDE) with variable coefficients.

When two line parameters $Y(x)$ admittance and $Z(x)$ impedance are arbitrary and continuous functions along the length x of the lines, the LDE for the propagating voltage $V(x)$ is

$$V'' - (Z'/Z)V' - YZV = 0. \qquad (1)$$

It seems that there are at least three available methods to solve (1) exactly, without using integral equations and any integral transforms. The three methods to be discussed are:

Method A—Specify Y, Z and solve for V.

Method B—Specify V and obtain $f(Y, Z) = 0$.

Method C—Change variables, specify $g(Y, Z) = 0$ if needed, and solve for V,

where f and g represent functional relationships.

Method A has been extensively used in theoretical analysis for mathematical physics. However, only a handful of specialized cases have been worked out whose solutions are connected with the familiar names of Mathieu, Tchebycheff, Hermite, Laguerre and Whittaker, to list a few. Slight deviations of Y and Z from variable coefficients given in these standard equations lead to prohibitive complexity for arriving at exact solutions. The originality of Method B has not been ascertained, yet Piaggio[3] mentioned it in 1920. Madelung[4] also contributed a similar method. One shortcoming of Method B, is that Y and Z are no longer independent; they are interrelated, as pointed out by the recent note on nonuniform transmission lines.[5]

Method C has a new approach. It uses newly discovered transforms and reduces a generalized Riccati's equation to a first order, LDE, specifying the interrelationship between Y and Z. No matter how Y and Z are interrelated, two old transforms[6] never reduce a generalized Riccati's equation to a first-order, LDE, and they can obtain at best a second-order, LDE of the form,

$$V'' - k(x)V = 0, \qquad (2)$$

where $k(x)$ is an arbitrary function of x, and this equation has not been solved exactly for any $k(x)$.

Using the same notations of the previous paper,[5] a generalized Riccati's NDE for the reflection coefficient $r(x)$ is

$$r' + P_1(x)r + Q_1(x)r^2 = R_1(x), \qquad (3)$$

where $R_1(x)$ is equal to $Q_1(x)$, and $R_1(x)$ is used to treat a general case. Two new transforms are

$$r(x) = \frac{R_1 s(x)}{s'(x) + P_1 s(x)}. \qquad (4)$$

and

$$r(x) = \frac{s'(x) - P_1 s(x)}{Q_1 s(x)}, \qquad (5)$$

* Received by the IRE, September 27, 1960.

[1] I. Sugai, "Supplementary Bibliography for Nonuniform Transmission Lines," to be submitted to IRE Trans. on Antennas and Propagation.

[2] I. Sugai, "On Exact Solutions for Ordinary Nonlinear Differential Equations," to be published in *Elec. Commun.*

[3] H. T. H. Piaggio, "An Elementary Treatise on Differential Equations and Their Applications," G. Bell and Sons, Ltd., London, Eng., p. 199; 1920.

[4] F. H. Hildebrand, "Introduction to Numerical Analysis," McGraw-Hill Book Co., Inc., New York, N. Y., pp. 255–256; 1956.

[5] I. Sugai, "The solutions for nonuniform transmission line problems," Proc. IRE, vol. 48, pp. 1489–1490; August, 1960.

[6] I. Sugai, "Riccati's nonlinear differential equation," *Am. Math. Monthly*, vol. 67, pp. 134–139; February, 1960.

where $s(x)$ is an arbitrary function of x. It is interesting to note that transforms for a generalized Riccati's NDE always appear in pairs, exhibiting dualisms between transforms. Application of (4) and (5) linearizes (3), respectively:

$$s'' - [(R_1'/R_1) - P_1]s' + R_1[(P_1/R_1)' - Q_1]s = 0, \quad (6)$$

and

$$s'' - [P_1 + (Q_1'/Q_1)]s' - Q_1[(P_1/Q_1)' + R_1]s = 0. \quad (7)$$

These transforms [(4) and (5)] provide coefficients for $s(x)$ so that it is possible to make these coefficients vanish at all times by requiring special interrelationships among $Y(x)$ and $Z(x)$,

$$(P_1/R_1)' = Q_1, \quad (8)$$

and

$$(P_1/Q_1)' = -R_1, \quad (9)$$

respectively. In terms of the characteristic impedance $K(x)$ of the line, (8) and (9) are reduced to

$$4Z(x) = K'(x) \ln C[K(x)]^{\pm 1/2}, \quad (10)$$

where the upper sign is for (8) and the lower sign is for (9) and C is any constant of integration.

It should be noticed that the interrelationships [(8) and (9)] are required in order to solve (6) and (7) exactly. Obviously, if by any chance (6) or (7) falls into a handful of cases worked out by using Method A, (8) or (9) is not required; however, such a probability is almost negligible. Method C differs from the other two methods discussed previously and this method is applicable to other transforms besides the conventional reflection coefficient. These other transforms, such as quasi-reflection coefficients, may provide any NDE other than Riccati's, and in theory it is possible to derive useful transforms so that the requirement of interrelationships among variable coefficients can be eliminated completely to obtain any solvable equation. Perhaps the diagram below may help in explaining this statement.

$$\boxed{V'' - (Z'/Z)V' - YZV = 0}$$

$$\downarrow \leftarrow r(x) = f_1(V, V', Y, Z)$$

$$\boxed{\text{any NDE of } r(x)}$$

$$\downarrow \leftarrow s(x) = f_2(r, r', Y, Z)$$

$$\boxed{\begin{array}{c}\text{exactly solvable equation for } s(x) \\ \text{with or without } g(Y, Z) = 0\end{array}}$$

where f_1 and f_2 are functional relationships.

Compared with a great deal of work done in the past for those few special cases using Method A, literally nothing has been done for Methods B and C, and to the best knowledge of the author, Method C appears original. In addition to contributing to exact solutions for nonuniform transmission lines, Method C also contributes to a new thinking which employs NDE's in order to solve LDE's exactly.

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Vectors for Waves and Electrons*

The universality of the vector approach in the mathematical derivation of Maxwell's equations was demonstrated by a recent correspondence.[1] This correspondence follows in the similar spirit to substantiate the utility of vectors in explaining a few physical phenomena for interacting slow electromagnetic waves and electron beams. The value of the universal use of vectors gives another added merit to the field theory of traveling wave tubes.

Five distinct second-order vector operators[2] for an arbitrary vector $\overline{F}$ and an arbitrary scalar f are:

$$\text{div grad } f = \nabla\cdot(\nabla f) = \nabla^2 f, \quad (1)$$

$$\text{div curl } \overline{F} = \nabla\cdot(\nabla\times\overline{F}) = 0, \quad (2)$$

$$\text{grad div } \overline{F} = \nabla(\nabla\cdot\overline{F}), \quad (3)$$

$$\text{curl grad } f = \nabla\times\nabla f = 0, \quad (4)$$

$$\text{curl curl } \overline{F} = \nabla\times(\nabla\times\overline{F}) = \nabla(\nabla\cdot\nabla\overline{F}) - \nabla^2\overline{F}. \quad (5)$$

Maxwell's equations on which these vector operations are to be performed in vacuum are:

$$\nabla\times\overline{E} = -\partial\overline{B}/\partial t, \quad (6)$$

$$\nabla\times\overline{H} = \overline{J} + (\partial\overline{D}/\partial t), \quad (7)$$

$$\nabla\cdot\overline{D} = \rho, \quad (8)$$

$$\nabla\cdot\overline{B} = 0, \quad (9)$$

$$\overline{D} = \epsilon_0\overline{E}, \quad (10)$$

$$\overline{B} = \mu_0\overline{H}, \quad (11)$$

Eq. (1) represents Laplace's equation for any scalar potential function, f. Vector operation (2) onto (6) gives (9), which, in turn, states vectorially that the magnetic flux density vector $\overline{B}$ is a curl of any magnetic vector potential $\overline{A}$, such that

$$\overline{B} = \nabla\times\overline{A}. \quad (12)$$

Vector operation (2) onto (7) gives a familiar equation of continuity of charge,

$$\nabla\cdot\overline{J} + (\partial\rho/\partial t) = 0. \quad (13)$$

Vector operation (3) onto (8) gives

$$\nabla(\nabla\cdot\overline{D}) = \nabla\rho. \quad (14)$$

Vector operation (5) onto (6) gives the usual space-charge wave equation for traveling wave tubes

$$(\nabla^2 - \epsilon_0\mu_0\partial^2/\partial t^2)\overline{E} = (\nabla\rho/\epsilon_0) + \mu_0(\partial\overline{J}/\partial t), \quad (15)$$

where (7) and (14) are used. Eq. (15) has been treated by books.[3,4] Vector operation (5) onto (7) gives

$$(\nabla^2 - \epsilon_0\mu_0\partial^2/\partial t^2)\overline{H} = -\nabla\times J \quad (16)$$

in which use was made of (6) and (9). Eq. (15) is used widely for the anticipation of the small-signal analysis and a harmonic-time function, such as $\exp[j(\omega t - \beta z)]$. However, in large-signal cases, the well-accustomed harmonic-time variation given above may not be of use at all, and (15) and (16) can be regarded on an equal utility basis.

Another interesting application of vector operation is the del operator for the electron motion in crossed electric and magnetic fields. The motion of the electron in crossed-fields (Fig. 1) is given by Lorentz's equation,

$$m(d\bar{u}/dt) = -e(\overline{E} + \bar{u}\times\overline{B}). \quad (17)$$

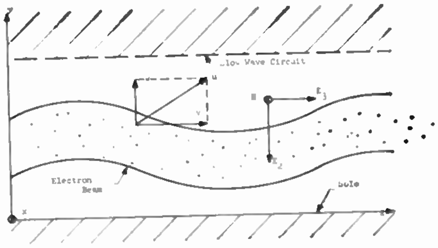

Fig. 1—The geometry of a linear M-type tube.

Now form the dot product of the del with (17),

$$\nabla\cdot(d\bar{u}/dt) = \omega_p^2 - \eta(D\cdot\nabla\times\bar{u} - \bar{u}\cdot\nabla\times\overline{B}), \quad (18)$$

where the angular plasma frequency, ω_p is given by

$$\omega_p^2 = -\eta\rho/\epsilon_0. \quad (19)$$

By invoking Maxwell's equation (7), (18) is further reduced to

$$\nabla\cdot(d\bar{u}/dt) = \omega_p^2[1 - (u^2/c^2)] - (\omega_c/H_1)[\overline{H}\cdot(\nabla\times\bar{u}) - \epsilon_0\bar{u}\cdot(\partial\overline{E}/\partial t)], \quad (20)$$

where c is the speed of light in a vacuum and the angular cyclotron frequency ω_c is given by

$$\omega_c = \eta\mu_0 H_1, \quad (21)$$

where H_1 is an arbitrary-scalar magnetic-field intensity. For the sake of simplicity, suppose the electron beam is a static, rectilinear $(w = 0)$ flow; then, (20) is simplified as

$$\nabla\cdot(d\bar{v}/dt) = \omega_p^2[1 - (v^2/c^2)] - (\omega_c/\overline{H}_1)H\cdot(\nabla\times\bar{v}). \quad (22)$$

If the curl of the electron velocity vector $\bar{v}$ and the divergence of the acceleration vector

* Received by the IRE, September 17, 1960; revised manuscript received, September 28, 1960.

[1] P. Clavier, "Electromagnetic theory from a mathematical viewpoint," PROC. IRE, vol. 48, pp. 1494–1495; August, 1960.

[2] H. Margenau, and G. M. Murphy, "The Mathematics of Physics and Chemistry," D. Van Nostrand Co., Inc., New York, N. Y., pp. 148–149; 1943.

[3] W. J. Kleen, "Electronics of Microwave Tubes," Academic Press, New York, N. Y., pp. 109–110; 1958.

[4] A. H. W. Beck, "Space-Charge Waves and Slow Electromagnetic Waves," Pergamon Press, New York, N. Y., pp. 100–101; 1958.

$d\bar{v}/dt$ are zero simultaneously, the electrons must travel with the speed of light in a vacuum. Therefore, no variation of the electron velocity with respect to y is incompatible with the zero divergence of the acceleration vector. If the curl of $\bar{v}$ is zero, there results

$$(\partial/\partial z)(dv/dt) = \omega_p^2[1 - (v^2/c^2)]. \quad (23)$$

If the acceleration vector is derivable from the curl of an arbitrary vector, and if $\bar{H}$ has H_1 (constant value) for its x component, (22) gives

$$\partial v/\partial y = (\omega_p^2/\omega_e)[1 - (v^2/c^2)]. \quad (24)$$

When the last equation is compared with the similar expression treated in a recent book,[5] it is found that the so-called slip parameter s is related to v and c via

$$s = 1 - (v^2/c^2). \quad (25)$$

For the planar Brillouin flow of electrons in crossed fields, s is unity. For a finite vector of the electron velocity, s is never equal to unity. This presents another proof that the existence of the Brillouin flow does not satisfy de Maxwell's equations if the magnetic field H_1 is independent of space variables. A similar statement was given by the previous paper.[6]

The other one of two first-order vector operators is the curl. Construct the vector product of the del with (17) and use (6).

$$\nabla \times (d\bar{u}/dt)$$
$$= (\omega_e/H_1)[(\partial\bar{H}/\partial t) - \nabla \times (\bar{u} \times \bar{H})]. \quad (26)$$

As before, the simple case of the static condition is considered. For this situation, (26) degenerates into (27) as H_1 is constant,

$$\nabla \times [(d\bar{u}/dt) + (\bar{u} \times \bar{H})(\omega_e/H_1)] = 0 \quad (27)$$

Field quantities inside the square parenthesis in (27) are the gradient of any scalar potential g yielding

$$(d\bar{u}/dt) + (\omega_e/H_1)(\bar{u} \times \bar{H}) - \nabla g = 0. \quad (28)$$

For the rectilinear ($w=0$) flow of electrons, the force in the y-direction is zero; thus, the first term of (28) is vanished. If the vector $\bar{H}$ has the x-component (H_1) only, the second term has a finite component in the y-direction alone. In order to make a sensible subtraction of two vectors in (28), the gradient of g must possess the y component. However, the y component of ∇g disturbs the electron, and the rectilinear flow is never realized.

The above examples successfully demonstrate the importance and practical value of the abstract vector notion in explaining the principles of electromagnetic theory. Vectors should be incorporated in presenting physical mechanisms of electronic phenomena, wherever it is possible. Vectorial operation, solely motivated by mathematical view points, presents the natural consequences of physical laws of nature, precisely and logically.

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[5] R. G. E. Hutter, "Beam and Wave Electronics in Microwave Tubes," D. Van Nostrand Co., Inc., New York, N. Y., pp. 235–237; 1960.
[6] I. Sugai, "Stable electron beam in static linear M-type tubes," submitted to *J. of Electronics and Control.*

WWV and WWVH Standard Frequency and Time Transmissions*

The frequencies of the National Bureau of Standards radio stations WWV and WWVH are kept in agreement with respect to each other and have been maintained as constant as possible with respect to an improved United States Frequency Standard (USFS) since December 1, 1957.

The nominal broadcast frequencies should, for the purpose of highly accurate scientific measurements, or of establishing high uniformity among frequencies, or for removing unavoidable variations in the broadcast frequencies, be corrected to the value of the USFS, as indicated in the table below.

WWV Frequency
With Respect to U. S. Frequency Standard

1960 December 1600 UT	Parts in 10^{10}†
1	−152
2	−152
3	−152
4	−152
5	−152
6	−151
7	−150
8	−150
9	−149
10	−148
11	−147
12	−147
13	−147
14	−147
15	−147
16	−148
17	−148
18	−149
19	−149
20	−150
21	−151
22	−152
23	−152
24	−152
25	−151
26	−151
27	−151
28	−151
29	−151
30	−151
31	−151

† A minus sign indicates that the broadcast frequency was low.

The characteristics of the USFS, and its relation to time scales such as ET and UT2, have been described in a previous issue,[1] to which the reader is referred for a complete discussion.

The WWV and WWVH time signals are also kept in agreement with each other. Also they are locked to the nominal frequency of the transmissions and consequently may depart continuously from UT2. Corrections are determined and published by the U. S. Naval Observatory. The broadcast signals are maintained in close agreement with UT2 by properly offsetting the broadcast frequency from the USFS at the beginning of each year when necessary. This new system was commenced on January 1, 1960. A retardation time adjustment of 20 milliseconds was made on December 16, 1959; another retardation adjustment of 5 milliseconds was made at 0000 UT on January 1, 1961.

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* Received by the IRE, January 23, 1961.
[1] "National standards of time and frequency in the United States," Proc. IRE, vol. 48, pp. 105–106; January, 1960.

On Stable Parametric Amplifiers*

In spite of the ability of diode parametric amplifiers to give low-noise amplification at microwave frequencies, the use of such amplifiers in microwave systems has not been extensive. There are several reasons for this. Amplifiers employing one variable element and one or more resonant cavities are very narrow-band, are sensitive to changes in pump frequency and power level, and must be operated with a circulator if the effects of impedance changes are to be minimized. The cavity-type amplifier is obviously eliminated from consideration for wide-band systems and, because of stability considerations, is often unsuitable even for narrow-band applications.

In an attempt to overcome these difficulties the traveling-wave parametric amplifier (TWPA), consisting of many diodes periodically spaced along a transmission line, has been developed. Compared to the cavity-type amplifier, the TWPA has considerably more bandwidth, is affected less by pump fluctuations, and is somewhat less sensitive to impedance variations. The price for these improvements is an increase in the complexity of the amplifier. However, even the increased complexity has not produced an amplifier which is unconditionally stable, a characteristic which is desirable in most applications, and a requirement of many. It is the purpose of this letter to emphasize the need for greater stability in parametric amplifiers, and to point out possible means of achieving this improved performance in traveling-wave versions.

The traveling-wave parametric amplifier is potentially unstable because the attenuation in the backward direction is, except for one special condition, less than the net forward gain. That is, waves reflected or originating at the output terminals can experience little attenuation (and sometimes gain) when traveling in the backward direction. Subsequent reflection of these waves at the input terminals can then result in large amplitude forward waves and eventually in oscillations. The criterion for unconditional stability is that the loss in the reverse direction be greater than the net gain in the forward direction. This can best be accomplished by introducing attenuation within the amplifier and adjusting the phase shift per diode to be an odd number of quarter cycles at the pump frequency. (The phase condition ensures no gain in the reverse direction for the lossless case.) Under these circumstances, unconditional stability results if the attenuation introduced is greater than one-half the foreward gain of the lossless structure. However, since the high gain is relatively hard to achieve in a TWPA, the dissipation of over half the gain by the introduction of reciprocal loss is not considered a practical means to stability. Instead, nonreciprocal attenuation is needed.

Proper incorporation of ferrite material in the amplifier structure can provide the nonreciprocal attenuation desired. The requirements of the ferrite isolator are varied. The isolation should be equal to or greater than the net forward gain; the insertion loss

* Received by the IRE, September 15, 1960; revised manuscript received, October 10, 1960.

should be small; the bandwidth should extend over the range of the signal, idler, and pump frequencies. The first condition ensures unconditional stability; the second, maximum gain. The latter condition makes the circuit nonreciprocal at the three frequencies of interest.

Perhaps it is not obvious that isolation is desirable at the pump frequency. The presence of a backward-traveling pump wave can, however, produce a large standing wave which "pumps" some diodes strongly, and others only slightly. This variation in pump level can alter the bias on the diodes, thus destroying the uniformity of the line; and in extreme cases, can result in narrow-band "cavity-type" operation. Isolation at the pump frequency is also important in structures where the pump power is fed to each diode individually. In this type of circuit the pump is in a stop band and theoretically does not propagate from diode to diode. Practically, however, there is often considerable propagation to adjacent diodes with substantial interference taking place. Distributed isolation at the pump frequency will reduce at least part of this interference.

We need now to consider what physical form of isolation is best. Should it be lumped, in the form of isolators placed at the input and output terminals of the amplifier, or should it be distributed evenly throughout the amplifier circuit? The lumped form, although it can be more readily realized, has two major disadvantages. The insertion loss of the input isolator adds directly to the noise figure of the amplifier, and there is no isolation provided between the individual diodes. The distributed form does not have these undesirable characteristics. The noise performance of the amplifier is virtually unaffected when the small forward loss of the isolator is distributed throughout the circuit; and the distributed form provides some isolation between diodes, which reduces the effect of internal reflections. An example of distributed isolation is the traveling-wave maser where a slab of ferrite has been successfully integrated into the circuit to make the device nonreciprocal.

Of the many possible nonreciprocal structures which are suitable as traveling-wave parametric amplifier circuits, a configuration developed recently by Anderson and Hines[1] appears particularly adaptable. The structure is a parallel plate transmission line, capacitively loaded by posts spaced along the direction of propagation. The lowest order TE mode consists of an electric field concentrated in the region of the posts, and a nearly circularly polarized magnetic field. With the placement of ferrite slabs and the application of a properly-inhomogeneous transverse magnetic field, good isolation over a frequency range from 1.5 kMc to 6.0 kMc was obtained. Thus, the bandwidth of the device is great enough to include the three frequencies of interest in the TWPA. Furthermore, it appears that diodes can be substituted for some of the posts without altering the nonreciprocal properties.

There are, of course, problems associated with adapting structures of this type as traveling-wave parametric amplifiers, such as the low impedance of the line and the difficulty of achieving well-matched broad-band transitions. However, the difficulties do not appear to be insurmountable.

The advantages to be gained from incorporating nonreciprocal loss in a TWPA are numerous. The broad-band, low-noise capabilities of the amplifier are retained, while the stability is increased to a degree that makes the device generally useful. The effects of internal reflections, backward waves, and terminal mismatches are reduced. Even the requirement that identical diodes be used as replacements is relaxed since internal reflections are less significant. Thus, the next logical step in achieving a truly practical parametric amplifier appears to be the introduction of nonreciprocal loss within the circuit of the traveling-wave parametric amplifier.

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[1] W. W. Anderson and M. E. Hines, "Wide-Band Resonance Isolator," presented at the Microwave Theory and Techniques Symp., Coronado, Calif.; May, 1960.

Comments on "Relativity: Blessing or Blindfold"*

Mr. Ruderfer's letter[1] mentioned Ives' derivation[2] of the Lorentz transformations. Basically, Ives considers the interaction of a finite wave train of radiation from a light source fixed in the observer's coordinate system (which may be taken at rest relative to the stars) with a perfectly reflecting particle traveling with velocity v in that system. By imposing conservation of energy and momentum on the collision, Ives derives the law of variation of particle mass with velocity. By further considering both light source and reflecting particle within a box moving with velocity v with respect to the fixed coordinate system, he goes on to derive the formulas for shortening of rods and clocks. Now, let us examine some of his own statements to see if his derivation is really independent of the special relativity postulates.

We read in Ives' article: "The mass equivalent of the incident section of the wave train (of unit cross section of energy density E which interacts with the perfectly reflecting particle for a time Δt) is

$$m_i = E\frac{c\Delta t}{c^2} \tag{5}$$

and of the reflected wave train

$$m_r = E\frac{c\Delta t}{c^2}\cdot\frac{c - f(v)}{c + f(v)} \tag{6}$$

[$f(v)$ being the average velocity during the impact]. *Since the velocities of both these wave trains are c . . .* " (author's italics). By this last statement, Ives accepts the value c for the velocity of light from the moving source (reflector). Hence, it appears the second postulate of special relativity is inherent in his derivation and is by no means a "superfluous hypothesis."

Regarding Ives' statement in his discussion: "It is the dimensions of the material instruments for measuring space and time that change, not space and time that are distorted," I prefer to avoid considering physical stresses due to velocity by saying that the space-time coordinates of an event simply must be different in two inertial systems with relative motion between them, in conformity with the invariant nature of the laws describing the event.

Although a measurement of the one-way velocity of light should be made, it is difficult to see how it can but yield the value of c (neglecting gravitational effects). For if we accept Maxwell's equations for a plane wave, we must agree the wave can propagate in either direction with the velocity expressed by c in those equations.

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* Received by the IRE, September 16, 1960.

[1] M. Ruderfer, "Relativity: blessing or blindfold" (Correspondence), Proc. IRE, vol. 48, pp. 1661–1662; September, 1960.

[2] H. E. Ives, "Derivation of the Lorentz transformations," *Phil. Mag.*, vol. 36, p. 392; June, 1945.

Author's Comment[3]

Mr. Bevensee's comments exemplify the forgetfulness of modern physics regarding the experimental verification of the special theory of relativity. Certainly, the propagation of electromagnetic radiation should be constant in all directions, but with respect to what? Maxwell referred his velocity c to a light-transmitting medium—the luminiferous ether. So did Fitzgerald, Lorentz and, in unequivocal terms, Ives.[4] (The velocity c used by Ives in the passage cited by Bevensee refers to the velocities of the incident and reflected wave trains with respect to the ether, not the reflector.) Einstein, in his second postulate of special relativity, took a different reference by postulating the velocity of light c to be constant with respect to any observer in any direction (in the absence of a gravitational field). This was then, and still is, verified with significant precision for only an out-and-back light signal.

In the contraction theory, an observer moving toward or away from a light signal with a velocity v in the ether measures the one-way velocity of light to be $c+v$ and $c-v$, respectively. The measured average velocity of the combined out-and-back signals in the contraction theory is c, as re-

[3] Received by the IRE, October 7, 1960.

[4] H. E. Ives, "Light signals on moving bodies as measured by transported rods and clocks," *J. Opt. Soc. Am.*, vol. 27, pp. 263–273, July, 1937; "Derivation and significance of the so-called 'chronoptic interval'," *ibid.*, vol. 29, pp. 294–301, July, 1939; "The measurement of the velocity of light by signals sent in one direction," *ibid.*, vol. 38, pp. 879–884, October, 1948; "Lorentz-type transformations as derived from performable rod and clock operations," *ibid.*, vol. 39, pp. 757–761, September, 1949.

quired by the special theory. The concordance between the two theories for an out-and-back light signal is exact to the second order. This makes it impossible for previous experiments to distinguish between the two theories. However, the difference between the velocities of the separate out-and-back portions of the light path is in contradiction with the second postulate of special relativity. A one-way measurement may therefore distinguish between the two theories.

Ives' derivation of the Lorentz transformations is based upon a classical treatment of elastic collision. When a moving body collides elastically with a body initially stationary in the ether, the conservation laws of energy and momentum require that the magnitude of the rebound velocity of the moving body be less than that of its impact velocity. When the moving body is a wave train, this change in speed is precluded because the velocity of the wave train in the ether is, by postulate, always c. To permit this constancy without sacrificing the conservation laws, Ives shows in a general way that mass must vary with velocity in the manner prescribed by the Lorentz transformations. By next considering the impact of a wave train and a moving body, Ives further derives the variations of length and interval with velocity as prescribed by the Lorentz transformations. No extraneous assumptions are introduced other than the constancy of the velocity of light in the ether and the usual conservation laws.

The velocity of light in the contraction and special theories is postulated to be constant. Both postulates are different. Which is the correct one? If one uses a philosophical criterion, such as Occam's Razor or Mach's Principle of Intellectual Economy, the original preference for the special theory, because of the *ad hoc* nature of the Fitzgerald-Lorentz contraction hypothesis, no longer applies in view of Ives' classical derivation of the Lorentz transformations. The situation, at present, may be reversed since the first postulate of special relativity now appears to be superfluous.

The interpretation afforded by each theory is also different and so biases our attempts to understand nature in different directions. The contraction interpretation is a physical one which requires the ether to have substance and the variations of mass, length and interval with velocity to be real. The relativistic interpretation, partly summarized by Bevensee, is a mathematical one, with emphasis on the "beauty" of the theory and denial of the possibility of detecting a subelectrical medium. If the relativistic interpretation is incorrect it is hiding a very important key to the microcosm. There are other arguments of a philosophical nature applicable to both theories, but the time-honored and proper way of resolving such an impasse is an experimental one. This may now be realizable by one-way tests such as those suggested by my letter in these PROCEEDINGS[1] and elsewhere.[5]

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[5] M. Ruderfer, "First-order terrestrial ether drift experiment using the Mössbauer radiation," *Phys. Rev. Lett.*, vol. 5, pp. 191–192; September 1, 1960.

The Significance of Transients and Steady-State Behavior in Nonlinear Systems*

With reference to comments made by Doba and Wolf,[1] I would like to add the following comments.

Doba correctly points out an error in Wolf's article and gives the correct result,

$$\int_t^\infty k(\tau)g(t-\tau)d\tau = 0,$$

since $g(t-\tau)=0$ for $\tau > t$.

Doba then proceeds to discuss the response to a suddenly applied sinusoidal $g(t)=\epsilon^{j\omega t}$ to obtain

$$g_2(t) = \int_0^\infty k(\tau)\epsilon^{j\omega(t-\tau)}d\tau - \int_t^\infty k(\tau)\epsilon^{j\omega(t-\tau)}d\tau.$$

At this point he repeats Wolf's error and quotes Carson that the term

$$\int_t^\infty k(\tau)\epsilon^{j\omega(t-\tau)}d\tau$$

". . . dies away for sufficiently large values of time." This term is obviously zero for a suddenly applied sinusoidal since

$$\epsilon^{j\omega(t-\tau)} = 0 \quad \text{for} \quad t < \tau.$$

One way to avoid this type of error is to be more explicit and write $g(t-\tau)u(t-\tau)$, where $u(t)$ is the unit step function, instead of $g(t-\tau)$ alone. For then it becomes obvious that

$$\int_t^\infty k(\tau)g(t-\tau)u(t-\tau)d\tau = 0$$

always!

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Author's Comment[2]

Mr. Dorato's confusion is justified inasmuch as my notation was unclear.

Eq. (3) stated: let

$$g_1(t) = \epsilon^{j\omega t} \qquad 0 < t.$$

Instead I should have stated: let

$$g_1(t) = 0 \qquad t < 0$$
$$= \epsilon^{j\omega t} \qquad t > 0$$

where $\epsilon^{j\omega t}$ exists for all t.

With this understood, I believe (4) and subsequent statements are correct.

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* Received by the IRE, August 29, 1960.
[1] S. Doba, Jr. and A. A. Wolf, "The significance of transients and steady-state behavior in nonlinear systems" (Correspondence), PROC. IRE, vol. 48, pp. 1480–1481; August, 1960.
[2] Received by the IRE, October 5, 1960.

Band-Pass Measurements of a Lunar Reflection Circuit*

Experiments have been carried out to investigate the useful modulation bandwidth of a UHF moon reflection circuit. These included measurements of the correlation between signals separated in frequency, and modulation experiments using both frequency modulation (FM) and single-sideband modulation (SSB).

At UHF the attenuation of a moon reflected signal by the ionosphere is not significant, and the Faraday rotation of the signal polarization can be avoided by the use of circular polarization. The effective depth of the moon as a reflector is more significant as it produces a multipath transmission problem. The libration of the moon causes the moon to present a continuously varying reflecting surface and hence a continuously changing multipath structure. The libration also causes different regions of the moon's surface to reflect radiation with slightly different Doppler frequencies, producing the libration fading observed with moon reflected signals. For a CW signal at 440 Mc, this fading is of the order of cycles per second.

The coherent bandwidth of a lunar communications circuit will depend upon the effective delays in transmission caused by the depth of the reflector. Pulse[1–3] and CW[4] lunar reflection experiments have led to the conclusion that most of the signal energy is reflected from a small central area of the moon. As a result of the geometry of this area, most of the energy is reflected with effective delay times of less than 500 microseconds spread. The multipath effects should restrict the useful coherent bandwidth possible with a moon reflection circuit to something of the order of 1 kc. The present experiments were designed to make a more direct measurement of this bandwidth at 440 Mc.

The experiments were carried out between the Millstone Hill Radar in Westford, Mass., and the Prince Albert Radar Laboratory in Prince Albert, Saskatchewan, Canada. During the correlation experiments, two CW signals having a frequency separation in the range of 0 to 10 kc were transmitted simultaneously and received in two independently tuned receiving channels each having 25 cps bandwidths. These signals were obtained by phase-modulating a 20-kw transmitter with a modulation frequency equal to the frequency separation desired and with a modulation index of 1.4. At this

* Received by the IRE, September 15, 1960; revised manuscript received, October 10, 1960. The work reported in this paper was performed in part at Lincoln Lab., a center for research operated by M.I.T.; this work was supported by the U. S. Air Force. The work was also performed in part at the Defence Res. Telecommunications Establishment under Project No. PCC D48-38-01-17.
[1] J. V. Evans, "The scattering of radio waves by the moon," *Proc. Phys. Soc.*, vol. 70B, pp. 1105–1112; 1957.
[2] J. H. Trexler, "Lunar radio echoes," PROC. IRE, vol. 46, pp. 286–292; January, 1958.
[3] G. H. Pettengill, "Measurements of lunar reflectivity using the millstone radar," PROC. IRE, vol. 48, pp. 933–934; May, 1960.
[4] R. P. Ingalls, J. C. James, and M. L. Stone, "A study of UHF space communications through an aurora using the moon as a reflector," *Proc. Fourth Symp. on Ballistic Missile and Space Tech.* Pergamon Press, Inc., New York, N. Y., to be published.

modulation index the amplitudes of the carrier and first-order sidebands are equal. The carrier and first-order upper sideband provided the two CW signals. The data recorded were the detected outputs of the "carrier" and "upper sideband" channels.

The correlation coefficient of samples of the carrier and upper sideband detected signals was computed for a number of different frequency separations. The correlation of the amplitude fluctuations of signals separated in frequency offers a measure of the useful pass band. The correlation coefficient calculations were accomplished using an IBM 709 computer. Edited magnetic tape records of the detected signals were digitally encoded and used as the computer input. Data samples of approximately 100 seconds duration were analyzed for signals recorded on May 8 and 11, 1960.

The results of the correlation coefficient computations are summarized in Fig. 1. It

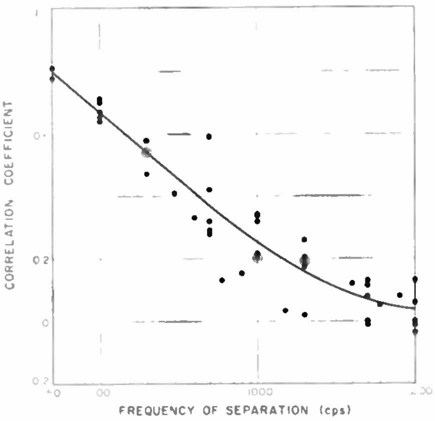

Fig. 1—Measured correlation coefficients of moon-reflected signals as a function of frequency separation (circled points are duplicate values).

is evident that the correlation coefficient drops off rapidly with frequency separation, reaching a value of 0.3 between 500 and 1000 cps. The results of the correlation coefficient measurements imply that the useful coherent bandwidth of the moon reflection path at 440 Mc is quite narrow. Any modulation scheme that transmits a wide bandwidth signal would require the use of special techniques to overcome the effects of multipath propagation. For voice transmissions single-sideband amplitude modulation seems to offer a simple solution to the problem. Frequency-shift teletype with the standard shift of 850 cps would be in considerable difficulty since the fading of the mark and space signals would be almost uncorrelated. A smaller shift, say 100 cps, could be used, but this would limit the bit rate and would make the receiver filtering more difficult. Frequency diversity with frequencies separated by as little as 1 kc could be used for the mark and space signals before being combined into the teletype signal.

Audio frequency signals were transmitted over the moon reflection circuit using narrow-band FM and SSB. The FM transmission tests used a deviation of less than 1 kc and were received in an IF bandwidth of 3 or 8 kc before limiting. The limiter and discriminator bandwidth was 16 kc. The received signals were characterized by severe multipath distortion and speech was almost unintelligible. The results might have been better if special techniques had been employed for using FM in the presence of multipath transmission. Single-sideband transmissions in a 2-kc bandwidth were more satisfactory. The effects of selective fading were noticeable, but the quality approached that of a typical long-distance telephone circuit.

The effort of M. L. Stone in initiating the experiment is gratefully acknowledged.

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Single-Sideband Communication*

The remarks concerning the SAC communications briefing[1] are very disturbing to me as a communications engineer. They typify the attitude of some people—in and outside the communications industry—that single-sideband (SSB) modulation techniques are pre-eminently suited for the majority of communication systems. It is unfortunate that these individuals have become "conservatives." Communications engineers should be questioning and flexible, always seeking better communications techniques and not become dogmatic to the point of favoring SSB modulation techniques to the virtual exclusion of other schemes.

SSB's principal "advantage" is its spectrum conservation by reducing the ratio of channel bandwidth to information rate. We can get a relative measure of this "advantage" by examining Shannon's equation for channel capacity, realizing that it is a limiting case, and equating channel capacity with information rate.

$$c = w \log_2 (1 + P/N), \tag{1}$$

where

c = channel capacity (bits/second)
w = channel bandwidth (cps)
P = transmitter average power
N = noise average power.

It can readily be seen that the required receiver signal-to-noise ratio goes up exponentially as the channel bandwidth is reduced, given the same channel capacity (or information rate).

* Received by the IRE, September 30, 1960.
[1] "SAC" (Poles and Zeros), PROC. IRE, vol. 48, p. 1373; August, 1960.

In the second paragraph,[1] actual radio contacts with stations around the world are enumerated:

". . . ; these seventeen contacts required less than two minutes of elapsed time. Unquestionably, the ability to achieve this performance is in part due to the wisdom of the Air Force in choosing single sideband as the basic communications technique."

Why attribute this speed of contacts to SSB? After all, the electromagnetic propagation velocity is not dependent upon the type of modulation. Well, you might say, this performance is due to the higher efficiency of SSB. But representative SSB systems require +10 to +20 db signal-to-noise ratio for reliable reception, so where is the system efficiency? Add to this the tacit assumption that this particular demonstration was done under ideal conditions, *i.e.*, channels kept open, no interference (unintentional or otherwise), how can one claim such superlative performance for SSB?

Don't get me wrong; for certain applications, SSB does an outstanding job, but there is no one modulation scheme that is universally adaptable to all communication problems. All I am asking is that each communication problem be examined individually, and the modulation scheme optimized for that particular problem.

Let us be realistic enough to acknowledge that SSB has its limitations, especially in the crowded and uncontrolled frequency spectrum that can be expected during a conflict, realize that we can't get all the channels we would like, and develop communication systems that *will* work in such electromagnetic environments.

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Noise Generated in the Ion Sheath of a Probe*

It was shown, for a frequency range between a few hundred kc and 10 Mc, that the noise generated in or near the negatively biased probe in the gas discharge plasma is essentially a shot noise contributed by both electrons and ions arriving at the probe.[1,2] For frequencies higher than 10 Mc, the saturated diode current I_{eq} which is equivalent to the noise current of the probe tends to increase.

* Received by the IRE, September 23, 1960; revised manuscript received, October 6, 1960.
[1] K. Shimada, "Impedance and Noise Measurements of Various Gas Discharge Devices," University of Minnesota, Minneapolis, Ph.D. dissertation, pp. 48–54; August, 1958.
[2] A. R. Galbraith and A. Van der Ziel, "Noise in Gas Discharges," *Internatl. Conf. on Ionization Phenomena in Gases*, Uppsala, Sweden, pp. 11A, 297–300; August, 1959.

Such a frequency dependence of I_{eq} is explained in this paper by considering three groups of particles, as shown in Fig. 1. Two

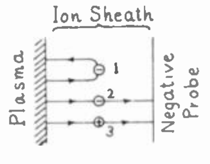

Fig. 1—Motion of three groups of particles in the ion sheath region.

groups of electrons which are labeled 1 and 2 enter into the ion sheath region with an average initial velocity determined by the electron temperature in the plasma. The electrons in group 2 and the ions in group 3 give rise to a full shot noise at the frequencies considered here. The electrons in group 1 are reflected due to the retarding field in the sheath, thus giving rise to short current pulses of the triangular form which is given by (1).

Although the actual shape of such a pulse is undoubtedly more complex because of the existence of the space charge in the sheath, the analysis based on the triangular current pulse can provide a sufficient insight to the noise spectrum. This current pulse is given by

$$y(t) = \frac{2e}{\tau}\left(1 - \frac{t}{\tau}\right) \quad \text{for} \quad 0 \leq t \leq 2\tau, \quad (1)$$

where 2τ is the time for an electron to be in the ion sheath. Hence the spectral intensity $w(f)$ of the noise current will be given by

$$w(f) = 2\lambda \mid F(w) \mid^2,$$

where λ is an average time rate of occurrence of $y(t)$ such that

$$\lambda = \frac{I_0}{e}.$$

I_0 being the current due to such electrons entering into the sheath, and

$$F(\omega) = \int_0^{2\tau} \frac{2e}{\tau}\left(1 - \frac{t}{\tau}\right)e^{-j\omega t}dt. \quad (2)$$

Eq. (2) yields

$$\mid F(\omega) \mid^2 = \frac{16e^2}{(\omega\tau)^2}\left(\frac{\sin\omega\tau}{\omega\tau} - \cos\omega\tau\right)^2. \quad (3)$$

Therefore,

$$w(f) = 32\frac{eI_0}{(\omega\tau)^2}\left(\frac{\sin\omega\tau}{\omega\tau} - \cos\omega\tau\right)^2. \quad (4)$$

Eq. (4) can be approximated for $0 \leq \omega\tau \leq 1$ with a good degree of accuracy by

$$w(f) = \frac{32}{9}eI_0(\omega\tau)^2. \quad (5)$$

Consequently, the total probe noise for frequencies smaller than the one determined from the transit time τ, such that $w\tau \leq 1$, will be given by

$$I_{eq} = I_e + I_i + \frac{16}{9}I_0(\omega\tau)^2, \quad (6)$$

where I_e and I_i are the electron current and the ion current arriving at the probe which give rise to a full shot noise. The last term is due to electrons which are reflected back to the plasma and it can be recognized as the noise similar to the total emission noise in a vacuum diode.[3] It is assumed here that the three types of current are independent for (6) to be valid.

The I_{eq} calculated from (6) shows an excellent agreement with the measurements when $I_i = 28$ μa, $I_0 = 300$ μa, $\tau = 3.6 \times 10^{-9}$ seconds and $I_{pr} = I_e - I_i$. The comparison of the calculated and the measured values of I_{eq} for a cylindrical needle probe in an argon gas discharge can be seen in Fig. 2. Here, the cur-

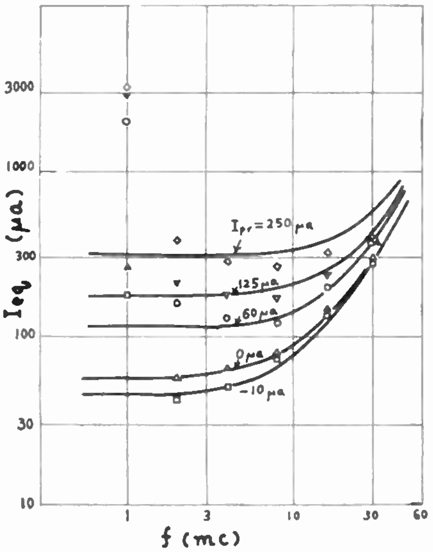

Fig. 2—Comparison of the calculated and the measured values of I_{eq} vs frequency. Parameter is dc probe current I_{pr}. Measured points are indicated by: ◇ for $I_{pr} = 250$ μa, ▽ for 125 μa, ○ for 60 μa, △ for 0 μa, and □ for -10 μa.

rent I_0 is estimated from the probe and the noise characteristics. The transit time τ of 3.6×10^{-9} seconds is calculated from the theoretical noise curves. The relatively small transit time is expected because the electrons having the initial velocity of the order of a few electron volts are reflected within the thin ion sheath without colliding with any others.

The sharp rise of measured I_{eq} at lower frequencies in Fig. 2 is due to the noise generated in the cathode fall region of the gas discharge which masks the probe noise. A recent report showed that it can be removed completely by a proper shielding of the gas discharge tube.[2] At much higher frequencies, such that $\omega\tau \gg 1$, the thermal part of the noise becomes predominant so that the noise temperature approaches to the electron temperature of the plasma. Hence the lower limit of the frequency above which the noise becomes essentially thermal appears to be of the order of 100 Mc.

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[3] A. Van der Ziel, "Noise," Prentice Hall, Inc., New York, N. Y., pp. 130–134; 1954.

Zero-Point Energy as the Source of Amplifier Noise*

This note gives still another derivation of the noise temperature of a maser amplifier. The mechanism of noise generation in masers has already been explained by many authors, using the concept of ***spontaneous emission***, and the subject is now believed to be well understood.[1] The following derivation uses, instead, the alternative viewpoint that maser noise arises from the maser's insistence on amplifying the *zero-point energy* coming from the input line. There is no real difference between these two alternative explanations, and so the following derivation gives the same results as usually obtained. However, it offers a simple and direct way to obtain the answer; and it emphasizes a somewhat different interpretation of the source of noise than is usually the case. Although the results are derived specifically for the maser, the same concepts seem to be relevant to any sort of coherent voltage amplifier. Thus, Weber has asserted that every free-electron amplifier is basically a maser.[1]

It should be noted that, although the following derivation was independently obtained by the author, the same basic idea has been set forth by several previous authors.[2] In particular, the paper by Shimoda, Takahasi and Townes discusses the same idea rigorously and in considerably more detail. It should also be noted that the simple noise power approach used here is a simplification which becomes an over-simplification in the limit where quantum effects become important. The more detailed statistical discussions of Shimoda, Takahasi and Townes then become essential.

Spontaneous emission means that whenever a quantum system is in a higher energy level, there is a certain probability that it will drop to a lower energy level, at the same time emitting a quantum of radiation at the appropriate transition frequency. This radiation is not coherent with a stimulating signal, and has the characteristics of noise. The spontaneous transitions are always downward, never upward.

Zero-point energy refers to the fact that, according to quantum theory, the energy of an harmonic oscillator is given by $(n+\frac{1}{2})hf$, where n is a positive integer or zero. The energy of the oscillator can thus

* Received by the IRE, August 29, 1960; revised manuscript received, October 5, 1960. This communication is based on research supported by the Wright Air Dev. Div. of the United States Air Force.

[1] *E.g.*, M. W. Muller, "Noise in a molecular amplifier," *Phys. Rev.*, vol. 106, p. 8; April 1, 1957. R. V. Pound, "Spontaneous emission and the noise figure of maser amplifiers," *Ann. Phys.*, vol. 1, p. 24; April, 1957. M. W. P. Strandberg, "On the inherent noise of quantum-mechanical amplifiers," *Phys. Rev.*, vol. 106, p. 617; May 15, 1957. J. Weber, "Maser noise considerations," *Phys. Rev.*, vol. 108, p. 537; November 1, 1957.

[2] K. Shimoda, H. Takahasi, and C. H. Townes, "Fluctuations in amplification of quanta with applications to maser amplifiers," *J. Phys. Soc. Japan*, vol. 12, p. 686; June, 1957. *Cf.* also K. Shimoda, T. C. Wang, and C. H. Townes, "Further aspects of the theory of the maser," *Phys. Rev.*, vol. 102, p. 1308; June 1, 1956. Also H. Friedburg, "General amplifier noise limit," and R. Serber and C. H. Townes, "Limits on electromagnetic amplification due to complementarity," in "Quantum Electronics," C. H. Townes, Ed., Columbia University Press, New York, N. Y., pp. 228, 233; 1960.

change only in discrete steps or quanta of energy hf. However, even with no quanta present ($n=0$) there appears to be a residual energy of one-half quantum, which is referred to as the zero-point energy. This energy cannot be removed from the system (n cannot go negative) and so must be treated differently from ordinary energy in making calculations.

The quantum theory of electromagnetic radiation can be formulated in such a way that each possible mode of electromagnetic radiation in a system appears as an harmonic oscillator. Each electromagnetic field mode can then be said to have the one-half quantum of zero-point energy.[3] This energy can be added to the usual blackbody or thermal energy density in an enclosure or a transmission line. However, because of the special nature of zero-point energy, this energy is usually stated not to participate in interactions with charged matter.[4]

It has been pointed out[4] that the rate of spontaneous emission in any quantum system is just equal to the rate of stimulated emission that would be caused by the presence of a noise signal with a strength of one quantum per mode. On the other hand, the zero-point energy has a strength of one-half quantum per mode. As a result, one can choose to say, at least formally, that *zero-point energy causes spontaneous emission.* Two conditions must be attached: 1) *the interaction of the zero-point energy with matter is limited to causing only downward transitions (which then comprise what is otherwise called spontaneous emission)*; 2) *the zero-point energy causes these transitions with twice the efficiency of ordinary energy.*

We now apply this idea to maser noise figure. Consider a maser with populations n_1 and n_2 in the upper and lower signal levels, respectively. Suppose a signal of power P_{in} is sent into the input. The power coming out the output will consist of the power input plus the power added by stimulated transitions in the maser spin system. The latter will be given by $W(n_2-n_1)$, where W is a transition probability which includes cavity geometry, transition-probability matrix element, filling factor, and so on. Also, W will be directly proportional to the power input P_{in}. We can write

$$\begin{aligned} P_{out} &= P_{in} + W(n_2 - n_1) \\ &= P_{in} + K(n_2 - n_1)P_{in} \\ &= GP_{in} \end{aligned} \tag{1}$$

where G is the power gain of the maser. From (1) we obtain

$$K(n_2 - n_1) = G - 1. \tag{2}$$

Suppose that the amplifier input is connected to a matched source at temperature T. The noise power input to the amplifier from the source will be

$$N_{in} = \frac{hfB}{\exp(hf/kT) - 1} + \frac{1}{2}hfB. \tag{3}$$

The first term is the ordinary thermal noise from the source. It is the "background noise" and is not counted against the amplifier. The second term is the zero-point energy term. This term will account for the amplifier's noise. The noise output due to this zero-point energy input will be the input power plus the power added by transitions stimulated in the maser spin system. The noise output due to the zero-point energy input will be, by analogy with (1),

$$N_{out} = \tfrac{1}{2}hfB + 2K\cdot n_2\cdot \tfrac{1}{2}hfB. \tag{4}$$

The K is the same as in (1). The factor of two comes from condition 2, and only n_2 appears because of condition 1 above. With a little manipulation, (4) becomes

$$\begin{aligned} N_{out} &= \tfrac{1}{2}hfB + K(n_2 - n_1)\frac{1}{1 - n_1/n_2}hfB \\ &= \tfrac{1}{2}hfB \\ &\quad + (G-1)\frac{hfB}{1 - \exp(-hf/k|T_m|)}, \end{aligned} \tag{5}$$

where T_m is the negative maser spin temperature defined by $n_2/n_1 = \exp(-hf/kT_m)$. The first term in (5) is the zero-point energy in the amplifier output; it can be neglected if the gain is high. The second term is exactly the usual expression for the "internal" noise of a maser amplifier.

This formulation can thus be interpreted as saying that the internal noise of a maser actually results from amplification of the zero-point energy input of $\frac{1}{2}hfB$. Moreover, the maser amplifies the zero-point energy more strongly than it does ordinary signals, as is evident from comparison of (1) and (4). For a perfect maser, *i.e.*, one with spins only in the upper level n_2, which means $|T_m|\to 0$, the zero-point energy is favored by three db because of condition 2. In a nonideal maser with spins also in the lower level, the factor is still larger because the signal causes both emissive and absorptive transitions while the zero-point energy causes only emissive transitions. These facts have also been pointed out, in somewhat different terms, by Shimoda, Takahasi and Townes.[2]

The same sort of argument can presumably be applied to other sorts of amplifiers than masers. However, it does not seem to be nearly as straightforward to identify the energy-level populations in, say, a parametric amplifier or a traveling-wave tube. In any case, the condition for any other amplifier to have minimum noise is for all of its elements to be in states where only emissive and not absorptive transitions can occur.

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[3] W. H. Heitler, "The Quantum Theory of Radiation," Oxford University Press, London, Eng., 3rd ed., p. 57; 1954. Prof. J. Weber of the University of Maryland points out that Heitler also gives an alternative formulation of the electromagnetic case in which the zero-point energy no longer appears. Therefore, there is no logical basis for asserting the existence of the zero-point energy in the electromagnetic case. However, it can still be used as a convenient formal way of getting at spontaneous emission.

[4] L. I. Schiff, "Quantum Mechanics," McGraw-Hill Book Co., Inc., New York, N. Y., 2nd ed., pp. 62, 382, 400; 1955.

Technique for Amplitude Modulating a Van Atta Radar Reflector*

This paper outlines a proposed technique for amplitude modulating a radar reflector. Modulated reflectors have been used for specific applications but because of limited modulating bandwidth, excessive size and large power requirements, they have not been used extensively. The proposed scheme would largely overcome these restrictions. Specifically, it is suggested that by introducing phase shifts in the interconnecting lines of a Van Atta array, the radar return can be amplitude modulated electronically. Modulating frequencies from a few tens of cycles to about 10 kc are feasible. Applications that suggest themselves include target enhancement on command, communications using radars, passive IFF and others.

An interesting use of the modulated array would be the identification and tracking of friendly satellites by suitable radars. The skin of the satellite would be made of antenna elements on an absorbant material to reduce the radar cross section to enemy radars. To detect the satellite, friendly radars would illuminate the vehicle with the appropriate coded signal which would be answered by coding the modulation of the Van Atta array. During the time when no interrogation was being effected the array would be biased to a "zero" state to reduce the radar cross section to a minimum. Thus our own satellite vehicles could operate in space for a considerable time undetected by enemy radars.

From a preliminary analysis of the Van Atta array it appears feasible to amplitude modulate electronically the radar return over a frequency range from about 20 cps to 10 kc. The method proposed to modulate the array is to break the interconnecting cables of the radiating elements and insert a suitable phase shifter such as a ferrite element to vary the phase of the energy transmitted through the cable.

To demonstrate that the array would be amplitude modulated consider the simple case of two dipoles as shown in Fig. 1. The following conditions are specified:

1) Antennas are spaced $2d$ apart.
2) A transmission line of length l (which gives rise to a phase shift of e^{jkl}) joins the antennas.

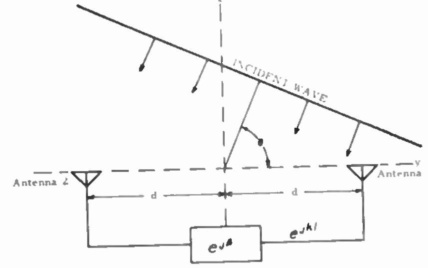

Fig. 1.

* Received by the IRE, October 18, 1960.

3) Phase shift of e^{jB} is inserted in the line.
4) Incident wave (plane) makes an angle θ with y.

For convenience, the origin of the coordinate system has been chosen as shown in the figure. It is also assumed that the antennas are properly terminated[1] and that no losses result from the cable. We now define the following:

E_{s1} = the field scattered by antenna 1.
E_{r1} = the field radiated by antenna 1 due to the energy induced in antenna 2.
E_{s2} = the field scattered by antenna 2.
E_{r2} = the field radiated by antenna 2 because of the energy induced in antenna 1.
E_t = total field radiated by the array.

From the geometry of the figure we obtain expressions for the above.

$$E_{s1} = \frac{\sqrt{2}}{2} E_0 e^{jkd \cos\theta} \tag{1}$$

$$E_{r1} = \frac{\sqrt{2}}{2} E_0 e^{-jkd \cos\theta} e^{jB} e^{jkl} \tag{2}$$

$$E_{s2} = \frac{\sqrt{2}}{2} E_0 e^{-jkd \cos\theta} \tag{3}$$

$$E_{r2} = \frac{\sqrt{2}}{2} E_0 e^{jkd \cos\theta} e^{jB} e^{jkl} \tag{4}$$

$$E_t = E_{s1} + E_{r1} + E_{s2} + E_{r2}, \tag{5}$$

where E_0 = maximum value of the incident field. Adding the four components and simplifying we obtain

$$\begin{aligned} E_t &= \sqrt{2} E_0 \cos(kd\cos\theta) \\ &\quad + \sqrt{2} E_0 e^{j(B+kl)} \cos(kd\cos\theta) \\ &= \sqrt{2} E_0 \left|1 + e^{j(B+kl)}\right| \cos(kd\cos\theta) \\ &= 2\sqrt{2} E_0 e^{j\left(\frac{B+kl}{2}\right)} \cos\left(\frac{B+kl}{2}\right) \\ &\quad \cdot \cos(kd\cos\theta) \end{aligned} \tag{6}$$

Eq. (6) shows that the array pattern E_t has an amplitude as a function of θ given by

$$\cos\left(\frac{B+kl}{2}\right) \cos(kd\cos\theta). \tag{7}$$

(The factor $e^{j(B+kl/2)}$ has no effect on the amplitude of the scattering pattern, hence can be disregarded.)

The array pattern amplitude can be varied from a maximum value to zero simply by varying B (kl is constant) with the phase shift inserted in the connecting transmission line.

By the use of the superposition techniques, this analysis can be extended to a multiple-element two-dimensional array. The result of such an exercise would be a change in pattern directivity but the amplitude would remain a function of $\cos(B+kl/2)$.

In practical applications, the use of printed circuit techniques would keep the reflector at a reasonable size. Further, the use of flat spiral[2] antenna elements would increase the RF bandwidth of the reflector. Preliminary analysis indicates, assuming ferrite phase shifter,[3] that the power required per phase shifter would be about 0.1 watt. The use of other phase shifting elements such as voltage-variable capacitors should not be ruled out and could further reduce the modulating power.

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[1] J. D. Kraus, "Antennas," McGraw-Hill Book Co., Inc., New York, N. Y., p. 47; 1950.
[2] E. D. Sharp, "Properties of the Van Atta Reflector Array," RADC Rept. RADC-TR-58-53 ASTIA Document No. AD-148684; April, 1958.
[3] F. Reggia and E. G. Spencer, "A new technique in ferrite phase shifting for beam scanning at microwave antennas," Proc. IRE, vol. 45, pp. 1510–1517; November, 1957.

A Mechanical Model of the Minkowski Representation of Lorentz Space*

In a recent note to this journal[1] and in a more complete form in another publication,[2] it was shown how the Minkowski representation of Lorentz space, well-known from the theory of special relativity, can be used in studying impedance, power, and noise transformations through reciprocal two-port networks. The fact that Lorentz space has an indefinite metric makes many of the geometric constructions in the Minkowski representation look strange to a person used to ordinary Euclidean geometry. In order to get familiar with the non-Euclidean constructions, the author has built a mechanical model of the Minkowski representation of two-dimensional Lorentz space. The model simply consists of a dielectric slab slotted partially along the unit hyperbola, one of its asymptotes, the symmetric tangent to the hyperbola, and the unit circle. (See Figs. 1–4). Movable pins are inserted into the slots and the pins are connected together by slotted steel bars. Figs. 1, 2, and 3 show that if one of the pins, for example, the one traveling along the hyperbola, is moved, all the other pins on the left hand side of the dielectric slab also move in such a way that the two parallel bars stay parallel. The different pins can be interpreted as points in different representations of non-Euclidean hyperbolic and elliptic geometries. The connections between these representations have recently been thoroughly discussed by this author.[3] According to this paper, the point A in Fig. 1 may represent the Minkowski representation, point C the Poincaré represen-

* Received by the IRE, October 3, 1960; revised manuscript received, October 20, 1960.
[1] E. F. Bolinder, "Radio engineering use of the Minkowski model of the Lorentz space," Proc. IRE, vol. 47, p. 450; March, 1959.
[2] E. F. Bolinder, "Impedance, power, and noise transformations by means of the Minkowski model of Lorentz space," Ericsson Technics, vol. 15, pp. 249–283; 1959.
[3] E. F. Bolinder, "A survey of the use of non-Euclidean geometry in electrical engineering," J. Franklin Inst., vol. 265, pp. 169–186; March, 1958.

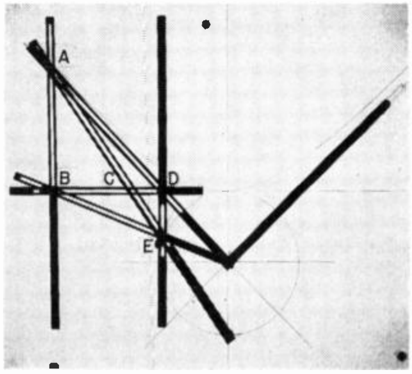

Fig. 1.

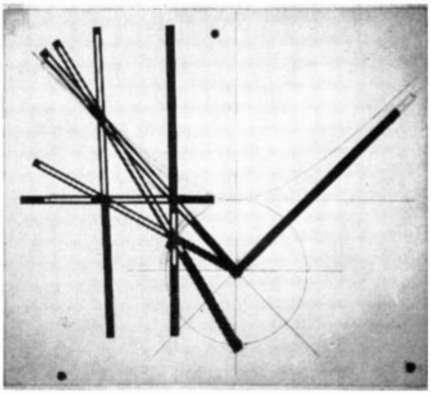
Fig. 2.

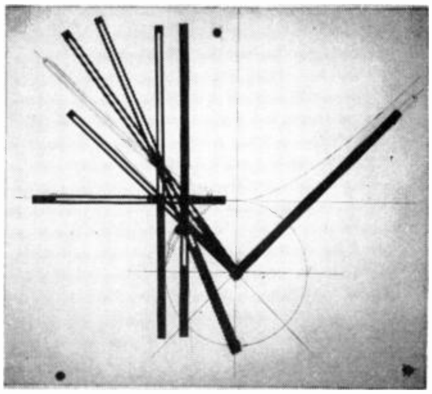
Fig. 3.

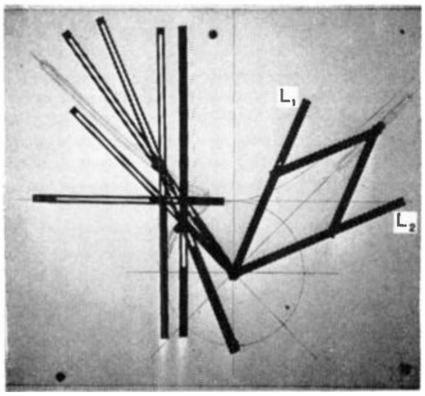

Fig. 4.

tation, and point D the Cayley-Klein representation of hyperbolic space. The points B and E may be set in correspondence with representations of elliptic space.

The transformation shown in Figs. 1 and 2 is a pure stretching, and it may represent, in electrical engineering, a transformation by an ideal transformer.[1-3]

Figs. 3 and 4 show different positions of two Lorentz orthogonal lines in the Minkowski representation of Lorentz space. The lines are marked L_1 and L_2 in Fig. 4. Two lines are, in this case, "Lorentz orthogonal" if they are conjugate diameters to the hyperbolas $y^2-x^2=\pm 1$. (Two diameters of a central conic, each of which bisects all cords parallel to the other, are called conjugate diameters.) It is interesting to note that the two lines coalescing along the asymptote in Fig. 3 are orthogonal to each other in the Lorentz sense.

Besides being useful in electrical engineering problems, the model may, of course, also be used in constructive treatments of problems in special relativity, for example, the Lorentz-Fitzgerald contraction of length and the dilation of time scales, both consequences of the Lorentz transformation.

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Calculation of the Rise and Fall Times in the Alloy Junction Transistor Switch Based on the Charge Analysis*

The concept of a junction transistor as a charge controlled device, which was introduced by Beaufoy and Sparkes[1] has been recognized as a powerful tool in the analysis of the junction transistor under transient conditions. In a recent correspondence, Ekiss and Simmons[2] have shown a useful method of rise and fall time calculation of junction transistor switch based upon this method of charge analysis. If we look a little more carefully at this problem, we are able to derive another version of the rise time (or fall time) equation based on the same analysis, but conceptually somewhat different. Thus, from the charge analysis of the junction transistor (Beaufoy and Sparkes), the total base charge is related to the collector current by

$$\int dq_b = \int \frac{1}{\omega_t}\, di_c.$$

From this fact, Ekiss and Simmons have developed their analysis based on

$$\int di_c = \int \bar{\omega}_t \cdot dq_b,$$

where $\bar{\omega}_t$ is defined as the average current gain-bandwidth product over the change of i_c and V_{ce}. Unfortunately, the variation of ω_t caused by the i_c and V_{ce} change is quite large, particularly at the relatively small I_c level (and also at very high current level, with which we are not concerned). Since i_c will swing in this range during the switching process, it is somewhat difficult to determine $\bar{\omega}_t$ over the range. Instead of dealing with the time integral of the current, by applying the lumped charge model the analysis of the transistor switching problem becomes quite simple. This is one of the principal virtues of the charge method as pointed out by Baker.[3]

Let us look at the basic charge equation (in the common emitter switching circuit) for the rise time interval [equivalent to (1) of Ekiss and Simmons].

$$\int_0^{t_r} I_\beta \cdot dt = \int_0^{t_r}\left(\frac{dq_b}{dt}+\frac{q_b}{\tau}+C_{tc}\frac{dv_{cb}}{dt}+C_{te}\frac{dv_{eb}}{dt}\right)\cdot dt \quad (1)$$

where I_β is the base driving current, q_b is the base charge, τ is the minority carrier life time in the base region, C_{tc} is the base to collector junction capacity, C_{te} is the base to emitter junction capacity, V_{cb} is the collector to base voltage, and v_{eb} is the emitter to base voltage.

If we assign limits as follows:

$$\begin{aligned} q_b(t=0)&=Q_{b0}, & v_{cb}(t=0)&=V_{cb0}, & V_{eb}(t=0)&=V_{eb0}\\ q_b(t=t_r)&=Q_{b1}, & v_{cb}(t=t_r)&=V_{cb1}, & V_{eb}(t=t_r)&=V_{eb1}\end{aligned}\Bigg\}, \quad (2)$$

(1) may be rewritten

$$\int_0^{t_r} I_\beta\cdot dt = \int_{Q_{b0}}^{Q_{b1}} dq_b + \int_0^{t_r}\frac{q_b}{\tau}\cdot dt + \int_{V_{cb0}}^{V_{cb1}} C_{tc} dv_{cb} + \int_{V_{eb0}}^{V_{eb1}} C_{te} dv_{eb}. \quad (3)$$

The left-hand side of the equation is obviously the total charge supplied by the external source during the rise time period. The right hand side of the equation is the charge consumed or stored during the same period. The first term is the required base storage charge to shift the current level. The second term is the base storage charge loss due to the bulk recombination. The third and fourth terms are the charges to clean up C_{tc} and C_{te}.

In a practical switching application, the initial base storage charge Q_{b0} and the required clean-up charge for C_{te} are negligible compared to the others, so that (3) may be simplified as follows:

$$\int_0^{t_r} I_\beta\cdot dt = Q_{b1} + Q_{tc} + \int_0^{t_r}\frac{q_b}{\tau}\cdot dt \quad (4)$$

where

$$Q_{b1} = \int_0^{Q_{b1}} dq_b = \frac{I_{c1}}{\omega_{t1}} = T_{c1}\cdot I_{c1}.$$

Here, I_{c1} is the final collector current (equal to I_{cs} if the transistor is to be saturated in the "on" condition), $\omega_{t1}(=1/T_{c1})$ is the gain-bandwidth product at $i_c=I_{c1}$ and $v_{ce}=V_{cb1}+V_{eb1}$ (at the final condition), and Q_{tc} is the required clean-up charge for C_{tc}. C_{tc} is a function of v_{cb}, so that it can be expressed as

$$Q_{tc} = \int_{V_{cb0}}^{V_{cb1}} C_{tc}\cdot dv_{cb} = \int_{V_{cb0}}^{V_{cb1}} \frac{K}{(\phi - V_{cb})^{1/n}}\cdot dv_{cb}. \quad (5)$$

Where ϕ is the barrier potential, K is a constant and n is 2 for the abrupt junction, and about 3 for the graded junction. In the practical calculation, we may take $V_{cb0}=V_{cc}$ (collector supply voltage) and $V_{cb1}=0$. (In practice, Q_{tc} can be calculated by graphical methods with the aid of C_{tc} vs v_{cb} plot.)

Returning to (4), if I_β is a constant current,

$$I_\beta\cdot t_r = Q_{b1} + Q_{tc} + \int_0^{t_r}\frac{q_b}{\tau}\cdot dt. \quad (6)$$

In order to solve for t_r, the last term should be evaluated. But since this recombination charge loss is quite small compared to the other two terms, this can be neglected in most cases. If a small inaccuracy may be tolerated (less than 10 per cent in most cases), we can utilize the following simple equation:

$$t_r = \frac{Q_{b1}+Q_{tc}}{I_\beta} = \beta_c\left(T_{c1}+\frac{Q_{tc}}{I_{c1}}\right). \quad (7)$$

Here, β_c is the current gain at I_{c1}, with the given driving current I_β, sometimes known as the circuit beta. As seen here, a reasonably accurate t_r can be calculated with only the final and driving conditions known, regardless of the complexities of the waveform of $i_c(t)$. A similar form of (7) can be derived by approximating a modified Ebers and Moll's equation. Thus, approximating (7) of Ekiss and Simmons, and substituting their notation

$$\tau = \frac{\beta_0}{\bar{\omega}_t}, \qquad \delta = \frac{Q_{tc}\bar{\omega}_t}{I_{cs}},$$

we get

$$t_r = \tau\frac{\beta_c}{\beta_0}(1+\delta) = \beta_c\left(\frac{1}{\bar{\omega}_t}+\frac{Q_{tc}}{I_{cs}}\right), \quad (8)$$

which is in the identical format of (7), but conceptually quite different. In (7) T_{c1} $(=1/\omega_{t1})$ is the value at the final current and voltage, while $\bar{\omega}_t$ is the average value over the current and voltage change, which is not always necessarily the same value of ω_{t1}.

Including the recombination charge loss term, we may be able to obtain better results. Unfortunately, in order to evaluate this term, we must know the time dependency of q_b. But, as mentioned before, this term is quite small compared to the others, so that an approximated $q_b(t)$ is satisfactory for the purpose. Based on

* Received by the IRE, September 22, 1960; revised manuscript received, October 13, 1960.

[1] R. Beaufoy and J. J. Sparkes, "The junction transistor as a charge controlled device," *J. ATE*, vol. 13, pp. 310–327; October, 1957.

[2] J. A. Ekiss and C. D. Simmons, "Calculation of the rise and fall times of an alloy junction transistor switch," Proc. IRE, vol. 48, pp. 1487–1488; August, 1960.

[3] A. N. Baker, "Charge analysis of transistor operation," Proc. IRE, vol. 48, pp. 949–950; May, 1960.

Beaufoy and Sparkes' derivation (in the case of omitting C_{tc}), we may assume

$$q_b(t) = Q_{t2}(1 - e^{-t/\tau}) \tag{9}$$

where

$$Q_{b2} = T_{c2} I_{c2} = \frac{\tau}{\beta_2} I_{c2} = \tau I_\beta. \tag{10}$$

Therefore, the recombination charge loss Q_r will be

$$Q_r \cong \int_0^{t_r} \frac{Q_{b2}}{\tau}\left(1 - e^{-t/\tau}\right)\cdot dt$$

$$\cong \frac{1}{2} I_\beta \frac{t_r^2}{\tau}\left(\text{with } \frac{t_r}{\tau} \ll 1\right). \tag{11}$$

Substituting this term into (6) and solving for t_r, we get

$$t_r = \beta_r\left(T_{c1} + \frac{Q_{tc}}{I_{c1}}\right)$$

$$\cdot\left[1 + \frac{1}{2}\left(\frac{\beta_c}{\beta_1} + \frac{Q_{tc}}{I_\beta}\right)\right]. \tag{12}$$

Again T_{c1} and β_1 are both at the final condition, $i_c = I_{c1}$ and $V_{cb} = V_{cb2}(=0)$.

Modifying the integral limits [see (2)], the same methods can be applied to the fall time calculation.

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Noise and Bandwidth Considerations of Kompfner Dip Couplers for Electron Beam Parametric Amplifiers*

Longitudinal and transverse field electron-beam parametric amplifiers have been studied for some time. Low-noise amplification has been demonstrated by the transverse-field type using resonant circuit. It is generally believed that for considerations of large bandwidth and high-frequency operations, traveling-wave-type interaction instead of the resonator type may be more desirable. Several analyses have shown the feasibility of traveling-wave low-noise parametric amplification using electron beams.

In all the proposed traveling-wave electron-beam parametric amplifiers, a coupler is used to transfer the signal input onto the beam in the form of a fast-wave modulation, and to remove the fast-wave shot noise from the beam. If the coupler is an idealized lossless transducer, the transfer of signal and removal of shot noise can be almost a hundred per cent. Therefore, the signal-to-noise ratio on the fast wave at the output end of the coupler is the same as that on the circuit wave at the input end. As it is known that, in general, any loss a transducer may have will decrease the signal-to-noise for a wave passing through it, one may expect that the same applies to the fast-wave coupler here. An analysis made recently has revealed that the signal-to-noise ratio at the output end of the coupler is decreased by an amount in decibels equal to about half of the circuit loss of the coupler in decibels if the coupler is assumed to be at the same temperature as the signal source. The analysis also revealed that with circuit loss taken into consideration, the circuit-wave dip point does not coincide with the point for complete noise removal. Therefore, an additional degradation in signal-to-noise is experienced, whether the operation is adjusted for complete transfer of circuit power, or for complete removal of fast-wave shot noise.

Traveling-wave couplers are generally believed to be wide-band. Our analysis has shown that as far as noise removal is concerned, the beam velocity is a critical parameter. Therefore, unless the velocity parameter for the Kompfner dip condition is not frequency sensitive, the traveling-wave coupler would not have the wide-band characteristics as one might have expected at first.

The above considerations and others relating to excitations of circuit wave, fast and slow space-charge waves along a traveling-wave interaction region as a function of loss, velocity of the beam and other parameters, are discussed in greater detail in a paper which will shortly be submitted for publication.

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* Received by the IRE, November 7, 1960.

The Significance of Transients and Steady-State Behavior in Nonlinear Systems*

In a recent note, Dr. Wolf[1] has attempted to answer a criticism[2] of a previous letter by him[3] made by Doba. In this second letter, Wolf[1] has compounded his original error by making a number of mathematical mistakes and by citing a large number of excellent references which lure the casual reader into accepting these errors as fact.

In his original letter Wolf[3] gives the following restriction on the function $g_1(x)$:

$$g_1(x) = \begin{cases} = 0 & \text{for } x < 0 \\ \neq 0 & \text{for } x > 0. \end{cases} \tag{1}$$

He then states that in general

$$\int_t^\infty k(\tau) g_1(t - \tau) d\tau \neq 0 \qquad \text{for } t > \tau. \tag{2}$$

This is meaningless, since the limits of integration restrict τ to the region $[t, \infty]$, while the second restriction in (2) requires that $\tau < t$.

The set of functions, $k(\tau)g_1(t-\tau)$ for which

$$\int_t^\infty k(\tau) g_1(t - \tau) d\tau = 0 \tag{3}$$

is not the "trivial class belonging to the null set," as Wolf states, but contains the set of functions for which

$$k(\tau) g_1(t - \tau) = 0$$

almost everywhere for $t < \tau$.[4,5]

Obviously, the "example" given by Wolf is not an example in which $g_1(x)$ satisfies (1), and, therefore, it appears to have no bearing on the problem at hand.

In conclusion, it might be noted that if one considers distributions, instead of Riemann or Lebesgue integrable functions, then it is possible to have

$$\int_t^\infty k(\tau) g_1(t - \tau) d\tau \neq 0.$$

This is shown by the following example. Let

$$g_1(x) = \delta(x) + H(x)$$

where $\delta(x)$ is the Dirac delta function[6] and $H(x)$ is the Heaviside unit function,[6] and let $k(x)$ be any "good function" defined by Lighthill.[6] Then, it is easily shown that

$$\int_t^\infty k(\tau) g_1(t - \tau) d\tau = \tfrac{1}{2} k(t),$$

since $\delta(x)$ is an even function of x.

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Author's Comment[7]

The author would like to thank Mr. Hartman for raising the several points in his note. Hartman's first point of relevance raises the interesting paradox leading to a contradiction of inequalities between the variable t and τ. This is easily avoided by folding the other function as noted in the original note[8] and carefully defining the range of variation of t and τ. Therefore, making use of the property of symmetry in folding,[9,10]

$$g_2(t) = \int_0^t (\tau) g_1(t - \tau) d\tau$$

$$= \int_0^t g_1(\tau) k(t - \tau) d\tau. \tag{1}$$

* Received by the IRE, September 9, 1960.

[1] A. A. Wolf, "The significance of transients and steady-state behavior in nonlinear systems" (Correspondence), Proc. IRE, vol. 48, pp. 1480–1481; August, 1960.

[2] S. Doba, Jr., "The significance of transients and steady-state behavior in nonlinear systems" (Correspondence), Proc. IRE, vol. 48, pp. 1480–1481; August, 1960. See also: H. A. Sabbagh, "Transient and steady-state behavior in linear and nonlinear systems" (Correspondence), Proc. IRE, vol. 48, pp. 1492–1493; August, 1960.

[3] A. A. Wolf, "The significance of transients and steady-state behavior in nonlinear systems" (Correspondence), Proc. IRE, vol. 47, pp. 1785–1786; October, 1959.

[4] M. E. Munroe, "Introduction to Measure and Integration," Addison-Wesley, Cambridge, Mass., p. 183; 1953.

[5] W. W. Rogosinski, "Volume and Integral," Oliver and Boyd, Edinburgh, Scotland, p. 99; 1948.

[6] M. J. Lighthill, "Fourier Analysis and Generalized Function," Cambridge University Press, Cambridge, Mass.; 1959.

[7] Received by the IRE, October 17, 1960.

[8] Wolf, *op. cit.*, footnote 7.

[9] G. Doetsch, "Theorie und Anwendung der Laplace Transformation," Dover Publications, Inc., New York, N. Y.; 1943.

[10] M. Gardner and J. Barnes, "Transients in Linear Systems," John Wiley and Sons, Inc., New York, N. Y., vol. 1; 1942.

Now noting for reference that

1) $-\infty < \tau < \infty$

2) $g_1(\tau)u(\tau) = \begin{cases} g(\tau); & \tau > 0 \\ 0; & \text{otherwise,}[11] \end{cases}$

3) $k(\tau)$ is defined in the interval $(-\infty, \infty)$.

The innermost integral of (1) was used previously.[3] To settle the apparent paradox we shall use the outermost integral. Both give the same result, since the problem referred to does not appear in the open interval $(0, t)$. Therefore, splitting the integral as suggested previously gives

$$\int_0^t g_1(\tau)k(t-\tau)d\tau = \int_0^\infty g_1(\tau)k(t-\tau)d\tau - \int_t^\infty g_1(\tau)k(t-\tau)d\tau. \quad (2)$$

Consider the first integral of the right member. Certainly t can take on any value in the open interval from $(0, \infty)$ and the three conditions given above are satisfied. The second integral likewise satisfies the three given conditions and, moreover, t can take on any value on the positive half line. Therefore, the point raised by Hartman is of no import. Consequently, the previous conclusions are not altered as a result. Particularly the integral

$$g_{2T}(t) = \int_t^\infty g_1(\tau)k(t-\tau)d\tau \quad (3)$$

is not necessarily zero in general as explained previously.[1]

Hartman's second point is not germane to the present problem despite the importance of the theorem which is alluded to in his note. The theorem[12] precisely stated is:

"If f is an integrable function such that $\int_F f d\mu = 0$ for every measurable set F, then $f=0$ almost everywhere."[13]

The theorem[12] does not apply to the present case since (3) is generally not zero.

Perhaps my use of the term "null function" is ludicrous. To be precise, if E represents the set for which (4) is satisfied, *i.e.*,

$$E = \{t : f(t) > 0\}, \quad (4)$$

then if

$$\int_E f d\mu = 0, \quad (5)$$

it follows that

$$\mu(E) = 0 \quad (6)$$

or E is a set of measure zero.

In general, if E is not a set of measure zero and f is positive over E then

$$\int_E f d\mu \neq 0. \quad (7)$$

Hartman has also shown that (3) is not zero for certain singular functions. Therefore, no problem seems to exist here since it agrees with the original note.

Finally, I should like to note that the example given previously[1] is relevant, since the forcing function clearly satisfies the required conditions, namely, that it is the unit step function.

I should now like to turn my attention to answering Sabbagh's reply to my original note. First may I thank him for his comments. Sabbagh raises several points, some of which are not pertinent to the original note nor germane to the question at hand. However, in general I cannot agree with his statements and claims. In the first place, the convolution integral is quite general for a class of linear systems. If one desires to take initial conditions into effect, he only has added a set of terms that are linear combinations of derivatives of the Dirac delta function to the forcing function $g_1(t)$; *i.e.*,

$$g_1{}^*(t) = g_1(t) + \sum_{k=1}^{n} a_{k-1}\delta^{(n-k)}(t) \quad (8)$$

for an nth order system where the coefficients a_j are determined by the initial conditions for $1 \leq j < n$, and $g_1{}^*(t)$ is the generalized forcing function containing the initial conditions. The next point deals with the integral given in (3). The claim is that $g_{2T}(t) \equiv 0$. This is not proven by Sabbagh, and the point is adequately answered above and in my reply to Hartman. Sabbagh's definition of the transient response of a nonlinear system is inconsistent with the transient terms appearing in a corresponding linear system since he does not indicate the effect of discontinuities in the forcing function.

The last statement in his note is most interesting,[2] "Perhaps the most general method of attacking nonlinear equations is via the perturbation and Poincaré-Bendixson theories making use of metric topology." If Sabbagh has any ideas leading to a general theory, he should publish them.

In conclusion, I should like to note that although I do not agree in general with the comments of Doba, Hartman, and Sabbagh, I nevertheless thank them for their views.

ACKNOWLEDGEMENT

I am indebted to J. Dietz with whom I have had the opportunity to discuss these comments and whose advice I have found invaluable. I should also like to thank Dr. J. Randolph, D. Keim, Dr. R. Weller, and K. Lord for their encouragement.

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[11] $u(\tau)$ is the unit step function as defined by Gardner and Barnes, *op. cit.*

[12] P. R. Halmos, "Measure Theory," D. Van Nostrand Co., Inc., Princeton, N. J.; 1956.

[13] μ is a measurable set function generally finite, non-negative, and additive on a given ring.

Analysis of Transient and Steady-State Behavior*

I would like to add some comments to those already made concerning the splitting of the convolution integral.[1-3] The general convolution integral for linear constant coefficient systems relating a forcing function $g_1(t)$ and the response function $g_2(t)$ can be written in either of the two forms:

$$g_2(t) = \int_{-\infty}^t K(t-\tau)g_1(\tau)d\tau \qquad K(t-\tau) = 0 \; \tau > t \quad (1)$$

or,

$$g_2(t) = \int_0^\infty K(\tau)g_1(t-\tau)d\tau \qquad K(\tau) = 0, \tau < 0 \quad (2)$$

where $K(t)$ is the impulse or delta function response of the system.

Eq. (1) obviously can be split into two integrals:

$$g_2(t) = \int_{-\infty}^t K(t-\tau)g_1(\tau)d\tau = \int_{-\infty}^{0^+} K(t-\tau)g_1(\tau)d\tau + \int_{0^+}^t K(t-\tau)g_1(\tau)d\tau. \quad (3)$$

The first integral takes into account the effect of initial conditions. Nonzero initial conditions can be transformed into an equivalent forcing function $g_1(t)$. The second integral represents the response for a quiescent system to a forcing function applied at $t=0$, *i.e.*, $g_1(t)=0$ for $t<0$. If we specify that $g_2(t)=0$ for $t \leq 0^-$, $g_1(t)$ is determined uniquely as the forcing function plus a sum of delta function and its derivatives. For the case of a second-order system:

$$L_t g_2(t) = a_2\frac{d^2g_2(t)}{dt^2} + a_1\frac{dg_2(t)}{dt} + a_0 g_2(t) = g_1(t) \quad t > 0$$
$$= 0 \quad t < 0$$

with

$$g_2(0^+) = c_1 \qquad g_2(t) = 0$$
$$\text{for } t \leq 0^-.$$
$$g_2'(0^+) = c_2 \qquad g_2'(t) = 0$$

It can be shown that the effective forcing function including the initial conditions is:

$$L_t g_2(t) = g_1(t) + (a_1c_1 + a_2c_2)\delta(t) + a_2c_1\delta'(t).$$

Eq. (3) then becomes

$$g_2(t) = \int_{-\infty}^{0^+} K(t-\tau)[g_1(\tau) + (a_1c_1 + a_2c_2)\delta(\tau) + a_2c_1\delta'(\tau)]d\tau + \int_{0^+}^t K(t-\tau)[g_1(\tau) + (a_1c_1 + a_2c_2)\delta(\tau) + a_2c_1\delta'(\tau)]d\tau$$
$$= (a_1c_1 + a_2c_2)K(t) - a_2c_1K'(t) + \int_{0^+}^t K(t-\tau)g_1(\tau)d\tau.$$

* Received by the IRE, October 7, 1960; revised manuscript received, October 21, 1960.

[1] A. A. Wolf, "The significance of transients and steady-state behavior in nonlinear systems," PROC. IRE, vol. 48, pp. 1785–1786; October, 1959.

[2] S. Doba, Jr., "The significance of transients and steady-state behavior in nonlinear systems," PROC. IRE, vol. 48, pp. 1480–1481; August, 1960.

[3] H. A. Sabbagh, "Transient and steady-state behavior in linear and nonlinear systems," PROC. IRE, vol. 48, pp. 1492–1493; August, 1960.

As an example, consider the response to a unit step of voltage applied at $t=0^+$ of an RC integrator with an initial voltage V_0 on the capacitor. The effective forcing function is:

$$g_1(t) = 1 + \frac{V_0}{\alpha}\delta(t)$$

$$K(t) = \alpha e^{-\alpha t} \quad \text{where} \quad \alpha = \frac{1}{RC}.$$

Then,

$$g_2(t) = \int_{-\infty}^{0^+} \frac{V_0}{\alpha}\alpha e^{-\alpha(t-\tau)}\delta(\tau)d\tau + \int_{0^+}^{t} \alpha e^{-\alpha(t-\tau)}d\tau$$

$$= V_0 e^{-\alpha t} + 1 - e^{-\alpha t} = 1 - (1 - V_0)e^{-\alpha t}.$$

Dr. Wolf[1,2] split the convolution integral into two parts:

$$g_2(t) = \int_{0^+}^{t} K(t-\tau)g_1(\tau)d\tau$$

$$= \int_{-\infty}^{t} K(t-\tau)g_1(\tau)d\tau - \int_{-\infty}^{0^+} K(t-\tau)g_1(\tau)d\tau. \qquad (4)$$

He then identified the first integral as the steady-state response and the second as the transient response. Strictly, the splitting is correct only for zero initial conditions. For arbitrary initial conditions, one can still obtain the correct response, provided one can simulate the initial conditions by a $g_1(t)$ in the transient part which differs from the $g_1(t)$ in the steady-state part. In the example above, *e.g.*, the appropriate expressions would be:

$$g_1(\tau) = 1 + \frac{V_0}{\alpha}\delta(\tau) \qquad -\infty < \tau < 0^+$$

$$= 1 \qquad -\infty < \tau < t.$$

If the initial conditions are zero, *i.e.*, $V_0=0$, then $g_1(t)=1$ at all times. For $\tau<0$, the two integrals have the same value and thus cancel out in the response; therefore, the splitting seems to be redundant and does not place in evidence that a unit step is applied at $t=0^+$.

Alternatively, an nth order differential equation $L_t g_2(t) = g_1(t)$ with initial conditions

$$\frac{d^i}{dt^i} g_2(0) = c_i \qquad (i = 0, 1, \cdots n-1)$$

can be solved by first obtaining a fundamental set of solutions $\{\phi_j(t)\}$, which are the solutions of the homogeneous system

$$L_t\phi_j(t) = 0$$

$$\frac{d^i}{dt^i}\phi_j(0) = 0 \quad i = 0, 1, \cdots, j-1, j+1, \cdots, n-1$$

$$= 1 \quad i = j.$$

The complete solution is then

$$g_2(t) = \sum_{i=1}^{n} c_i\phi_i(t) + \int_{0^+}^{t} K(t-\tau)g_1(\tau)d\tau. \qquad (5)$$

Eqs. (3) and (5) are identical. The solution $g_2(t)$ is unique for $t>0$. For zero initial conditions, (3) and (5) reduce to the more familiar convolution integral

$$g_2(t) = \int_{0^+}^{t} K(t-\tau)g_1(\tau)d\tau.$$

The author wishes to thank Dr. A. A. Pandiscio for a critical reading of the manuscript.

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A Possibility for Determining the Existence of a Permanent Form of Magnetic Field-Aligned Ionization Irregularities*

It is interesting to consider the results that might be obtained when an oblique-looking radar, sensitive enough to obtain incoherent scatter from individual electrons[1] in the E and F layers, is directed in such a way that its beam intersects the earth's magnetic field lines in the E and F layer at perpendicular incidence.

Field-aligned ionization in the Arctic has been shown to exist a very large percentage of the time by use of auroral radars[2-4] and by the study of radio star scintillations.[5]

In the middle latitudes, routine observations with oblique HF ionospheric radars have demonstrated the existence of field-aligned ionization at E- and F-layer altitudes.[6,7] In addition, radio star scintillation experiments have also verified the existence of this field-aligned ionization.[8]

More recently, field-aligned ionization in the equatorial regions has been conclusively identified using HF ionospheric radars as part of the IGY program.[9] In addition, oblique VHF radio circuits[10] have also shown that much of the anomalous VHF propagation occurring at the equator is due to field-aligned ionization which is in some way related to the equatorial electrojet.

The existence of such field-aligned ionization over a wide portion of the earth has been well demonstrated, and the occurrence of echoes is at such a high level as to indicate that some form of field-aligned ionization is present all of the time provided a sensitive enough radar is used.

The concept of incoherent scatter[1] can be described by

$$\text{signal-to-noise ratio} = \frac{PA\delta N\sigma}{4R^2FkTB}$$

where

P = peak power of the radar,
A = antenna collecting aperture of the radar,
δ = pulse width of the radar,
N = electron density of the media,
σ = scattering cross section per solid angle of a single electron,
R = range to the reflection point,
F = noise figure of the receiving system,
k = Boltzmann's constant,
T = equivalent temperature of the receiver,
B = bandwidth of the receiving system.

Thus if a radar is sufficiently sensitive (*i.e.*, if peak power and collecting aperture are large enough), echoes from electrons in the ionosphere can be detected. The strength of the echoes is proportional to the radar sensitivity and the number of electrons which exist in the region being studied.

Radar echoes from field-aligned ionization arise due to scattering from blobs of ionization whose length is greater along the magnetic field lines than across them. Such scattering is most efficient when the radar signals intersect the magnetic field lines at right angles. That is to say, field-aligned scattering exhibits aspect sensitivity.

Such scattering has been mathematically described by Booker[11] by the formula

$$\sigma_B = \frac{2^{3/2}\pi^3}{\lambda_N{}^4}\left(\frac{\overline{\Delta N}}{N}\right)^2 T^2L \exp\left[\frac{-8\pi^2T^2}{\lambda^2}\right] \cdot \exp\left[\frac{-8\pi^2L^2\psi^2}{\lambda^2}\right]$$

where

σ_B = the backscatter coefficient per unit solid angle per incident power density,
λ_N = plasma wavelength,
$\overline{(\Delta N/N)^2}$ = mean square fractional deviation of electron density,
L = correlation distance along the field line,

* Received by the IRE, October 14, 1960.
[1] W. E. Gordon, "Incoherent scattering of radio waves by free electrons," Proc. IRE, vol. 46, pp. 1824–1829; November, 1958.
[2] K. L. Bowles, "Some Recent Experiments with VHF Radio Echoes from Aurora and Their Possible Significance in the Theory of Magnetic Storms and Auroras," Ph.D. dissertation, School of Elec. Engrg., Cornell University, Ithaca, N. Y.; June 1, 1955.
[3] R. B. Dyce, "Communication Aspects of VHF Auroral Reflections," Ph.D. dissertation, School of Elec. Engrg., Cornell University, Ithaca, N. Y., June 1, 1955.
[4] R. L. Leadabrand, L. T. Dolphin, and A. M. Peterson, "Preliminary results of 400-Mc radar investigations of auroral echoes at College, Alaska," IRE Trans. on Antennas and Propagation, vol. AP-7, pp. 127–136; April, 1959.
[5] J. M. Lansinger, C. G. Little, R. P. Merritt, and E. Stiltner, "Fluctuations in the apparent amplitude and position of extraterrestrial radio sources as observed near the auroral zone," IRE Trans. on Antennas and Propagation, vol. AP-5, p. 319; July, 1957.
[6] A. M. Peterson, O. G. Villard, R. L. Leadabrand, and P. B. Gallagher, "Regularly observable aspect-sensitive radio reflections from ionization aligned with the earth's magnetic field and located within the ionospheric layers at middle latitudes," J. Geophys. Res., vol. 60, pp. 497–512; December, 1955.
[7] R. B. Dyce, L. T. Dolphin, R. L. Leadabrand, and R. A. Long, "Aurora-like radar echoes observed from 17° latitude," J. Geophys. Res., vol. 64, pp. 1815–1818; November, 1959.
[8] H. G. Booker, "The use of radio stars to study irregular refraction of radio waves in the ionosphere," Proc. IRE, vol. 46, pp. 298–314; January, 1958.
[9] R. D. Egan, "Anisotropic field aligned ionization irregularities in the ionosphere near the magnetic equator," J. Geophys. Res., vol. 65, pp. 2343–2358; August, 1960.
[10] K. L. Bowles, R. Cohen, G. R. Ochs, and B. B. Balsley, "Radio echoes from field aligned ionization above the magnetic equator and their resemblance to auroral echoes," J. Geophys. Res., vol. 65, pp. 1853–1855; June, 1960.
[11] H. G. Booker, "A theory of scattering by nonisotropic irregularities with application to radar reflections from the aurora," J. Atmos. Terrest. Phys., vol. 8, p. 204; 1956.

T = correlation distance transverse to the field line,

λ = radio wavelength,

ψ = off-perpendicular angle with respect to earth's magnetic-field lines.

Typical values found from VHF and UHF Alaskan auroral studies[12] for the various terms are

$L = 3.5$ meters,

$T = 0.1$ meter,

λ_N = corresponds to 10^6 electrons /cm^3,

$\overline{(\Delta N/N)^2} = 6\times10^{-4}$.

As some radar auroral studies have indicated very high percentages of occurrence, and considering the high likelihood of the natural inhomogeneity of the atmosphere, it is reasonable to expect that a value for $\overline{(\Delta N/N)^2}$ would very seldom be far below 6×10^{-4}.

If the values of L, T, and λ_N found in the aurora are retained, an echo strength equivalent to incoherent scatter from the same region will occur when $\overline{(\Delta N/N)^2} = 10^{-11}$.

Thus, if one used a radar of sufficient sensitivity to obtain oblique incoherent scatter echoes from the E and F region, a signal-to-noise level greater than incoherent scatter would be seen where the line of sight from the radar intersects the E and F regions of the ionosphere at perpendicular incidence to the earth's magnetic field lines.

It is recognized that the values of L and T may not be the same during a nonvisual auroral condition as during a strong aurora. However, little experimental evidence exists to indicate that L and T do change. In fact, many physical facts concerning the atmosphere lead one to believe that T may not change. For example, the gyro diameter of the positive ions is in the order of one meter; the mean free path of nitrogen molecules is in the order of a meter; the gyro diameter of 5-kev electrons (found by rocket measurements[13]) is also in the order of one meter. The strength of field-aligned scattering most likely is primarily dependent upon values of $\overline{(\Delta N/N)^2}$.

The exciting possibility of verifying the existence of a permanent form of field-aligned ionization utilizing radars of sensitivity sufficient to obtain incoherent scatter suggests that such measurements be conducted in the near future. Future high-power radar sensitivity will undoubtedly be limited by incoherent scatter. Even above this, future high-power radar sensitivity may be limited by field-aligned scattering from a weak, although permanent, field-aligned ionization.

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[12] R. I. Presnell, R. L. Leadabrand, A. M. Peterson, R. B. Dyce, J. C. Schlobohm, and M. R. Berg, "VHF and UHF radar observations of the aurora at College, Alaska," *J. Geophys. Res.*, vol. 64, pp. 1179–1190; September, 1959.

[13] C. E. McIlwain, "Direct Measurement of Particles Producing Visible Aurora," Physics and Astronomy Dept., State University of Iowa, Iowa City, Rept. SUI 60-7; June, 1960.

Value Engineering—1959*

The review of "Value Engineering 1959"[1] seemed out of place in a scientific journal. The review was condescending and nonobjective. The subject matter of the book is too well thought of among responsible people and too spectacular in its results to merit the arch and cavalier treatment it received from the reviewer.

Value engineers do not take the position that "common sense and Yankee ingenuity" have not been applied to design problems for years. Unfortunately, both the structure of American industry and the education of our engineers combine to inhibit the full application of common sense and Yankee ingenuity to design problems.

In industry, the functions of engineering, accounting, purchasing and manufacturing are separated into specialized departments which, in practice, have a tangential interest in each other. Even when pulled together on committees, the department representatives are seldom able to explore thoroughly the possibilities of value analysis applied to a particular project. The activities of committees tend to be generalized and there is seldom time to bird-dog individual programs. Aside from committees, departments meet on an incidental basis, often in a state of crisis, when aspirin-thinking is the mood. The chain of command in organizational structure, the over-specialization of departments and the angle-of-attack of departments *vis-à-vis* each other, all conspire to filter out good old Yankee horse sense.

The education of American engineers also mitigates against Yankee ingenuity. The average engineer has too much specialized knowledge to digest in his learning years to acquire "common sense" (*i.e.*, manufacturing experience, time study, cost accounting, quality assurance techniques, etc.). Most importantly, engineers do not know enough about the making of things. They are not usually drawn from the ranks of machinists and toolmakers, as is frequently the case in Europe. And in their work years they are also not exposed to direct experience with machine problems, dies, brakes and inspection equipment.

The value engineer is not a degree man only. To qualify, he must also have broad experience in the fields his brother engineers are not familiar with. A value engineering group reports to management, and its activity cuts across department lines. Such a group works through existing departments by focussing the attention of different department specialists on value analysis projects.

One could say that this activity is something any management could do for itself without giving it a fancy name. One could also say that toolmakers could do their own inspecting, accountants could do their own billing and posting, and management could run a few scope readings. But in fact this is not done.

In the past forty years, we have been told we did not need efficiency experts, time and motion people, or quality control programs. The need for all these is recognized today, and appropriate activities are incorporated in every industrial organization. It is now time to assess the potentialities of value engineering in the sober light of rising costs and corporate complexity and to do so by a less emotional yardstick than an appeal to Yankee ingenuity.

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* Received by the IRE, August 23, 1960.

[1] "Value Engineering 1959, EIA Conference on Value Engineering," reviewed by R. R. Batcher, PROC. IRE, vol. 48, p. 1348; August, 1960.

Author's Comment[2]

Mr. MacCarthy and the author are not in disagreement with the main objectives of the EIA Conference—that of getting better equipment designs. Nowhere in the review was it even intimated that this concept could not function. Some of the reasons he cites why less-than-perfect designs sometimes occur are undoubtedly correct. I expect that my main error was in considering that this book gave enough sound advice to engineers to warrant a review in this magazine. I regret that the book gave offense. From comments received from others personally I hear that my views were not singular. I concur most emphatically with the editorial[3] which stated in part:

"Whatever is done in the name of value engineering can be done more effectively within the design engineering organization. It simply means exercising some of the neglected techniques of good design."

Whether effective designing procedures are established in a company by roving groups of value engineers or by adequate supervisional assistance to the actual designers is perhaps no more than a matter of company titles. Then, some companies do not discount the beneficial effect of the value engineer concept on potential clients by their public espousal of this "new" plan for improving their products, which may be its most important contribution

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[2] Received by the IRE, October 18, 1960.

[3] *Machine Design*; September, 1960.

Variable Capacitance Diodes Used as Phase-Shift Devices*

In a recent note,[1] some experimental results were presented on the use of variable capacitance diodes as phase-shift devices. This note is intended to present a simple derivation of the measured results and to discuss some variations of the parameters utilized.

* Received by the IRE, October 21, 1960.

[1] R. N. Hardin, *et al.*, "Electronically-variable phase shifters utilizing variable capacitance diodes," PROC. IRE, vol. 48, pp. 944–945; May, 1960.

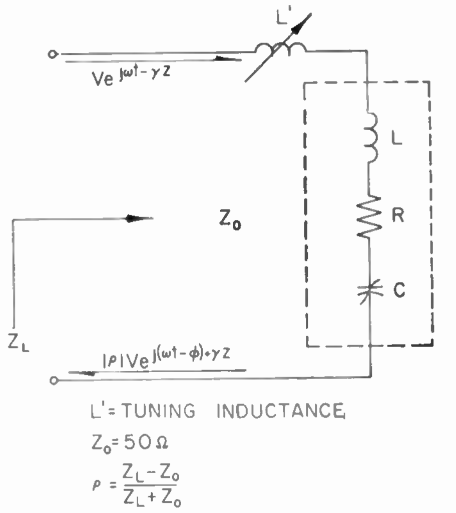

Fig. 1—Phase-shift circuit.

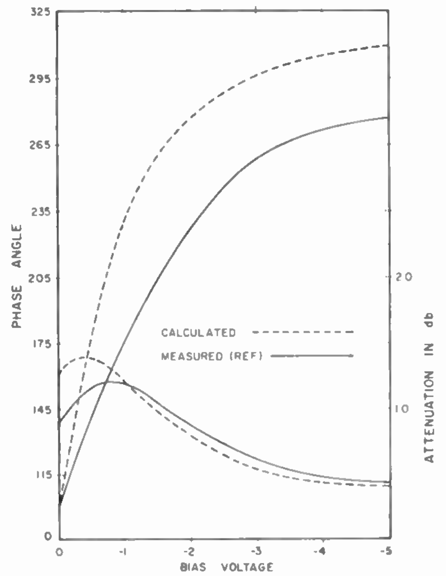

Fig. 2—Phase shift and loss at 1 kMc.

The model assumed for this analysis is a lossless transmission line terminated in a voltage-tuned diode as in Fig. 1.

The reflection coefficient is defined as $\rho = |\rho| e^{j\phi}$. For the termination shown, the following are obtained:

$$|\rho| = \frac{\sqrt{[(1-\omega^2LC)^2 + \omega^2C^2(R^2 - Z_0^2)]^2 + 4Z_0^2\omega^2C^2(1-\omega^2LC)^2}}{(1-\omega^2LC)^2 + (R+Z_0)^2\,\omega^2C^2}, \tag{1}$$

and

$$\phi = \tan^{-1}\left[\frac{2\omega^3C^2LZ_0 - 2\omega CZ_0}{(1-\omega^2LC)^2 + (R^2 - Z_0^2)\omega^2C^2}\right]. \tag{2}$$

There are two types of diode functions available, but we will confine our attention to the abrupt function type where C is defined as[2]

$$C = \frac{C|_{v=0}}{\sqrt{1 - v/\phi}} = \frac{C_0}{\sqrt{1 - v/\phi}}.$$

For this work we will take $\phi = \frac{1}{3}$. Substitution of these expressions in (1) and (2) gives

$$|\rho| = \frac{\sqrt{\left[\left(1 - \frac{\omega^2LC_0}{\sqrt{1-3v}}\right)^2 + \frac{\omega^2C_0^2(R^2 - Z_0^2)}{1-3v}\right]^2 + \frac{4Z_0^2\omega^2C_0^2}{1-3v}\left(1 - \frac{\omega^2LC_0}{\sqrt{1-3v}}\right)^2}}{\left(1 - \frac{\omega^2LC_0}{\sqrt{1-3v}}\right)^2 + \frac{(R+Z_0)^2\,\omega^2C_0^2}{1-3v}}. \tag{3}$$

and

$$\Phi = \tan^{-1}\left[\frac{2\omega^3C_0^2LZ_0 - 2\omega C_0Z_0\sqrt{1-3v}}{(\sqrt{1-3v} - \omega^2LC_0)^2 + (R^2 + Z_0^2)\omega^2C_0^2}\right]. \tag{4}$$

From these expressions, we observe that two changes of sign are possible for certain restricted parameters. Hence, it is possible for a phase shift of 180° to occur. The restrictions on the variables are as follows:

$$1 < \omega^2LC_0 < \sqrt{1-3v}$$

and

$$(1 - \omega^2LC_0)^2 < \omega^2C_0^2(Z_0^2 - R^2) < (\sqrt{1-3v} - \omega^2LC_0)^2.$$

It is observed that these restrictions are not independent and the constants must be juggled in order to obtain the desired combinations.

At $f = 1000$ Mc, the specifications of the Hughes HPA-2800 require about 10 MUH additional inductance to fulfill the above restrictions, and this can be provided by the use of tuned stubs. Reference to Fig. 2 indicates about 210° of phase shift can be expected from the diode with $\omega^2LC_0 = 1.5$.

Note that the curves are very similar in form and cover about the same range as the curves measured in Hardin.[1] The discrepancy may be due to variations of the diode characteristics from the average values used for the calculations. The linear range of both the measured and calculated curves are about the same.

Using (3), the loss calculations are also plotted on Fig. 2. It is seen that the calculated losses are slightly higher in the region of less than one-volt bias, but are almost equal for the rest of the range.

Setting the derivative of (3) equal to zero gives the bias where the maximum loss can be expected. This gives

$$v = \frac{1 - (\omega^2LC_0)^2}{3}$$

and in the case of the HPA-2800, $v \approx -0.4$. At this point, the value of $|\rho|$ becomes

$$|\rho|_{\max} = \frac{(R^2 - Z_0^2)}{(R + Z_0)^2}. \tag{5}$$

From this relation, we see that the maximum loss depends only on the ratio of R/Z_0 or on the series resistance of the diode. Therefore, it appears that Z_0 should be made as high as possible, but still maintain the restrictions on the other parameters involved, in order to further reduce the losses associated with the phase shift of the diode.

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[2] C. Blake, "Review of reactance amplifier theory," in "Solid State Microwave Amplifiers and Oscillators," University of Michigan, Ann Arbor, Summer Session; 1960.

Model Parameter Controls for an Adaptive System*

In an adaptive control system, the time-varying parameters of a plant are monitored by means of sensing and computing elements. The resulting information is used to provide a basis for optimum controller action. Thus, a plant dynamic characteristic is maintained "optimum" essentially independent of time, *i.e.*, independent of changing environmental conditions, inertia parameters, etc.

A particularly interesting approach to an adaptive system is centered in the utilization of a learning or self-evaluating plant model. The model, an analog of the plant which contains time-varying parameters, is excited in parallel with the plant. The difference between the response of the plant and that of the model provides a feedback signal for inner control loops and the adjustment of the parameters of the model. This adjustment or control maintains the model parameters in close correspondence to the slowly changing parameters of the plant. Sensing elements transmit the model parameter values to the optimum controller.

The design of model parameter controls for an adaptive system is a complex nonlinear problem. To the writer's knowledge, it has not been solved for a plant of order higher than the first. A clarification of the design problem seems to be needed before a significant attempt at a solution can be made. This note is directed specifically toward the design problem of model parameter controls for adaptive systems; the points raised, however, are also pertinent to other adaptive system design methods.

In an attempt to clarify the statement of the design problem, the following specifica-

* Received by the IRE, October 26, 1960.

tions are suggested for an "ideal" model parameter control applied to an nth-order, linear, time-varying plant:

1) The parameter controls are to be accomplished on the basis of the availability of the instantaneous value of the plant excitation function, the plant and model responses, and with the possible use of instantaneous values of the first derivative and integral of these functions.

2) All model parameters are to be adjusted continuously and simultaneously as a result of the continuously monitored "error" information.

3) Any detected plant-model response "error" is to be used in the adjustment of all the model parameters so that the difference between the model parameters and the respective unknown plant parameters approach zero monotonically.

4) Conditions 1), 2) and 3) are to be accomplished for well-behaved finite excitation functions, such as sinusoidal, step, ramp, polynomial, or exponential functions or their combinations, with the provision that these functions need not be initiated at the same time.

5) The speed of approach of the model parameters toward the respective plant parameters is to be at a maximum rate consistent with good over-all system stability.

There is reason to believe that a model parameter control satisfying these specifications cannot be designed. Thus, it is desirable to examine the broader significance of the model parameter controls for adaptive systems in an attempt to provide a relaxation of these specifications. The following questions are suggested to aid this examination:

1) What is the manner by which the model parameters are to be made available for ultimate system optimum control? Will the parameter values be used to provide instantaneous information for plant optimum controller action, or will the parameter values be used at suitable time intervals to correct stored information?

2) Is it necessary to adjust all model parameters simultaneously, or can this be done in a pattern sequence, adjusting only one or a few of the parameters during a single disturbance, part of a disturbance, or a set of disturbances?

3) What is the nature of the expected plant-model disturbances? Will the disturbances be restricted in magnitude and separated sufficiently in time for the system dynamics (including the parameter adjustment dynamics) to reach steady state before the next disturbance is applied?

4) What are the maximum allowable differences between respective plant and model parameters, following an adjustment?

A particularly difficult requirement of the model parameter control design, for example, is to insure a monotonic approach of the model parameters toward the unknown plant parameters. Answers to the first three questions may permit the relaxation of this requirement. While the answer to the fourth question would certainly be pertinent to the problem of instrumentation, it could also guide approximations for further analytical work, such as the effective reduction of the order of the plant and model.

Model parameter combinations appear as derivative coefficients in the model characteristic equation. It seems intuitive that there is merit in designing for the adjustment of higher-order derivative coefficients during the first portion of a step response and for the adjustment of the lower derivative coefficients during the final portion of the response. Consequently, an answer to the second question could prove valuable.

A complete resolution of the design problem of model parameter controls is intimately associated with the information available in a differential equation solution. The magnitude of the derivative coefficients certainly affects the solution of a nonhomogeneous differential equation, and it is this effect that must be detected and utilized for the model parameter controls. It is this effect, furthermore, that establishes the nature of a set of realizable "ideal" specifications.

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Reduction of Beam Noisiness by Means of a Potential Minimum Away from the Cathode*

During the course of experimental work performed on a low-noise traveling wave tube, a reduction of beam noisiness which is thought to be a result of the existence of a potential minimum at some distance from the cathode was observed. Observations of this sort using the type of gun shown in Fig. 1 have been made by others.[1,2]

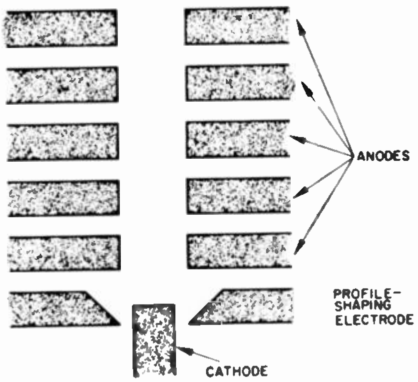

Fig. 1.

The electrode configuration of the gun employed is that of the Hughes low-noise gun[1] as shown in Fig. 1. When the anode voltages were fixed and the voltage of the profile-shaping electrode was slowly increased, the current passing through the gun would gradually rise until a particular value of this increasing voltage was reached. At this time, the current would suddenly jump to some lower value and remain at that value for all higher values of the increasing voltage. If the profile-shaping electrode voltage was decreased from a high value, the upward jump in current appeared at a slightly lower voltage than the drop in current for increasing voltage.

This type of behavior is almost identical to that described by Fay, Samuel, and Shockley for electrons injected with homogeneous initial velocities between parallel plane electrodes.[3] They showed that when the point of instability is reached, the transmitted current density should suddenly drop to 22.5 per cent of its previous value. A decrease in current of this magnitude should not be expected in a finite beam in which current density and potential are not uniform in the transverse direction.

Fig. 2, which is a plot of some typical data taken at 2700 Mc with fixed anode voltages, shows that the drop in current at the discontinuity was small. This suggests that the instability with its accompanying drop of the potential to zero actually took place, when it first occurred, over a small portion of the cross section of the beam. Because of the geometry of the cathode-first-anode region, the beam was thought to be largely hollow. Therefore, the depression of potential to zero which would occur first on the inner edge of the hollow beam would not involve a large fraction of the current.

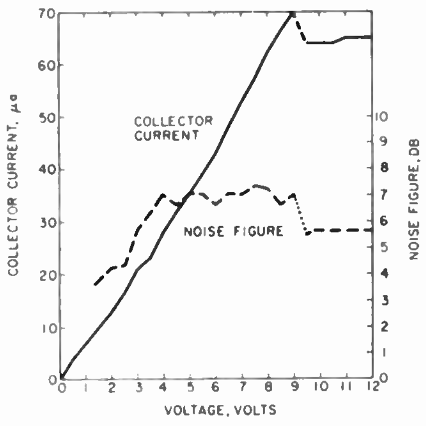

Fig. 2.

The fact that the transmitted current changed very little when the profile-shaping electrode voltage was increased far above the value necessary to produce the discontinuity suggests that the portion of the beam which was not cut off increased in density, while the region of zero potential slowly extended radially outward. It is also possible that the outer radius of the beam expanded slightly as a result of the increased radial gradient of potential which resulted from the depression

* Received by the IRE, October 25, 1960.

[1] M. R. Currie and D. C. Forster, "New method of noise reduction in electron beams," *J. Appl. Phys.*, vol. 30, pp. 94–103; January, 1959.

[2] M. Coulton and G. E. St. John, private communication of observations made at Bell Telephone Labs.

[3] C. E. Fay, A. L. Samuel, and W. Shockley, "On the theory of space charge between parallel plane electrodes," *Bell Sys. Tech. J.*, vol. 17, pp. 49–79; January, 1938.

of its center to cathode potential. Both of these effects would tend to increase the gain of the tube without an increase in current—a phenomenon which was observed.

The most significant result of this experiment was a sudden discontinuous decrease in the noise figure of the tube when the discontinuity in the transmitted current occurred. For the conditions of Fig. 2, this decrease was 1.5 db and the noise figure in the constant current region was constant.

There were a number of conditions for which this kind of result could be obtained, but for one set of conditions the even more spectacular effect of Fig. 3 resulted. In this case, the noise figure dropped 2.1 db at the discontinuity and then rose abruptly to remain approximately 1 db lower than for the region to the left of the discontinuity. This effect was reproducible and was measured several times. Hysteresis in the noise figure corresponding to that in the current-voltage characteristic was also measured.

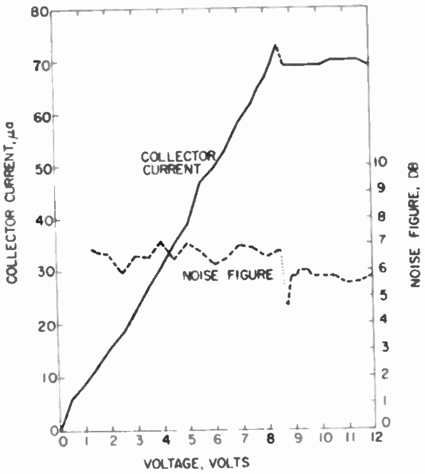

Fig. 3.

Results of calculations recently published[4,5] indicate that beam noisiness can be reduced by allowing a multivelocity beam to drift at a low potential or by accelerating it slowly through a low-potential region. It seems clear from the above data that there was a reduction in the noisiness of the beam as a result of its passage through a potential minimum away from the cathode. In addition to a reduction in noisiness due only to the passage of the beam through a low-potential region, it is possible that some velocity sorting occurred at this potential minimum and that this affected beam noisiness. Also, the returned current interacting with the forward current in the long region between the cathode and its potential minimum, if any, and this potential minimum could have had some effect on noise propagating on the beam.

Although the exact mechanism is as yet unknown, it is reasonable to expect that a potential minimum returning a larger part of the beam or perhaps several minima in series, as contemplated by Jory,[6] could have even more interesting consequences than those reported here. It should be noted that the noise performance shown in Fig. 2 is not representative of our better guns. These have produced noise figures below 3 db with no such potential minima.

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[4] A. W. Shaw, A. E. Siegman, and D. A. Watkins, "Reduction of electron beam noisiness by means of a low-potential drift region," Proc. IRE, vol. 47, pp. 334–335; February, 1959.

[5] M. R. Currie and W. M. Mueller, "Noise propagation on uniformly accelerated multivelocity electron beams," *J. Appl. Phys.*, vol. 30, pp. 1876–1880; December, 1959.

[6] H. Jory, University of California, private communication.

Vertical Incident Doppler Ionogram*

The vertical movement of the ionosphere was precisely observed by the Doppler shift method which utilized the standard frequency transmission, and considerable information about the radio wave propagation and the ionosphere was obtained.[1,2] However, there are still some disadvantages in this method. The first one is that the observational error caused by the relative frequency difference between the oscillator in the transmitter and the reference oscillator in the receiver remains. Secondly, since the reflection is made by the ionosphere of the large area because of the oblique incidence, it is difficult to observe the movement of the small area.

The authors constructed an apparatus to overcome these disadvantages. The block diagram of the apparatus is shown in Fig. 1. The 100-kc continuous wave oscillator is followed by the continuous frequency multiplier, which are both heavily shielded. The 400-kc output signal is introduced to the gated frequency multiplier, which is followed by the gated buffer amplifier. Finally, the 2-Mc pulsed wave is amplified by the power amplifiers and transmitted from the antenna to the vertical direction. The reflected signal from the ionosphere is received at the pose interval of the transmitter. After some amplification, the receiving signal is introduced to the phase sensitive mixer and mixed with the 2-Mc reference signal which is introduced from the continuous frequency multiplier. The keying procedure in the *E* layer observation is shown in Fig. 2. The transmitting and receiving antennas are both horizontal half-wavelength and have vertical directivity by the earth reflection. They are stretched perpendicularly to each other in order to minimize the direct coupling.

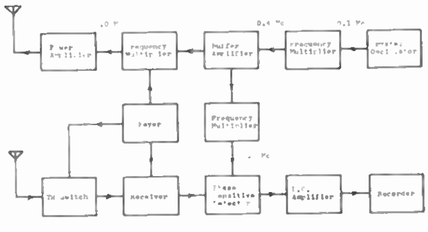

Fig. 1—Block diagram of apparatus.

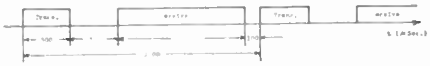

Fig. 2—Keying procedure in *E* layer observation.

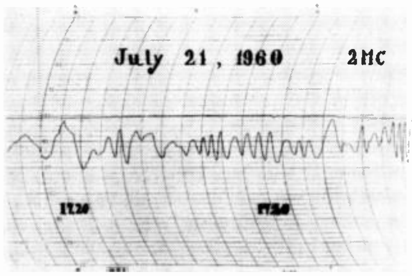

Fig. 3—Typical example of record in *E* layer reflection.

When this method is used, the error produced by the frequency fractionization of the oscillator becomes very small, because only the variation in the short time interval in which the radio wave goes to and from the earth's surface and the ionosphere comes into question. This variation is estimated to the order of 10^{-10} or smaller in the case of the bridge crystal oscillator now used. With this vertical incidence method, the reflection area is small compared with the oblique incidence method, although the directivity of the antenna is not so sharp.

Fig. 3 shows a typical example of the *E* layer observational record. The frequency variations are 4.2 to 16.7×10^{-9}; these values correspond to the vertical velocity of the ionosphere of 0.63 to 2.51 meters per second.

The observation is now continued and the additional refinement is planned so as to be able to specify the direction of the vertical movement of the ionosphere by the 90° reference signal.[1]

The authors express their sincere thanks to Prof. I. Takahashi and Prof. K. Maeda of Kyoto University for their encouragement and valuable suggestions. They are also much obliged to the other members of their seminar for their assistance.

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* Received by the IRE, November 7, 1960.

[1] T. Ogawa, "Frequency variations in short-wave propagation," Proc. IRE, vol. 46, pp. 1934–1939; December, 1958.

[2] T. Ogawa, "Ionosphere observations by Doppler effect," *Rept. Ionosphere and Space Res. Japan* (to be published).

Dispersive Properties of Broad-Band Antennas*

Several types of antennas which operate over extremely wide frequency bands have been developed recently. Examples are the log-periodic and the spiral. The patterns and input impedance of these antennas are nearly constant over many octaves.

The measurement techniques commonly used to determine the performance of antennas give detailed information about the variation of amplitudes with frequency, but the delay, or dispersive properties, are seldom measured or specified.

Most of the so-called broad-band antennas are dispersive, and introduce distortion when used for the transmission of signals requiring a pass band which approaches that of the antenna.

Some measurements of dispersion in microwave antennas have been made using a very short, fast-risetime, dc pulse and a sampling oscilloscope. In contrast to the pulsed carrier techniques normally used at microwave frequencies, the dc pulse has a spectrum which covers many octaves and, in conjunction with a wide band sampling oscilloscope, is ideal for dispersion measurements. The experimental setup is shown schematically in Fig. 1. Typical results obtained with a pair of 6-inch diameter, 16-turn spiral antennas are given in Fig. 2. In the upper half of Fig. 2(a), the output of the pulse generator is shown. The pulse width is 1.3 nsec, and amplitude is approximately 50 volts. The width of the display is 45 nsec.

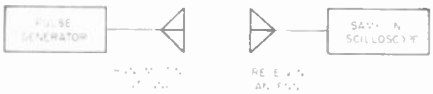
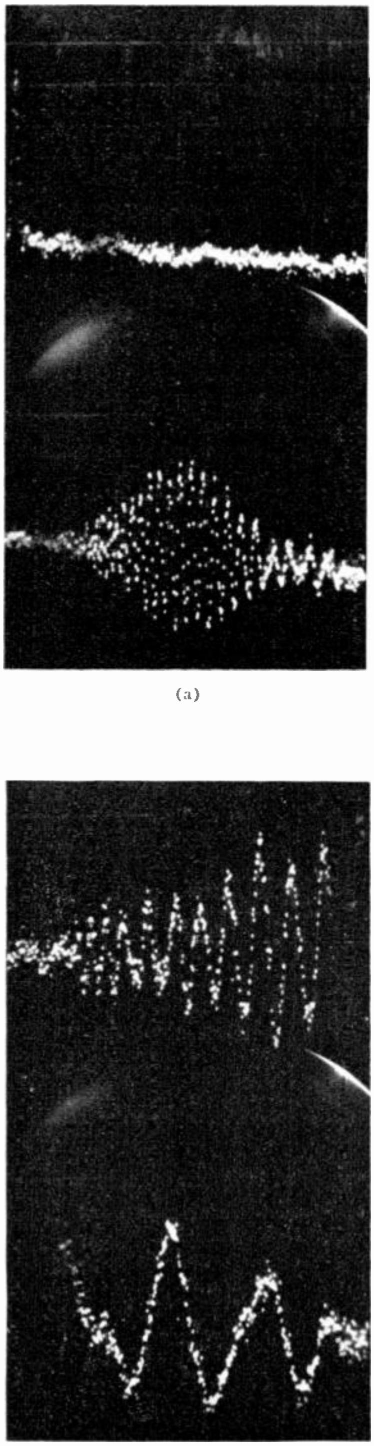


Fig. 1.



(a)

(b)

Fig. 2.

In the lower half of Fig. 2(a), the signal output from the receiving spiral is displayed. Again the sweep width is 45 nsec. The output has the form of a pulsed carrier whose frequency varies from about 3500 Mc at the leading edge to 400 Mc at the tail 30 nsec later.

Fig. 2(b) shows expanded views of the leading and lagging edges of the output pulse. The sweep length is 9 nsec in both cases.

Other measurements have been made using broadside and end-fire log-periodic antennas, broad-band dipoles, T-fed slots, and horns. All of these antennas show some dispersion, which in general increases with the bandwidth of the antenna.

The dispersive property might possibly be utilized for pulse compression, as for example in chirp radars.

The technique has also been used to study UHF and microwave components other than antennas which require an input signal having a spectrum which is nominally flat over many octaves. The results obtained are interesting and sometimes quite unexpected.

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* Received by the IRE, October 31, 1960.

A Low-Loss, Semiconductor Microwave Switch*

A new semiconductor switch configuration has proven to be very useful. Rather than mounting the diode in the center of the transmission line, as in the normal switch,[1] this device mounts it in the arm of symmetry of an H-plane tee. As a basis of comparison, using the same 1N419 diode[2] in each type of mount produces the following characteristics: in the normal switch, 28 db peak isolation, with a minimum insertion loss of 0.7 db and 1.3 VSWR; in the tee switch, 14 db peak isolation, with less than 0.1 db insertion loss and 1.08 VSWR. A CW power-handling capability of 4 watts is common to both types. The tee switch has a narrower bandwidth, usually less than 2 per cent at 3 db below peak isolation, but, in addition to its very low insertion loss, it has a useful peak isolation which is tunable over the greater part of a waveguide frequency range.

A flat-faced sliding short will completely block the arm of symmetry of an H-plane tee if it is located at the junction of the arm, flush with the main guide wall; the main guide is then effectively a length of straight waveguide which gives nearly perfect transmission. As this short is moved away from the junction, a point of maximum attenuation of the transmitted signal is reached. If a diode is then inserted at distance a, as in Fig. 1, and biased in the forward direction, it will introduce a small phase shift which necessitates readjustment of the short (distance b in Fig. 1) to again obtain maximum isolation of the signal. When the bias is reversed, the diode no longer passes energy to the short, but acts as a short itself, giving almost as much main guide transmission as the sliding short had given when located at the junction. Note that the polarity is reversed from that of the normal switch.

Fig. 2 shows the isolation as a function of frequency for a fixed position of short and diode. Insertion loss is less than 0.1 db over the entire range except between 9.15 and 9.25 kMc, where a cavity resonance effect between short and diode brings it above the isolation curve to peak at 0.3 db. The secondary peak at 10.4 kMc results from the fact that the short is in the position of the second isolation maximum for this frequency; at the first maximum, a half wavelength closer to the junction, isolation would improve, and bandwidth would increase greatly. For a fixed position of the diode, the short may be tuned to give a maximum isolation for any frequency in the range, as indicated by the upper line in the graph, which is the envelope of isolation peaks. The insertion loss at each adjustment is less than 0.1 db. The choice of distance a depends on the diode and the frequency or frequencies to be used. Fig. 3 shows the effect of this distance on peak

* Received by the IRE, November 4, 1960.

[1] R. V. Garver, E. G. Spencer, and M. A. Harper, "Microwave semiconductor switching techniques," IRE Trans. on Microwave Theory and Techniques, vol. MTT-6, pp. 378–383; October, 1958.

[2] M. Bloom, "Microwave switching with computer diodes," *Electronics*, vol. 3, pp. 85–87; January 15, 1960.

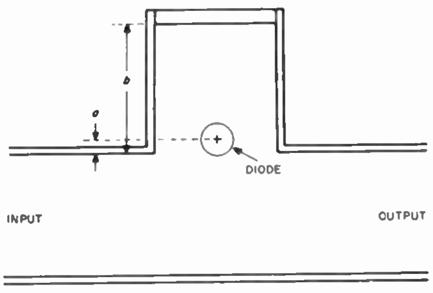

Fig. 1—Diode mounted in H-plane tee, RG 52/U guide.

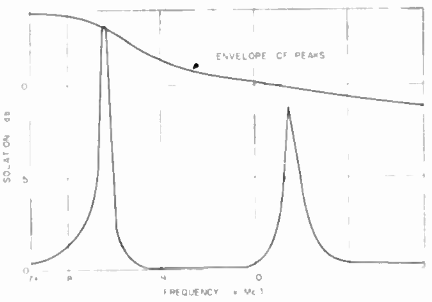

Fig. 2—Isolation for 8.4 kMc switch, with envelope of peaks obtained by adjusting short.

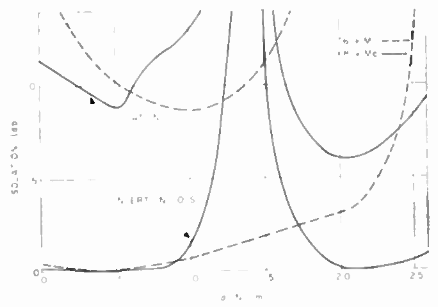

Fig. 3—Isolation and insertion loss vs distance of diode from junction, for two frequencies in RG 52/U guide.

isolation and insertion loss at two widely different frequencies. These characteristics vary considerably for different types of diodes. For some diodes and frequencies, there is an a which will give isolations of 20 db, still with 0.1 db insertion loss.

Cascaded mounts can produce high isolations or wider bandwidths. For example, two mounts have given 26 db peak isolation with 0.15 db insertion loss. A C-band tee switch has performed similarly. Besides possible systems applications, such as TR devices, the switch has much value in lab work; it can modulate RF a thousand times faster than generally available modulators, with only 0.08 watt bias power.

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Sub-Surface Communication Systems*

Much interest has recently been shown in subsurface or "earth current" communication systems, more precisely defined as communication systems wherein transmitting and receiving "antennas" are buried in the ground. The immunity of the hardware of such a system to hazards, either natural or man-made, is evident. The author has found, in perusing the early history of radio development, that the results of transmitting to distances of a *few* miles, recently heralded as significant achievements, certainly are not new.

During World War I, James H. Rogers presented to the U.S. Navy Department a system which was tested in transmitting and receiving from underground and underwater antennas with creditable results. Let us cite some specifics: A straight-line antenna enclosed in an air-filled coaxial cavity formed by the earth or a surrounding cylinder (as done in recent experiments) provided transmission capability of 50 miles. Antenna depths from 3 to 50 feet were employed. Spiral antennas were also tested with equally satisfactory results by lowering into a well; transmitting power consisted of a few hundred watts; the frequency was 10 kc to 40 kc. European stations were received with this system, and of course the particularly noteworthy characteristic at that time was the absence of "static."

Rogers' name has not been mentioned, to this author's notice, in any reports of experiments or theoretical descantings on the rebirth of interest in this subject. Much could be said about the numerous instances of re-experimentation, rediscovery, and reinvention, which information has long since gathered dust in technical depositories, but it will suffice to say that Rogers unquestionably contributed more to this subject than is realized by most practitioners of today, not to mention the pioneering work of Nikola Tesla which Rogers had gratefully acknowledged.

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* Received by the IRE, November 17, 1960.

A Cyclotron Wave Amplifier with Magnetic Pumping*

Siegman[1] has recently described an amplifier in which the coupling between slow and fast cyclotron waves is produced by a twisted electrostatic quadrupole structure.

* Received by the IRE, November 21, 1960.

[1] A. E. Siegman, "The dc pumped quadrupole amplifier—a wave analysis," Proc. IRE, vol. 48, pp. 1750–1755; October, 1960.

Another type of coupling mechanism exists in which a transverse twisting magnetic field is used to effect the interaction between the fast and slow waves rather than an electrostatic field.

The equations of motion for the electrostatic quadrupole coupler, as given by Siegman are

$$\frac{d^2x}{dt^2} + \omega_c \frac{dy}{dt} - \eta \frac{\partial V}{\partial x} = 0 \tag{1}$$

$$\frac{d^2y}{dt^2} - \omega_c \frac{dx}{dt} - \eta \frac{\partial V}{\partial y} = 0. \tag{2}$$

He assumes a potential function for the quadrupole

$$V = -\frac{K}{2}[(x^2 - y^2)\sin 2\beta_q z - 2xy\cos 2\beta_q z]. \tag{3}$$

If the equations of motion are now set up for transverse magnetic fields B_x and B_y, assuming that the axial field is uniform as before and equal to $m\omega_c/e$ then

$$\frac{d^2x}{dt^2} + \omega_c \frac{dy}{dt} - \eta u_0 B_y = 0 \tag{4}$$

$$\frac{d^2y}{dt^2} - \omega_c \frac{dx}{dt} + \eta u_0 B_x = 0, \tag{5}$$

where u_0 is the axial velocity. Suppose the magnetic field can be derived from a potential function Φ such that

$$B_x = \frac{\partial \Phi}{\partial x}, \qquad B_y = \frac{\partial \Phi}{\partial y},$$

then the potential function given below when substituted in (4) and (5) gives the same equations of motion as substituting (3) into (1) and (2).

$$\Phi = \frac{K}{2u_0}[(y^2 - x^2)\cos 2\beta_q z - 2xy\sin 2\beta_q z]. \tag{6}$$

Note that (6) is identical with (3) if the origin of the z coordinate system is moved by an amount $\pi/4\beta_q$.

There are several possible ways of setting up a twisting magnetic field having a potential function near the axis of the form required by (6). The most obvious is a magnetic quadrupole structure where the poles are magnetized N-S-N-S. A staggered quadrupole structure is envisaged in which alternate quadrupoles along the length of the coupler are rotated through 90°. By utilizing a permanent magnet construction, one could possibly magnetize each quadrupole in a longitudinal as well as a transverse direction, thereby providing the cyclotron field.

The required distribution may also be produced by a two-start helix, each wire of the helix carrying equal current in the same direction; or by a four-start helix in which one set of diametrically opposite wires carries current in one direction, the other pair of wires carrying the same current in the reverse direction.

For a four-start helix, radius a, each conductor carrying a current I, the appropriate potential function is

$$\Phi = \frac{I\mu_0}{\pi a^2}[(y^2 - x^2)\cos 2\beta_q z - 2xy\sin 2\beta_q z]. \tag{7}$$

From (6) and (7), therefore,

$$K = \frac{2I\mu_0 u_0}{\pi a^2}. \tag{8}$$

The gain coefficient[1] is given by

$$\alpha = \frac{\eta K}{u_0\omega_c} = \frac{2\eta I\mu_0}{\pi\omega_c a^2}.$$

Note that the gain coefficient is independent of u_0. Putting in the values $B_0=500$ gauss, $I=10$ amperes, and $a=2$ mm gives $\alpha=3.5$ db/cm.

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Bi-Signal Amplification by a Forward Wave Crossed-Field Amplifier*

The simultaneous amplification by a forward wave crossed-field amplifier of two signals differing in frequency has been observed. Pulsed operation was employed. The time relationships between the amplifier voltage pulse and each signal pulse could be varied at will by means of delay networks. Gain characteristics of the forward wave crossed-field amplifier with emitting sole have been reported earlier.[1] The measurements to be described here were performed on the same tube at X-band frequencies.

The first experiments were designed to test the following hypothesis: Suppose, for a fixed amplifier voltage, we can adjust the relative signal strength such that the RF power generated by the amplifier at signal frequency (1) in the absence of a signal at frequency (2) is equal to the generated power at signal frequency (2) in the absence of a signal at frequency (1). Then under these same voltage and RF input conditions but with the two signals injected simultaneously, the RF generated power at each frequency should remain equal to each other; however, each will be of the order of half that obtained in the absence of a second signal. We now restate the proposition in terms of gain and establish its basis. We define the quantities:

- G = electronic gain,
- $P(V)$ = peak RF output power with voltage on,
- $P(O)$ = peak RF output power with voltage off,
- P' = RF power generated in the amplifier.

Subscript 1, 0 refers to properties of signal (1) in the absence of signal (2). Subscript 1, 2 refers to properties of signal (1) in the presence of signal (2). Subscripts 2, 0 and 2, 1 are similarly defined for properties of signal (2):

$$G \equiv \frac{P(V)}{P(O)} = \frac{P' + P(O)}{P(O)} = 1 + \frac{P'}{P(O)}$$

$$(G-1)P(O) = P'.$$

We have considered that at constant amplifier voltage we can set

$$P_{10}' = P_{20}'.$$

Then

$$(G_{10}-1)[P(O)]_{10} = (G_{20}-1)[P(O)]_{20}$$

$$(G_{10}-1) = (G_{20}-1)\frac{[P(O)]_{20}}{[P(O)]_{10}} = (G_{20}-1)C_0$$

where C_0 is as constant of the order of unity. Rewriting, we get

$$\frac{G_{10}}{G_{20}} = C_0 + \frac{1-C_0}{G_{20}} \approx C_0 \approx 1.$$

The measured dependence of the RF output power on the RF input power[1] indicates that the forward wave crossed-field amplifier with emitting sole operates normally under conditions approaching a saturated amplifier. Under such circumstances, the power generated by the amplifier is relatively insensitive to the signal level. Therefore, the magnitude of RF generated power is mainly fixed by the magnitude of the dc input power. If two signals have the same capability of interacting with the dc power, it would be expected that the RF power generated would divide equally between the two signal frequencies. In the experiment, we have compensated for differences in electronic efficiency at different frequencies by adjusting signal strengths and have used the condition $P'_{10}=P'_{20}$ as a criterion for equality of interaction capability. (When simultaneously injected, each signal sees twice the dc impedance obtained in the absence of the other. We assume the relative interaction capabilities remain constant.) Thus, for voltage conditions $V_{10}=V_{20}=V_{12}=V_{21}$, RF conditions such that $P'_{10}=P'_{20}$ and operation approaching that of a saturated amplifier we expect

$$\frac{G_{12}}{G_{21}} \approx C_0 \approx 1 \tag{1}$$

$$G_{12}/G_{10} \approx G_{21}/G_{20} \approx \tfrac{1}{2}. \tag{2}$$

Eqs. (1) and (2) have been verified experimentally for the frequency pair 9.0 and 9.2 kMc and the pair 9.0 and 9.4 kMc to better then 10 per cent. The difference in circuit propagation constant between 9.0 and 9.4 kMc was 14° per section. Amplification at both frequencies has been observed over a range of relative signal levels. Further experiments have shown that the output frequency can be altered during a voltage pulse by injecting the RF input pulses contiguously in time rather than simultaneously. These results indicate that the forward wave crossed-field amplifier with emitting sole is indeed a saturated amplifier rather than a locked oscillator.

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* Received by the IRE, November 30, 1960.
[1] R. J. Collier, "Gain measurements on a forward wave crossed-field amplifier," PROC. IRE, vol. 49, p. 372; January, 1961.

The Ineffectiveness of Absorbing Coatings on Conducting Objects Illuminated by Long Wavelength Radar*

The coating effects which Hiatt, Siegel and Weil[1] describe have long been known in optics.

When an electromagnetic wave is incident upon a conductor (a reflecting surface), a standing-wave pattern is produced. At the surface, the amplitude of vibration (electric vector) is, of course, zero, since the surface is a conductor. If an absorbing material whose thickness is small as compared to the wavelength is placed on the surface, it will have little effect on the standing-wave pattern, since it corresponds to a region of near zero vibration.[2]

Wiener[3] in 1890 first demonstrated the existence of this standing-wave pattern. He used a thin photographic film which made a small angle to a front-surface mirror. The incident light caused a standing-wave pattern which blackened the emulsion along a series of lines where the film cuts antinodes of the standing wave.

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Authors' Comment[4]

The coating effects Mr. Laikin refers to in his letter concern films that are thin compared to a free space wavelength and deposited on objects whose size and radii of curvature are both very large compared to the wavelength. This is a different situation from that considered in our paper[1] where the object itself is small compared to the free space wavelength.

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* Received by the IRE, September 26, 1960.
[1] R. E. Hiatt, K. M. Siegel, and H. Weil, "The ineffectiveness of absorbing coatings on conducting objects illuminated by long wavelength radar," PROC. IRE, vol. 48, pp. 1636–1642; September, 1960.
[2] G. Hass, "Filmed surfaces for reflecting optics," *J. Opt. Soc. Am.*, vol. 45, pp. 945–952; November, 1955.
[3] O. Wiener, *Wiedem. Ann.*, vol. 40, p. 203; 1890.
[4] Received by the IRE, October 17, 1960.

A Simplified Technique for the Determination of Output Transforms of Multiloop, Multisampler, Variable-Rate Discrete-Data Systems*

The analysis of pulsed-data feedback control systems generally requires the determination of the output transforms of the

* Received by the IRE, March 16, 1960; revised manuscript received, December 2, 1960.

system. In the case of multiloop, multisampler, variable-rate control systems, the output transform is usually rather difficult to determine. The need for a simple, yet general, method of deriving the system output transform has long been felt. Recent publications[1,2] have indicated much interest in solving this difficult but important problem. However, the methods proposed in the literature appear either quite involved or lack of generality. This note attempts to present a simple, general approach for finding the output transforms of multiloop, multisampler control systems.

The method involves three major steps:

1) The given sampled-data system is first described by a conventional signal-flow graph. If the given system is of the multirate or variable-rate type, it can be reduced to equivalent single-rate configuration by use of the concept of equivalent samplers.[3] Based upon the principle of superposition, the equations describing the signal at each node of the system are written down by inspection of the conventional signal-flow graph for the system. The node signal is equal to the sum of all the signals fed into that node. These signals are derived from all possible input sources through various transmission branches and from the output terminals of all possible samplers which are not blocked by another sampler. For instance, at node n, the node signal is given by

$$X_n(s) = \sum_j a_j(s)X_j^*(s) + \sum_k b_k(s)R_k(s). \quad (1)$$

In the above equation, $X_j^*(s)$ is the pulsed signal from the sampler following node j, which will flow to node n; $a_j(s)$ is the transmission from the sampler following node j to node n, which is not blocked by another sampler; $R_k(s)$ is the input signal applied at node k, which will flow to node n; $b_k(s)$ is the transmission from node k to node n, which is not blocked by a sampler. Examples illustrating the derivation of these node-signal equations are presented in the following paragraphs. After the equations for the node signals have been written down, the z transform (or starred transform) for each term of the equations are taken. This yields a set of z-transform equations for node signals:

$$X_n^*(s) = \sum_j a_j^*(s)X_j^*(s) + \sum_k \overline{b_k(s)R_k(s)}^* \quad (2)$$

or

$$X_n(z) = \sum_j a_j(z)X_j(z) + \sum_k b_kR_k(z). \quad (3)$$

2) From (2) or (3), derive a pulsed-signal flow graph. Clearly, this derivation is simple and straightforward.

3) Applying Mason's theorem,[4] determine the output transform of the system. The sampled-data system described by a pulsed-signal flow graph is shown in Fig. 1. The output in response to inputs $I_j^*(s)$ is $C^*(s)$. Then

$$C^*(s) = \frac{1}{\Delta^*(s)} \sum_{j=1}^{n} \left[I_j^*(s) \sum_k G_k^*(s)\Delta_k^*(s) \right], \quad (4)$$

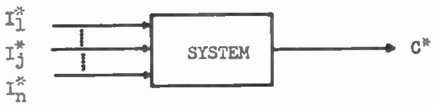

Fig. 1—Pulsed-signal flow-graph representation for discrete-data systems.

where

$\Delta^*(s) = 1 -$ (sum of all individual loop gains),
$+$(sum of the product of loop gains of all possible nontouching loops taken two at a time),
$-$(sum of the product of loop gains of all possible nontouching loops taken three at a time),
$+ \cdots,$

$G_k^*(s) =$ gain of the kth forward path,

$\Delta_k^*(s) =$ value of $\Delta^*(s)$ for that part of the pulsed-signal flow graph not touching the kth forward path.

The above procedure is quite simple and perfectly general. It can be used to analyze multiloop, multirate and variable-sampling control systems with multiple inputs and outputs. The application of this technique is illustrated by examples. It is to be noted that the procedure involved in Step 2 and Step 3 is essentially the solution of simultaneous equations given in (2) by the flow-graph technique. Thus, an alternate approach to the determination of output transforms is to solve the node-signal equations (2) by use of determinants.

Example

Consider the multiloop system shown in Fig. 2. Determine the z transform and the modified z transform of the system output.

The signal flow graph for the given system is sketched in Fig. 3, from which the node-signal equations are derived:

$$X_1 = R_1 - X_3^*H_1,$$

$$X_2 = R_1G_1 - X_3^*(G_1H_1 + H_2) + R_2,$$

$$X_3 = R_1G_1G_2 - X_3^*(G_1G_2H_1 + G_2H_2) + R_2G_2,$$

$$C = X_3.$$

Taking the starred transforms,

$$X_1^* = R_1^* - H_1^*X_3^*,$$

$$X_2^* = \overline{R_1G_1}^* - (\overline{G_1H_1}^* + H_2^*)X_3^* + R_2^*,$$

$$X_3^* = \overline{R_1G_1G_2}^* - (\overline{G_1G_2H_1}^* + \overline{G_2H_2}^*)X_3^* + \overline{R_2G_2}^*.$$

From the above equations, a pulsed-signal flow graph is drawn in Fig. 4. Applying (4), one obtains

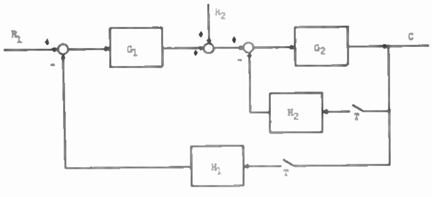

Fig. 2—Block diagram for the illustrative example.

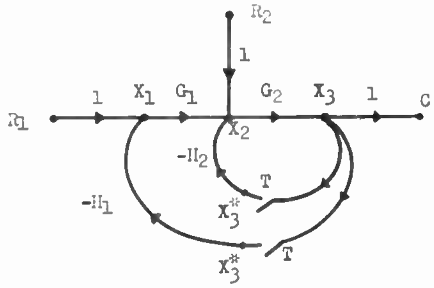

Fig. 3—Signal flow graph for the system of Fig. 2.

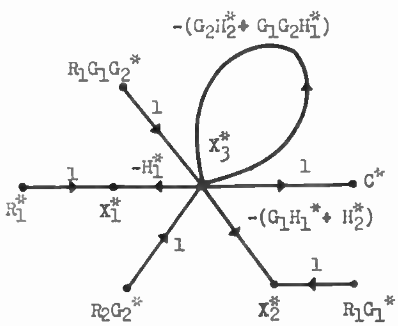

Fig. 4—Pulsed signal flow graph for the system of Fig. 2.

$$C^* = \frac{\overline{R_1G_1G_2}^* + \overline{R_2G_2}^*}{1 + \overline{G_2H_2}^* + \overline{G_1G_2H_1}^*}.$$

Since, by inspection of Fig. 3,

$$C = R_1G_1G_2 + R_2G_2 - (G_1G_2H_1 + G_2H_2)X_3^*$$

the output transform is

$$C(s) = R_1G_1G_2(s) + R_2G_2(s)$$
$$- \frac{[R_1G_1G_2^*(s) + R_2G_2^*(s)][G_1G_2H_1(s) + G_2H_2(s)]}{1 + G_2H_2^*(s) + G_1G_2H_1^*(s)}.$$

The z transform and the modified z transform are then given by

$$C(z) = \frac{R_1G_1G_2(z) + R_2G_2(z)}{1 + G_2H_2(z) + G_1G_2H_1(z)},$$

$$G(z, m) = R_1G_1G_2(z, m) + R_2G_2(z, m)$$
$$- \frac{[R_1G_1G_2(z) + R_2G_2(z)][G_1G_2H_1(z, m) + G_2H_2(z, m)]}{1 + G_2H_2(z) + G_1G_2H_1(z)}.$$

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Transistor Upper Noise Corner Frequency*

The noise figure F of a transistor amplifier is relatively constant at medium frequencies and increases with increasing frequency above a noise corner frequency f_A, as shown in Fig. 1.

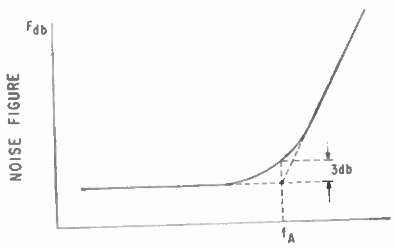

Fig. 1.

The expression usually quoted for the upper noise corner frequency[1] f_A is

$$f_A = f_\alpha \sqrt{1 - \alpha_0} \qquad (1)$$

where

α_0 = low-frequency value of common-base forward-current transfer ratio,

f_α = frequency at which the common-base forward-current transfer ratio has decreased to $\sqrt{2}/2$ times its low-frequency value.

Eq. (1) is calculated from the formula given by Nielsen[2] for noise figure by considering only the collector noise term (fourth term on the right-hand side)

$$F = 1 + \frac{r_b'}{R_g} + \frac{r_e}{2R_g} + \frac{(1 - \alpha_0)\left[1 + \left(\frac{f}{f_\alpha}\right)^2 \frac{1}{(1 - \alpha_0)}\right](R_g + r_e + r_b')^2}{2\alpha_0 R_g r_e} \qquad (2)$$

where

r_b' = ohmic base resistance,
R_g = source resistance,
r_e = dc emitter resistance $= kT/qI_E$
$= 25/I_E(\text{ma})$ ohms,
f = frequency of measurement.

The purpose of this letter is to re-emphasize that in many practical cases the first terms in (2) may be significant so that the noise corner derived from (1) will be too low in general. [This was pointed out by Nielsen but appears to have been forgotten, due to the simple form of the approximate expression, (1).] A second purpose of this letter is to point out that the upper noise corner frequency is, indeed, determined by the alpha-cutoff frequency f_α rather than by the so-called transition frequency f_T,[3,4] defined as the frequency for which the magnitude of the common-emitter forward-current transfer ratio (h_{fe}) can be extrapolated to one (assuming that $|h_{fe}|$ is decreasing at the rate of 6 db per octave).

A more exact form for the upper noise corner frequency is obtained by equating the frequency-dependent term in (2) to the sum of the four non-frequency-dependent terms and solving for the upper noise corner frequency, f_A.

$$f_A = f_\alpha \sqrt{\alpha_0 r_e \frac{(2R_g + 2r_b' + r_e)}{(R_g + r_e + r_b')^2} + (1 - \alpha_0)} \quad (3)$$

or, if $\alpha_0 \leqq 1$,

$$f_A = \frac{f_\alpha}{(R_g + r_e + r_b')} \sqrt{r_e(2R_g + 2r_b' + r_e)}. \quad (3a)$$

TABLE I

Transistor Type	f_T Mc	f_α Mc	α_0	r_b' ohms	r_e ohms	Upper Noise Corner Frequency f_A in Mc when $R_g = 50$ ohms			
						Measured	Computed (1)	Computed (3) with f_α	Computed (3) with f_T
2N544 (DRIFT)	28	40	0.991	22	16.6	24	3.8	23.5	16.5
OC170 (PADT)	88	110	0.992	34	16.6	62	9.8	64.0	49
T1832 (MADT)	275	470	0.9615	38	16.6	280	91.7	268	155
2N1405 (MESA)	460	620	0.984	46	16.6	320	78.4	330	245

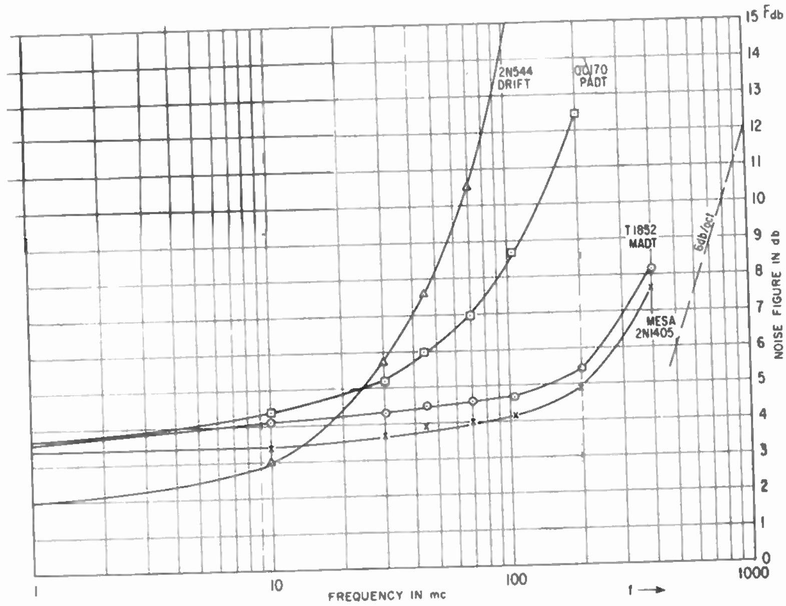

Fig. 2—Experimental values for transistor noise figure vs frequency for four types of germanium high-frequency transistors. $R_g = 50$ ohms, $I_E = 1.5$ ma, and $V_{CB} = -9.0$ volts.

In Table I, transistor parameters are presented for four types of transistor structures, together with calculated values for the upper noise corner frequency, f_A (for a source resistance $R_g = 50$ ohms), using the classical equation (1), and the more exact expression (3) derived above. Also shown is the calculated upper noise corner frequency using the more exact expression (3) but substituting the frequency f_T in place of f_α. The measured values for f_A were obtained from Fig. 2, by locating the frequency at which the noise figure had risen 3 db above the low-frequency (1 Mc) value. Note the very good agreement between measured values and the noise corner calculated according to the more exact equation (3) employing f_α rather than f_T. This is true for a wide variety of transistors with cutoff frequencies ranging from 40 to over 600 Mc.

Experimental values for the noise figure as a function of frequency are shown in Fig. 2. These values are in good agreement with values calculated from Nielsen's (2) using the appropriate transistor parameter data.

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* Received by the IRE, November 16, 1960.

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[3] R. R. Webster and P. G. Thomas, "Letters to the Editor," *Elec. Design News*, vol. 5, pp. 12–13; July, 1960.

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A Note on Instantaneous Spectrum*

Various authors have been interested in the concept of "instantaneous spectrum" and have formulated it in a number of ways. It is the purpose of this note to present a "natural" and interesting method of obtaining an expression for the instantaneous or, more appropriately, the up-to-date, time-varying spectrum of a given (real) signal.

Let the signal of interest, $x(t)$, be fed into a linear, passive, constant-parameter network having frequency and impulse-response function $H(\omega)$ and $h(t)$, respectively, as in Fig. 1. The output $y(t)$ is given by the

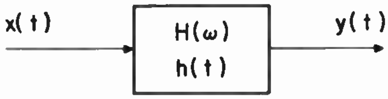

Fig. 1—Signal into a linear, passive network.

familiar superposition or convolution integral as

$$y(t) = \int_{-\infty}^{t} x(u)h(t-u)du.^{1} \qquad (1)$$

This integral is a natural starting point. Since

$$h(t) = \frac{1}{2\pi}\int_{-\infty}^{+\infty} H(\omega)e^{j\omega t}d\omega, \qquad (2)$$

$$y(t) = \frac{1}{2\pi}\int_{-\infty}^{t} x(u)\int_{-\infty}^{+\infty} H(\omega)e^{j\omega(t-u)}d\omega du. \qquad (3)$$

Assuming interchangeability of the order of integration gives

$$y(t) = \frac{1}{2\pi}\int_{-\infty}^{+\infty} H(\omega)e^{j\omega t} \cdot \left[\int_{-\infty}^{t} x(u)e^{-j\omega u}du\right]d\omega. \qquad (4)$$

It seems reasonable, then, to define the bracketed term on the right side of (4) as the *time-varying spectrum, i.e.*,

$$X(\omega, t) \triangleq \int_{-\infty}^{t} x(u)e^{-j\omega u}du. \qquad (5)$$

This spectrum is an up-to-date spectrum and does not depend upon knowing future values of $x(t)$, but only past values, in order to determine the spectrum. Eq. (4) indicates that the output of the filter $y(t)$ is also not dependent upon future values of $x(t)$. Page [3] uses an expression similar to (5) (by defining a running transform of a continually changing auxiliary signal) in formulating the instantaneous power spectrum. By Parseval's theorem, the total energy of the signal up to the time t is

$$E(t) = \int_{-\infty}^{t} [x(u)]^2 du = \frac{1}{2\pi}\int_{-\infty}^{+\infty} | X(\omega, t) |^2 d\omega. \qquad (6)$$

* Received by the IRE, November 21, 1960. This work was supported by the U. S. Signal Corps under Contract No. DA-36-039 sc 78283.

[1] Of course, if $x(t)=0$ for $t \leq t_0$, then the lower limit on (1) and in the appropriate place in many of the succeeding equations will be t_0. This does not alter the analysis in any manner.

Consequently $|X(\omega, t)|^2$ can be considered as the instantaneous *energy density* spectrum (using radian frequency) and the instantaneous *power density* spectrum of the signal $x(t)$ is

$$\rho_{xx}(\omega, t) = \frac{\partial}{\partial t} | X(\omega, t) |^2. \qquad (7)$$

Eq. (5) can be treated as a time-variable transform of the function $x(t)$. Gerlach [8], extending the work of Zadeh [9], discusses integrals of this form and some of their properties. The inverse (transform) of (5) is found readily by first substituting (5) into (4) to give the output of the filter $y(t)$ as

$$y(t) = \frac{1}{2\pi}\int_{-\infty}^{+\infty} H(\omega)X(\omega, t)e^{j\omega t}d\omega, \qquad (8)$$

and then letting $H(\omega)$ be unity, so that $y(t) = x(t)$. Thus, as expected,

$$x(t) = \frac{1}{2\pi}\int_{-\infty}^{+\infty} X(\omega, t)e^{j\omega t}d\omega \qquad (9)$$

is the inverse relationship. However, a very simple and perhaps useful means of transforming the instantaneous spectrum back to the original signal is obtained by differentiating $X(\omega, t)$ of (5) with respect to t, *i.e.*,

$$\frac{\partial}{\partial t} X(\omega, t) = \frac{\partial}{\partial t}\int_{-\infty}^{t} x(u)e^{-j\omega u}du = x(t)e^{-j\omega t}$$

so that

$$x(t) = e^{j\omega t}\frac{\partial X(\omega, t)}{dt}. \qquad (10)$$

This technique is indeed a much simpler operation than (9) and, by the way, appears applicable to the time-variable transform of Gerlach [8].

It should be noted, though, that if $Y(\omega, t)$ is defined in a manner similar to that for $X(\omega, t)$, *i.e.*

$$Y(\omega, t) = \int_{-\infty}^{t} y(u)e^{-j\omega u}du, \qquad (11)$$

it can be readily shown that

$$Y(\omega, t) \neq H(\omega)X(\omega, t).$$

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An Analysis of Recent Measurements of the Atmospheric Absorption of Millimetric Radio Waves*

In a recent paper,[1] the authors reviewed measurements of attenuation of radio waves by atmospheric gases and compared the measured losses with those predicted by Van Vleck.[2,3] It was pointed out that the line breadth constant of 0.02 cm^{-1} chosen by Van Vleck for oxygen seemed to explain the measured losses of this gas, but that the line breadth constant of 0.1 cm^{-1} chosen for water vapor did not satisfactorily account for the losses that had been correlated with changes in water vapor density. A line breadth constant of 0.27 cm^{-1} was used by the authors as a means of approximating the water vapor losses in the millimeter region, but even this expediency left considerable discrepancy between the calculated and measured values of attenuations.

More recent investigations have shown additional anomalies in the absorption of radio waves by atmospheric gases. A critical analysis of these and previous data reveal a pattern which provides at least qualitatively a reason for the large observed values of water vapor attenuation. It is the purpose of this paper to present these new studies and to propose a hypothesis that can explain the measured results.

The data reported in Straiton and Tolbert[1] of water vapor attenuation in the millimeter spectrum were primarily of absorption values in the "windows" where the promise of successful communications and radar applications was greatest. The choice of frequencies at which the measurements were conducted was dictated by the availability of signal generators and the difficulty of measuring relatively small values of water vapor attenuation. One set of measurements described in the previous paper was over the frequency interval of 100 to 118 kMc.[4] These data revealed a considerably higher value of water vapor loss than would have been predicted by interpolation between the results of measurements made at 70 and 140 kMc.

More recently, the Naval Research Laboratory has reported the results of oxygen and water vapor absorption measurements in the region of the 50 to 60 kMc complex of oxygen lines.[5] The data showed water vapor losses 6 to 10 times greater than was indicated by the trend of the values given in Straiton and Tolbert.[1]

Additional water vapor absorption data has been obtained by The University of Texas in conjunction with radiometric measurements of the sun at frequencies of 100,

* Received by the IRE, December 13, 1960. This work was sponsored by the Office of Naval Research, Washington, D. C., under Contract Nonr 375(01).

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[5] K. M. Decker and R. C. Dodson, "Propagation Measurements in the 5-Millimeter Region," Naval Res. Lab., Washington, D. C., Rept. No. 5385; October 19, 1959.

109.8, 116 and 140 kMc.[6,7] On a number of different days, concurrent with the measurement of solar temperatures at these frequencies, the total absorption of radiation passing normally through the atmosphere was obtained. The losses showed a high degree of correlation with the total precipitable water in the atmosphere. From the slope of the lines representing the losses as functions of the total atmospheric precipitable water, it was possible to obtain values of the attenuation in decibels per gram of precipitable water in a square centimeter vertical column. These losses involve and therefore reflect the integrated effect of pressure and temperature upon line widths from essentially one through zero atmospheres. The results, while they cannot be directly compared with those obtained from transmissions over paths near sea level, are, however, significant in the relationship of the magnitude of their relative values.

All of the currently published water vapor absorption data including the transmission losses through the entire atmosphere are shown in Fig. 1. Theoretical water vapor and oxygen losses are shown for the line breadth of constants of 0.1 cm^{-1} for water vapor and 0.02 cm^{-1} for oxygen originally proposed by Van Vleck[2,3]

When the reported water vapor losses are presented as shown in Fig. 1, a distinctive feature is apparent. *The water vapor losses are greatly enhanced near the oxygen absorption lines. It is, therefore, hypothesized that the line breadth constants for the oxygen absorption lines are greatly increased by the presence of water vapor.* While spectroscopists have known that this occurs, they have predicted a change of approximately 10 per cent for the range of water vapor densities to be expected in the atmosphere. If these apparent water vapor losses are actually changes in oxygen losses, the change in line width would need to be much greater than the predicted value.

[6] C. W. Tolbert, W. W. Bahn and L. C. Krause, "Solar Emission and Atmospheric Attenuation of 2.15 mm Wavelength Radiation," Elec. Engrg. Res. Lab., University of Texas, Austin, Rept. No. 5-54; July 15, 1960.

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The existing theories of collisional line broadening do not quantitatively account for so large an effect on oxygen line widths by water vapor. It is to be expected, however, that changes in path attenuation associated with the broadening of oxygen lines by the addition of water vapor would be greater in the "wings" and "skirts" of these lines than the attenuation produced by the water vapor alone. At or near oxygen line

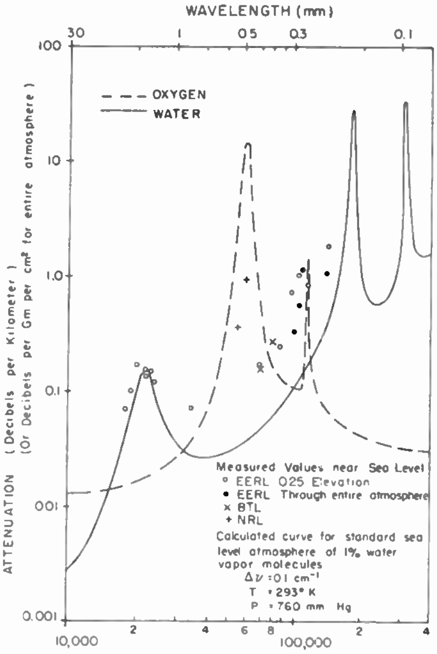

Fig. 1.

center frequencies, the change in path attenuation resulting from the addition of water vapor would be less than the attenuation produced by water vapor alone. The change in path attenuation at frequencies on either side of an oxygen line broadened by water vapor should, therefore, be greater than at the line center frequency or at frequencies far removed from the line center.

In the data reported in Straiton and Tolbert,[1] such a peak was noted somewhat below the 118.7 kMc oxygen line center frequency. The pertinent data are as follows:

Frequency (kMc)	Changes in attenuation vs water vapor density db/km/gram/m³
100.00	0.083
104.75	0.098
110.00	0.142
113.00	0.110
117.50	0.117

The maximum at 110 kMc is not predicted in the current water vapor absorption theory.

The water vapor sensitive losses for transmissions through the entire atmosphere were also enhanced near the 118.7 kMc oxygen lines as shown in Fig. 1. Although the four measured points do not permit locating such a maximum, they indicate that it is closer to the oxygen line center frequency than it was for the sea-level conditions. Since the losses vertically through the atmosphere are associated with progressively narrower line widths with increasing elevation, the effective integrated value of the line widths is therefore less than would be encountered near sea level. Displacement of the peak value of the apparent water vapor losses toward the oxygen line center for narrower line widths is predicted in this hypothesis.

A decreasing loss with increasing water vapor at the 118.7 kMc oxygen line center, dictated by the proposed hypothesis, has not been investigated because of the lack of a signal source operating at this frequency or at its subharmonic.

Measurement by the Naval Research Laboratory showed the water sensitive losses in the midst of the 50 to 60 kMc complex of oxygen lines to be greater than the anticipated trend. If the oxygen losses had resulted from a single line in this frequency interval, the losses would have been expected to decrease instead of increase near the maximum value of the oxygen absorption. Since this was not observed by NRL, it is probably due to the effect of the summation of the individually broadened lines of the complex maintaining an increasing value of oxygen attenuation at the absorption peak for increasing value of water vapor density.

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Convention Highlights

Technical Program

A schedule of 54 technical sessions appears on the next page, followed by abstracts of all the papers to be presented.

The IRE Show

This year's exhibition will again be held in the New York Coliseum at 59th St. and 8th Ave. A list of the 850 exhibitors and their products appears in "Whom and What to See at the IRE Show" in the advertising section of this issue.

Annual IRE Banquet

Time: 6:45 P.M., Wednesday, March 22.
Place: Grand Ballroom, Waldorf-Astoria Hotel.

Speaker: P. E. Haggerty, President, Texas Instruments, Inc., "Where Are the Uncommon Men?"
Toastmaster: D. E. Noble, Executive Vice President, Motorola, Inc.
Presentation of IRE Awards: L. V. Berkner, IRE President
Spokesman for Newly Elected Fellows: C. R. Wischmeyer, Master of Baker College, Rice Institute

Cocktail Party

Time: 5:30–7:30 P.M., Monday, March 20.
Place: Grand Ballroom, Waldorf-Astoria Hotel.

Women's Program

An entertaining program of tours and shows has been arranged for the wives of members, who are also cordially invited to the Cocktail Party and the Annual IRE Banquet. Women's headquarters will be located in the Regency Suite on the fourth floor of the Waldorf.

SCHEDULE OF TECHNICAL SESSIONS

	WALDORF-ASTORIA HOTEL						NEW YORK COLISEUM		
	Starlight Roof	Astor Gallery	Jade Room	Sert Room	Empire Room	Grand Ballroom	Faraday Hall	Marconi Hall	Morse Hall
Monday March 20 2:30 P.M.–5:00 P.M.	*Session 1* DISCRETE AND ADAPTIVE CONTROL SYSTEMS	*Session 2* REACTOR INSTRUMENTATION	*Session 3* ENGINEERING WRITING AND SPEECH	*Session 4* RADIO FREQUENCY INTERFERENCE	*Session 5* ENGINEERING MANAGEMENT		*Session 6* PRODUCT ENGINEERING AND PRODUCTION	*Session 7* ADVANCES IN NAVIGATION AND FLIGHT SAFETY SYSTEMS	*Session 8* ELECTRON DEVICES
Tuesday March 21 10:00 A.M.–12:30 P.M.	*Session 9* CONTROL THEORY AND PRACTICE	*Session 10* NUCLEAR INSTRUMENTATION	*Session 11* BROADCASTING	*Session 12* ELECTRO-ACOUSTICS		*Session 13** ENGINEERING MANAGEMENT	*Session 14* MEDICAL ELECTRONICS	*Session 15* THIS WORLD AND THE ADJACENT ONE	*Session 16* BROADENING DEVICE HORIZONS
Tuesday March 21 2:30 P.M.–5:00 P.M.	*Session 17* CODING THEORY	*Session 18* INDUSTRIAL ELECTRONICS APPLICATIONS	*Session 19* BROADCASTING	*Session 20* STUDIES IN MAGNETIC RECORDING			*Session 21* THE CHANGING ROLE OF BIO-MEDICAL ELECTRONICS IN SCIENCE AND TECHNOLOGY	*Session 22* IMPLEMENTATION OF RELIABILITY PREDICTIONS	*Session 23* MICROWAVE DEVICES
Tuesday March 21 8:00 P.M.–10:30 P.M.						*Session 24* PANEL: NEW ENERGY SOURCES			
Wednesday March 22 10:00 A.M.–12:30 P.M.	*Session 25* DETECTION THEORY AND SIGNAL ANALYSIS	*Session 26* BROADCAST AND TELEVISION RECEIVERS	*Session 27* APPLICATION OF SOLID-STATE DEVICES AS COMPONENTS	*Session 28* SPACE ELECTRONICS		*Session 29** GRADUATE EDUCATION IN ELECTRICAL ENGINEERING	*Session 30* COMMUNICATIONS SYSTEMS—TECHNIQUES	*Session 31* MATHEMATICAL APPROACH TO RELIABILITY PREDICTION	*Session 32* MICROWAVE SOLID STATE
Wednesday March 22 2:30 P.M.–5:00 P.M.	*Session 33* DATA RECORDING AND STORAGE	*Session 34* CIRCUIT THEORY—I	*Session 35* ADVANCES IN COMPONENT DESIGNS	*Session 36* TELEMETRY			*Session 37* COMMUNICATIONS SYSTEMS—BASIC THEORY	*Session 38* PROPAGATION	*Session 39* MICROWAVE MEASUREMENTS
Thursday March 23 10:00 A.M.–12:30 P.M.	*Session 40* ANALOG AND HYBRID TECHNIQUES	*Session 41* CIRCUIT THEORY—II	*Session 42* ULTRASONICS ENGINEERING—I	*Session 43* RADAR	*Session 44* SPACE COMMUNICATION SYSTEMS OF THE FUTURE		*Session 45* HUMAN FACTORS IN ELECTRONICS	*Session 46* ANTENNAS	*Session 47* ADVANCES IN INSTRUMENT CALIBRATION AND PRECISION
Thursday March 23 2:30 P.M.–5:00 P.M.	*Session 48* DIGITAL COMPUTER TECHNIQUES	*Session 49* SYMPOSIUM ON TIME-VARYING NETWORKS	*Session 50* ULTRASONICS ENGINEERING—II	*Session 51* MILITARY ELECTRONICS			*Session 52* VEHICULAR COMMUNICATIONS	*Session 53* ANTENNAS	*Session 54* ADVANCES IN INSTRUMENTATION TECHNIQUES AND SYSTEMS

* Sessions terminate at 12:00 noon.

ABSTRACTS OF TECHNICAL PAPERS

SESSION 1*

Mon. 2:30–5:00 P.M.

Waldorf-Astoria Starlight Roof

DISCRETE AND ADAPTIVE CONTROL SYSTEMS

Chairman: LOUIS B. WADEL, *3546 Caruth Blvd., Dallas, Tex.*

1.1. On "Bang-Bang" Adaptive Control Systems

RICHARD E. KOPP, *Grumman Aircraft Engrg. Corp., Bethpage, N. Y.*

This paper describes techniques for applying the "Adaptive Control" concept of design to a "Bang-Bang" control system. Such a design results in a relay-type control system which will adapt itself to the environment in which it operates. One principal advantage of the relay-type system is that the full output of the actuator is being used at all times. A second and equally important advantage is that the input to the controlled process is always well defined, which is of considerable aid in the determination of the process characteristics.

1.2. A Statistical Measurement of the Effectiveness of Adaptation in Control Systems

R. A. NESBIT, *University of California at Los Angeles, Los Angeles, Calif.*

A statistical measure of the effectiveness of adaptive variation of one or more control parameters is developed in terms of the environmental parameter's distribution. This measure allows the evaluation and comparison of different types of control systems. This comparison is applicable to linear and nonlinear systems with one or many control variables.

The concept of ideal adaptive control with respect to a particular control parameter is defined, and this definition is used to compare a given control system with the ideal adaptive system. This comparison shows where adaptive control is not needed, as well as where it is desirable. System reliability is easily incorporated in the comparison.

This technique is applied to a simple control system to demonstrate the different types of parameter variations and their effect on the value of an adaptive controller.

* Sponsored by the Professional Group on Automatic Control. To be published in Part 4 of the 1961 IRE INTERNATIONAL CONVENTION RECORD.

1.3. An Adaptive System Using Periodic Estimation of the Pulse Transfer Function

S. C. BIEGELOW, *Dept. of Elec. Engrg., Columbia University, New York, N. Y.*, AND H. RUGE, *Central Inst. for Industrial Res. Oslo-Blindern, Norway*

This paper describes a study made of a plant-adaptive sampled data control system. A pulse transfer function model is assumed to describe the plant, and the parameters of this model are automatically adjusted as the plant characteristics change, so as to minimize the weighted sum of errors between plant and model outputs.

The parameters of the model are estimated from measurements of the plant input and output only by means of correlation techniques. No special test signals are used. This method of estimation ordinarily fails during prolonged periods of steady-state operation A method for avoiding this difficulty is presented. Experimental results obtained from a computer simulation are given.

1.4. Digital Computers for Stabilizing Control Systems

W. ZDAN, *American Bosch Arma Corp., Arma Div., Garden City, N. Y.*

The high accuracy capability of digital computers has made it an integral part of many systems. When the system involves control functions, the digital computer may be part of one or more control loops. The sampled nature of the computer output creates a stabilization problem, since the control system operates on sampled data.

The use of conventional networks in sampled data systems creates many design problems. However, digital computers offer a very effective and precise method of compensating such systems so as to meet a desired set of design criteria.

This paper presents a method for designing the compensation difference equations for stabilizing a sampled data control system. The paper shows how a set of design criteria can be met by following a simple set of rules. The dynamic behavior of the system is met by specifying the exact location of the roots of the characteristic equation and then calculating the difference equation to be implemented in the digital computer. The paper illustrates the method of design by working out a sample problem.

1.5. Computer Optimization of Nonlinear Control Systems by Means of Digitized Maximum Principle

S. S. L. CHANG, *Dept. of Elec. Engrg., College of Engineering, New York University, University Heights, New York, N. Y.*

A discrete version of Pontryagin's maximum principle is derived for nonlinear sampled data systems and also continuous systems which can be approximated by difference equations. The computation of the optimal process for minimum time, maximum range, or minimum cost problems by means of the digitized maximum principle is simple, exact, and requires relatively low computer memory. The computed data can be utilized for programmed control, feedback control or adaptive control, depending on the way the control computer is programmed.

SESSION 2*

Mon. 2:30–5:00 P.M.

Waldorf-Astoria Astor Gallery

REACTOR INSTRUMENTATION

Chairman: HAROLD E. DEBOLT, *Avco Res. & Dev. Div., Wilmington, Mass.*

2.1. The Log Count Rate Period Meter Used with Safety Circuits

H. CHRISTENSEN†, *Royal Norwegian Council for Industrial and Sci. Res., Oslo, Norway*, AND R. B. STANFIELD‡, *M.I.T., Cambridge, Mass.*

Automatic protection of nuclear reactors in the start-up range is usually based on the counting of individual neutrons, and care must be taken to avoid spurious reactor scrams due to the inherent noise. A circuit, representative of those used in most reactors, has been analyzed with the application of random noise theory. Formulas are presented which give the probable spurious scram rate as a function of circuit parameters and count rate. The results are discussed and presented to show the limitations and the capabilities of the counter period circuit.

2.2. A Nuclear Reactor Regulating-Rod Position Indicator

R. I. LITTLE, *Phillips Petroleum Co., Atomic Energy Div., Idaho Falls, Idaho.*

* Sponsored by the Professional Group on Nuclear Science. To be published in Part 9 of the 1961 IRE INTERNATIONAL CONVENTION RECORD.
† Now at Argonne Natl. Lab., Argonne, Ill.
‡ Now at Esso Res. Labs., Baton Rouge, La.

This paper discusses some of the aspects of the problem of regulating-rod position indication in the Advanced Reactivity Measurement Facility now in operation at the National Reactor Testing Station. The solution, a system employing a high-resolution shaft angle digitizer and all solid-state digital and analog circuitry, is described. The system's capabilities and shortcomings are reviewed.

2.3. A Digital Start-Up Control Unit for Nuclear Reactors

J. D. Schmidt, B. K. Eriksen, and W. Peil, *GE Co., Syracuse, N. Y.*

This paper describes the design and development of a nuclear reactor start-up control and display unit utilizing the active components (transistors) in a switching mode, either saturated or at cutoff. The unit operates with input pulses that vary in amplitude from 2.5 to 50 mv and pulses spaced as little as 1 μsec apart. The reactor level is obtained as the output of a binary counter and the period is computed using several binary counters that perform a time-modulation division operation. Statistical smoothing of the period computation is obtained by employing a memory unit in the time-modulation computation. Relay driver outputs are provided and both the level and period are displayed with decimal read-out indicators.

2.4. Proportional Control of Pressurized Water Reactors

Donald E. Rathbone, *University of Pittsburgh, Pittsburgh, Pa.*

An investigation of the transient behavior of the CVTR (a pressurized, heavy-water reactor) indicated a definite need for external control to handle even normal load perturbations. Three proportional controllers were developed which were effective in containing the transients of the system for changes in load. A comparison of the three controllers indicated little preference between them with regard to variations in reactor power, primary loop temperature or system pressure. The final selection of a controller was thus an economic consideration.

2.5. Transient Effects of Pulsed Nuclear Radiation on Electronic Parts and Materials

H. J. Degenhart and W. Schlosser, *U. S. Army Signal Res., & Dev. Lab., Fort Monmouth, N. J.*

Transient effects in electronic parts and materials obtained by the most recent experiments conducted at Godiva II pulse reactor will be described and discussed.

The electronic parts exposed to, investigated and monitored under such an environment include: 1) resistors of all types of make and in the range from 100 ohms up to 1 megohm; 2) thermistors; 3) capacitors (ceramic and tantalum); 4) Si- and Se- rectifiers; 5) magnetic cores (ferrites); and 6) coaxial cables.

Typical results obtained on the above parts will be shown and interpreted as to the possible mechanism involved. The instrumentation and setup used in the above experiments will be described briefly.

2.6. Problems of Testing Military Computers and Computer Components in Nuclear Radiation Environments

P. E. Brown and A. L. Long, Jr., *Burroughs Corp.—Res. Ctr., Paoli, Pa.*

Military computers are exposed to the threat of nuclear radiation from natural and artificial sources. Definition of these environments is difficult. Simulation problems exist because of the difference in reactor characteristics. Omissions of pertinent material limit the value of published data.

The testing program is designed to subject all critical components in the active and passive condition to accurately measured irradiation in reactors and accelerators selected as test machines for optimum simulation of environments. There are major problems in making dynamic nuclear measurements and in instrumentation. Data will be collected automatically for machine computation and correlation.

SESSION 3*

Mon. 2:30–5:00 P.M.

Waldorf-Astoria
Jade Room

ENGINEERING WRITING AND SPEECH

Chairman: Keith Henney, *McGraw-Hill Publication Co., Inc., New York, N. Y.*

3.1. Creative Aspects of Engineering Writing

Herbert B. Michaelson, *IBM Res. Ctr., Yorktown Heights, N. Y.*

Writing an engineering paper is shown to be an intrinsic part of the engineering work, rather than a mere recording of results. The process of writing a paper for publication in an engineering journal has some rather interesting aspects of creativity.

This paper shows how any careful attempt to record and analyze the results of an engineering project will actually contribute to the engineer's understanding of his own work. Writing a paper not only affords a fresh insight to the author, but may even inspire a more thorough study and a new approach to laboratory work before the manuscript is finished.

Preparing a clear exposition is shown to be a thought-provoking, stimulating activity and a source of fresh, new concepts.

* Sponsored by the Professional Group on Engineering Writing and Speech. To be published in Part 10 of the 1961 IRE International Convention Record.

3.2. Readability or Common Sense?

Cyril A. Dostal, *Advance Engrg. Subsection, Heavy Military Electronics Dept., GE Co., Syracuse, N. Y.*

Engineering writers have recently shown interest in formulas that purport to measure readability by word and syllable count. Attractive as this idea may seem, it does not stand up under critical scrutiny. Common sense tells us not to use a long word or sentence where a short one will do. But common sense should also tell us that we cannot substitute counting skills for writing skills. The professional writer, especially the engineering writer, must concern himself with words and sentences only as they convey the true product of his labor: *ideas* clearly, logically, appropriately presented.

3.3. Literature on the Linguistic Problem for the Engineer

J. D. Chapline, *Philco Corp., Willow Grove, Pa.*

In order to improve the linguistic expression of the engineer, many different efforts are presently being made.

One approach that has not received its proper attention is through the variety of textbooks available which prove the very fundamentals of the communication problem from a scientific point of view. These texts should interest the typical engineer because they are scientifically oriented and might, as a result, aid the engineer through self-help.

This paper will describe some of the basic communication problems and review presently available texts that would meet the above requirements.

3.4. On the Engineering of Self-Expression

David M. Krigbaum, *Motorola, Inc., Military Electronics Div., Western Ctr., Scottsdale, Ariz.*

Engineers who "can't write" owe it to themselves, their profession and their companies to improve self-expression. Many engineers have a severe mental block against writing and speaking, but might overcome it. It is suggested to engineers who find the grammatical structure "too hard" to master that certain basic precepts of engineering structure and scientific method are synonymous with those of good writing and speech. By relating familiar hardware concepts to less familiar grammatical concepts, the engineer might overcome his mental block and improve his skill in self-expression. Examples of this process are given.

3.5. The Engineer—Engineering Writer Relationship

Hunter P. McCartney, *Burroughs Corp.—Res. Ctr., Paoli, Pa.*

With the increasing role of engineering writing in recent years, there has developed a much broader interface between the engineer and the engineering writer. Like most situations that develop rapidly, this relationship has not been without its rough spots.

The need for the engineering writer, in this age that depends so heavily on the written word, is unquestioned. How can he best fulfill his role as a supplementary force in the engineering assault on the walls of technology?

This paper will explain what engineering writers are and what they do. It will deal with the awkward situations that sometimes arise because representatives of the engineering and the engineering-writing professions do not entirely understand or appreciate the functions of one another.

SESSION 4*

Mon. 2:30–5:00 P.M.

Waldorf-Astoria
Sert Room

RADIO FREQUENCY INTERFERENCE

Chairman: JOSEPH H. VOGELMAN, *Dynamic Electronics Div., Capehart Corp., Richmond Hill, N. Y.*

4.1. Radiation Characteristics of Antenna at Other Than Design Frequencies

J. C. PULLARA AND J. P. JONES, *Melpar, Inc., Falls Church, Va.*

This presentation is intended to fulfill a need for a more adequate appreciation of the antenna's role in the generation of radio frequency interference (RFI). In the prediction and reduction of RFI, the contribution of the antenna is usually either totally neglected or, at best, is estimated by statistical means from its performance at the design frequency. The data presented in this paper show the spatial distribution of spurious energy emitted by the antenna. These data can be used by the RFI engineer to better approximate the antenna performance at interference frequencies. Antenna characteristics such as gain, pattern configuration, and VSWR have been measured and mathematically evaluated for typical antenna types, such as electromagnetic horns, sleeve dipoles, reflector systems, and arrays. In most instances, each antenna was investigated over at least 7 to 1 frequency band. It is hoped that this presentation of actual experimental measurements will augment future efforts in the prediction and reduction of RFI contributed by antenna systems.

4.2. The Relationship between Broad-Band Interference Measurements (DBMC) and Pulsed-CW Signals

LAWRENCE R. PANGBURN, *Light Military Electronics Dept., GE Co., Utica, N. Y.*

In order to properly analyze the effects of broad-band interference on a system, it is necessary to understand the meaning of broad-band interference data that are provided in the conventional units of DBMC. Furthermore, it is necessary to observe certain precautions to avoid drawing erroneous conclusions from measured data on pulsed-CW signals. The intent of this paper is to provide a clear understanding of the conventional units of measurement, particularly with respect to pulsed-CW signals.

A pulsed-signal frequency spectrum is applied to a device exhibiting ideal pass-band characteristics, and the output in the time domain is developed graphically. It is shown that broad-band interference measuring instruments determine the spectral voltage density of a broad-band signal and provide the answer in DBMC. It is further shown that the spectral voltage density at the center of the spectrum of a rectangular pulsed-CW signal is

DBMC = 20 log (pulse width in microseconds $\times$ peak pulse height in microvolts).

This has been verified experimentally. The above expression shows that the original pulsed-CW signal cannot be reconstructed in the time domain when the only information available is DBMC, since DBMC is a function of pulse area. In addition, the measuring instrument does not actually determine DBMC if the instrument impulse bandwidth is greater than one divided by the pulse width. These considerations are important when attempting to predict the effect of measured interference on a system which has a bandwidth different from that of the measuring instrument.

4.3. Shielding Enclosure Performance Utilizing New Techniques

R. B. SCHULZ, *Armour Res. Foundation of Illinois Inst. Tech., Chicago, Ill.*, AND D. P. KANELLAKOS, *Radioscience Lab., Stanford University, Stanford, Calif.*

The techniques for measuring shielding enclosures are revised to serve as a basic for both an IRE standard and a government specification, intended to be compatible. The selected methods provide for measurement at any frequency from 100 cps to 10 G, with three spot frequencies being recommended as standard procedure. At 15 kc, the source field is set up by a tilted, single-turn loop around the enclosure; at the lowest natural resonant frequency (normally 10 to 100 Mc), the source field is set up by a dipole; at X band, the source may be either a horn or parabola. In each case, a corresponding pickup is used at the center of the enclosure. Measurements by the new techniques are reported on several styles of enclosures for each of three major manufacturers.

4.4. Graphical-Numerical Prediction of Tuned RF Amplifier Output Spectrum

WILLIAM G. DUFF, *Jansky & Bailey, Inc., Washington, D.C.*

In an interference prediction study, both the funamental and the harmonic outputs of transmitters must be determined. To describe the total output adequately, the effect of the dynamic loading of the output circuit must be considered.

Previous analysis techniques for predicting the output spectra of tube-type transmitters have been restricted by the assumption that resistive load lines may be used to approximate the "loading" of the tank circuit.

The graphical-numerical analysis provides a general unrestricted prediction method that will be applicable to Class AB, B or C operation of the tube and to single tube, push-pull or parallel operation of the amplifier. This method of solution utilizes successive approximations to determine the "actual path of operation" on the characteristic curves. The graphical-numerical solution accounts for the effect on the output caused by the input signal, the nonlinearity of the tube, the angle of plate current flow of the tube, and both the loading and filtering effect of the output circuit.

4.5. Radar Mutual Interference Problem

C. GAGER, A. RUVIN, AND C. FOWLER, *Airborne Instruments Lab., Deer Park, L. I., N. Y.*

With the increasingly large number of radars in use, mutual interference between radars has grown at an alarming rate in recent years.

This paper analyzes the several propagation paths by which interference from one radar enters another. Tropospheric scatter and anomalous propagation paths are treated.

The ineffectiveness of frequency separation as a solution to the problem is shown, and the need for and the effects of drastically limiting the spectral content of the transmitted pulse in a conventional radar are discussed.

It is shown that broad-band, coded-pulse radars are, paradoxically, relatively immune to conventional pulse interference, but that they have mutual interference problems that are analogous to the problems of narrow-band radars.

SESSION 5*

Mon. 2:30–5:00 P.M.

Waldorf-Astoria
Empire Room

ENGINEERING MANAGEMENT

Chairman: JOHN E. KETO, *Wright Air. Dev. Div., Wright-Patterson AFB, Ohio.*

5.1. PERT—An Empirical Approach To Resources Planning

JEROME PEARLMAN, *Light Military Electronics Dept., GE Co., Utica, N. Y.*

* Sponsored by the Professional Group on Radio Frequency Interference. To be published in Part 8 of the 1961 IRE INTERNATIONAL CONVENTION RECORD.

* Sponsored by the Professional Group on Engineering Management. To be published in Part 10 of the 1961 IRE INTERNATIONAL CONVENTION RECORD.

The Program Evaluation and Review Technique (PERT) has been publicly credited by Navy and civilian officials as a prime factor in the successful completion of the Polaris program *ahead of schedule*. One company which has had considerable contact with this technique is General Electric.

This paper describes in some detail the working of PERT and the experience of the Light Military Electronics Department of General Electric in implementing it. The author's thesis is that PERT, to be effective, must be treated as an analytical planning and measurement device rather than a management reporting tool. Used in this fashion, PERT enables the engineer to analyze his own situation, to program his uncertainties, to evaluate the impact of his effort on that of others, and eventually to make more realistic decisions.

5.2. Designing the Corporate Structure to Combine Small-Company Vitality with Large-Company Strength

A. W. Tyler and A. D. Ehrenfried, *TYCO, Inc., Boston, Mass.*

Modern corporations appear in a dilemma. Through merger, small companies are striving to become large; and through decentralization, large companies are striving to be small. This paper deals with the current bilateral struggle for an optimum corporate structure. The fundamental needs for profitability and growth are defined; barriers to growth, encountered by both small and large companies, are analyzed. The structure of a unique divisional corporation is evolved which combined the quick capability of the small company with the long-range planning capability of the large company. A working example of this "Corporate Core" form of structure is cited, and compared with the organizational structures of a number of successful divisional corporations.

5.3. Steps in the Transitions from Engineer to Entrepreneur

James L. Hollis, *Rixon Electronics, Inc., Silver Spring, Md.*

Many good engineers are absolutely certain that if they had a little money, or an angel, they could develop the better mousetrap that would make customers beat a path to their door. Some do just that. *Fortune Magazine* frequently publishes short stories of their success. What they don't publish are stories about the many engineers who lost the fruits of their effort to the so-called angel or went broke before their mousetrap was accepted.

Why? What makes an engineer a technical optimist and a financial pessimist? Or a technical genius and a financial idot? Is it the protected large company environment in which most of them gained their early experience, or is it a misplaced confidence in the infallibility of the financier? The engineer is usually better educated in the laws of logic than his counterpart in the financial world. He has the advantage in that he can learn and usually understand the natural laws of finance, whereas his counterpart is at a genuine disadvantage if he tries the reverse.

The answer is usually preoccupation and a misplaced belief that a successful technical accomplishment must automatically lead to financial success.

This paper discusses the transition of a working engineer into the manager of a small independent company and highlights some of the open doors he must successfully select or avoid. It is based on the personal experience of the author in guiding the growth of a small electronics research and development company to over 150 employees in three years without serious dilution of ownership.

5.4. Research Administration in an Explosive Technology

R. Weller and N. A. Finkelstein, *Stromberg-Carlson Div., General Dynamics Corp., Rochester, N. Y.*

Most aspects of research management are best discussed with relation to a specific industry and its general operational characteristics. In industries built around an explosive technology, such as electronics, particular attention must be directed towards the mixture and balance of the research and development efforts, the relation between R & D and marketing, and the development of scientific and technical competence in those basic areas underlying company interests. A basic problem is the attraction of highly competent technical personnel with capabilities in the desired directions. These must be chosen with an eye to the relative need for critical ability as opposed to creative ability, and group skills as opposed to individual skills.

SESSION 6*

Mon. 2:30–5:00 P.M.

Coliseum
Faraday Hall

PRODUCT ENGINEERING AND PRODUCTION

Chairman: J. Maurice Lee, *Missile Air Frame Section, Missile Support Branch, Bur. of Naval Weapons, Navy Dept., Washington, D. C.*

6.1. Microminiature Components and Packaging Techniques

S. M. Stuhlbarg and L. P. Sweaney, *P. R. Mallory & Co. Inc., Indianapolis, Ind.*

A comprehensive market analysis is described, including visits with more than 300 cognizant engineers and scientists, followed by a mail survey and several presentation tours. The results of this analysis indicate that there is an expanding market for reliable, discrete microcomponents, and that the advent of functional circuitry utilizing thin film and semiconductor techniques will not diminish this market for a number of years.

A number of wafer and pellet-shaped microcomponents are discussed, including tantalum and ceramic capacitors, carbon and metal oxide film resistors, and silicon rectifiers. Various packaging techniques which lend themselves to production mechanization are described. A unique program is outlined in which development activities, reliability analyses, and pilot production functions are integrated to provide prototype sample lots having incrementally reducing failure rates.

6.2. A Dot Component Packaging System for Electronics

A. E. Hawley, E. A. Klein, and S. Rubin, *Hughes Aircraft Co., Culver City, Calif.*

A new microminiature electronics packaging design philosophy and an application to a digital system are described in detail. The package utilizes the new miniature "dot" components mounted in ceramic wafers. The "dot" components are 0.05 inch in diameter and 0.03 inch thick. Component connections are made by multilayer deposition techniques, and connections to modules by a novel pressure connection method. A unique and compact heat transfer sheeme is described. The design example contains 2280 components in an approximately 1.25-inch cube. The component density of the package (including all thermal, interconnection, and structural provisions) is 2,080,000 per cubic foot. Repairability is such that component replacement is possible, and module replacement in the field is practical. The package is designed to function at temperatures to 96°C with 100°C components, can be sealed against contamination, and is sufficiently rugged to withstand space environments. The major design features are shown in eleven illustrations; numerical data and comparison with other packaging schemes are shown in two tables.

6.3. New Developments in Multilayered Etched Circuitry

N. Schuster and W. Reimann, *Computer Systems Lab., Litton Systems Inc., Woodland Hills, Calif.*

A survey is made of high-density computer module construction techniques including flat card, board-to-board, welded, and microcircuitry. Comparative volumes, weights and maintainability are discussed.

Interconnection problems are indicated and it is shown that the wiring can consume a disproportionate percentage of the volume in high-density construction. A solution to this problem is shown in the form of multilayer etched circuit wiring developed for this purpose. Various examples of applications are shown. Size, weight, cost, reliability, and maintainability of this technique are discussed and comparisons are made with standard wiring. Recent developmental work is described with effects on applications indicated.

6.4. The Application of Thermoelectric Spot Cooling to Electronic Equipment

William Stubstad, *Collins Radio Co., Cedar Rapids, Iowa*

The results of an investigation on the evaluation and application of thermoelectric spot cooling to electronic equipment are presented. The evaluation of a designed spot cooler in-

* Sponsored by the Professional Group on Product Engineering and Production. To be published in Part 6 of the 1961 IRE International Convention Record.

cluded mechanical and thermal tests which indicated that spot coolers can perform satisfactorily under operational conditions as predicted by theory. Based on the results of the evaluation, spot coolers were analytically applied to forced-convection cooled equipment and equipment cooled by natural means. The analysis indicates that spot cooling can reduce the forced-convection cooling requirements and allow natural cooled equipment to operate in higher-temperature environments.

6.5. Picture-Tube Improvement Through Controlled Environment and Ultrasonic Techniques

J. C. HALBROOK, *Electron Tube Div., RCA, Marion, Ind.*

The trend toward higher-voltage picture-tube operation requires basic improvements in manufacturing techniques. The threshold of high-voltage instability characteristic of modern picture tubes cannot be increased significantly by design without adversely affecting focus and other performance characteristics. A practical technique of increasing the threshold of high-voltage instability by about 6 kv has been developed by means of extensive revisions of the picture-tube electron-gun manufacturing processes. Reduction of arcing, stray emission, neck fluorescence, and interelectrode shorts and leakages has resulted from the use of ultrasonic cleaning processes and "clean" environments. A precision method of controlling the grid-to-cathode spacing to improve the control of cutoff voltages by about 40 per cent has also been developed.

The physical geometry and relatively small size of picture-tube gun components required extensive investigations to determine the most efficient application of ultrasonic cleaning techniques, application of precision-controlled K-G_1 assembly technique, effective materials handling and storage methods, and a system for the protection of completed guns from particulate contamination. Concepts of environmental "white-room" nature were employed to house the program adequately.

The extensive revisions to the picture-tube manufacturing processes and the new equipment and facilities at the RCA Marion, Ind., plant are described.

SESSION 7*

Mon. **2:30–5:00 P.M.**

Coliseum
Marconi Hall

ADVANCES IN NAVIGATION AND FLIGHT SAFETY SYSTEMS

Chairman: LUDLOW B. HALLMAN, JR., *Wright Air Dev. Div., Wright-Patterson AFB, Ohio.*

* Sponsored by the Professional Group on Aerospace and Navigational Electronics. To be published in Part 5 of the 1961 IRE INTERNATIONAL CONVENTION RECORD.

7.1. Star Tracking and Scanning Systems—Their Performance and Parametric Design

JOHN E. ABATE, *Astronautics Dept., Kearfott Div., General Precision, Inc., Little Falls, N. J.*

This paper deals with star tracking and scanning systems whose ultimate application is the navigation of satellite, lunar, and deep space vehicles. It discusses the considerations and develops the analysis required to yield the optimum performance and system design of star trackers and scanners. The technical literature is surprisingly void of the study and investigation of star tracking and scanning. This paper will attempt to fill part of that void by discussing in detail several of the critical areas related to the design of star tracking and scanning systems. It discusses the input data, their character and limitations; radiation detectors, their performance and capabilities; the decision or discrimination problem and its probabilistic nature; and the tracking and scanning systems, their parametric design, performance, and limitations.

7.2. Semi-Automatic Flight Inspection of Navigation-Aid Stations

J. S. PRITCHARD, J. LOVELL, AND E. DROGIN, *Airborne Instruments Lab., Deer Park, L. I., N. Y.*

A semi-automatic system designed for use by the Federal Aviation Agency in the periodic flight inspection of VOR and TACAN ground stations is described. The accuracy of the bearing information being transmitted by these stations, as well as other pertinent information, is determined.

The measuring function is accomplished by a number of similarly equipped aircraft. Each aircraft is capable of gathering data on a number of stations simultaneously. The desired coverage of stations within the United States is obtained by flights along a prescribed grid. A ground-based digital computer processes the data collected by these aircraft and prepares reports on the stations covered.

7.3. An Active Radar Surveillance Beacon

A. R. ALMOND AND D. F. GUMB, *Aero Geo Astro Corp., Alexandria, Va.*

An active radar surveillance beacon has been developed which makes use of a traveling-wave amplifier tube and performs in the manner discussed above. The augmentor was completely transistorized except for the traveling wave tube. An added feature to the augmentor was the loss of signal-destruct annunciator. If the target were to exceed the range of the tracking radar, the absence of signal would allow a relay to initiate a detonated charge circuit.

Other features of the augmentor are regulated input, dc-to-dc converter, and a time delay circuit for allowing the filament of the traveling-wave tube to warm up before application of high voltage. The traveling-wave tube provided a minimum sensitivity of −45 dbm and a maximum saturated power of one watt over a 300-Mc bandwidth. Still another feature was a tunable preselector which allowed frequency selection in the frequency band of operation.

A device of the nature of that developed is capable of providing gain over a broad frequency range of at least one octave, as determined by the characteristics of the tube. Increased gain could be had by series tubes, but the limitation in maximum gain available is determined by the effective isolation between input and output which can be accomplished in any actual installation. Variable augmentation might also be had by means of selected attenuators.

7.4. Gross Errors in Height Indications from Radar Altimeters Operating Over Thick Ice or Snow

A. H. WAITE AND S. J. SCHMIDT, *U. S. Army Signal Res. and Dev. Lab., Ft. Monmouth, N. J.*

Operation of 400-Mc pulsed altimeters over thick ice in the Antarctic and Greenland, throughout the International Geophysical Year and afterwards, have revealed the occurrence of many, sometimes fatal, errors. Studies of the controlling electrical characteristics of thick ice and snow and the behavior of both vertically and horizontally polarized radio waves in this medium are described. Results are analyzed and compared with actual field observations in both areas. Measurements at several frequencies between 200 and 4000 Mc are discussed and the article concludes with a series of specific limits for over-ice pilots that cannot be exceeded safely.

7.5. Performance in Clutter of Airborne Pulse MTI CW Doppler, and Pulse Doppler Radar

D. MOONEY AND G. RALSTON, *Air Arm Div., Westinghouse Electric Corp., Baltimore, Md.*

The clutter situation for airborne pulse MTI, CW Doppler, and pulse Doppler radars is reviewed.

Typical mechanizations for rejection of airborne clutter are discussed. Circuit configurations of varying complexity for permitting target detection in the vicinity, and at the same frequency as sidelobe clutter are described. The clutter spectrum resulting from a ground model of homogeneous random scatterers is calculated for an actual antenna pattern. Typical system parameters for each of the three types of systems are assumed in order to obtain representative results. The relative performance of the systems is indicated as a function of the radar-target geometry.

SESSION 8*

Mon. **2:30–5:00 P.M.**

Coliseum
Morse Hall

ELECTRON DEVICES

Chairman: C. G. Thornton, *Philco Corp., Lansdale, Pa.*

8.1. Fundamental Limiting noise of Depletion Layer Capacitance

L. J. Giacoletto, *Dept. of Elec. Engrg. and Div. Engrg. Res., Michigan State University, East Lansing, Mich.*

In addition to noise arising from the circuit, a semiconductor diodic junction must contain a basic noise source. This basic noise mechanism is due to fluctuations in the ionization state of the impurity atoms which occur at random relative to the probability of ionization, $w = n_{D+}/n_D$. In an n-type semiconductor, a neutral impurity that suddenly becomes ionized releases a mobile electron whose movement forms a noise current pulse; similarly for the elemental deionization event. The net result is a short-circuited noise current,

$$\overline{I_{\omega_m}}^2 \approx 2q^2 \frac{n_D A W}{\tau_{D^+}} \frac{(1-w)}{w} \left[-\frac{q(V_B+V_C)}{kT}\right]^{-1} \Delta f.$$

Using typical numbers, this formula indicates that the fundamental noise associated with a 0.3-$\mu\mu$f depletion layer capacitance at 100 Mc is equivalent to the thermal noise of a 6-ohm series resistor at 40°K and a 0.1-ohm series resistor at 300°K. Experimental verification of this type of noise is not available, but when it is observed experimentally, a new method for evaluating some of the basic properties of semiconductors will be available.

8.2. Block-Diagram Representation of Junction Diodes and Transistors

Georg Bruun, *Dept. of Elec. Eng., University of California, Berkeley, Calif.*

This paper discusses a block-diagram description of junction diodes, diffusion transistors and drift transistors under large-signal operating conditions. The purpose of the work is to give a description of the devices that facilitate the connection between the physics and the nonlinear circuitry of the devices. A further purpose is to make a step toward a better understanding of the nonlinear operation of more complicated devices such as mesa transistors. The block diagrams are of a simple type, as they are made up of nonlinear time-independent blocks and of linear operator blocks. The diagrams assume that the diffusion equation is linear; this is not correct at large currents. The other nonlinearities in the devices as given from the Boltzman equation are, however, so pronounced that they will be dominating even in many cases where the nonlinearity of the diffusion equation is significant.

Nonlinear HF circuit problems to which the block-diagram representation has proven useful are switching, almost linear amplifier (cross-talk interference), and class C amplifier problems.

8.3. Recent Advances in Gallium Arsenide Transistors

M. E. Jones and E. C. Wurst, Jr., *Texas Instruments, Inc., Dallas, Tex.*

Techniques for constructing an n-p-n alloy diffused mesa gallium arsenide transistor will be presented. The parameters achieved to date will be discussed, with the emphasis on the application of this device as a high-speed switching transistor. These parameters will include the output characteristics, power gain, current gain and other h parameters, static characteristics, HF characteristics, and switching characteristics.

8.4. Uniform Turn-On in Four-Layer Diodes

K. Hubner, M. Melehy, and R. L. Biesele, Jr., *Shockley Transistor, Unit of Clevite Transistor, Palo Alto, Calif.*

Turn-on characteristics of four-layer diodes have been investigated as a function of the rate of rise of the applied voltage close to the breakover point. A very fast rate of rise allows bringing the voltage up to or higher than the designed avalanche voltage of the center junction, even if localized spots having a lower breakdown voltage are present. Such spots may be due to crystalline defects, surface conditions, or statistical variation of impurity concentration. There is evidence that a fast rate of rise results in uniform turn-on and allows pulse current densities n excess of 50,000 amperes/cm^2 without damaging the device.

8.5. A New High-Gain Ultraviolet Detector Tube of High Output Power

D. H. Howling and R. C. Roxberry, *Thomas A. Edison Res. Lab., Div., McGraw-Edison Co., West Orange, N. J.*

This paper presents the characteristics of a new high-gain device that is sensitive to ultraviolet radiation. Parameters governing tube design are discussed. Applications in the field of fire detection and communication are analyzed. Probability formu ations are applied in determining signal-to-noise levels encountered in various environments using various systems. Experimental data are presented involving the various interrelations of spectral response, quantum efficiency, sensitivity, applied voltage, power gain, power supply frequency and spatial sensitivity. The theory of tube operation is fully discussed.

8.6. Solid-State Display Device

S. Yando, *General Telephone and Electronics Lab., Bayside, N. Y.*

A solid-state display device based on an entirely new principle is described. The device consists of a thin, flat panel of piezoelectric material, one surface of which supports an electroluminescent layer. Voltage pulses, applied to several electrodes suitably positioned on the periphery of the panel, introduce traveling acoustical waves into the piezoelectric material. Electric fields accompany the waves so produced and interact with the electroluminescent layer to produce a localized "spot" of illumination. The position of the "spot" is controlled by varying the relative timing of the pulses to produce either a raster or an oscilloscope pattern. Means for continuously modulating the light intensity of the "spot" are also described.

* Sponsored by the Professional Group on Electron Devices. To be published in Part 3 of the 1961 IRE International Convention Record.

SESSION 9*

Tues. **10:00 A.M.–12:30 P.M.**

Waldorf-Astoria
Starlight Roof

CONTROL THEORY AND PRACTICE

Chairman: John E. Ward, *Electronics Systems Lab., M.I.T., Cambridge, Mass.*

9.1. An Extention of Wiener Theory to Multivariable Controls

L. G. McCracken, *Inst. of Res., Lehigh University, Bethlehem, Pa.*

For multivariable controls with equal numbers of command and actual output signals, vector integral and matrix transmission equations serve as a starting point for a variational procedure yielding minimum squared-error between desired and actual outputs. Deriving the vector Wiener-Hopf integral equation, its solution via Fourier transforms is shown. Possible regions of applicability are indicated.

9.2. Analysis of Linear Control Systems Containing Distributed and Lumped Parameters—A Comparative Study

Olle I. Elgerd, *Dept. of Elec. Engrg., University of Florida, Gainesville, Fla.*

The objective of this study was to determine the feasibility of extending into the area of control system analysis a novel method developed earlier by the author for study of transient phenomena in electric power systems containing long transmission lines.

Linear systems containing components of both the lumped and distributed parameter type constitute a particular challenge to a system designer. The presence of one or several components characterized by distributed parameters results usually in a considerable

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mathematical complication. Furthermore, it is impossible to accurately simulate such a component which means that it is not possible to bypass the mathematical obstacles by resorting to analog computer techniques. One may, however, if extensive analog computers are available, simulate approximately the continuous element by certain "lumping" techniques, but such methods often are deceiving and may lead to very large errors.

The analysis methods presented in the present paper make use of a duality feature of distributed-type elements. It is shown how such a component can be considered either as a wave-carrying medium or as a sequence of an infinite number of infinitesimal coupled circuits. It is demonstrated by examples how the analysis work may be extensively simplified by using proper circuit concept.

The author is convinced that by combining the techniques of this paper with the high-speed digital computing means now available, one obtains an optimum tool for the study of this type of system.

9.3. Harmonic Analysis and Describing Function of Nonlinear Systems

DAVID M. MAKOW, *Radio and Elec. Engrg. Div., Natl. Res. Council Ottawa, Ont., Canada.*

A method of calculating the output harmonics and the describing function of most common nonlinear systems is presented. A nonlinear characteristic which consists of a threshold, linear and a saturating region has been approximated by a product of gaussian and linear functions. This leads to integrals which can be expressed in terms of modified Bessel functions which are tabulated. Nonlinearities having a linear and saturating region and those with a threshold and a linear region have been treated in a similar manner and are shown to be special cases of the former. The coefficients of the functions which are required to approximate a given nonlinear characteristic have been also evaluated. The derived formulas permit rapid and accurate determination of the harmonics and the describing function for a given input amplitude, in a wide range of cases in which straight-line approximation departs considerably from the physical characteristic.

9.4. Considerations in the Optimum Design of a Precision Radar Track Loop

STEPHEN ADELMAN, *Surface Armament Div., Sperry Gyroscope Co., Great Neck, L. I., N. Y.*

A systematic approach toward the design of a tracking servo is described. An analysis of the expected target dynamics, required tracking accuracy, response time, and allowable jitter are correlated to the closed-loop system function and dynamic error coefficients. From these criteria, an optimum closed-loop system function is selected.

The next step is to choose a process function and compensation system to yield the desired closed-loop transfer function. The process function is assumed to be fixed, and through the inverse root-locus, an open-loop transfer function is selected. Knowing the process function, it becomes a simple matter to choose a suitable compensation network.

9.5. Short Time Stability in Linear Time-Varying Systems

PETER DORATO, *Polytechnic Inst. of Brooklyn, Brooklyn, N. Y.*

The concept of short time stability is introduced to deal with systems operating over a relatively short interval of time. Short time stability assures suitably bounded outputs, in this interval of time, for suitably bounded inputs. This definition of stability finds many applications in missile systems.

Conditions for short time stability are studied in linear time-varying systems. A necessary and sufficient condition for short time stability, in terms of the impulsive response, is given. Sufficient conditions for short time stability, in terms of the coefficients of a set of linear differential equations, are included. Illustrative examples are also included.

SESSION 10*

Tues. 10:00 A.M.–12:30 P.M.

Waldorf-Astoria Astor Gallery

NUCLEAR INSTRUMENTATION

Chairman: H. E. BANTA, *Oak Ridge Natl. Lab., Oak Ridge, Tenn.*

10.1. Four-Channel Magnetic Tape System for Medical Studies

R. HINDEL, *Atomium Corp., Waltham, Mass.*

The paper describes a four-channel, four-speed magnetic tape system which was developed for dynamic studies of renal clearance rates. A commercial tape recorder was modified to give four recording and playback speeds; four tracks on a ¼-inch tape. Any of the four outputs may be switched to a linear and logarithmic count-rate meter. Channels C and D are connected to a ratio ratemeter which delivers a linear analog indication of the ratio $C(C+D)$ with a maximum statistical error of 3 per cent. Four scintillation detectors are placed close to each of the two kidneys, the heart, and one thigh. Any one of the channels may be plotted during test. Generally the ratio ratemeter output is connected to an X-Y plotter to quickly indicate the symmetry of the kidney function. Expanded logarithmic output may be used in playbacks to define the clearance time constants.

10.2. A Digital Data Handler for Use with Pulsed Particle Accelerators

W. A. HIGINBOTHAM AND D. W. POTTER, *Brookhaven Natl. Lab., Upton, N. Y.*

The paper describes a digital data handler for storing information in a magnetic core memory during the pulse of a synchrotron and transferring it to a slow memory during the dead time. Digital measurements of trajectory, pulse height, time of flight, run number, etc. are typical data. The magnetic core memory provides capacity for storing 32 words (events) of 96 bits during a burst. The information contained in the core memory is then transferred to one-inch magnetic tape during the dead time of the accelerator. Hence the information may be fed to a computer for future study. For economy, the data handler was one buffer which serves as the input, output and shift register. Indicator lights are used to serve as a check of all bits.

10.3. Automatic Sample Handling and Processing of Nuclear Data

G. M. KERRIGAN, L. E. BABCOCK, AND O. FORRANT, *Instrument Products Engrg., Tracerlab Inc., Waltham, Mass.*

An increase in the application of nuclear isotopes in the research and medical fields has made it necessary for the electronic industry to provide the facilities for automatically handling samples and nuclear data.

Reliability, versatility, simplified operation and low cost are major objectives in the system designs. Two most significant characteristics of these systems are the inherent reduction of the human errors and increased handling rate.

With suitable modules it is practical to design systems to meet the required objectives. A typical two-channel system will be discussed. This has been designed to identify any one of 10^5-1 randomly arranged samples, record the counts, time and channel identification with the sample number on punch tape. An IBM format is provided to permit access to a computer for correlation and computation.

A description relating to the data acquisition from scalers and timers will be given.

10.4 The Design of Regulated, Miniature High-Voltage DC Power Supplies for Satellite and Deep Space Probe Applications

JERRY B. MINTER, *Components Corp., Denville, N. J.*

Small high-voltage dc-to-dc power converters will be described which employ a closed-loop servo control system deriving primary reference from a pair of stable Zener diodes in a bridge circuit.

A special circuit arrangement will be shown which reduces by more than an order of magnitude the bleeder current usually required to stabilize the relative operating potentials of multiplier photo tubes and still provide linear anode current over a wide range.

Supplies have been built which operate from 3- to 32-volts input and 300- to 4000-volts output. Short-term output stabilities of 0.1 per cent with respect to both input and moderate load changes have been attained. A stability of 1 per cent can be maintained over a temperature range of −10°C to +60°C, or the temperature compensation can be adjusted to correct for variation of multiplier photo tube gain vs temperature. Overall efficiencies of 40 to 50 per cent have been obtained at power output levels of 50 to 100 mw.

* Sponsored by the Professional Group on Nuclear Science. To be published in Part 9 of the 1961 IRE INTERNATIONAL CONVENTION RECORD.

10.5. A New Instrument for Differential DME Polarography

S. Rankowitz and W. A. Higinbotham, *Brookhaven Natl. Lab., Upton, N. Y.*

A new approach to instrumentation for dropping mercury polarography has been developed at this laboratory. The dropping mercury electrode (DME) current is converted to a voltage by a dc negative feedback amplifier. The output of this amplifier is sampled at a fixed delay after the drop fall. The value of each sample is stored on a capacitor and successive differences are taken by a simple switching arrangement. The instrument includes a precise potential supply for the polarographic cell which may be used for scanning or location of the half-wave potential. Drop fall is detected by the change in an RF signal, and accurate timing circuits control the sampling and display.

10.6. Use of Entrance Hodoscope for Particle Identification in Very-High Energy Bubble Chamber Experiments

W. Selove, H. Brody, E. Leboy, and R. Fullwood,* *University of Pennsylvania, Philadelphia, Pa.*

At energies of 10 Bev and higher, it is not easy to obtain physically separated beams of π's and K's. A hodoscope system is under construction which will register the identity of each of 20 particles entering a bubble chamber over a 100-μsec time interval. Particles are localized by a scintillator hodoscope with matrix elements 1 cm square. Particle identity is determined with Cherenkov counters. The combined information is displayed on an oscilloscope and photographed at each bubble chamber expansion.

10.7. A Double-Delay-Line Clipped Linear Amplifier

R. L. Chase and V. Svelto,† *Brookhaven Natl. Lab., Upton, N. Y.*

A compact transistorized linear amplifier has been designed that is suitable for many radiation counting applications. The amplifier delivers symmetrical double-delay-line differentiated output pulses, up to ± 10 volts in amplitude with a differential nonlinearity of ± 1 per cent. It tolerates input signals 200 times full scale without producing spurious output pulses. A prompt output and one delayed by 2 μsec are both available. The clipping lines and the signal delay line are all terminated at both ends so that physically small, relatively imperfect delay lines can be employed. Five amplifiers occupy only 10 inches in a standard 19-inch relay rack.

* Now at Linear Accelerator Lab., R.P.I., Troy, N. Y.

† Now at C.I.S.E., Milan, Italy.

SESSION 11*

Tues. 10:00 A.M.–12:30 P.M.

Waldorf-Astoria
Jade Room

BROADCASTING

Chairman: Adolph B. Chamberlain, *CBS Television Network, New York, N. Y.*

11.1. ABC Scan Converter

A. W. Malang, *American Broadcasting Co., New York, N. Y.*

11.2. Minimizing the Effects of Vidicon Lag with a Broad-Band Delay Line

W. L. Hughes, *Iowa State University, Ames, Iowa.*

The main cause of vidicon lag is that the readout process during scanning is not completely destructive. The output signal contains the contemporary field plus varying amounts of previous fields. A scheme using a very long delay line (262 lines long) has been used which matrices residual information with the direct signal from the camera tube leaving only the contemporary field. The simple theory will be explained and experimental results will be presented.

11.3. Improved Video Recording System

Frank Gillette, *General Precision, Inc., Pleasantville, N. Y.*

Uniform terminology and a method of graphical representation are established. Factors affecting exposure uniformity are described by reviewing fundamental relations between the film exposure cycle and the television scan. Practical arrangements for recording television pictures on motion-picture film are described and analyzed. Effects of phosphor persistence are considered, and a detailed analysis of persistence effects in single-field recording is offered.

11.4. Recent Advances in Vidicons

Martin Rome, *Machlett Labs., Inc., Springdale, Conn.*

The paper is in the nature of a report on new and improved vidicons by American and some foreign manufacturers. Although principal emphasis is on tubes primarily designed for broadcasters, recent, special-purpose devices are also considered. Tubes are reviewed on the basis of improvement or novelty of the characteristics of sensitivity, spectral response, lag and gamma. The applications made possible by these tubes are also briefly discussed. Because of current standardization activity, particular emphasis is given to a review of gamma, the transfer characteristic, with regard to methods of test, and variation with tube parameters.

* Sponsored by the Professional Group on Broadcasting. To be published in Part 7 of the 1961 IRE International Convention Record.

SESSION 12*

Tues. 10:00 A.M.–12:30 P.M.

Waldorf-Astoria
Sert Room

ELECTROACOUSTICS

Chairman: Philip B. Williams, *Jensen Mfg. Co., Chicago, Ill.*

12.1 The Concept of Linear Interpolation in Spectral Compensation

C. E. Maki and J. Chirnitch, *MB Electronics, New Haven, Conn.*

Spectral compensation is usually achieved with equalizers cascaded so as to generate a desired response. In the concept of linear interpolation, a series of points are located along the desired response and linear interpolation provided between adjacent points. This is accomplished with contiguous band-pass filters designed so as to minimize the effect of filter cross over. The performance limitations depend upon the filter characteristics, crossover ripple, and the type of response to be equalized. Data are presented for the most severe cases of a peak notch resonance encountered in acoustic and vibration systems.

12.2. Adjustable Shelf-Type Treble Equalizer with Separate Control of Frequency and Limiting Loss or Gain

Robert H. Rose, *Newark College of Engrg., Newark, N. J.*

High-frequency attenuation is produced by a resistance-capacitance filter arranged with separate controls for adjusting the cutoff frequency and the asymptote of maximum HF attenuation. The system output is taken from this network if attenuation characteristics are desired, or if the network is inserted in the negative feedback path of a high-gain amplifier, it gives an amplifier output with a rising HF response having the same properties as the attenuation performance of the filter. Continuous

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control is provided for cutoff frequency, maximum loss or boost, and transition between attenuating and boosting modes of operation.

12.3. A Low-Noise Microphone Preamplifier

ALEXANDER B. BERESKIN, *University of Cincinnati, Cincinnati, Ohio.*

This paper describes a low-noise two-transistor preamplifier which has been developed for use with microphones. For a source resistance of 1000 ohms, a noise figure of 1.3 db has been achieved. A corresponding middle frequency gain of 40 db, bandwidth of 30 kc and output impedance of 175 ohms resulted.

12.4. Transient Distortion in Loudspeakers

R. J. LARSON AND A. J. ADDUCCI, *Jensen Mfg. Co., Chicago, Ill.*

The response of loudspeakers to nonrecurring sudden changes in input signal level is discussed, together with various ways to measure such transient response. Waveforms of loudspeaker response to various input signals are shown and a method of plotting a continuous transient response curve is described. The degree of correlation between transient curves and other tests, including listening tests, is discussed.

12.5. "Apparent Bass" and Nonlinear Distortion

JOHN D. GRIFFITHS, *Rome Air Dev. Ctr., Griffiss AFB, N. Y.*

It has been noted by psycho-acousticians and others that the human auditory mechanism can often "hear" a low-frequency note when only its harmonics are present. The ability of cheap loudspeakers to sound better than their frequency response curves would indicate has been attributed to this phenomenon. This paper deals with listener reaction to test material (various selected musical passages) played through an electrical analog of such a loudspeaker. The degree of distortion is varied by the listener in an attempt to achieve a "best match" condition to a full-range undistorted signal, and the results are correlated with the particular type of test material. Conclusions are drawn concerning the applicability of such a device.

12.6. Artificial Reverberation Facilities for Auditoriums and Audio Systems

G. A. BROOKES AND R. L. FISHER *Westrex Corp., Hollywood, Calif.*

Two new equipments for producing artificial reverberation are discussed. One is used to increase the effective reverberation time of churches or other auditoriums where the natural reverberation time is below the desired value. The other is intended for audio studio application to introduce special effects. The artificial reverberation is produced in a magnetically-recorded multiple output memory system. In the auditorium application, the reverberation information is fed to a series of side-wall speakers which simulate a series of reflecting surfaces, each set receiving its own distinctive reverberant information. In both auditorium and studio applications, the reverberation time and reverberation frequency response can be controlled over a wide range.

SESSION 13*

Tues. 10:00 A.M.–12:00 NOON

Waldorf-Astoria Grand Ballroom

ENGINEERING MANAGEMENT

Chairman: ERNEST WEBER, *Polytechnic Inst. of Brooklyn, Brooklyn, N. Y.*

13.1. Changing Personality of Today's Engineer

I. NEVIN PALLEY, *ITT Labs., Nutley, N. J.*

Engineering management faces a crisis of extremes. At one end it struggles constantly to acquire talent, method and business to overcome its competitors, and at the other it joins with these same competitors to protect our national liberty.

Success in meeting this critical dual responsibility is assured only through unquestioned superior technical accomplishment. Engineering management must provide the engineer with more time and a more conducive atmosphere to assist him in achieving scientific excellence. But with this greater freedom, the engineer relinquishes some of his general authority and must be conditioned to accept more support and control from others.

13.2 The Current Technological Revolution in Business and Management Methods

HERBERT W. ROBINSON, *C-E-I-R, Inc., Arlington, Va.*

As head of the country's largest independent computing service organization, the author has had wide and varied experience in the practical application of many new analytical and management techniques to complex problems of business, industry, government and finance.

The most modern high-speed electronic computers are bringing great improvements in the management of all types of enterprises. Such computers, together with modern mathematical techniques, have increased the profitability and efficiency of a wide variety of industries such as petroleum, chemical, electric utility, food processing, steel and many others. Continued advances in the speed and capability of high-speed computers, coupled with a steady reduction in cost per computation, have made wide applications of these techniques economical. Before the advent of the high-speed computer, the use of most of these was prohibited from an economic standpoint. The author will outline several examples of practical and valuable applications of these techniques such as linear programming, mathematical model building, simulations and other such methods. The availability of the high-speed electronic computer, and the many analytical methods which it makes possible, constitutes a real technological revolution in business and management methods.

13.3. The Professional Engineer as a Manager

ROBERT E. LEWIS, *Sylvania Electric Products, Inc., New York, N. Y.*

There is a tendency in the engineering profession to look upon the employment of good technical men as engineers as a waste of technical talent. Far from being the case, the application of technical talents to managerial work provides great opportunity to multiply the effectiveness of engineering because it involves the broad responsibility of organizing, directing, and stimulating others toward effective group effort. Group effort has become more and more the key to scientific and engineering achievement. There is a vital and increasing need for men who can effectively direct these groups.

The characteristics of a good manager in a technical area include objectivity, intellectual honesty, flexibility, willingness to accept responsibility, and the ability to sell ideas.

SESSION 14*

Tues. 10:00 A.M.–12:30 P.M.

Coliseum Faraday Hall

MEDICAL ELECTRONICS

Chairman: GEORGE N. WEBB, *The Johns Hopkins Hospital, Baltimore, Md.*

* Sponsored by the Professional Group on Engineering Management. To be published in Part 10 of the 1961 IRE INTERNATIONAL CONVENTION RECORD.

* Sponsored by the Professional Group on Bio-Medical Electronics. To be published in Part 9 of the 1961 IRE INTERNATIONAL CONVENTION RECORD.

14.1. Real-Time Spectrum Analyzer and Digital Correlator for Brain Potentials

W. K. Hagan, *The Magnavox Co., Fort Wayne, Ind.*, and G. C. Manning, Jr., M.D., *Parkview Memorial Hospital, Fort Wayne, Ind.*

Real-time processing of the EEG signals in the study of background patterns and localization of sources of abnormal potentials is considered as a possible tool in clinical analysis.

Background patterns are studied by a multichannel filter that displays the spectrum from 2–30 cps averaged over a 10-second epoch. Localization is performed by a digital correlator that computes and displays the crosscorrelation function over 20 discrete delays. The use of zero crossings and a shift register serves as the delay mechanism.

Clinical tests and use of these equipments by the EEG clinician and the neurosurgeon is described.

14.2. High-Level Electromagnetic Energy Transfer Through a Closed Chest Wall

J. C. Schuder, Ph.D., H. E. Stephenson, Jr., M.D., and J. F. Townsend, A.B., *Dept. of Surgery, University of Missouri, Columbia, Mo.*

The successful temporary substitution of a mechanical unit for the heart during open-heart surgery has stimulated interest in the development of a permanently implanted artificial heart. If such a heart is to duplicate the function and efficiency of an adult human heart, it will require a maximum input power of approximately 35 watts.

An analysis indicates the conditions under which this power level may be transmitted by inductive coupling between a flat coil on the surface of the chest and a similar coil within the chest. A power loss of less than five per cent in the coupling coils and biological tissue is predicted. Experiments at a 50-watt level with dogs yield a very small coil-tissue temperature rise and no apparent discomfort to the animal.

14.3. A Current Distribution Electrode System for Defibrillation

D. G. Kilpatrick, E. D. Banta, D. K. Detweiler, and D. E. Sunstein, *Atronics, Bala-Cynwyd, Pa.*

This paper describes a cardiac current distribution concept, evolved from an ideal homogeneous spherical solid. Through mathematical analysis and experimentation with a sphere of physiological saline solution, an improved defibrillation electrode was predicted. The performance of such electrodes and their required driving equipment is described.

Animal experimental data are presented. The decrease of current requirements for defibrillation implies elimination of surface burning and decrease of other physiological damage particularly where multiple application is indicated. It may make possible the design of safer electrodes to the user and very small, hence more available in an emergency, equipment.

14.4. Electronic Obstacle and Curb Detector for the Blind

J. Malvern Benjamin, Jr., *Biophysical Electronics, Inc., New Hope, Pa.*

An obstacle detector ranging from 2 feet to 8 feet has been built and field tested. A laboratory model of a curb detector ranging from 3 feet to 7 feet has also been briefly tested.

Both instruments range by optical triangulation using pulse light in the near-infrared, and a germanium photodetector. Output from a gated amplifier trips a multivibrator which operates a tactile stimulator in the handle.

The curb detector detects holes, down-steps and up-steps either by means of the high rate of range change when the beam traverses a curb, or by momentary light loss on approaching a curb.

14.5. The Measurement of Internal Physiological Phenomena Using Passive-Type Telemetering Capsules

V. K. Zworykin, *Rockefeller Inst. for Medical Res., New York, N. Y.*; J. T. Farrar, *N. Y. Veterans Admin. Hospital, New York, N. Y.*; R. C. Bostrom, *Airborne Instruments Lab., Deer Park, L. I., N. Y.*; F. L. Hatke, *RCA, Princeton, N. J.*; and G. J. DeBoo, *Airborne Instruments Lab., Deer Park, L. I., N. Y.*

A passive-type telemetering capsule has been developed for measuring internal physiological phenomena, particularly the measurement of pressure in the gastrointestinal tract. Because early systems were extremely sensitive to orientation and position of the capsule, their use in obtaining long-term data for motility studies was severely limited. A cylindrical antenna has been developed that greatly increases the coupling to the capsule coil. In addition, an antenna switching system selects automatically from three mutually perpendicular antennas the antenna that provides a signal adequate for limiting in the external receiver. Clinical tests show that with the present system, continuous measurements can be obtained for all possible positions of the capsule as it passes through the intestine. Other applications of the capsule for the study of the functioning of the bladder and uterus will be briefly discussed.

14.6. Representation of Electrocardiograph by Orthogonalized Exponentials

T. Y. Young and W. H. Huggins, *Dept. of Elec. Engrg., The Johns Hopkins University, Baltimore, Md.*

A discussion is given for characterizing each ECG waveform by a few numbers. This compact numerical representation may be used for further statistical study and analysis. We show that a typical ECG waveform may be expressed as the sum of a small set of exponential components, the amplitudes of which describe the signal vector in an orthogonal signal space. Thus, each entire ECG wave corresponds to a single fixed vector in this signal space.

The instrumentation for measuring the coordinates of these signals on an orthogonalized exponential basis will be described and experimental results given showing the accuracy achieved by 10 to 20 components.

SESSION 15*

Tues. 10:00 A.M.–12:30 P.M.

Coliseum
Marconi Hall

THIS WORLD AND THE ADJACENT ONE

Chairman: K. C. Black, *Inst. of Defense Analyses, Cambridge, Mass.*

A. Lunar Exploration

15.1. Velocity Sensing for Soft Lunar Landing by Correlation between Spaced Microwave Receivers

Frank R. Dickey, Jr., *Electronic Equipment and Systems Lab., GE Co., Syracuse, N. Y.*

A new technique is proposed for measuring velocity with respect to the surface of the moon. The moon is illuminated from the earth by a CW microwave transmitter, and velocity is then determined in the vehicle by crosscorrelation of the outputs of two receivers connected to spaced, low-gain antennas. The direct and reflected waves in the vicinity of the moon combine to form a random diffraction field or standing-wave pattern which, as a consequence of the very low libration rate of the moon, is almost stationary. This field may be thought of as an artificial atmosphere in the sense that it permits measurement of the velocity vector as an "air speed" and as two mutually perpendicular "angles of attack" with respect to it.

15.2. Surveying and Mapping of the Moon from an Orbiter

Bert C. Aschenbrenner, *Autometric Corp., New York, N. Y.*

In order to lay a sound foundation for the exploration and the operational use of the moon, it is imperative that an accurate, tridimensional survey of the entire moon be made, and that the surface and subsurface properties of the moon be uniquely described in

* Sponsored by the Professional Group on Aerospace and Navigational Electronics. To be published in Part 5 of the 1961 IRE International Convention Record.

terms of position within the framework of such a survey. Maps of all or part of the moon which depict parameters of interest such as topography, rock type, depth of the surface mantle, etc., can be meaningful only if they are based on a coherent survey of sufficient accuracy.

The problems inherent in surveying and mapping the lunar surface can be divided into those concerned with 1) selenodesy and surveying, and 2) surface and subsurface analysis and mapping. As far as selenodesy and surveying are concerned, a framework of coordinates and a lunar datum must be established and all points on the surface of the moon must be related to such a selenodetic reference system so that each point is uniquely determined. Therefore, concepts and analytical methods have been developed for surveying the moon with a minimum sensing package consisting of a radar altimeter only, and with a more sophisticated television system consisting of two divergent terrain line scans and one star scan in addition to the radar altimeter. (It is assumed that the sensor carrying spacecraft can be injected into a polar orbit around the moon, and that it can be stabilized and maintained in such an orbit for at least 14 or 27 days, depending on the sensors carried.) Surveying with the radar system is independent of illumination and is based on the measurements of the orbital altitudes of the spacecraft above the surface of the moon, made at equal intervals of time. By analytical methods, the following parameters can be obtained:

1) major axis of the lunar ellipsoid;
2) eccentricity of the lunar ellipsoid;
3) selenocentric latitude of the nadir point;
4) selenodetic latitude of the nadir point;
5) longitude of the nadir point;
6) elevation of the nadir point above the selenodetic datum.

Surveying the moon with the television line scan system is based on the knowledge of the orbital altitude above the lunar surface measured at equal time intervals on star data, and on the identification of at least two conjugate ground images for each pair of corresponding space stations. At least 27 days in orbit are required since the system depends on illumination. In addition to the parameters obtained by the radar altimeter system, the following parameters can be derived analytically:

1) orientation of the moon's axis referenced to both space and time;
2) true axial wobble;
3) true rate of rotation;
4) true shape of the moon.

As far as surface and subsurface analysis and mapping of the entire moon are concerned, the lunar orbiter sensors must provide information from which the surface geometry (topography) and various surface and subsurface properties such as the existence and depth of the loose surface mantle, particle size and packing, physical and petrological characteristics, etc., can be determined. Topography can be derived from radar altimeter profiles alone since each nadir point can be located as to latitude, longitude and elevation by the previously mentioned method of surveying. In the case of the television system, the stereoscopic coverage obtained by the divergent terrain scans can provide topography through photogrammetric evaluation of the transmitted images. By filtering these images properly, all linear features can be extracted automatically from the terrain images for further analysis.

Surface and subsurface properties can be derived from the results of multiple frequency electromagnetic interrogation and, possibly from the analysis of the radiation flux from the surface of the moon. The sensors for acquiring the pertinent data are a radar operating on 10 wavelengths from 3 to 300 Mc and a suitable gamma-ray spectrometer. Investigations by the University of Michigan Radiation Laboratory have shown that electromagnetic surface interrogation is particularly well suited for determining the existence and depth of a surface layer or layers of loose particles, the particle size and the packing factor, as well as the petrologic characteristics of the surface and subsurface lunar material. The results of some of these investigations are the subject of an accompanying paper. Analysis of the nuclear flux from the moon's surface can supplement the electromagnetic measurements particularly as far as the chemical and mineralogical composition of the lunar surface material is concerned. Isotopic ratios which can be deduced from gamma-ray spectra are quite diagnostic and are geochemically well understood. The multiple coverage of a large portion of the moon combined with the availability of accurate positional information make possible meaningful nuclear flux integration resulting in improved signal-to-noise ratios and resolution.

It is feasible to prepare from the information acquired by an unmanned lunar orbiter maps of the entire lunar surface showing topography, surface features such as fractures, surface properties such as the depth and particle size of a loose surface layer, and surface composition.

The study of lunar surveying and mapping systems was carried out by Autometric Corporation under contract with the Army Map Service as part of the U. S. Army Corps of Engineers' Lunar Analysis and Mapping Program (Project LAMP).

15.3. Summary of Methods and Results of Estimation of the Physical Constants of the Lunar Surface

KEEVE M. SIEGEL, *Radiation Lab., Dept. of Elec. Engrg., The University of Michigan, Ann Arbor, Mich.*

Values are derived for the electromagnetic constants and thermal constants of the outer layer of the lunar surface. Upper and lower bounds on particle size and a lower bound on depth of the outer layer of the surface of the moon have been obtained. Penetrometer tests in dust-like materials took on new meaning. Results of these tests showed that the danger of sinking or partially sinking into the lunar surface upon landing should not be considered lightly.

Electromagnetic constant determinations, petrographic analyses, and compression wave analyses have been made on pertinent rocks and minerals to see if they could qualify as lunar materials. Special emphasis was given to the analysis of meteorites and tektites. Analysis of materials included the effects of particle size and packing factor as a function of vacuum conditions.

B. Meteorological Electronics Panel

Brief presentations will be made on the objectives, problems and accomplishments of the U. S. Air Force's 433L weather data program. Col. G. A. Guy, Program Director of the 433L Systems Project Office, will describe the concepts and the major technical features of the system, as well as its relation to the weather data needs of civil and military aviation. Two components of the 433L system will be described by representatives of one contractor, Olympic Radio & Television: a K_a-band radar for cloud base and top measurements, and the FMQ-5 automatic meteorological station.

For the following panel discussion and question and answer period, the authors will be joined by representatives of other agencies which have prime responsibilities in this field. The additional two panelists are:

1) LT. COL. ALVIN B. BUCK, USAF, *Chief, Weather Systems Branch, Systems Engrg. Div. (Code RD 220), Bur. of Res. and Dev., Federal Aviation Agcy., Washington, D. C.*

2) ALBERT K. SHOWALTER, *Chief, Observations and Stations Facilities Div., U. S. Weather Bur., Washington, D. C.*

15.4. The 433L Weather Data System

COL. GEORGE A. GUY, USAF, *Air Force Command and Control Dev., Div., Bedford, Mass.*

A brief background is given of the evolution of modern meteorology. Emphasis is placed on provision of weather information in support of aviation, both military and civil. The need for improvements in data acquisition and transmission are presented with emphasis on problems of digitizing sensor outputs. The problems of processing meteorological data by automatic methods are treated. Presentation of processed information to the user is discussed.

The role of System 433L in the modernization of the National Aviation Weather System is presented together with the current status of the program. The design goals of the entire system are discussed, with emphasis on the desired reliability and maintainability. Problem areas requiring future work in the field of electronics are indicated.

15.5 A K_a-Band Radar for Cloud Base and Top Measurements

I. MARSON AND H. KATZENSTEIN, *Olympic Radio & Television Div., The Siegler Corp., Long Island City, N. Y.*

The problem of radar observation of clouds is reviewed with the objective of providing reliable radar returns to be obtained for any cloud formation affecting optical visibility. Considerations of radar cross section in the Rayleigh scattering region point toward the use of the shortest feasible radar wavelengths while considerations concerning the radar transmissivity of the atmosphere and the availability of power sources and detectors impose short wave limits. The most reasonable compromise is found in the use of K_a Band (8 mm). A practical equipment (AN/TPQ-11) has been developed for incorporation in the 433L weather network.

15.6. The AN/FMQ-5 Automatic Meteorological Station

JOSEPH BECK AND GERALD HARRISON, *Olympic Radio & Television Div., The Siegler Corp., Long Island City, N. Y.*

An automatic meteorological station has been designed and is being tested. It performs the following functions:

1) Acquires weather data from various sensors.
2) Acquires weather data from weather observers.
3) Stores the data.
4) Performs operations to produce mean and peak speed winds.
5) Digitizes wind direction information which originates from a synchro-generator.
6) Computes runway visual range and the 20 and 90 per cent probability point of approach light contact height.
7) Distributes the data to teletypewriter circuits, to visual displays, printers and to permanent storage.

The approach used was as follows:

1) Multiplex the sensor data and convert to digital form.
2) Enable weather observers to include manual data by means of multiposition switches.
3) Store the data in transistorized flip-flop circuits.
4) Convert dc wind speed signed to a pulse rate, average pulses for one minute to obtain mean wind speed, count pulse rate every second and store peak pulse rate to obtain peak speed wind.
5) Use a magnetic shaft incoder, coupled to a synchro receiver to convert data to digital form.
6) Design a special-purpose digital computer which utilizes an add and subtract accumulator to help solve the transcendental equation.
7) Use one set of storage registers for the four output messages but four separate commutators whose outputs are staggered, so that the data may be multiplexed, and then demultiplex the data at the four output stages.

The test results will be known at the time of the presentation.

SESSION 16*

Tues. 10:00 A.M.–12:30 P.M.

Coliseum
Morse Hall

PANEL: BROADENING DEVICE HORIZONS

Chairman: JOHN G. LINVILL, *Stanford University, Stanford, Calif.*

The Session will consist of a panel of speakers on new developments in the field of electron devices, which are continuing to broaden the vista of the electronics industry. The particularly significant frontier areas of Optical Masers and Devices for the Microwave-Infrared Gap and the rapidly expanding field of Solid-State Devices will be covered. These correlated talks will survey the current state-of-the-art, consider application possibilities and indicate future development potentialities. Questions from the floor will be invited.

* Sponsored by the Professional Group on Electron Devices. To be published in Part 3 of the 1961 IRE INTERNATIONAL CONVENTION RECORD.

16.1. Electron Devices for Millimeter Infrared Gap

P. D. COLEMAN, *University of Illinois, Champaign, Ill.*

16.2. Optical Masers

G. C. DACEY, *Bell Telephone Labs., Murray Hill, N. J.*

16.3. Solid-State Devices

E. O. JOHNSON, *RCA Semiconductor Div., Somerville, N. J.*

SESSION 17*

Tues. 2:30–5:00 P.M.

Waldorf-Astoria
Starlight Roof

CODING THEORY

Chairman: NORMAN M. ABRAMSON, *Elec. Engrg. Dept., Stanford University, Stanford, Calif.*

17.1. Improvement of Two-Way Communication by Means of Feedback

S. S. L. CHANG, *Dept. of Elec. Engrg., New York University, University Heights, New York, N. Y.*

The reliabilities and channel capacities or both of a two-way communication system can be improved drastically by means of feedback. This is true whether fading is present or not. The channels can be matched to wide ranges of sources by interlacing information and decision feedback systems.

17.2. Sequential Transmission Using Feedback

MICHAEL HORSTEIN, *Hughes Aircraft Co., Culver City, Calif.*

The presence of a feedback channel makes possible a variety of sequential transmission procedures, each of which can be classified as either a block-transmission or a continuous-transmission scheme according to the way in which the information is encoded. A sequential continuous-transmission system employing a binary symmetric forward channel and a noiseless feedback channel is described, and its error exponent is derived from all rates less than capacity. The average value and the first-order probability distribution of the constraint length found by simulating the system on an IBM 709 computer, are also given. A model for sequential block-transmission systems is presented, and it is shown that the above continuous system yields a larger error exponent than is possible with a block-transmission system.

* Sponsored by the Professional Group on Information Theory. To be published in Part 4 of the 1961 IRE INTERNATIONAL CONVENTION RECORD.

17.3. Capacity of 2-3 and 3-3 Channels

S.-H. CHANG AND E. REID, *Northeastern University, Boston, Mass.*

This paper attempts to present and interpret to a wider audience the use of the algebraic and geometrical methods for the discrete channel capacity calculation by Muroga and Shannon, respectively. In particular, the results of calculation for 2-3 and 3-3 channels are given. These are compared to the results of the binary or 2-2 channel previously studied by Silverman. Some interesting relations between the algebraic and geometrical methods are also discussed. As a further application of these methods the cascading and decomposition of 2-2, 2-3, and 3-3 channels are studied. The importance of 2-3 channels in this and other applications is stressed.

17.4. Low-Density Parity Check Codes

R. G. GALLAGER, *M.I.T., Cambridge, Mass.*

An ensemble of parity check codes is considered in which each digit is contained in a small fixed number, $j \geqq 3$, of parity checks. The typical minimum distance of these codes increases linearly with block length for fixed rate and fixed j, while the error probability using maximum likelihood decoding decreases exponentially with an almost optimum exponent.

A simple decoding scheme operating directly from the channel *a posteriori* probabilities is described for which both the equipment complexity and the data-handling rate in bits per second increase approximately linearly with block length. Some experimental results and a weak bound on the error probability using this decoder indicate its potentiality.

SESSION 18*

Tues. 2:30–5:00 P.M.

Waldorf-Astoria
Astor Gallery

INDUSTRIAL ELECTRONICS APPLICATIONS

Chairman: I. K. MUNSON, *Central Engrg., RCA, Camden, N. J.*

* Sponsored by the Professional Group on Industrial Electronics. To be published in Part 6 of the 1961 IRE INTERNATIONAL CONVENTION RECORD.

18.1. Transistorizing the Industrial Image Orthicon Camera

RICHARD W. COOK, *Thompson Ramo Wooldridge Inc., Dage Television Div., Michigan City, Ind.*

This paper describes the design of a fully transistorized image orthicon camera. Through the use of detailed circuit descriptions in areas such as the preamplifier, shading circuits and focus current regulator, the advantages transistors offer are pointed out. These advantages show themselves in the form of substantial reduction in weight, size, cost and operating power. Charts and photographs are used to describe in detail the sensitivity, capabilities and applications of such a camera. Schematics are used in describing pertinent circuit advantages.

18.2. Computers for Industrial Control

R. W. SONNENFELDT, *Engrg. Industrial Computer Systems Dept., RCA, Natick, Mass.*

General-purpose digital computers are now making their appearance in industrial plants. For the most part, they do not merely mechanize tasks previously handled by humans, but make possible an entirely new era in control of complicated processes. Industrial control computers are now being designed for such application. This paper discusses in basic terms the characteristics and performance features of industrial computers and how they can increase process profitability.

Computer speed, memory capacity, kind of memory, mechanical design, programming features, reliability and other specifications are related to requirements of industrial control. A typical application analysis is explained through use of high-speed tin plate line as an illustrative example. Several suggestions are offered as an aim in the writing of better purchase specifications.

Currently, about three years are needed to go from first conception to an operating industrial computer installation. A discussion is given of the many tasks to be completed by user and supplier in this process.

18.3. The Infrared Radiometric Method and its Application to Remote Temperature Measurement

HERBERT L. BERMAN, *Radiation Electronics Co., Chicago, Ill.*

It is a common observation that objects having different temperatures exchange energy by radiative transfer. The radiant power emitted by an object is a definite function of its temperature, so that measurement of this radiation provides a measurement of temperature without contacting the emitting object.

The basic instrument for measurement of radiant flux is the radiometer. The functional components of the radiometer, such as infrared optical materials and detectors, are described. Operational features and application of the radiometer to temperature measurement and control are discussed in detail.

The effect of emissivity errors on temperature accuracy is developed and various methods of minimizing these errors are described.

18.4. A Phase-Shift Data-Transmission System for Analog-to-Digital or Digital-to-Analog Conversion

HENRY P. KILROY, *Concord Controls Inc., Boston, Mass.*

In the field of digital control, the conversion of a shaft angle to a digital output or the conversion of a digital input to a shaft angle are frequently encountered. One method of analog-to-digital encoding or digital-to-analog decoding utilizes a phase-shift data-transmission system. Such a system uses a digital time base to establish a reference phase signal in one or more synchro receivers and the necessary encoding or decoding circuitry wh ch establish a second phase-signal to compare with the reference signal. This paper discusses the basic logical blocks necessary to establish the digital time base and the refinements required to the basic arrangement to achieve the phase-shifted signal used with an encoding or decoding system.

Applications of a decoding system to a machine tool positioning control and an encoding system to a multispeed data-transmission print-out are demonstrated.

SESSION 19*

Tues. 2:30–5:00 P.M.

Waldorf-Astoria Jade Room

BROADCASTING

Chairmen: CLURE OWEN, *ABC, New York, N. Y.*

19.1. An Improved Loudness Indicator

JARRETT L. HATHAWAY, *NBC, New York, N. Y.*

Despite certain deficiencies, present-day-type volume indicators have been employed almost exclusively in audio level control by American broadcasters. A new unit has been developed and is now being evaluated as an indicator of loudness peaks. With this, the staccato type of speech produces greater relative indication than our present-day indicators, and as a result, control engineers find it necessary to reduce the level of many overly loud commercials. In general, loudness peaks have been found to be more accurately portrayed by the new indicator.

19.2. The International Broadcasting System of the Voice of America

E. T. MARTIN AND G. JACOBS, *Broadcasting Service, U. S. Information Agcy., Washington, D. C.*

The Voice of America, the international broadcasting service of the U. S. Information Agency, speaks for America in more than 36 different languages to a worldwide audience. The technical facilities that make this possible literally encircle the globe. Thirty short-wave transmitters at 7 locations in the continental United States range in power from 25 to 200 kw. Overseas, VOA has 9 relay stations with 47 transmitters ranging in power from 35 to 1000 kw. This paper discusses the development of this technical system from its wartime inception. Highlighted in the discussion are the problems encountered in the development of the system, techniques designed to counteract these obstacles, and future plans for strengthening the signal of the Voice of America.

19.3. FCC Laboratory Observations of Precision Frequency Control of TV Stations

EDWARD W. CHAPIN, *Lab. Div., FCC, Laurel, Md.*

A paper published in the June, 1958, issue of the IRE TRANSACTIONS ON BROADCAST TRANSMISSION SYSTEMS covered laboratory observations of precision offset. Some question was raised concerning the effects of propagation on the benefits to be derived from precision offset operation, especially at larger distances. Tests have been made over extended periods at the Commission's Laboratory near Laurel, Md., of Channel 4 signals received from Washington, D. C., being interferred with by a simulated TV signal, controlled in frequency by the instantaneous received frequency of the Channel 4 signal received from New York. In addition to propagation effects, certain receiver characteristics were noted to alter the interference susceptibility.

19.4. The CBS NetALERT—A System for Network Signaling

A. A. GOLDBERG, A. KAISER, AND G. D. POLLACK, *CBS Labs., Stamford, Conn.;* AND D. M. VORHES, *CBS Radio, New York, N. Y.*

Broadcast nework operations require a means for rapid and reliable communication between the network headquarters and the affiliated stations over the program lines. The CBS NetALERT® provides such a means. Three requirements were placed upon the system: 1) signal so unobtrusive that it could be transmitted during a network broadcast with out conscious awareness on part of the listeners; 2) reliable reception of the transmitted signal; and 3) reliable immunity operation was desired in terms of freedom from false alarms. The first requirement was met by using a 30-msec signal code 20 db below program peaks. The signal is keyed automatically by means of a modified telephone dial, and is received by a logic filter which recognizes and accepts only the particular code being used. The CBS NetALERT® permits the signaling of cues, closed-circuit announcements, news bulletins, etc. Those codes which signify extremely important or emergency news in addition are transmitted automatically to the station manager's home.

* Sponsored by the Professional Group on Broadcasting. To be published in Part 7 of the 1961 IRE INTERNATIONAL CONVENTION RECORD.

SESSION 20*

Tues. 2:30–5:00 P.M.

Waldorf-Astoria
Sert Room

STUDIES IN MAGNETIC RECORDING

Chairman: S. J. BEGUN, *Clevite Corp., Cleveland, Ohio.*

20.1. Analysis of Sine Wave Magnetic Recording

IRVING STEIN, *Res. Div., Ampex Corp., Redwood City, Calif.*

The recording of a sine wave on a magnetic material through the use of a magnetic gap is analyzed and is found to consist of two processes: 1) a virtual scanning of the tape by the recording magnetic field, and 2) interference of these consecutively recorded scannings with each other as the tape passes over the magnetic gap. Using an idealized head-to-tape theoretical model as our starting point, the distortion, attenuation, and phase shift of the recorded signal is found as a function of the relevant variable such as gapwidth, wavelength, head-to-tape spacing and recording level.

20.2. A New Model for Magnetic Recording

B. B. BAUER AND C. D. MEE, *CBS Labs., Stamford, Conn.*

Magnetic recording is a complicated process which has in the past been largely portrayed in terms of models based upon the magnetic characteristics of the recording medium. The previous models have been incomplete and sometimes incorrect, and they have left unexplained many of the experimental phenomena known to exist in magnetic recording. The proposed new model is not claimed to be precise in every detail. However, it has the virtue of presenting a unified and simplified picture of magnetic recording. The recording process is viewed as an interaction between the idealized properties of magnetic particles and the idealized geometry of the recording field. The latter appears as a series of "bubbles" and "shells" of critical field strengths which grow and collapse throughout the cycles of bias and record current.

20.3. The Mechanism of AC Biased Magnetic Recording

DONALD F. ELDRIDGE, *Ampex Corp., Redwood City, Calif.*

The mechanism of ac biased magnetic recording is directly related to the particulate nature of the recording medium. A theory has been developed which describes this relationship, both qualitatively and quantitatively. The action of ac bias on a single-domain particle is examined, and the factors determining its remanent state are analyzed. When the analysis is extended to an aggregate of such particles, it is found that the interaction fields created by the particles themselves are responsible for the biased recording mechanism. The transfer characteristic obtained with ac biasing is derived directly from the distribution of interaction fields in the aggregate material.

* Sponsored by the Professional Groups on Electronic Computers and Audio. To be published in Part 2 of the 1961 IRE INTERNATIONAL CONVENTION RECORD.

20.4. Magnetic Recording of Short Wavelengths

MARVIN CAMRAS, *Armour Res. Foundation of Illinois Inst. Tech., Chicago, Ill.*

Magnetic recording densities of 10,000 cycles per inch or more give rise to problems in recording heads, playback heads, record media, mechanical contact, and alignment. An analysis of these problems, and techniques for achieving high densities are described.

20.5. Flutter in Magnetic Recording of Data

CHARLES B. PEAR, JR., *Minneapolis-Honeywell Regulator Co., Beltsville, Md.*

Among the sources of error in magnetic tape recording, one of the more important is the distortion of the reproduced time scale generally described by the term "flutter." Flutter is defined as the deviation in reproduced frequency from the original recorded frequency which results from nonuniform speed of the recording medium during recording and reproduction.

The present paper provides a qualitative and quantitative discussion of flutter including:

1) Causes—eccentricities, resonances, frictional variations.
2) Effects—FM noise, AM noise, time displacement error.
3) Measurements—methods, units and relations between them.
4) Compensation—methods and limitations.

SESSION 21*

Tues. 2:30–5:00 P.M.

Coliseum
Faraday Hall

SYMPOSIUM: THE CHANGING ROLE OF BIO-MEDICAL ELECTRONICS IN SCIENCE AND TECHNOLOGY

Chairman: OTTO H. SCHMITT, *University of Minnesota, Minneapolis, Minn.*

* Sponsored by the Professional Group on Bio-Medical Electronics. To be published in Part 9 of the 1961 IRE INTERNATIONAL CONVENTION RECORD.

Until very recent years, Bio-Medical Electronics conceived its primary task as that of providing theoretically sound and well-engineered instrumentation and techniques to aid the biologist and medical scientist and practitioner in his work. While this is still an honorable and worthy objective, new factors have arisen which have insidiously extended the mission of this technological area by at least a decimal order of magnitude and have frightened us with respect to our ability to recruit and educate an adequate number of engineers and scientists in this interdisciplinary area. The principal factors in this metamorphosis are: the recognition of the importance of engineering designs based on biological models, the emergence of quantitative theory in biology and medicine, the necessity for designing tightly coordinated man-machine systems and the rapid development of computer technology, much of which hinges on our ability to communicate efficiently with computers and to build them and their subsystems into solutions for our everyday problems. The speakers in this symposium will offer an historical review of bio-medical electronics and, on the basis of their combined experience in the academic, the basic science, the industrial, the military and the medical fields, will attempt some specific and some general estimates of the direction which bio-medical electronics will take in the 1960–1970 decade.

Symposium Members: OTTO H. SCHMITT, *University of Minnesota, Minneapolis, Minn.;* HERMAN P. SCHWAN, *Moore School of Elec. Engrg., University of Pennsylvania, Philadelphia, Pa.;* JOSEPH ALMASI, *GE Co., Syracuse, N. Y.;* ALBERT H. SCHWICHTENBERG, BRIG. GEN. RET. USAF, MC, *Lovelace Clinic, Albuquerque, N. M.;* AND JEROME B. WIESNER, *Res. Lab. of Electronics, M.I.T., Cambridge, Mass.*

SESSION 22*

Tues. 2:30–5:00 P.M.

Coliseum
Marconi Hall

IMPLEMENTATION OF RELIABILITY PREDICTIONS

Chairman: LEON PODOLSKY, *Sprague Electric Co., North Adams, Mass.*

22.1. Reliability Trade-Off Analysis

A. STERNBERG AND J. S. YOUTCHEFF, *GE Co., Philadelphia, Pa.*

* Sponsored by the Professional Group on Reliability and Quality Control. To be published in Part 6 of the 1961 IRE INTERNATIONAL CONVENTION RECORD.

This paper presents a technique which permits optimum test planning for reliability demonstration. Costs, time, and available sample sizes have been considered relative to the system reliability which can be demonstrated for various equipment test levels. The paper also presents the methodology for establishing system curves, allowing the rapid prediction of equipment operational life. The curves may also be used to evaluate a reliability proposal so that necessary design or test program changes can be made. The presented procedures can be used wherever an optimized system reliability test program is required.

22.2. A Study for Determining an Optimum Burn-in of Fixed Glass Dielectric Capacitors

LAWRENCE D. HINES, *Corning Glass Works, Bradford, Pa.*

Historically it has been believed that high levels of hi-potting would eliminate potential early load life failures. It is proven by many analyses of variance that hi-potting causes failures rather than merely finds potential failures. It is shown that a good burn-in will eliminate potential early load life failures much more effectively than hi-potting.

Again, it has been believed that the higher the level of burn-in voltage the more effective the burn-in is. It is shown that a given level of burn-in voltage will eliminate a certain mode of failure regardless of the capacitor voltage rating. It appears that every elimination or reduction of primary and secondary failure modes will necessitate a review of the burn-in voltage levels.

Good correlation is shown between voltage levels of dielectric breakdown and life performance of the group of capacitors from which the samples used in obtaining the breakdown distribution had come. This correlation may be used to help determine new sets of burn-in voltage levels as primary and secondary failure modes are eliminated or reduced.

22.3. Significance of Nuclear Radiation for Military Computer Reliability

P. E. BROWN AND A. L. LONG, JR., *Burroughs Corp.,—Res. Center, Paoli, Pa.*

Nuclear radiation environments pose a threat to military computer reliability. New applications expose computers to nuclear radiation from natural and artificial sources. Effects of nuclear radiation on computer performance is described. Improvement of computer reliability for nuclear radiation environments will be effected through a testing program which involves simulation of radiation environments, with dynamic measurements of neutron and gamma flux and spectra; through component improvement based on studies of radiation damage mechanisms; and through the use of advanced techniques to provide compensating and protective circuits.

22.4. Transistor Reliability Estimated with the Poisson Distribution

C. H. LI, *Semiconductor Div., General Instrument Corp., Hicksville, N. Y.*

This paper shows a method to determine transistor reliability and yields using the Poisson's distribution. A special reliability coordinate paper is presented along with a simple case. By plotting on this paper the yield data of transistors against the junction diameter or other suitable variables, a straight line is expected. The slope of this line may suggest the likely failure mechanism. The effect of some processing, operating, or testing voltages, temperatures, and times is then added to the basic yield equation. Finally, the simple case is generalized to cover cases where several types of defects exist, each having different probabilities to cause transistor failures.

22.5. Does Derating Improve Reliability-Longevity?

W. C. DRANE AND H. L. BENJAMIN, *Light Military Electronics Dept., GE Co., Utica, N. Y.*

Empirical data will be presented to substantiate several hypotheses concerning the functional relationship between environmental stress, part failure rates, and longevity. From these data, derating, that is, the use of pieceparts at stress levels lower than that for which they are rated, will be evaluated. A means of predicting equipment longevity will also be proposed.

The basic hypothesis to be demonstrated is that a definable period of time exists during which there is practically no probability that a good part will fail. During this time substandard parts, if they have not previously been eliminated, will have a failure rate which is not significantly different from some constant value and that this value will not be decreased by derating. It is proposed that equipment should be designed to make use of these optimum time periods for parts.

SESSION 23*

Tues. 2:30–5:00 P.M.

Coliseum Morse Hall

MICROWAVE DEVICES

Chairman: PAUL W. CRAPUCHETTES, *Litton Industries, San Carlos, Calif.*

23.1. A Tunable *L*-Band Tunnel-Diode Amplifier

H. M. WACHOWSKI, *Kearfott Div., General Precision, Inc., Van Nuys, Calif.*

A tunnel diode has a negative dynamic resistance over a certain range of applied voltage. A one-port amplifier can be realized by terminating a uniform transmission line by a tunnel diode. The junction capacitance and parasitic series inductance of the diode must be tuned out. Kearfott has developed a tunable *L*-band tunnel-diode amplifier of this kind, providing a gain of 17 db, a bandwidth of 8 Mc, and a noise figure of 6 db. Being a one-port device, the amplifier is used with a circulator, or, alternatively, two amplifiers are used in conjunction with a hybrid in a balanced bridge arrangement. The outstanding advantage of such an amplifier is its extremely low power requirements.

23.2. The Maser Amplifier as a Practical Microwave Component

F. E. GOODWIN, J. E. KIEFER AND G. E. MOSS, *Hughes Res. Labs., Malibu, Calif.*

Microwave maser amplifiers, with typical noise temperatures near 10°K, can offer substantially improved performance in a variety of systems, *e.g.*, satellite communications, long-range radar. Until recently, the complexity and bulkiness of maser amplifiers has seriously restricted their usefulness. This paper describes the results of a program to develop the maser as a rugged practical component. Through unconventional packaging, single-port and traveling-wave *X*-band masers, together with their magnets, circulators and isolators, have been developed to fit within a miniature dewar less than 14 inches long, weighing less than 12 pounds. These masers will operate 20 hours in any position on one charge of helium. The cryogenic technology is being further refined to allow the use of a self-contained miniature helium refrigerator weighing 14 pounds.

23.3. A Voltage-Tunable Magnetron with a Matrix Cathode and Improved RF Structure

JOHN W. MCLAUGHLIN, *Eitel-McCullough, Inc. San Carlos, Calif.*

A new RF structure has been used in a voltage-tunable magnetron to reduce leakage currents from the interaction region of the tube. The structure is a specially arranged three-conductor interdigital line that shields the RF region from the dc electrodes of the tube and permits direct connection of a coaxial line to the interdigital circuit.

A pressed matrix cathode is also used in this voltage tunable magnetron, providing several advantages to the operation of the tube. Among these advantages are: 1) better resistance to backbombardment, 2) less sensitivity to heater power fluctuation, 3) use of ac heater power, and 4) rugged cathode structure to withstand severe environmental conditions.

23.4. A New Method of Magnetron Tuning and Frequency Stabilization

R. M. SALZER AND R. STEINHOFF, *Electron Tube Div., RCA, Harrison, N. J.*

A control of frequency deviation not previously available in any tunable magnetron is accomplished by the use of an internal cavity closely coupled to the magnetron resonator system. This new approach has produced a

* Sponsored by the Professional Groups on Electron Devices and Microwave Theory and Techniques. To be published in Part 3 of the 1961 IRE INTERNATIONAL CONVENTION RECORD.

tunable pulsed magnetron with a high degree of frequency stability for X-band beacon service.

Thermal compensation of the capacitive loading element of the tuning cavity, together with the stabilization inherent in the use of a coupled cavity results in a frequency deviation of ±2 Mc at any point in a 40-Mc band due to all causes including pulling, pushing, temperature variation over a 180°C range, and average power variations of approximately 3000 to 1.

The design approach used to accomplish simultaneously the stabilization, tunability, and compensation is described and test results on developmental models are given.

23.5. A Survey of the Elements of Power Transmission by Microwave Beam

W. C. Brown, *Spencer Lab., Raytheon Co., Burlington, Mass.*

Traditionally, microwave beams have been limited to applications involving information handling. More recently, the prospect of large amounts of economically generated microwave power have encouraged proposals to transfer large amounts of energy for certain specialized applications by microwave beam. This paper reviews the status of the elements involved in the transfer of such energy: 1) the generation of large amounts of microwave energy, 2) the antenna requirements needed to transfer energy efficiently between two points, and 3) various methods of converting the transmitted microwave energy back into more directly usable forms of energy. Factors affecting the choice of frequency to be used are considered. The limitations imposed upon component development by the nature of the application are discussed.

SESSION 24

Tues. 8:00–10:00 P.M.

Waldorf-Astoria Grand Ballroom

PANEL: NEW ENERGY SOURCES

Chairman: Gordon S. Brown, *School of Engrg., M.I.T., Cambridge, Mass.*

Developments in the field of new energy sources have come so fast that few people have had the opportunity to assess their significance. We are privileged to bring you apanel discussion by outstanding individuals who have pioneered in their respective areas of new energy sources. Dr. Gordon S. Brown, Dean of Engineering at M.I.T., will lead the panel in a review of current and future demands which will be made upon electronics as our knowledge and the use of new energy sources advance.

To be published in Part 3 of the 1961 IRE International Convention Record.

24.1. Thermoelectricity

Paul H. Egli, *Naval Res. Lab., Washington, D. C.*

24.2. Magnetohydrodynamics

Arthur R. Kantrowitz, *Everett Avco Res. Labs., Everett, Mass.*

24.3. Thermionic Converters

Volney Wilson, *GE Res. Lab., Schenectady, N. Y.*

24.4. Fuel Cells

Anthony M. Moos, *Leesona Corp., Jamaica, N. Y.*

24.5. Solar Energy

John I. Yellott, *Yellott Solar Energy Labs., Phoenix, Ariz.*

24.6. Report of Russian Thermoelectricity Program

R. L. Petritz, *Advanced Energy Conversion Projects, Texas Instruments, Inc., Dallas, Tex.*

24.7. Status of New Energy Sources in Western Europe

Pierre R. Aigrain, *University of Paris, Paris, France*

SESSION 25*

Wed. 10:00 A.M.–12:30 P.M.

Waldorf-Astoria Starlight Roof

DETECTION THEORY AND SIGNAL ANALYSIS

Chairman: George Turin, *University of California, Berkeley, Calif.*

25.1. Applications of Stochastic Approximation Methods to Optimum Filter Design

David J. Sakrison,† *Res. Lab. of Electronics, M.I.T., Cambridge, Mass.*

A method of designing nonlinear filters for performance criteria other than minimum mean-square error is described. The performance criteria considered are minimization of $E\{w(e)\}$ where w may be any convex nonnegative function of the error. The method assumes a filter design of fixed form that contains k variable parameters. A technique for iteratively adjusting the parameters is given. Stochastic approximation methods are used to show that the sequence of parameter settings generated by the technique converges in the mean to the parameter setting which minimizes $E\{w(e)\}$. Certain variations of the iterative scheme are considered, and corresponding estimates of the rates of convergence are derived.

* Sponsored by the Professional Group on Information Theory. To be published in Part 4 of the 1961 IRE International Convention Record.

† Space Technology Laboratories Fellow.

25.2. Radar System Performance in a Dense-Target Environment

E. N. Fowle, E. J. Kelly, and J. A. Sheehan, *Lincoln Lab., M.I.T., Lexington, Mass.*

This paper is addressed to the problem of the detection of multiple targets by radar, and the concomitant measurement of range and range-rate. Angular resolution is not considered. Two types of multiple target complex are considered: the case of a high density of similar targets and the case of a single target in a dissimilar clutter background.

A method of signal-processing is described, which is partly motivated by the application of the maximum likelihood principle to this problem. Performance and signal design criteria are then studied largely in terms of a signal-to-interference power ratio, and a logical basis is evolved for the design of signal waveforms in terms of the structure of the target complex.

25.3. A Method of Designing Signals of Large Time-Bandwidth Product

E. L. Key,* E. N. Fowle, and R. D. Haggarty, *Lincoln Lab., M.I.T., Lexington, Mass.*

This paper is devoted to the problem of establishing a method for the design of large duration-bandwidth product signals wherein the envelope shape and autocorrelation function may both be separately specified. Such signals find use in radar and communications. The design problem hinges on an integral equation, for which an approximate solution, valid for large duration-bandwidth products, is found by the method of stationary phase.

Following the method presented in this paper the signal designer is able to control the envelope shape and time duration of the signal while at the same time specifying independently the receiver output waveform. The receiver in addition, may be exactly matched to the signal, thus optimizing detection capability.

* Now with the Mitre Corp., Bedford, Mass.

25.4. On the Recognition of Signal Patterns in Noise

J. K. Wolf,† *Communications Directorate, Rome Air Dev. Ctr., Griffiss AFB, N. Y.;* and J. B. Thomas, *School of Engrg., Princeton University, Princeton, N. J.*

In the application of statistical decision theory to the recognition of two-dimensional patterns in noise, the decision as to which of a set of patterns is present involves the calculations of a likelihood function for each of the possible signals. In this paper, systems are developed for the calculation of these functions when the signal patterns are perturbed by multiplicative and additive noise. The resulting realizations are shown to reduce to two-dimensional matched filters. In the development, a useful orthogonal expansion of two-variable random processes is derived.

SESSION 26*

Wed. 10:00 A.M.–12:30 P.M.

Waldorf-Astoria
Astor Gallery

BROADCAST AND TELEVISION RECEIVERS

Chairman: John F. Bell, *Zenith Radio Corp., Chicago, Ill.*

26.1. A Report on the Midwest Program of Airborne Television Instruction

T. F. Jones, *Purdue University, Lafayette, Ind.*

The Midwest Program on Airborne Television Instruction is a regional exploration in education. Educational courses on video tape will be telecast from an airplane flying over North-Central Indiana to classroom TV sets in parts of six states. Demonstration telecasts, beginning in February, 1961, will be followed by a full academic year of telecasting beginning in September, 1961.

Technical, economic, and educational aspects of this important educational experiment, and important new use of TV transmitters and receivers, will be discussed briefly.

† On military leave from RCA Labs., Princeton N. J.

* Sponsored by the Professional Group on Broadcast and Television Receivers. To be published in Part 7 of the 1961 IRE International Convention Record.

26.2. TV *is* Feasible for Regular Graduate Courses

Wayne B. Swift, *Dept. of Elec. Engrg., University of Wisconsin, Madison, Wis.*

Last fall, a beginning graduate level course in Network Theory was operated at the University of Wisconsin over a closed circuit TV system simultaneously to three remote locations—two 80 miles away. Each location had available a microphone for interrupting the lecturer with questions. One of the remote locations was in a Milwaukee industrial plant; the others were on University premises.

Operation was definitely successful. Anticipated difficulties were overcome; unexpected favorable effects were noted. *Lecture preparation was no more than for a normal classroom situation.*

26.3. Subminiature Tubes for TV Tuners

T. E. Gausman, *Sylvania Electronic Tubes, Receiving Tube Operations, Emporium, Pa.*

The subminiature electron tube has enjoyed widespread usage in industrial and military applications. Recent developments have resulted in the practical manufacturing of a strap frame grid which provides for much higher transconductance. By combining these two developments and looking beyond military and industrial applications to the entertainment field, Sylvania has produced a low-noise, high-gain triode for television RF amplifier service. The proven advantages of the subminiature construction and the strap frame grid result in improved performance over conventional miniature types, and competitive performance with other recent innovations in electron tube design.

26.4. Horizontal Scan Nonlinearity in Television Receivers and the Saturable Reactor

Harry W. Claypool, *TV-Radio Div., Westinghouse Electric Corp., Metuchen, N. J.*

Reaction horizontal scanning systems as universally used in commercial television receivers are simple, efficient and provide an excellent source of high-voltage power to excite the CRT. As scan angles increase, however, maintaining good horizontal scan linearity becomes increasingly difficult. It also becomes more important when coupled with increased corner viewing area such as provided by recent developments in CRT faceplate contours. The use of the saturable reactor as a linearity compensating device, although neglected in this country, provides a simple and effective solution to this problem. With a minor modification, the same reactor can be made into a combination device, providing control over both horizontal linearity and width.

SESSION 27*

Wed. 10:00 A.M.–12:30 P.M.

Waldorf-Astoria
Jade Room

APPLICATION OF SOLID-STATE DEVICES AS COMPONENTS

Chairman: Rudolfo M. Soria, *Amphenol-Borg Electronics Corp., Broadview, Ill.*

27.1. Semiconductor Band-Pass Filters

S. N. Levine and J. J. Sein, *RCA SurfCom Div., New York, N. Y.*

The possibility of semiconductor band-pass filters has been described by Shockley. (U. S. Patent No. 2,761,020, August, 1960). In the present report a detailed analysis is provided of semiconductor filters which utilize iterated impurity distributions or variations in geometry. The analysis is extended to filters which employ applied electric fields that are periodically varied along the length of the structure. Filters of these types are tunable by means of a dc bias and have a bandwidth of the order of five per cent about the center frequency. With materials characterized by sufficiently high resistivity and minority carrier lifetime, operating frequencies in the range of 10^4 to 10^6 cps can be achieved.

The performance of filters constructed by alloying techniques from high-resistivity *P*-type silicon with minority carrier lifetimes of 10^{-3}—10^{-4} seconds will be presented in detail.

27.2. Limitations of Film-Type Microsystem Circuits Consisting of Resistive and Capacitative Layers

W. W. Happ and G. C. Riddle, *Lockheed Missiles and Space Div., Palo Alto, Calif.*

A microsystem consisting of alternate resistive and capacitative layers is limited in its operating range by (1) a lower limit of resistance, about 1 ohm due to ohmic contacts; (2) an upper limit of resistance, about 0.1 megohm due to film stability; (3) a lower limit due to interelectrode capacitance, about 1 pf; and (4) an upper limit of capacitance due to area limitation about 10 $m\mu f$. An experimental and analytical study assesses the effects of contributing factors, such as interelectrode spacings. Material properties are examined in terms of device design objective. Recommendation and design criteria for microsystem circuits are presented in tabular form, with several representative illustrative examples.

* Sponsored by the Professional Group on Component Parts. To be published in Part 6 of the 1961 IRE International Convention Record.

27.3. Silicon Oxide Capacitor

OLIN B. CECIL, *Texas Instruments Inc., Dallas, Tex.*

A new miniature capacitor has been developed which utilizes thermally grown silicon dioxide as the dielectric. Packaged in a 0.095-inch-diameter × 0.250-inch-length epoxy package, the device has capacitance values which range from 10 to 150 pf and is rated at 50 volts over the temperature range +10° to 55°C. The capacitor has dissipation factor values of <0.002 at 1 Mc and a rated temperature coefficient of capacity ≤ ±100 ppm/°C over the operating temperature range. Life-test data for 3000 hours indicate a low failure rate. More complete electrical characterization data are given and discussed.

A brief discussion of the potentialities of this device with respect to microminiature design and other possible packaging approaches is given.

27.4. New Concepts in Thermoelectric Device Design

W. H. CLINGMAN, *Texas Instruments Inc., Central Res. Labs., Dallas, Tex.*

One area of research to improve the performance and reduce the cost of thermoelectric devices is thermoelectric system design. To optimize the design for a given set of materials and technology, the effects of the thermal circuit and electrical circuit on entropy production within the device are considered.

Methods of choosing the basic design concept for the thermoelectric part of the system are presented. Then optimization of the dimensions of each of the individual thermocouples and materials is discussed. Finally, the effect of thermal resistance between the thermoelectric junctions and the heat source and sink on the entropy production within the entire system is considered.

27.5. Ceramic-Metallizing-Tape for Reliable Metal-Ceramic Sealing

H. D. DOOLITTLE, K. ETTRE, R. F. SPURCK, AND P. F. VARADI, *Machlett Labs., Springdale, Conn.*

A new technique in the metallizing of ceramics was developed. The metal powder coating, applied on the ceramic surface, is prefabricated in the form of a tape. This self-supporting metallizing tape can be prepared with very uniform thickness and density and is then applied to the ceramic surface. This application can be carried out in a simple way using a suitable solvent to form a bond between the metallizing tape and the ceramic or by warm sealing (molding). The automation of the tape metallizing requires only a modest setup.

The tape preparation, materials, application and bond test results are given.

27.6. A Ceramic Band-Pass Transformer and Filter Element

A. LUNGO AND F. SAUERLAND, *Clevite Electronic Components, Clevite Corp., Cleveland, Ohio.*

Available in production quantities, a unique component for use in IF circuitry is described. Fabricated of a highly stable piezoelectric ceramic, this component takes the form of a small multiple-electrode disk operating at the first overtone of the radial mode.

The electrode configuration in the form of a ring and dot provides an impedance transformation. Also, being a resonant device, a frequency band-pass characteristic is provided.

A simplified equivalent circuit of the ceramic transformer is presented along with an analysis of the circuit. Also, a discussion is included of the application of the ceramic transformer. Reference is made to two well-known impedance transforming networks, the L-section and the Pi-network which are used to explain the circuit behavior of the ceramic transformer.

SESSION 28*

Wed. 10:00 A.M.–12:30 P.M.

Waldorf-Astoria Sert Room

SPACE ELECTRONICS

Chairman: PHILIP D. DOERSAM, *Lockheed Missile and Space Div., Sunnyvale, Calif.*

28.1. The Effects of Van Allen Belt Radiation on Material

ROBERT S. SHANE, *Light Military Electronics Dept., GE Co., Utica, N. Y.*

The paper is a discussion of the interaction of the Van Allen Belt with certain components and materials. This radiation belt, located between latitudes 50°N and 50°S (auroral zones) and roughly between 1000 statute miles and 3500 statute miles above the equator, has a radiation intensity which is about one order of magnitude more than the area above or below it.

An estimate of the effects of Van Allen radiation on various materials and components is ncluded as an extrapolation of data secured from nuclear fission fragment bombardment and gamma irradiation. The estimated effects of high-energy radiation on several specific components and materials are discussed, and recommendations are made for an additional testing and evaluation program.

* Sponsored by the Professional Group on Space Electronics and Telemetry. To be published in Part 5 of the 1961 IRE INTERNATIONAL CONVENTION RECORD.

28.2. The Existence of Periodic Variations in the Observations of Jovian Eclipses

MARTIN RUDERFER, *Dimensions, Inc., Brooklyn, N. Y.*

A statistical analysis of the residuals between calculated and observed times of Jovian eclipses shows the presence of variations periodic with the orbital motions of Jupiter and the earth. The possibility that these variations may result, in part, from a variation in the one-way velocity of light in contradiction with the second postulate of special relativity is discussed with respect to other possible causes. It also appears possible that there is much information in the eclipse data relevant to the surface and atmospheric conditions on Jupiter.

28.3. ATLAS Missile Flight Safety System for Project Mercury

J. W. SCHAELCHLIN, R. D. GADBOIS, AND T. F. HEINSHEIMER, *Convair Astronautics Div., General Dynamics Corp., San Diego, Calif.*

This paper describes the flight safety system being flown aboard the ATLAS missile for all flights supporting Project Mercury, the National Aeronautics and Space Administration's "man in space" program. Known as ASIS (Abort Sensing and Implementation System), it is designed to insure the highest possible degree of safety for the MERCURY astronaut during the ATLAS powered portion of his flight. ASIS monitors the performance of all critical missile systems and automatically initiates the capsule escape sequence in case the performance of one or more of these systems should fail, indicating an impending missile failure. Both the design philosophy and the resulting flight hardware are discussed.

28.4. Diagnostic Instrumentation for an Electric Propulsion Plasma Engine

L. ARONOWITZ AND A. STEINBERG, *Plasma Propulsion Lab., Republic Aviation Corp., Farmingdale, N. Y.*

This work covers the experimental techniques used to explore plasma motion and properties in plasma "pinch" engines and other pulse discharge applications. Microwave *K*-band systems, magnetic probes, and photodetector techniques as applied to the measurement of plasma velocities, current amplitudes and transient magnetic fields will be discussed. A Hall effect current measuring device will be discussed. Typical data illustrating the results of these applications will be presented.

28.5. Inherent Errors in Locating Electrical Storms with a Surveillance Satellite

R. A. WHITEMAN AND D. FRYBERGER, *Armour Res. Foundation, Technology Center, Chicago, Ill.*

This is a study of the effects of refraction of electromagnetic waves through the troposphere and ionosphere upon the errors in locating electrical storms with a surveillance satellite at 500-km altitude. The errors were computed with the aid of a UNIVAC 1105 computer for "dip-angles" from 20° to 80° and frequencies from 20 Mc to 300 Mc. The standard atmosphere for noon over Washington, D. C., was established with data from Contract AF 30(602)-1514 and IGY Project No. 6.9. The model atmosphere approximating the standard atmosphere for computational purposes was established by dividing the troposphere into seven shells and the ionosphere into twelve shells. With "dip-angle" of 44.5° at the satellite, the inherent error in locating an electrical storm using 150 Mc was computed as 2310 meters.

In addition to the inherent errors of this technique for locating electrical storms, a study was made and the results presented concerning the attenuation, expected field intensities at the satellite generated by a lightning flash, the signal-to-noise ratio expected in the region of the satellite and the induced "dip-angle" error due to this signal-to-noise ratio.

28.6. Logarithmic Navigation for Precise Guidance of Space Vehicles

W. G. GREEN, *Astrionics Lab., ITT Lab., Ft. Wayne, Ind.*

The principles of logarithmic guidance are derived and their application to various space flight guidance problems is discussed. Logarithmic guidance is shown to be ideal during the terminus of control where considerations of minimum fuel, minimum heating, etc., can be subordinated to precise matching of vehicle kinematics to the desired trajectory. This precise trajectory control is achieved utilizing velocity and position measurements to govern the vehicle deceleration. Multidimensional effects are considered and it is shown that various "degrees of control" of velocity vector magnitude and angle, time-of-arrival, acceleratious, geographical or inertial directions of approach, etc., can be achieved.

The tolerance of logarithmic guidance to instrumentation errors and parameter variations are confirmed by error analyses of these guidance principles applied to the control of the velocity vector during the deceleration process.

SESSION 29*

Wed. 10:00 A.M.–12:00 NOON

Waldorf-Astoria Grand Ballroom

GRADUATE EDUCATION IN ELECTRICAL ENGINEERING

Chairman: RONALD L. MCFARLAN, *20 Circuit Road, Chestnut Hill, Mass.*

* Sponsored by the Professional Group on Education. To be published in Part 10 of the 1961 IRE INTERNATIONAL CONVENTION RECORD.

This session will concern itself with a critical examination of the objectives and future direction of graduate electrical engineering education in the United States. It will endeavor to establish and analyze appropriate criteria with respect to faculty, admissions, programs of study, resident requirements, etc.

This session, as well as a previous program held at the national AIEE convention in February, is an outgrowth of several years of discussion and collaboration of the IRE Professional Group on Education, the AIEE Education Committee, and the ASEE Electrical Engineering Division. These three educational committees, each representing a different segment of the electrical engineering profession, believe that a thorough analysis of graduate electrical engineering education is now necessary and can contribute much to the over-all profession. A third program on this same theme is planned for the annual meeting of the ASEE this June at the University of Kentucky.

Panel Members: ERNST WEBER, *Polytechnic Inst. of Brooklyn, Brooklyn, N. Y.;* J. R. WHINNERY, *University of California, Berkeley, Calif.;* R. L. MCFARLAN, *Consultant, 20 Circuit Road, Chestnut Hill, Mass.;* AND S. W. HERWALD, *Westinghouse Elec. Corp., Pittsburgh, Pa.*

SESSION 30*

Wed. 10:00 A.M.–12:30 P.M.

Coliseum Faraday Hall

COMMUNICATIONS SYSTEMS —TECHNIQUES

Chairman: CHRISTOPHER BUFF, *Mackay Radio and Telegraph Co., Inc., New York, N. Y.*

30.1. A Queuing Problem of Mixed-Type Traffic

K. IKRATH AND H. ULFERS, *U. S. Army Signal Res. and Dev. Lab., Fort Monmouth, N. J.*

The queue situations on the link side of central office arising from service requests for direct (circuit switched calls) and indirect, *i.e.*, store and forward (message switched messages) traffic hand ing and processing is analyzed. The results of this analysis are presented in tabulated form and partially graphically in terms of mean queue lengths and their standard deviations, and mean waiting times as functions of average traffic arrival rates and release rates per unit time at and from the central office.

* Sponsored by the Professional Group on Communications Systems. To be published in Part 8 of the 1961 IRE INTERNATIONAL CONVENTION RECORD.

30.2. Wide-Band Channel for Emergency Communications

HENRY MAGNUSKI, *Motorola, Inc., Chicago, Ill.*

Two kinds of communication needs are distinguished; one is called "Emergency" and the other "Routine." It is pointed out that for better spectrum utilization a single, wide-band channel could be assigned to all emergency communication users in place of many individual narrow-band channels. Many independent systems or military nets would have access to this channel at random without any central coordination, and would be able to transmit messages without delays. Obviously, modulation, coding and/or addressing schemes should be so selected that many simultaneous conversations can occur on this single channel without objectionable interference between talkers. This paper indicates what techniques could possibly best implement such a system.

30.3. Voice Modulated SSB and DSB Peak-to-Average Envelope Power Ratios

JOHN D. GRIFFITHS, USAF, *Rome Air Dev. Ctr., Griffiss AFB, N. Y.*

Analysis of linear modulation techniques has been made for single-tone, two-tone, and square wave modulating signals. Since none of these approximate the spectrum and phase characteristics of voice modulation, the latter has been treated here for DSB and the two methods of SSB, all of which have different RF envelopes for the same modulating waveform. Further, some conclusions are drawn regarding possible modification of linear modulation systems regarding optimization of the peak to average RF envelope power ratio for various modulating waveforms.

30.4. Improvement of Unbalance Distortion in a Baseband Combiner

MASAHISA MIYAGI, *Radio Communication Industrial Div., Nippon Electric Co., Ltd., Kanagawa-ken, Japan.*

A common cathode-type postdetection ratio squarer has been the widely accepted art of design in the baseband combiners, which are used for over-the-horizon, diversity receiving radio system. This conventional combiner is vulnerable to unbalance distortion due to the baseband signal levels not equal at the combiner control grids, like when selective fading occurs in a multipath propagation.

We could first improve the unbalance distortion by 30 db by developing a common plate-type postdetection ratio squarer; later, another 30-db improvement was achieved by further modifying the combiner into push-pull common plate type.

30.5. Telephone Lines, Their Simulation and Equalization

ALLEN GATFIELD, *Engrg. Dept., Electronics, Inc., Silver Spring, Md.*

A detailed discussion of the phase and time delay characteristics of telephone lines as they affect data transmission systems is given. The synthesis of a transmission line simulator is discussed using calculated and measured data on a particular simulated line. One form of delay equalizer is discussed and applied to the correction of the simulated line. A more flexible equalizer design is examined.

30.6. Frequency Division Multiplexing on Transoceanic Cables

Walter Lyons, *RCA Communications, New York, N. Y.*

High data transmission speeds require multiplexing in order to reduce the distortion in the received signal. A certain degree of time division multiplexing is desirable although it is more economical and otherwise required to utilize frequency division multiplexing to a greater degree.

The article shows how a cable voice channel can accommodate traffic at 2200 bits per second with reasonably low error rates. Techniques for this utilize sine-wave keying pulses at the fundamental keying rate, of subcarriers spaced every 120 cps from 420 cps to 2940 cps, and time division multiplex of the two 50-band input information channels to each subcarrier.

Examples of filter characteristics for reception and transmission to accomplish this are shown as well as typical equipment for each tone channel. Curves presented give distortion at various speeds per subcarrier and illustrate the effects of crosstalk and tone jitter as per cent distortion vs keying rate.

SESSION 31*

Wed. **10:00 A.M.–12:30 P.M.**

Coliseum
Marconi Hall

MATHEMATICAL APPROACH TO RELIABILITY PREDICTION

Chairman: Seymour Nozick, *RCA, Van Nuys, Calif.*

31.1. Reliability of System Components under Stationary Random Perturbations

D. W. C. Shen, *The Moore School of Elec. Engrg., University of Pennsylvania, Philadelphia, Pa., and Stromberg-Carlson Div. of General Dynamics Corp., Rochester, N. Y.*

The variation of a component parameter with time caused by random disturbing factors arising from manufacture processes and usage may be expressed as a Taylor's series over the time interval within the useful life of the component. Assuming that these disturbing factors are normally distributed and statistically independent, the probability density functions of the Taylor's coefficients are also normal. The two moments involved are the resulting values of the respective moments of the stationary random disturbing factors.

When the coefficient involving the first time derivative alone is considered, the probability density function of the component parameter variation is a symmetrical bimodel curve with zero value at $t=0$, and with two maxima equally spaced about $t=0$. The integral of this density function from 0 to a given probable useful life of the component then gives the probability that the useful life of the component lies within the limits specified.

This paper discusses the quasi-linear parameters of nonlinear elements subjected to random disturbances by means of a statistical linearization technique utilizing only the first two moments of the random process. The nonlinear element may include either a single-valued or a double-valued hysteretic characteristic.

31.2. Utilization of Reliability Factors for Prediction of Spare Parts Requirements

Jerome Klion, *Rome Air Dev. Ctr., Griffiss AFB, N. Y.*

This paper presents a general technique for the quantitative determination of the spare parts requirements of any type of electronic equipment, given a desired probability that the number of spare parts will be sufficient. This technique utilizes component part failure rates and Poisson experimental limits to provide an accurate prediction of spare parts requirements as early in equipment development as the design stage. Since reliance is placed on component part failure rates rather than past field experience with other equipment, spare part requirements may be validly predicted for equipments containing new types of circuitry as well as for equipments of conventional design.

A comparison of the proposed procedures and the present spare parts provisioning "key" techniques is made and it is concluded that the proposed procedure is more accurate and economical than the presently used method.

31.3. Generalized Mathematical Model for Reliability Studies of Electronic Equipment Complexes

F. P. Randazzo and W. J. Stahl, *Communications Systems Dept., Kellogg Switchboard and Supply Co., Chicago, Ill.*

A measure of the reliability of an electronic equipment complex is the availability of the complex for a period of time T. The generalized mathematical model presented consists of constructing a functional equipment block diagram of the complex; writing a set of Boolean failure equations for all types of failures of the system from the block diagram; determining the probability of failure for the components in the complex during a time increment Δt; determining a component repair priority; and using an availability computation equation. Using these parameters as inputs, a computer simulation may be performed using the Monte Carlo technique.

31.4. On the Reliability of Sequentially Operated Networks

G. H. Weiss and M. M. Kleinerman, *U. S. Naval Ordnance Lab., White Oak, Silver Spring, Md.*

In several earlier analyses of the reliability of interconnected networks, including redundant elements, expressions for the over-all reliability were derived by enumerating all possible modes of operation and calculating the reliability of single and combined modes. For all but the simplest networks the chief difficulty in this method lies in the enumeration which may be astronomical. In this paper we describe a class of networks of frequent occurrence for which one can bypass the enumeration difficulty. This class consists of sequential networks which are characterized by the fact that they function in several levels, sequentially. Hence, it is possible to treat such a network as a Markov chain. For each level there exists a transition matrix. The product of these matrices multiplied by a vector which specifies the task which the device is supposed to perform gives the reliability in vector form. The elements of the transition matrix are calculated in a straightforward manner from the sensing and switching reliabilites, and from the switching rules which specify which component is to be tried when a given component is found to have failed. Several variations of this basic model are presented. The enumeration difficulty is thus eliminated and the problem becomes a numerical rather than a combinatorial one.

31.5. A Markovian Model for Predicting the Reliability of an Electronic Circuit from Data on Component Drift and Failure

D. M. Brender and M. Tainiter, *IBM Watson Lab., New York, N. Y.*

Cumulative variations in the component-parameters of a circuit can result in the failure of that circuit. Hence the cause of a system failure need not be attributable to the catastrophic failure of any single component. A discrete-state, continuous-time Markov process is used to characterize both the parameter fluctuation with age and the catastrophic failure properties of each individual component. The behavior of the over-all circuit is then evaluated as a joint function of its component processes. From this resultant process, which is also Markovian, an expression for the circuit reliability as well as for other measures of circuit performance is determined.

* Sponsored by the Professional Group on Reliability and Quality Control. To be published in Part 6 of the 1961 IRE International Convention Record.

SESSION 32*

Wed. 10:00 A.M.–12:30 P.M.

Coliseum
Morse Hall

MICROWAVE SOLID STATE

Chairman: Harold Seidel, *Bell Telephone Labs., Murray Hill, N. J.*

32.1. Recent Advances in Solid-State Microwave Devices

M. E. Hines, A. Uhlir, and R. Damon, *Microwave Associates, Inc., Burlington, Mass.*

The paper reviews the present state of the art in new semiconductor and ferrite devices for microwave signals. Emphasis will be on applications of low-loss ferrites and diodes of Varactor, Pin, and Esaki or Tunnel types. Applications include parametric amplification harmonic generation, RF power control, signal limiting, crystal protection, oscillation, mixing, negative resistance amplification and tunable filtering.

In certain cases the new devices offer advantages such as improved sensitivity, lower power supply requirements, reduced size and weight and increased ruggedness and reliability as compared with previous methods of accomplishing the equivalent circuit functions.

32.2. Microwave Ferrite Stripline Filter and Power Limiter

J. Carter, *Microwave Tubes Branch, U. S. Army Signal Res. and Dev. Labs., Ft. Monmouth, N. J.;* R. A. Moore, *Air Arm Div., Westinghouse Electric Corp., Baltimore, Md.;* and I. Reingold, *Microwave Tubes Branch, U. S. Army Signal Res. and Dev. Labs., Ft. Monmouth, N. J.*

Electronically tunable band-stop and band-pass microwave filters can be constructed from ferromagnetic resonators coupled to stripline or coaxial circuit elements. A theory for the small signal coupling including effects from associated conducting planes agrees well with experiment. Measured power limiting threshold and dynamic range for ferromagnetic resonators used in transmission configurations is presented. Within the dynamic range of limiting the initial spike transient duration decreases with increasing excitation power. The limiting threshold and initial spike energy for spherical resonators of single-crystal yttrium iron garnet are shown to be sufficiently low for adequate crystal protection.

* Sponsored by the Professional Group on Microwave Theory and Techniques. To be published in Part 3 of the 1961 IRE International Convention Record.

32.3. Low-Noise Tunnel Diode Reflection-Type Amplifiers

John J. Sie, *Micro State Electronics, Springfield, N. J.*

A reflection-type tunnel diode amplifier can be defined as a tunnel diode terminated transmission line whose magnitude of reflection coefficient is greater than unity. A coupling network, however, is needed to separate the incident and the amplified reflected waves. Two possible means of coupling are by the uses of 1) circulator and 2) hybrid. These two schemes are considered in detail as to gain, noise figure, stability, cascaded connections, dynamic range, and their interrelationships. The limitations of practical tunnel diodes with respect to these characteristics are discussed. Experimental data on both schemes of coupling are presented and apparent noise reduction due to shot noise suppression of tunnel diodes is discussed.

32.4. *X*-Band Parametric Amplification—An Integrated Approach to the Diode and Circuit Problem

S. M. Ku, R. I. Harrison, and S. W. Harrison, *General Telephone & Electronics Laboratories Inc., Bayside, L. I., New York*

A joint effort by semiconductor and microwave groups for developing a point-contact GaAs varactor and the complementary circuitry for a parametric amplifier operating at *X*-band frequencies will be described. Fabrication of the diode, techniques of characterizing its microwave properties and dynamic tests in the amplifier will be discussed. Specific reference will be made to the relative importance of resistivity of bulk material, package design, pulsing, capacitance variation, etc., needed to produce a diode suitable for parametric action at these frequencies.

32.5. Recent Advances in Microwave Mixers

J. J. Chacran, *Sage Laboratories, Inc., Natick, Mass.*

During the past several years, much effort has been devoted to the design and development of improved and radically new types of microwave mixers. This paper will discuss two of the main types, which are as follows:

1) Wide RF bandwidth coverage with conventional low-frequency IF output.
2) Medium or wide RF bandwidth coverage with high-frequency IF output.

In the wide RF bandwidth category, octave coverage has been achieved with both waveguide and coaxial systems. In the case of high IF mixers, IF center frequencies from UHF to *X* band have been obtained with IF bandwidths up to 40 per cent.

In addition, several mixers have been developed with the RF signal at a lower frequency than the IF center frequency.

Several different mixers are discussed in detail. Final results of some typical units will be given.

SESSION 33*

Wed. 2:30–5:00 P.M.

Waldorf-Astoria
Starlight Roof

DATA RECORDING AND STORAGE

Chairman: Otto Kornei, *General Products Div., IBM Corp., San Jose, Calif.*

33.1. The Design of a High-Performance 14-Channel Magnetic Record/Playback System for Use as a Precise Frequency Multiplier

S. Himmelstein, *Data-stor Div., Cook Electric Co., Skokie, Ill.*

Details of system design and performance of Model 33600 Recorder/Reproducer System are presented. The system serves as the heart of a complex signal analyzer which accomplishes the identification of sonar targets at great distances in the presence of masking background noise. Simply stated, the signal analysis is accomplished by the use of a unique frequency spectrum analysis technique. This technique is made practical by the use of the Model 33600 System whose primary function is to provide a precise and stable frequency multiplication of 100 times for all input signal components. In addition to accomplishing this end, its use permits time division multiplexing of the remainder of the analysis equipment and provides a permanent record of "raw data" for a 13-hour period.

33.2. A Unique Variable Time Delay Network with Application to Linearizing Magnetic Recording Systems

R. A. Wainwright, *Rixon Electronics, Inc., Silver Spring, Md.*

This paper describes the phase linearity requirements for processing of complex waveforms including digital information. The synthesis and design of a series of specially terminated networks and their application to linearizing magnetic tape recorders is described. A system for measuring the phase distortion on recording systems where normal periodic display instrumentation cannot be used is shown with measured results. The presentation includes quantitative data for finished equalized systems resulting from these methods.

* Sponsored by the Professional Groups on Audio and Electronic Computers. To be published in Part 2 of the 1961 IRE International Convention Record.

33.3. Analog Recording of Thermoplastic Film

WILLIAM C. HUGHES, *GE Co., Schenectady, N. Y.*

Thermoplastic recording is a new method for the permanent storage of information in the form of deformations in the surface of a thin thermoplastic film. The method has great potential application in the field of analog recording. It makes possible the recording of frequencies in excess of 10 Mc and because of the high density obtainable, several hundred hours of audio-frequency information can be stored on a single reel. Other advantages are dc response, immediate playback and long tape life.

An electron beam is used to record on the plastic and a light beam is used for readout. The recording is developed by heating the tape electronically and it can be erased for re-use.

33.4. A Harmonic Analysis of Saturation Recording in a Magnetic Medium

BOHDAN KOSTYSHYN, *IBM Product Dev. Lab., Endicott, N. Y.*

A single write-read head coupled with saturation recording techniques is commonly used to store digital information. Because of the experimental difficulty in determining the contribution of individual parameters to the system, a theoretical equation describing the output of a system in terms of the physical, magnetic, and electrical parameters of the system has been developed and programmed for the IBM 704 Data Processing System.

When applied to an experimental NRZ system, excellent agreement between observed and calculated results was obtained. The phenomena of "peak" or "phase" shift and amplitude shift occurring for an isolated pair of adjacent "ones" at high bit densities is demonstrated and discussed. The calculated dependence of the zero-to-peak output and the peak-and-amplitude shifts is shown for variations in the thickness, retentivity, coercivity and squareness of the storage medium, and for variations in the write current, the head-to-medium spacing, and the pole gap dimensions.

33.5. Design and Operation of a High-Speed Increased Capacity Magnetic Drum

R. R. SCHAFFER AND D. W. GILL, *Dev. Lab., IBM General Products Div., Endicott, N. Y.*

To meet data-processing system requirements for increased storage capacity and greater speeds, an electroplated Co-Ni alloy magnetic drum utilizing high-density recording and high-frequency circuits is described. This drum has a capacity of 2 megabits, a bit rate of 750 kc, and an average access time of 3 msec. The logical concepts and functional characteristics of the drum are discussed. These include a description of the input/output translators used to transmit required data into memory; the spacial selecting of the recording heads in the address decoders; and the circuitry for the write drivers and sense amplifiers. The primary code utilized in the drum memory is binary coded decimal, with data flow serial by bit, serial by character. The character code uses 7 bits per character, with a bit space for memory logical purposes, and a bit space provided for an end-of-word mark. This mark provides flexibility for variable word lengths from 1 to 100 character words. Magnetic recording is performed with "ring-type" recording heads operating in a noncontact environment.

To provide a framework for magnetic drum development within the range of technology, a mathematical relationship is described for projecting this memory technology over a range of equivalent magnetic drum systems. This relationship includes bit capacity, average access time, number of tracks, bit frequency, and other major magnetic drum considerations. A unique tear-drop magnetic head is described and illustrated which provides simple head structure capable of providing a well-defined head gap for high-density recording. Diagrams of the head selection matrix, the sense amplifier, the timing generator, and the drum storage organization are also included.

SESSION 34*

Wed. **2:30–5:00 P.M.**

Waldorf-Astoria
Astor Gallery

CIRCUIT THEORY—I

Chairman: S. J. MASON, *Dept. of Elec. Engrg., M.I.T. Cambridge, Mass.*

34.1. Synthesis of Passive Networks for Networks Active at p_0

ROBERT W. NEWCOMB, *Dept. of Elec. Engrg., Stanford University, Stanford, Calif.*

If a one- or two-port network N is active at p_0 (in the sense of Desoer and Kuh), it is always possible to find a passive embedding network N_P such that a natural frequency at p_0 is obtained. In this paper we will limit ourselves to proving this for an important special class of N's. These are the N which possess an admittance matrix Y and for which Y further has its imaginary skew-symmetric part zero.

For the one-port or the two-port for which σ_0 or ω_0 is zero, the synthesis is straightforward and N_P can be found which have no gyrators. For the two-port with σ_0 and $\omega_0>0$, the synthesis of N_P is broken into four cases, which depend upon the rank and signature of the real symmetric part of Y. For each case, transformers are used to obtain a canonical form for Y, from which synthesis can proceed. In two cases, a cascaded gyrator is also required to obtain the canonical form and in one case, a new theorem on the "diagonalization" of two indefinite matrices is required.

34.2. On the Rate of Parameter Variations in Feedback Systems

I. M. HOROWITZ, *Hughes Res. Labs., Malibu, Calif.*

It is shown that the effect of parameter variations in a feedback system is identical to the effect of an external disturbance on the time-varying feedback system. The value of equivalent disturbance is readily obtained. The usual design technique for attenuating disturbances is used to insure that the system response is always within the desired tolerances, whatever the rate of parameter variation. This method gives an upper bound on the required loop-gain bandwidth of the loop transmission. The same method is used to find a similar upper bound in order that a feedback system with nonlinearities may respond linearly within desired tolerances to a class of input signals.

34.3. Analysis of Circuits Containing Variable Capacitance Diodes

D. R. ANDERSON AND B. J. LEON, *Hughes Res. Labs., Malibu, Calif.*

This paper presents a method of analysis for circuit models consisting of a capacitive diode imbedded in an arbitrary, linear, time-invariant network. The diode characteristics that we assume are ones that have been verified by careful measurement. We entirely avoid both the simplifying assumption of ideal filters in the linear circuit and that of a two-term Taylor series for the diode characteristic. The main points of this method are:

1) A useful set of *a priori* conditions on the circuit and its excitation that guarantee operation within the capacitive range of the diode.
2) A method for finding the periodic response for the circuit used as a frequency multiplier.
3) A method for evaluating the parameters in the linear, time-variant model that characterizes the small signal performance of parametric amplifiers. An estimate for the errors introduced by this linearization is given.

34.4. A New Gain and Power Concept with Circuits Extending the Frequency Spectrum in Transistors into the Microwave Region

R. ZULEEG, *Hughes Aircraft Co., Semiconductor Div., Newport Beach, Calif.*; AND V. W. VODICKA, *Lenkurt Electric Co., Inc., San Carlos, Calif.*

In certain types of drift-transistors, frequency bands beyond the usually defined maximum frequency of oscillation

$$f_{\max} = \sqrt{\frac{\alpha_0 f_c}{8\pi r_b' C_c}}$$

are available in which power gain can be obtained and harmonic power generation is possible.

The basic theory of this operation will be discussed. Practical circuits and measurements will be demonstrated and reported. To date, the following results have been achieved:

1) Conversion gain in mixers at 500 Mc 2 kMc from 60 20 db.
2) Harmonic power at the fifth harmonic (3.6 kMc) with 2 per cent efficiency; measurable output at the ninth harmonic.

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* Sponsored by the Professional Group on Circuit Theory. To be published in Part 4 of the 1961 IRE INTERNATIONAL CONVENTION RECORD.

3) Power gains of 46 db–8 db from 500 Mc–2 kMc.
4) Noise figures of 5–8 db at 500 Mc.

The measurements reported are taken on graded base transistors with selected or specially designed characteristics. The maximum frequency of oscillation in these units was in the order of 500–800 Mc.

34.5. Noise in Oscillators with General Tank Circuits

R. Esposito and J. A. Mullen, *Res. Div., Raytheon Co., Waltham, Mass.*

The analysis of noise effects in a one-port representation of nonlinear oscillators is extended to cover arbitrarily complicated tank circuits. It is shown that, under appropriate conditions which are determined, the AM noise and FM noise are independent of each other.

The noise spectra are solved for by a perturbation expansion about the steady oscillation. The AM noise spectrum is the noise generator spectrum shaped by the magnitude squared of the symmetrized frequency response of the tank circuit using the actual oscillating frequency as the reference center.

The FM noise spectrum is the noise generator spectrum shaped by the squared magnitude of an anti-symmetrized response, and therefore is also symmetric.

SESSION 35*

Wed. 2:30–5:00 P.M.

Waldorf-Astoria
Jade Room

ADVANCES IN COMPONENT DESIGNS

Chairman: Paul S. Darnell, *Bell Telephone Labs., Whippany, N. J.*

35.1. General Theory of a Class of UHF Resonators

Joel L. Ekstrom, *Westinghouse Electronic Div., Baltimore, Md.*

A general theory of UHF resonators composed of a cascade connection of a shorted, high-impedance line and an open-circuited low-impedance line is presented from the point of view of the poles and zeroes of the driving point immittances at the shorted end and the junction point. It is shown that the configuration studied is a general one from which re-entrant and quarter-wave resonators may be derived as special cases. The Q factor of such resonators is considered, and it is shown that conventional resonators do not have as large a Q per unit volume merit factor as is possible with proper capacitive loading. The coupling problem is considered, and practical experimental results at 450 Mc are given.

* Sponsored by the Professional Group on Component Parts. To be published in Part 6 of the 1961 IRE International Convention Record.

35.2. Materials and Form Factors for Micromodule Inductors

G. G. Hauser, *Semiconductor and Materials Div., RCA, Somerville, N. J.*

This paper discusses the design problems encountered in converting some typical inductors of conventional design into microminiature equivalents.

Ferrite, iron-powder and high-permeability metal-alloy materials are used for miniaturization in connection with a great variety of core form factors such as toroids, cup cores, tape cores and others to allow optimization of individual inductor performance.

The importance of winding techniques for miniature inductors will be discussed; toroidal and printed windings will be considered.

Variable miniature inductors and their associated problems are included in this paper.

35.3. Micromodule Reliability Status Report

D. T. Levy, *Semiconductor and Materials Div., RCA, Somerville, N. J.*

The micromodule offers the twin advantages of microminiaturization and proven reliability. This paper discusses the scope of the micromodule and reliability program and the results so far.

As a frame of reference, the reliability of conventionally packaged components operating under severe environments are discussed. The specifications for conventional electronic components which are most directly applicable to microelements requirements are listed and discussed. Based on the demands of missile and satellite applications, the reliability goals for micromodule and microelement are formulated.

Two basic technical approaches were used to achieve the desired reliability levels. The micromodules and the microelements have inherent in their design many built-in features which enhance their reliability. These features are enumerated and discussed. The second technical approach toward micromodule reliability has involved a broad-base test and qualification program. The scope, achievements, and requirements of this program are presented and interpreted.

35.4. Application Characteristics of Solid Tantalum Capacitors

Raymond Rhodes, *Federal Systems Div., IBM Corp., Kingston, N. Y.*

The movement from vacuum tube to transistor circuits has created a need for low-voltage—high-current power supplies. This type of supply has been found capable of delivering tremendous amounts of current for short time intervals while at the same time protective devices react to turn them off upon detection of a fault condition. These transient conditions create a momentary overload of such magnitude that component parts can be rapidly destroyed.

The normal failure mode of solid tantalum capacitors under low-impedance condition is catastrophic short circuiting, which can easily occur by application of reverse voltage to the part. The investigation was concentrated upon the solid tantalum capacitor.

This paper will summarize the findings of an attempt to make equipment designers aware of the considerations which must be taken into account with the low-voltage—high-current power supplies characteristic of solid-state equipment.

35.5. The Design of Bowl Magnets Using the Electrolytic Tank

John C. Wurr, *Electron Tube Div., Litton Industries, San Carlos, Calif.*

A method of designing bowl-shaped permanent magnets using an electrolytic tank is described. By plotting the magnetic flux leaving all surfaces of the magnetic circuit, a knowledge of the total flux through every portion of the magnet shell can be obtained and the thickness of the shell designed to maximize the energy product, BH, throughout the magnetic material. A study can be made, at the same time, of how bow shape affects flux leakage and magnetization.

35.6. The Sealed Silver-Cadmium Battery

Paul L. Howard, *Yardney Electric Corp., New York, N. Y.*

The silver-cadmium battery system, offering long life and high energy output, has been reported before as a conventional rechargeable battery. The latest advance, resulting from current requirements, is the development of sealed silver-cadmium cells which have the unique feature of not generating high internal pressures. We find that the sealed form offers better capacity maintanance over a longer cycle life than does a vented battery. Also standard packaging allows more flexibility in capacity sizes than do button cells. A 12-volt 5-ampere-hour test battery has already exceeded 700 deep cycles; it still gives 15.2 wh/pound and 0.93 wh/inch^3, compared with its initial of 21 wh/pound and 1.30 wh/inch^3. Characteristics of the sealed batteries are discussed further and comparisons are made between sealed and nonsealed types.

SESSION 36*

Wed. 2:30–5:00 P.M.

Waldorf-Astoria
Sert Room

TELEMETRY

Chairman: Robert V. Werner, *Cubic Corp., San Diego, Calif.*

* Sponsored by the Professional Group on Space Electronics and Telemetry. To be published in Part 5 of the 1961 IRE International Convention Record.

36.1. The Use of Magnetic Fields in the Elimination of Re-Entry Radio Blackout

H. Hodara, *The Hallicrafters Co., Chicago, Ill.*

This paper first reviews the most significant results concerning wave propagation through the plasma sheath surrounding a re-entering missile, secondly, it presents a new evidence showing that re-entry radio blackout can be eliminated when a magnetic field of 300 gauss is applied through the sheath. The evidence is based on the results of an analysis of transmission and reflection losses taking place at a plasma-air interface. The analysis shows that in the absence of collisions ($\nu = 0$), maximum transmission occurs when the signal frequency (ω) is half the gyrofrequency (ω_h), the ratio of transmitted to incident power in this case equals approximately the ratio of gyro to plasma frequency. This result is also shown to hold when collisions are present provided that $\nu^2 \ll (\omega_h - \omega)^2$.

36.2. Data Transmission for the NRL Space Surveillance System

M. G. Kaufman and F. X. Downey, *U. S. Naval Res. Lab., Washington, D. C.*

A data-transmission system has been developed which links four distant receiving sites of the U. S. Navy Space Surveillance system to a data-reduction center located at Dahlgren, Virginia. The receiving sites form a fence located on a great circle route across the southern United States from Georgia to California. Each receiver site is coupled to the data center by a commercial, voice-quality, duplex (two-way) telephone line. Standard FM telemetry techniques are used to transmit eight channels of analog data on each telephone line. These data are transmitted on eight discrete frequency-modulated carriers in a frequency band from 270 cps to 2455 cps. In addition to these FM data carriers, unmodulated tones are used for monitoring, compensation, and command functions.

The data from each receiver site are permanently stored on paper recordings at the data-reduction center, so that this information can be assimilated at one location on a real-time basis. These data are used to compute the orbital parameters of satellites detected by the Space Surveillance system.

The data-transmission system has been in operation for a year on a 24-hour basis with negligible down time. Off-line calibration techniques have been employed so that errors introduced into the data by the transmission system can be held to 2 per cent without interfering with the detection capabilities of the surveillance system. Tests indicate that the number of channels can be increased from 8 to 24 per telephone line by the use of crystal-controlled oscillators and crystal filters.

36.3. A Predetection Recording Telemetry System

W. R. Johnson and G. N. Johnson, *Minnesota Mining and Manufacturing Co., Los Angeles, Calif.*

Predetection recording provides greater system reliability and more data-handling flexibility than present analog recording methods.

As demonstrated with the MINCOM Model CM-100, predetection recording reduces the number of elements before data storage. The recorder also becomes more versatile since it can simulate all types of received FM data.

This system uses an FM receiver and converter with a standard MINCOM CM-100 Recorder/Reproducer. The IF carrier and its sidebands are recorded after being heterodyned down to within the pass band of the CM-100. During reproduce, the recorded carrier and its sidebands are heterodyned back up to the receiver's IF frequency and reinserted at the first IF stage. Data with a frequency response of dc to 100 kc or greater appears at the output of the receiver.

36.4. PCM Telemetry Recording at High Densities

George E. Comstock, III, *Potter Instrument Co., Inc., Plainview, L. I., N. Y.*

A new system of high-density magnetic tape recording is described which utilizes bit packing densities of 1500 to 2000 per inch at bit rates up to 3 Mc with multichannel systems. At this density the system reliability is better than conventional digital recording systems. When operated at packing densities in the range from 1200 to 1500 bits per inch, transient errors occur less than once in 10^9 to 10^{10} bits and permanent errors are an order of magnitude less frequent.

The new method of recording is well suited for recording PCM data. A system for this purpose will be described together with an analysis of the results obtained to date.

36.5. Globetrotter, An Air-Transportable Satellite Tracking Station

R. L. Scrafford, *Space Technology Labs., Inc., Los Angeles, Calif.*

Globetrotter is a satellite tracking station capable of being air-lifted in a single C-124 type aircraft. Complete with automatic tracking 28-foot dish, it can be completely erected on a new site in three to four days. While the station was built for the specific purpose of tracking and receiving telemetry during the injection phase of the new Able Star second stage, it may be used for tracking any satellite or probe with an appropriate transponder on board. The paper describes the construction features on the station, its performance, and some of the technical and nontechnical experiences gained in operating the station in Germany, Chile and Southern Rhodesia.

36.6. The Courier Recorder-Reproducers

J. P. Buffington and S. L. Whig, *Advanced Electronic Data Lab. Div., of Consolidated Electrodynamics Corp., a subsidiary of Bell & Howell Co., Pasadena, Calif.*

This paper describes the magnetic tape recorder-reproducers used as the communication data storage element in the Courier Satellite System. The satellite is equipped with both digital and analog models of the recorder-reproducer to permit maximum performance on both types of data.

The purpose of the recorder-reproducer is to provide the space-borne data storage link in an earth-to-satellite-to-earth communication system. Operating at a power consumption of approximately 10 watts, the analog version has a bandwidth of 50 kc with maximum harmonic distortion of 25 per cent and a signal-to-noise ratio of better than 36 db. The digital model accommodates 55,000 bits per second at a packing density of 1833 bits per inch with a data loss of less than 1 bit per 100,000.

SESSION 37*

Wed. 2:30–5:00 P.M.

Coliseum Faraday Hall

COMMUNICATIONS SYSTEMS—BASIC THEORY

Chairman: Mischa Schwartz, *Polytechnic Inst. of Brooklyn, Brooklyn, N. Y.*

37.1. An Orthogonal Coding Technique for Communications

G. A. Franco and G. Lachs, *Res. Div., Stromberg-Carlson Div. of General Dynamics Corp., Rochester, N. Y.*

A scheme is described whereby the orthogonal relationships of trigonometric functions are utilized to generate large alphabets within reasonably small bandwidths. The alphabets are considered in terms of equal energy criteria and investigated by means of a vector algebra. Optimum alphabet members are selected for use in the communication channel. At the receiving terminal, the need for active logic circuitry or storage is eliminated by use of summing networks which perform error-correcting decoding. The scheme is analyzed in the presence of white Gaussian noise. Improvements of 10^5 in error rates and 3:1 in time-bandwidth product over narrow-band FSK (correlation detection) are indicated.

* Sponsored by the Professional Group on Communications Systems. To be published in Part 8 of the 1961 IRE International Convention Record.

37.2. Analysis of Multiple-Tone Clipping

C. James Stylers, *624-31st St., S.E., Cedar Rapids, Iowa.*

The demand for greater reliability in transmission of intelligence in multiple-tone systems has brought about a study of the consequences of clipping a multiple-tone system. An analytical expression of clipping has been derived which furnishes a complete breakdown of the generated spectrum within and external to the desired pass band, the exact number of jth-order intermodulation terms, signal terms, in-phase noise terms, and randomly phased noise terms.

For 20 tones of equal amplitude and equal spacing, there are exactly 32,760,960 seventh-order intermodulation terms of which 998,720 are signal terms, 144 are in-phase noise terms, and 220,235 are randomly phased noise terms at the center frequency of the pass band. For a voltage clipping level of 50 per cent of peak amplitude there is a reduction in peak-signal-to-rms-noise ratio of 12 db. This level of clipping shows no increase in the binary error rate. Except for the transfer characteristic representing clipping, the analysis is completely general and may be applied to any number of equally spaced tones of equal amplitude.

37.3. Control of Over-Modulation with Multiplexed Coherent or Noncoherent Frequencies

D. R. Anderson, S. G. Lutz, and J. H. Zeilenga, *Hughes Res. Labs., Malibu, Calif.*

A multiplex of frequencies

$$e(t) = Ee^{j\Omega t} \sum_{n=0}^{N-1} e^{j(n\omega t+\theta_n)} \qquad (\Omega \gg \omega)$$

reaches NE if all add in phase. The total peak power, P_p, is N times the sum of the channel peak powers, each being derated to $1/N$th its share of the total. Lower deratings are desirable and obtainable by dephasing. For noncoherent frequencies, the phases are random and deratings correspond to probabilities of exceeding P_p. With coherent frequencies, phases are constants which can be chosen to control power peaks. Though no general solution for optimum phasing with arbitrarily high N's is known, techniques are described for phasing to low deratings; generally below 3 db.

37.4. Statistics of Hyperbolic Error Distribution in Data Transmission

Pierre Mertz, *Consultant to The RAND Corp., 66 Leamington St., Lido, Long Beach, L. I., N. Y.*

Error bursts in data transmission systems do not usually occur completely at random. It has been found that often they follow a hyperbolic rather than a Poisson distribution. Several statistical quantities consistent with the hyperbolic distribution have been developed. They are compared with the corresponding quantities for a Poisson distribution. Specifically, the quantities are the probability of just c bursts in a time interval for which the long-time average is a, the cumulative probability of at least c bursts in this time interval, and the cumulative probability of burst-free stretches of u time intervals or longer.

37.5. An Evaluation of the Effects of Delay Distortion in FM Data Transmission

R. A. Gibby, *Bell Telephone Labs., Inc., Murray Hill, N. J.*

A method is outlined for evaluating the performance of a frequency-modulated data system by means of simulation on a high-speed digital computer. Performance is designated by the aperture value of the "eye" pattern formed by the received data signal. A transmission path is considered which has ideal amplitude shaping. Phase (or delay) distortion conditions are introduced to produce a degradation in system performance. The delay characteristics are designated by a set of parameters. The system performance is expressed in terms of these parameters, as they vary over a range of values of interest in data communication.

SESSION 38*

Wed. 2:30–5:00 P.M.

Coliseum
Marconi Hall

PROPAGATION

Chairman: Sidney A. Bowhill, *Dept. of Elec. Engrg., Pennsylvania State University, University Park, Pa.*

38.1. The Plasmas of Rocket Flight

W. W. Balwanz, *Naval Res. Lab., Washington, D. C.*

A rocket in flight is attended by plasmas from a number of sources; these include the existing plasmas of the ionosphere and outer space, as well as plasmas induced by the propulsion system, by component erosion due to excitation of molecules outgassed from the rockets. Such plasmas interact with radio waves to produce a variety of effects, some of which are undesirable. A combination of experimental and therorectical studies provide the knowledge required for operational systems. Further investigations are required to optimize communications links for the space vehicle of the future.

38.2. Enhancement of Radar Returns Through Double-Bounce Circular Polarization

Sheldon Isaacson, *The Martin Co., Orlando, Fla.*

A method is discussed for radar air-to-surface target identification in heavy precipitation by the use of a circularly polarized signal reflected from the ground to the target, then back to the source. A reversal in screw sense allows discrimination between background clutter and target return. Curves are presented to show relative effectiveness variations with angle of incidence, degree of precipitation, and type of terrain. Applications are suggested for use of the of the system as an all-weather adjunct to conventional radar systems and for foul weather navigation with a system of passive ground reflectors.

* Sponsored by the Professional Group on Antennas and Propagation. To be published in Part 1 of the 1961 IRE International Convention Record.

38.3. VHF and UHF Signal Characteristics Observed on a Long Knife-Edge Diffraction Path

A. P. Barsis and R. S. Kirby, *Natl. Bur. of Standards, Boulder, Colo.*

During 1959 and 1960, long-term transmission loss measurements were performed over a 223-km path in eastern Colorado, using frequencies of 100 and 751 Mc. This path is characterized by a knife-edge type obstacle (4290-meters-high Pikes Peak), which is visible from both terminals.

The transmission loss measurements have been analyzed in terms of the distributions of hourly medians and their diurnal and seasonal variations. Other results include a description of the character of short-term variations (within-the-hour fading), height gain measurements at the receiving terminal, and correlation measurements using spaced medium-gain antennas. Principal results are a lack of marked diurnal and seasonal variations of hourly median transmission loss values and a high degree of correlation between signals received on vertically spaced antennas.

38.4. An Ionospheric Scatter Mode Associated with the Earth's Magnetic Field

B. Bailin, *Rome Air Dev. Ctr., Griffiss AFB, N. Y.;* and J. L. Heritage, *Smyth Res. Associates, San Diego, Calif.*

An experimental program sponsored by the Rome Air Development Center, investigating the various aspects of what appears to be a new type of scatter from field-aligned ionization, is presently being conducted by the Smyth Research Associates. These signals, referred to as "H_E Scatter" were discovered by the Smyth Research Associates in the course of experimental work in radio propagation, for RADC, involving a high-power 200-Mc pulse transmitter near Laredo, Tex. This paper describes the experimental program, including equipments utilized, results obtained, and possible applications.

38.5. Wave Propagation in Magneto-Ionic Slabs

H. Hodara, *The Hallicrafters Co., Chicago, Ill.* and G. I. Cohn, *Illinois Inst. Tech., Chicago, Ill.*

The propagation characteristics of electromagnetic waves in magneto-ionic slabs are of interest in predicting the behavior of trapped modes in anisotropic waveguide structures such as the ion ducts formed by the lines of the earth's magnetic field. This paper derives the expression for waveguide modes present in an infinite plasma slab. The slab has finite thickness, is filled with lossless plasma of constant electron density and threaded by a uniform static magnetic field along the direction of propagation.

It is shown that two sets of hybrid modes can propagate in the magneto-ionic slab at frequencies below plasma resonance. These two sets reduce to a set of TE and a set of TM modes when the magnetic field is zero.

SESSION 39*

Wed. **2:30–5:00 P.M.**

Coliseum
Morse Hall

MICROWAVE MEASUREMENTS

Chairman: Helmut M. Altschuler, *Microwave Res. Inst., Brooklyn, N. Y.*

39.1. A Precision Microwave Phase-Measurement System with Sweep Presentation

S. B. Cohn and H. G. Oltman, *Rantec Corp., Calabasas, Calif.*

This paper describes a method of phase measurement especially suited for rapidly determining deviations from phase linearity of microwave components such as filters. An experimental system was constructed for use in a 50-Mc band at 3000 Mc; however, either wider or narrower bandwidths anywhere in the microwave range are equally feasible. A principal advantage is convenience of data presentation—either swept display on an oscilloscope or recorder, or calibrated meter reading. The experimental system yielded a resolution and repeatibility of about 0.1°, and is inherently capable of even greater precision. Reflection interactions which can increase the total error to a few tenths of a degree are discussed in detail.

39.2. A Precise Method for Measuring the Incremental Phase and Gain Variations of a Traveling-Wave Tube

A. Zacharias, *Bell Telephone Labs., Inc., Murray Hill, N. J.*

Preservation of relative phase information is of major importance in many radar systems. While a low-noise input traveling-wave tube is attractive in improving system noise performance, the phase distortion requirements demand extreme performance from the tube. This paper describes the precision phase measurements of a tube having over 60 wavelengths of accumulated phase between 5 and 6 kMc. Since commercial phase shifters have inaccuracies exceeding the 2° phase shift tolerance initially specified for the traveling-wave tube, measurements are described to calibrate a rotary shifter by means of a slotted line used as a linear phase shift transfer element. In addition, the measurement method employed allowed the gain-frequency variation to be measured to within ±0.02 db. Data are presented on representative tubes and with this information a pair of tubes were adjusted to have phase equality to within ±2° over a 10 per cent bandwidth.

39.3. A Transient Analysis of the Traveling-Wave Resonator with Application to High-Power Microwave Testing

Henry Berger, *Surface Armament Div., Sperry Gyroscope Co., Great Neck, L. I., N. Y.*

The theory of steady-state CW operation of the traveling-wave resonator is reviewed. A system of finite difference-equations that describe transient operation is derived and solved to obtain power gain and optimum coupling as functions of time, pulse width, frequency, and ring attenuation. The Q of the TWR is obtained from the energy-decay time constant and compared to the Q in the literature, which is derived from steady-state bandwidth considerations. Temperature effects, measurements, and high-power breakdown applications are considered.

39.4. Gas Discharge Noise Sources in Pulsed Operation

N. J. Kuhn and M. R. Negrete, *Hewlett-Packard Co., Palo Alto, Calif.*

The growing importance of pulsed-noise figure measurements necessitates investigation and calibration of pulsed-noise sources. By alternately pulsing two noise sources, sampling their noise power outputs, and comparing the samples of each tube, measurements of source properties may be made to ±0.02-db accuracies. High accuracies are achieved by a null type of measurement and the inclusion of AGC which makes the measurement insensitive to gain fluctuations.

Experimental data showing variations of noise power during pulse build-up and decay, dependency of noise power on tube current and the variation in steady-state noise power between tubes are presented. The accuracy of the results, and facility with which they were obtained, indicate advantages of pulsed measurements over CW measurements.

39.5. A Sequential Detection System for the Processing of Radar Returns

Aaron A. Galvin, *Lincoln Lab., M.I.T., Lexington, Mass.*

This paper describes a radar data-processing system capable of the efficient detection of narrow-band radar returns which may fall into any part of a wide Doppler band. The system utilizes a two-step process, the first of which provides a coarse, high false alarm indication of range and Doppler, and the second of which provides high-quality detection and parameter estimation. This processing system employs only a fraction of the equipment required in the more conventional matched comb filter.

The basic principles are discussed, followed by a description of the experimental prototype system.

Experimental results obtained during some satellite tracking operations are presented.

* Sponsored by the Professional Group on Microwave Theory and Techniques. To be published in Part 3 of the 1961 IRE International Convention Record.

SESSION 40*

Thurs. **10:00 A.M.–12:30 P.M.**

Waldorf-Astoria
Starlight Roof

ANALOG AND HYBRID TECHNIQUES

Chairman: W. W. Seifert, *M.I.T., Cambridge, Mass.*

40.1. A Simulator for the Evaluation of Electromagnetic Systems

L. G. Fisher, *ITT Labs., Nutley, N. J.;* F. S. Barbeck, *Wright Air Dev. Div., Wright-Patterson AFB, Ohio;* and G. Frenkel, *ITT Labs., Nutley, N. J.*

The Evaluator produces within the laboratory on a complete, closed-loop basis, the precise electromagnetic environment generated by a large variety of systems, such as search and track radars, active and passive guidance systems, proximity fuse and others. In addition, an ECM complex within the system is capable of reproducing a large variety of Electronic Countermeasures signals. The evaluator has CCM capabilities in the form of logarithmic and Dicke-Fix receivers, side-lobe cancellers, pulse compression and integration circuits, CFAR and phase reversal methods. The Data Section presents a comprehensive recording display and analysis of electronic defense problems. The system is intended to serve as a design tool for major system analysis, and is finding increasing usage as its reliability and broad scope become evident. The paper includes a discussion of the comprehensive analog techniques employed.

40.2. Theory and Practice of Hall Effect Multipliers

G. S. Glinski and J. P. Landolt, *Elec. Engrg. Dept., University of Ottawa, Ottawa, Ont., Canada.*

The theoretical part of the paper is concerned with the systematic analysis of errors arising when the physical principles of Hall ef-

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fect are translated into engineering design of a Hall multiplier suitable for electronic analog computer applications.

The practical part of the paper describes the development prototype of a completely transistorized self-contained multiplier, based on Hall effect and utilizing the commercially available components.

40.3. A Tunnel-Diode Function Generator

PHILIP SPIEGEL, *Philco Corp., Lansdale, Pa.*

A new method of analog function generation has been investigated in which tunnel diode networks provide step approximations of a desired graphical function. The advantages of such a function generator over photoformers and conventional diode voltage-biased networks are high speed; simple circuitry eliminating a need for bias supplies; and potentially low-cost, microminiature fabrication.

A model with variable resistors proved the feasibility of this technique by allowing generation of various arbitrary functions. A model designed for the function $V_{OUT} = V_{IN}^{1/2}$ was constructed with 16 germanium tunnel diodes. The accuracy over a 1.5- to 10.0-volt range of input pulses was better than ± 6 per cent. The maximum turn-off time for the 16 diodes was 0.16 μsec and the pulse duration 0.4 μsec.

40.4. Stabilized Synchro-to-Digital Converter

M. MASEL AND D. BLAUVELT, *Eclipse-Pioneer Div., The Bendix Corp., Teterboro, N. J.*

The utilization of a digital computer in a real-time, airborne control system creates the requirement for preparing sensor information in a form that can be accepted by the computer. Many sensors produce signals which are analog in nature and must be converted to digital form before they can be utilized by the computer. This paper will be concerned with the utilization of synchro resolvers as the input transducer.

The resolvers have their stators excited with quadrature voltages and the shaft position information is contained in the phase of the rotor output voltages. The phase of each rotor voltage is compared to the phase of a fixed reference voltage, thus defining a time interval. Clock pulses are gated into a counter during this time interval, producing a binary number proportional to shaft position. The accuracy of the shaft position to digital conversion is obtained by utilizing feedback techniques to maintain amplitude equality and the quadrature relationship of the stator voltages.

40.5. Real-Time Analog-Digital Computation

MARK E. CONNELLY, *Electronic Systems Lab., M.I.T., Cambridge, Mass.*

After a brief summary of the respective advantages of analog and digital computing techniques with regards to performance, size, cost, reliability, flexibility, and power consumption, a hybrid computer design is suggested suitable for solving large-scale simulation problems in real-time. This design is based on efficient procedures for carrying out the subsidiary operations of function generation, trigonometric resolution, integration, decision-making, and input/output transfers. Efficiency, in this case, involves a graceful compromise between simple implementation and high speed.

40.6. Obtaining the Frequency Response of Physical Systems by Analog Computer Techniques

GEORGE W. OGAR, *Elec. Engrg. Dept., Inst. of Technology, Wright-Patterson AFB, Ohio.*

A method is presented by means of which the Nyquist and Bode plots or any other presentation of the frequency response of a physical system may be obtained. By representing the transfer function of a system by means of a complex number, it is possible to construct the real and imaginery parts which are polynomials in angular frequency ω. With the equipment at hand in any analog computer installation, the polynomials can be instrumented directly. These furnish the data necessary for either the Nyquist or Bode plots or any other display. The method yields values which are in good agreement with theoretical values.

SESSION 41*

Thurs. 10:00 A.M.–12:30 P.M.

Waldorf-Astoria Astor Gallery

CIRCUIT THEORY—II

Chairman: C. A. DESOER, *Elec. Engrg. Dept., University of California, Berkeley, Calif.*

41.1. The Central Limit Theorem in Circuit Theory

A. PAPOULIS, *Polytechnic Inst. of Brooklyn, Brooklyn, N. Y.*

A modified form of the central limit theorem is developed to evaluate the convolution

$$f(t) = f_1(t) * \cdots * f_n(t)$$

of n positive functions; in circuit theory $f(t)$ is the output of an n-stage amplifier—in probability theory, the distribution of the sum of n random variables. The central limit theorem gives an asymptotic form for $f(t)$

$$f(t) \to \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{1}{2}(t-t_0)^2/\sigma^2},$$

but the above expression does not give an adequate estimate of $f(t)$ for moderate values of n. In this paper we use as asymptotic form the X^2 distribution function

$$s(t) = \frac{t^\alpha e^{-t/\beta}}{\beta^\alpha \Gamma(\alpha+1)} U(t),$$

which has a rational transform and equals zero for $t<0$, and we develop a method for the evaluation of the error $f(t)-s(t)$; the series

$$f(t) - s(t) = s(t)\{A_3L_3^{(\alpha)}(t) + \cdots\}$$

results, where the A's are constants that can be simply evaluated and the L's are the Laguerre polynomials. Even for small n, the first term gives a satisfactory evaluation of the error.

41.2. The Tchebycheff Approximation of a Prescribed Impulse Response with RC Network Realization

DONALD T. TANG, *IBM Corp., Res. Ctr., Yorktown Heights, N. Y.*

The problem treated in this paper is the time domain approximation with the maximum deviation (error) minimized; *i.e.*, the approximation is to be the best in Tchebycheff sense. If the given transient response $f(t)$ is continuous and bounded for $t \geq 0$, then for any n, the existence of a "polynomial" of the form

$$g(t) = \sum_{i=1}^{n} \lambda_i e^{-\alpha i t}$$

which approximated $f(t)$ best in Tchebycheff sense is justified. The particular form of $g(t)$ is chosen so that its Laplace transform gives a function which can be realized in the form of an RC network.

A procedure of obtaining such an approximation in time domain is given with the convergence of the procedure proved. The use of a weighting function is also considered.

41.3. Synthesis of an Arbitrary Bank of Filters by Means of a Time-Variable Network

ELI BROOKNER, *Dept. of Elec. Engrg., Electronics Res. Labs., Columbia University, New York, N. Y.*

The time-variable delay line filter referred to as the Coherent Memory Filter consists of a single-loop feedback circuit whose forward path contains a delay line and whose feedback path contains a time-variable amplifier. The phase shift of this amplifier increases linearly at a rate of 2π radians per T second, where T is the delay-line period. In this report, two methods are shown whereby this time-variable delay-line network can be made to synthesize an arbitrary homogeneous or nonhomogeneous bank of filters. One method employs complex time weighting of the input; that is, simultaneous amplitude modulation of the input. The other method utilizes a passive time-invariant amplifier at the output.

A unique feature of the techniques considered are their flexibility. By simply changing the complex time function on the output filter, one can synthesize a different bank of filters.

Experimental results are given for the synthesis of two banks of filters.

41.4. Synthesis of Input and Output Networks for a Resonant Transfer Gate

G. B. THOMAS, JR., *Bell Telephone Labs., Inc., Murray Hill, N. J.*

From an analysis of a resonant transfer gate, requirements are developed enabling a

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skilled filter designer to synthesize suitable input and output networks. The ideal networks for this application are shown to present constant resistance to the gate in the signal band and zero resistance outside the band. The reactance is the minimum reactance as associated with this resistance characteristic.

Such an impedance is shown to be necessary and sufficient for satisfactory resonant transfer. A novel method of approximating it is given and the measured performance of a sample network is presented.

41.5. A Limit Theorem on Passive Reactance Two-Ports with Constraints

H. G. Baerwald, *Sandia Corp., Sandia Base, Albuquerque, N. Mex.*

Power from an ohmic source is transmitted through an elementary reactive (capacitive or inductive) imperfect coupler of given coupling factor k to an ohmic load. Two equalizing reactance two-ports are interposed, one on each side of the coupler. It is shown that passivity imposes the upper limit $(1+k)/(1-k)$ on the bandwidth ratio for zero insertion loss transmission. Furthermore, networks approaching this limit uniformly in any closed frequency subinterval are realizable. One realization requires resonance-antiresonance ladders only, and a few meshes suffice for engineering approximations. The theorem is basic to electromechanical transducer application.

SESSION 42*

Thurs. 10:00 A.M.–12:30 P.M.

Waldorf-Astoria
Jade Room

ULTRASONICS ENGINEERING—I

Chairman: Rudolph Bechmann, *U. S. Army Signal Res. and Dev. Labs., Fort Monmouth, N. J.*

42.1. The Ultrasonically Coupled Oscillator

Yujiro Yamamoto, *Borg-Warner Controls, Div. of the Borg-Warner Corp., Santa Ana, Calif.*

In this paper the theory of an oscillator consisting of an amplifier incorporating an ultrasonic feedback path is presented. In the course of study, two methods of controlling the oscillation of the ultrasonically coupled oscillator are investigated: 1) a highly selective circuit in the electronic amplifier controls the oscillation, and 2) the effective length of the feedback path is employed as a frequency selective element of the oscillator.

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42.2. The Bandwidth, Insertion Loss and Reflection Coefficient of Ultrasonic Delay Lines for Backing Materials and Finite Thickness Bonds

W. F. Konig, L. B. Lambert, and D. L. Schilling, *Electronics Res. Labs., Columbia University, New York, N. Y.*

The results obtained from a theoretical and experimental investigation of the variation of insertion loss and reflection coefficient with frequency for ultrasonic delay lines are presented. The effects of a finite thickness, conductive bond and backing materials are included in the development and analysis of several equivalent circuits. For an unbacked quartz transducer, the bandwidth is shown to be a critical function of bond thickness and a bandwidth of 50 per cent is achieved for a thin (0.01 wavelength) bond. By backing the transducer, a bandwidth of 70 per cent may be achieved but the reflection coefficient is shown to be a function of bond thickness and the mechanical impedances of the backing and bond materials. Design parameters are presented which minimize the reflection coefficient across the pass band.

42.3. Techniques for the Determination of Ultrasonic Attenuation in Fused Silica

Richard F. Weeks, *Richard D. Brew and Co., Inc., Concord, N. H.*

The frequency dependence of the intrinsic ultrasonic attenuation in fused silica is of both theoretical and practical interest. Because the attenuation constant of fused silica is so small, it is difficult to measure. Measurements of conventional delay lines are unsatisfactory because of uncertainties in the losses at the transducers and at the finite apertures of the polygonal delay blanks that must be used.

The uncertainties in the transducer losses may be reduced by bonding the transducers to test blocks and making a series of measurements to determine the transducer losses before coupling the test blocks to the polygons under study.

A second technique makes use of two optical measurements of the integrated acoustical signal within a polished fused silica test sample. This system is, in principle, independent of frequency and the form of radiated field from the transducer.

We shall discuss these techniques in detail and present several measurements of the ultrasonic attenuation of both the longitudinal and transverse modes in fused silica.

42.4. Depletion Layer Ultrasonic Transducer—A New High-Frequency Transducer

Donald L. White, *Bell Telephone Labs., Inc., Whippany, N. J.*

The depletion layer transducer is a new efficient ultrasonic transducer for use at microwave frequencies. The elastic waves are generated in the thin high-resistance surface barrier formed between a metal electrode and a piezoelectric semiconductor. Although a semiconductor is usually too conductive to support the large electric fields needed to generate significantly large piezoelectric stresses, it is possible to maintain large fields across a thin depletion layer, such as that which exists at *p-n* junctions and nonohmic surface contacts. If an ac voltage is impressed across a depletion layer in a piezoelectric semiconductor, such as GaAs or CdS, piezoelectric stresses are created in the layer and it behaves much like a normal piezoelectric transducer but with a resonant frequency range of 300 Mc to well above 1000 Mc. The resonant frequency is variable because the thickness of the depletion layer can be altered by a reverse bias voltage.

42.5. Ultrasonic Instrumentation for Research on Bats

J. J. G. McCue, *Lincoln Lab., M.I.T., Lexington, Mass.*

Lincoln Laboratory, collaborating with D. R. Griffin of Harvard University, is studying echolation as practiced by bats. The work necessitated advances in instrumentation for the range 20 to 300 kc. These include improvements in loudspeakers, microphones, pulse-detection equipment, and sound movies. The transducers have been used in a study of jamming, to which the bats are very resistant. For the movies, the sound is recorded on tape while the events are being photographed at 768 frames per second. Modifications to a high-speed camera simplify the synchronizing of the tape with the film; the final print has a sound track that plays back at one thirty-second of the original frequency when it is projected at 24 frames per second.

SESSION 43*

Thurs. 10:00 A.M.–12:30 P.M.

Waldorf-Astoria
Sert Room

RADAR

Chairman: Salvatore E. Petrillo, *U. S. Army Signal Res. and Dev. Lab., Fort Monmouth, N. J.*

43.1. The Exploration of a Given Volume with a High-Accuracy Radar: Considerations of Power, Data Rate and Accuracy

P. R. Dax, *Westinghouse Electric Corp., Baltimore, Md.*

Long range and high accuracy can only be achieved in a radar of limited power by means of high antenna gains and narrow beamwidths. If a large volume is to be searched, the resultant data rate may suffer.

The accuracy of measurement of angle is also dependent on the beamwidth. It is therefore apparent that transmitter power, data

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rate and accuracy are interrelated, *i,e.* one can be traded off against the other depending on the requirements of the system.

This paper derives formulas relating peak power, PRF, data rate, beamwidth, required accuracy, etc., in a search radar. The case of the landbased or shipborne 3D radar, where the slant range varies with direction, enabling the PRF and beamwidth to be suitably programmed, is particularly considered.

43.2. Correlation Radar Using Pseudo-Random Modulation

W. Fishbein and O. E. Rittenbach, *Radar Div., U. S. Army Signal Res. and Dev. Lab., Fort Monmouth, N. J.*

The conventional pulse radar has two shortcomings. First, since the pulse width and pulse repetition frequency are constrained by resolution and maximum range requirements, the average transmitted power of a conventional radar can be increased only by increasing the peak transmitter power. Second, the limitation imposed by the sampling theorem prevents unambiguous measurement of of Doppler frequencies higher than one-half the pulse repetition frequency.

This paper describes a radar system which circumvents these disadvantages by operating with continuous transmission and provides unambiguous range and velocity information. The range and velocity information is obtained by phase modulating the transmitter with a pseudo-random waveform and correlating returned echoes with a delayed replica of the modulating signal.

43.3. Single-Pulse AFC System

John G. Isabeau, *Special Products Section, R S Electronics Corp., Palo Alto, Calif.*

A fast Automatic Frequency Control system for radar application is described. The system will readjust the local oscillator to establish the proper intermediate frequency before the end of the transmitted pulse, and maintain its value during the interpulse period.

The fast-acting feedback loop uses special circuitry to permit a reduction of the frequency error of better than 70:1 in less than 1 μsec.

An analysis of the feedback network is given showing the theoretical limitations of the system and a physical realization and particular measurement techniques are described.

43.4. An Experimental Laser Radar

D. A. Buddenhagen, B. A. Lengyle, F. J. McClung, Jr., and G. F. Smith, *Hughes Res. Labs., Malibu, Calif.*

Optical radars employing the new laser light source will be discussed. The ruby laser, recently achieved for the first time by T. H. Maiman, provides intense pulses of monochromatic light in a sharply directional beam. The pulsed output permits ranging. High angular resolution can be obtained with no additional optics. Spectral filtering at the receiving photodetector provides discrimination against unwanted optical signals.

A simple experimental radar using a ruby laser transmitter and a receiver consisting of photomultiplier, spectral filter and five-inch telescope will be described. Experimental data will be presented.

43.5. Application of Molded Wiring Boards to Low-Quantity Production

J. C. Gioia, *Light Military Electronics Dept., GE Co., Utica, N. Y.*

An extremely low-cost tooling technique has been developed which permits small quantity consumers of circuit boards and component supporting media to employ a molding process in the fabrication of components. The complete freedom of sul strate material provides for excellent mechanical and electrical properties and increases component reliability. Holes and recessed runs can be molded into the board, providing an ideal cross section of holes for "plating-through" and creating a greater bond for the conductor in the run. Finally, maximum design freedom is obtained since metal inserts (connectors, etc.) and third-dimension projections are easily molded into the component.

The steps involved in making these low-cost, photo-engraved molds will be discussed in this paper, as well as the molding process and the final "plating-on" of the conductor.

SESSION 44*

Thurs. 10:00 A.M.–12:30 P.M.

Waldorf-Astoria Empire Room

SPACE AND OTHER COMMUNICATION SYSTEMS OF THE FUTURE

Chairman: Walter Lyons, *RCA Communications, Inc., New York, N. Y.*

44.1. Pseudo-Redundancy in Communication Systems

R. N. Close, M. Schwartz, M. Chomet, H. Keen, and L. Fogel, *Airborne Instruments Lab., Deer Park, L. I., N. Y.*

Reliability is of the utmost importance in many modern multichannel communications systems, and particularly in unattended systems. One approach to improving reliability has been to use redundant components that are switched in when original components fail. Complex monitoring and decision-making equipments are required in systems of this type. This paper shows how in a multichannel communications system a pseudo-redundant mode of operation can be established that does not require the complex decision-making circuitry or the additional redundant components. Experimental results of such a system are presented, as are realiability calculations comparing the pseudo-redundant system with a conventional system.

44.2. The Courier Communications Satellite Electrical Design

J. M. Rosenberg, J. T. Nawrocki, and H. A. Kelley, *Philco Corp., Western Dev. Labs., Palo Alto, Calif.*

The Courier Communications Satellite electrical design is the subject of this paper. Upon ground command, the satellite can repeat teletype or voice messages in real time, or record them in digitial or analog form on magnetic tape for delayed transmission. Messages can be stored and repeated simultaneously. The microwave band is used for message transmission, and VHF band for tracking and telemetry. Power and operating life are conserved by activating satellite electronic equipment only in the reception area of a ground station, using the command system. Redundant equipment is available in case of operational failure. Power is obtained from solar energy converted by solar cells and stored in rechargeable batteries. The electronic equipment has a predicted lifetime of one year.

44.3. The Dwindling High-Frequency Spectrum

G. Jacobs and E. T. Martin, *Broadcasting Service, U. S. Information Agency, Washington, D. C.*

This paper discusses the trend of the solar cycle and its probable impact on high-frequency radio communications during the next five years, and in a more general way, during the remainder of the century. It is shown that the present cycle (which reached an unprecedented peak during early 1958) is now declining, and that the next three cycles may have exceptionally low maxima. Such a drastic reduction in solar activity would be accompanied by a corresponding reduction in the amount of high-frequency spectrum propagationally useful for long-distance communications. This reduction, coupled with the ever increasing worldwide demands for additional high-frequency communication circuits, leads to the conclusion that the high-frequency spectrum will become progressively less useful for communications in the years ahead.

44.4. The First Commercial Comprehensive Microwave and Tropospheric Communication System in South America

F. B. Woodworth, *Oficina Tecnica Amando Capriles C.A., Caracas, Venezuela.*

The text of this paper will include a history of the use of troposheric and microwave communications in Venezuela. The first two portions of this system were installed toward western Venezuela for Shell Company of Venezuela between Caracas and Maracaibo. The take-off point near Caracas is 7200 feet; a large microwave system was installed for Menegrande Oil Company, going to eastern

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Venezuela. These two systems were integrated there. By providing the only long-distance toll quality systems in Venezuela, direct dial telephone data and teletype services are provided. One section of this microwave system has a hop of 175 miles between two mountaintops, probably the longest 6000-Mc hop in the world. Data on propagation reliability and engineering problems encountered will be given. A brief description of another 324-mile tropo system for Orinoco Mining Company will also be given.

SESSION 45*

Thurs. 10:00 A.M.–12:30 P.M.

Coliseum
Faraday Hall

HUMAN FACTORS IN ELECTRONICS

Chairman: ALEXANDER E. JAVITZ, *Electro Technology, New York, N. Y.*

45.1. Radar Target Identification by Aural Display

R. W. PEW, *University of Michigan, Ann Arbor, Mich.;* AND J. I. ELKIND, *Bolt, Beranek and Newman, Inc., Cambridge, Mass.*

Experiments were performed to determine how well experienced and inexperienced radar operators could discriminate among different aircraft target types and maneuvers when the modulations of radar echoes that these targets produced were presented aurally. Noncoherent and coherent signals obtained from a C-band pulse Doppler radar and actual aircraft targets were used in these experiments. When reduced to a symmetrical two-alternative decision matrix, it was found that experienced operators could discriminate between aircraft with one turbojet engine and aircraft with two turbojet engines and between one aircraft and two aircraft correctly with probability of about 0.75. Furthermore, they could detect a velocity change and the occurrence of a 180° turn with almost no error.

45.2. Acoustic Iso-Preference Contours and TPU's

W. A. MUNSON AND J. E. KARLIN, *Bell Telephone Labs., Inc., Murray Hill, N. J.*

Subjective listening experiments have been conducted to establish a method for determining: 1) contours of equal listener preference for a variety of transmission conditions in the audio space; and 2) a scale of intensity of preference between contours based on preference difference thresholds in which the numbers are called TPU'S (Transmission Preference Units).

The data show that the method satisfies the basic requirement of transitivity for a scale of measurement; *i.e.*, if condition *A* equals condition *B* in preference, and condition *B* equals condition *C*, then *A* and *C* are also found to be judged equal. This holds even when *A*, *B*, and *C* are widely different in their physical parameters. The method therefore permits assigning an intensity of preference number to any transmission condition such that any other transmission condition with the same number can be predicted to be equal in preference.

The method involves only simple *AB* preference comparisons for two brief samples of speech heard consecutively. Preference contours and TPU's on signal level-noise level planes are shown for a number of filter cutoffs.

45.3. A Judgmental Method for Voice Communication System Evaluation

WILLIAM ROBERTS, *ITT Labs., Palo Alto, Calif.*

The use of intelligibility tests for communication system evaluation has been an acceptable practice for several years. The use of such a test has certain shortcomings, however, in that intelligibility tests do not measure more than one known effect upon the users of the systems. With the advent of certain exotic-type devices, such as vocoders, it is now necessary to measure other aspects of the listener's reaction to the device, one of which is his opinion as to the quality of the perceived sound.

Recent experiments performed at ITT Laboratories in Palo Alto, Calif., and based on the paired-comparison test technique show that a rank order and separation scaling of listener opinions about the sound of a voice transmitted through a communication system are possible. The scale values thus obtained express the conditional probability of the system under test being acceptable, given that the user may compare it to a set of standard transmission distortions. Such a measure of system performance is particularly desirable for amplitude and bandwidth compression devices where extraordinary demands are imposed upon the listener.

45.4. The Application of Feedback Techniques to the Measurement of Maximum Human Operator Bandwidth in Closed-Loop Control

J. S. SWEENEY AND H. P. BIRMINGHAM, *U. S. Naval Res. Lab., Washington, D. C.*

The nonstationarity of the human operator and his dependence on loop parameters necessitates the determination of his bandwidth in closed-loop methodology.

A system has been developed in which the bandwidth required to stabilize a compensatory closed-loop tracking system an inverse function of system error. The smaller the error level becomes, the greater the bandwidth that is required to stabilize the system. The bandwidth thus required of the human is measured and taken as an index of his ability to furnish such bandwidth.

45.5. Why Design for Maintainability?

JOSEPH G. WOHL, *Dunlap and Associates, Stamford, Conn.*

The relationships among down time (a system maintainability measure), time between failures (a system reliability measure), equipment availability, number of equipments, number of on-call technicians, and system readiness reliability are developed under the assumption of constant failure and repair rates. Design trade-off between reliability and maintainability is shown to be feasible with resulting reduction in both design and operating costs. A technique for specifying combined reliability, maintainability, and availability constraints to manufacturers is reported which allows the latter a great deal of design flexibility in meeting operational requirements at least cost. Finally, the need for research to establish the quantitative effects of maintainability design practice upon down time is explored.

SESSION 46*

Thurs. 10:00 A.M.–12:30 P.M.

Coliseum
Marconi Hall

ANTENNAS

Chairman: ROBERT J. ADAMS, *Naval Res. Lab., Washington, D. C.*

46.1. A Monopulse Antenna Having Independent Optimization of the Sum and Difference Modes

P. W. HANNAN AND P. A. LOTH, *Wheeler Labs., Smithtown, N. Y.*

A monopulse antenna for a tracking radar has been developed which overcomes the usual need for compromise between sum and difference mode performance. The reflector of this antenna is illuminated by an unusual feed which enables independent optimization of all three modes: sum, azimuth difference, and elevation difference.

The feed achieves suitably tapered illumination in all the modes by selective excitation of four stacked horns in one plane, and by utilization of three waveguide modes in each horn in the other plane. Measurements of the antenna confirm an improvement in both the azimuth and elevation difference modes of over 3-db increase in peak gain, and over 10-db further sidelobe suppression, while retaining the optimum sum-mode performance.

46.2. Calculation of Radiation Patterns from Apertures with Arbitrary Field Distributions by the Fourier Integral Method

J. S. HOLLIS AND R. E. MOSELEY, *Scientific-Atlanta, Inc., Atlanta, Ga.*

It is well known that the transformation between the aperture field distribution of a narrow-beam antenna and the far-zone radiation pattern can be expressed as a Fourier in-

* Sponsored by the Professional Group on Human Factors in Electronics. To be published in Part 5 of the 1961 IRE INTERNATIONAL CONVENTION RECORD.

* Sponsored by the Professional Group on Antennas and Propagation. To be published in Part 1 of the 1961 IRE INTERNATIONAL CONVENTION RECORD.

tegral. Analytically, this integral is still difficult to evaluate for most forms of the illumination function. A method for solving problems of this type in a relatively simple manner is described. Solutions to several types of previously unwieldy problems are presented. A special-purpose analog computer which provides graphical solutions to the Fourier integral is employed in these problem solutions. The computer is easily programmed and the resulting solution is recorded in graphical form on an ordinary antenna pattern recorder.

46.3. The Design of Log-Periodic Dipole Antennas

ROBERT L. CARREL, *University of Illinois, Urbana, Ill.*

The results of a mathematical analysis of the logarithmically periodic dipole class of frequency independent antennas are presented. A high-speed digital computer (ILLIAC) is used to calculate the input impedance, gain, and bandwidth, as well as the input current and voltage of the several elements. The results from this mathematical model are shown to be in good agreement with measurements. A simplified picture of the mechanism of radiation from these types of antennas is deduced. The results of the analysis are displayed as graphs and nomograms which enable one to design a log-periodic dipole antenna over a wide range of the parameters that control input impedance, bandwidth, gain, and antenna size.

46.4. Log Periodic Monopole Array

D. G. BERRY AND F. R. ORE, *Res. Div., Collins Radio Co., Cedar Rapids, Iowa*

This paper describes a vertically-polarized, unidirectional, frequency-independent antenna that utilizes its image to reduce its maximum height to $\frac{1}{4}$ wavelength at its lowest operating frequency rather than the $\frac{1}{2}$ wavelength dimension that has been necessary in other types of log-periodic antennas. This relatively small dimension makes this antenna particularly desirable for use in the lower portion of the HF spectrum as well as in other frequency ranges where frequency-independent operation must be coupled with small size. The frequency-independent properties of the antenna are produced by a unique arrangement of reactive elements which introduce additional degrees of freedom in the design. Radiation pattern and phase center data are given as a function of the usual log-periodic parameters. In addition, design data are given that allow the designer to control the antenna characteristic impedance and VSWR by adjusting the additional parameters. Techniques that are necessary to insure proper operation are discussed as well as methods of analysis that were attempted. Finally, the measured VSWR of an antenna designed to operate from 4 to 20 Mc is presented.

46.5. Helical Top-Loading of Electrically Small Monopole Antennas

R. O. SCHILDKNECHT, *ITT Labs., Nutley, N. J.*

Comprehensive tests and analysis have been made of a novel form of top loading for monopole antennas of about 0.03 wavelength electrical height. The configuration has some advantages over the usual types of electrically small antennas, especially for high-power applications in the VLF to HF ranges. Since the helical top load resonates the entire structure, the supporting tower (and guy wires, if used) may be grounded, eliminating many high-voltage problems. Low-impedance coaxial transmission lines may be conveniently matched by tapping the helix, or in a number of other ways.

Results are given for 20- and 200-foot models operating at 1500 and 150 kc, respectively. Parameters of bandwidth, efficiency and power handling capability have been extrapolated to other sizes and frequencies, including a 2000-foot design for VLF.

SESSION 47*

Thurs. 10:00 A.M.–12:30 P.M.

Coliseum
Morse Hall

ADVANCES IN INSTRUMENT CALIBRATION AND PRECISION

Chairman: HARVEY W. LANCE, *Electronic Calibration Ctr., Radio Standard Lab., U. S. Dept. of Commerce, Natl. Bur. of Standards, Boulder, Colo.*

47.1. Calibration of Electromagnetic Flowmeters

WILLIAM D. JACKSON, *Res. Lab. of Electronics and Dept. of Elec. Engrg., M.I.T., Cambridge, Mass.*

Utilization of emotional induction effects in fluids for flow measurement is now a well-established instrumentation technique and electromagnetic flowmeters have been developed for fluids with properties differing as widely as those of blood and liquid metals. Calibration of flowmeters of this type can be obtained either by the use of standard empirical methods or, in certain circumstances, through the application of channel flow theory for an electrically conducting fluid (magnetohydrodynamics).

The factors to be considered in establishing the calibration of electromagnetic flowmeters are briefly reviewed and the errors to which they give rise are discussed. It is shown that, contrary to the widely claimed features of this flowmeter, flow characteristics, fluid properties and location in a flow system can introduce significant calibration errors. Theoretical and experimental results are presented to illustrate the magnitude of these effects in both liquid metals and aqueous solutions and to establish the conditions required for accurate flow rate recording.

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47.2. Calibration of a UHF Q Meter

CHARLES G. GORSS, *Boonton Radio Corp., Boonton, N. J.*

This paper will deal with the creation of coaxial standard impedances which have been used to verify the calibration accuracy of a UHF Q Meter, operating in the frequency range 210–610 Mc. The standard configuration is a short-circuited coaxial line of accurately known dimension, material, and surface condition. Methods for analyzing and experimentally verifying the effect of connecting the coaxial device to the two-terminal Q Meter will be covered. Special fabrication and machining techniques will be covered along with a discussion of the effects of surface finish and previous working. The results of using typical units will be discussed and the factors controlling the precision of these devices when used with a practical Q Meter such as the Boonton Radio 280A will be evaluated.

47.3. A Frequency Standard of Exceptional Spectral Purity and Long-Term Stability

LEONARD CUTLER, *Hewlett-Packard Co., Palo Alto, Calif.*

Design considerations and performance data are presented for a transistorized quartz crystal frequency standard with an aging rate of a few parts in 10^{10} per day together with unusual spectral purity. Spectral characteristics are measured by comparison of the oscillator harmonics with the signal from an ammonia maser at 24 kMc.

47.4. Short-Term Frequency Stability Measurements

HERBERT D. TANZMAN,* *Bridge Electronics Co., Inc., Beverly, N. J.*

During the past several years, attention has been drawn to the behavior of oscillators over short time intervals, but because of lack of instrumentation, very little work has been done on this problem.

The system that is described has a resolution of ± 3 parts in 10^9 when the sampling time is eight-thousandths of a second. The evaluation of the system reveals that the limiting consideration is the noise in the multiplier chains.

The values presented on the short-term frequency stability of a number of precision oscillators are indicative of the valuable information that can be obtained with this method of measurements.

47.5. Analysis of Drifts in a Transistor Chopper

R. H. OKADA, *Moore School, University of Pennsylvania, Philadelphia, Pa.*

* Formerly associated with USASRDL, Ft. Monmouth, N. J.

Transistor choppers may be used as replacement for mechanical types and used over a wide temperature range if the drifts with temperature in the former are reduced. The sources of drift in transistor choppers have been analyzed and exact and approximate equations presented which enable prediction of drift in an actual circuit configuration.

Formulas are given as functions of circuit and transistor parameters. The variations of the transistor parameters have been measured from 20°C to 85°C for a silicon type. Good correlation was obtained between predicted and measured drift in a 1-kc silicon transistor chopper.

A chopper type transistor amplifier was constructed and using results of the above analysis had (in an operational mode): a gain of 10, an input impedance of 100 kilohms, and a drift of 1×10^{-10} amperes from 25°C to 75°C referred to the input.

All results are applicable to switching circuits if temperature variations are important.

47.6. An Implementation of the Correlation Process in the Manner of a Parallel Digital Computer

Roger L. Boyell, *Surface Armament Div., Sperry Gyroscope Co., Great Neck, L. I., N. Y.*

While correlation processing is a well-known technique in the fields of target detection and tracking, acoustics, and bioelectronics, existing systems tend to be difficult to calibrate and maintain. However, if the correlation processor is designed around logic elements typical of those used in digital computers, many of the manufacturing and maintenance procedures become considerably simplified, and at only a small loss in SNR. This paper discusses the theory and implementation of a correlation processor that operates on quantized, sampled signals in the audio-frequency range, using binary logic elements. The complete cross-correlation function can be obtained in real time, with no loss of information. An application of the equipment to sonar is also noted.

SESSION 48*

Thurs. 2:30–5:00 P.M.

Waldorf-Astoria Starlight Roof

DIGITAL COMPUTER TECHNIQUES

Chairman: L. W. Vontersch, *Michigan State University, East Lansing, Mich.*

* Sponsored by the Professional Group on Electronic Computers. To be published in Part 2 of the 1961 IRE International Convention Record.

48.1. On a Random Walk Related to a Nonlinear Learning Model

Laveen Kanal, *Stromberg-Carlson Co., A Div. of General Dynamics Corp., Rochester, N. Y.*

This paper continues the author's analysis of a nonlinear learning model proposed by D. Luce. One specialization of the model is shown to lead to a random walk, on the real line, in which the steps which the "particle" takes to the right and to the left are not equal and the probability of the "particle" taking a step to the right is given by

$$p_n = \frac{1}{1+e^{-x_n}}$$

where x_n is the position of the "particle" at the end of trial n. The asymptotic distribution of p_n has all its density at $p=0$ and $p=1$ and the amount of the density at $p=1$ is obtained by solving the functional equation

$$f(v, \beta_1, \beta_2) = \frac{v}{1+v} f(\beta_1 v, \beta_1, \beta_2) + \frac{1}{1+v} f(\beta_2 v, \beta_1, \beta_2),$$

where

$$0 \le v < \infty;\ \beta_1 > 1;\ \beta_2 < 1;$$
$$f(0, \beta_1, \beta_2) = 0$$

and

$$\lim_{v\to\infty} f(v, \beta_1, \beta_2) = 1.$$

The methods presented have application to other decision models.

48.2. A Systematic Method for Computer Simplification of Logic Diagrams

F. A. Rocket, *IBM Product Dev., Lab., Poughkeepsie, N. Y.*

Presently, logic diagrams tend to appear on paper in the same sequence as they are conceived in the mind of the designer. Upon completion of the design, they seem disorganized and are cluttered with nonlogical elements necessary for circuit action, but confusing to the man learning and trying to follow the logic.

The author proposes a machine manipulation to arrange the logic in naturally occurring levels and to remove all nonlogical elements These diagrams would be useful primarily in servicing the computer and in teaching the serviceman. Diagnostic programmers and simulators could also use such diagrams to advantage.

48.3. Design of Computer Circuits Using Linear Programming Techniques

G. H. Goldstick and D. G. Mackie, *Electronics Div., The National Cash Register Co., Hawthorne, Calif.*

A step-by-step procedure for formulating circuit synthesis problems in a manner which is amenable to solution using linear programming is presented. A method of systematizing component value determination using linear programming is explained. The design equations and conditions required to synthesize a flip-flop, and a design procedure for achieving an optimum circuit is presented. The Simplex Method is used to determine component values, such that gain is maximized.

48.4. Systematically Introduced Redundancy in Logical Systems

William C. Mann, *Westinghouse Electric Co., Baltimore, Md.*

The systematic use of redundancy in logical devices can result in higher reliability, lower costs, reduction of random error rate, and easier maintenance. Redundancy inserted at the level of the basic device logic will improve the reliability performance of both single-line and multiple-line logic. Special voting elements designed to utilize the outputs of redundant circuits will allow operation with a large portion of a device in a failed condition. Optimum amounts of redundancy may be found for both repairable and nonrepairable devices using several simple realistic criteria. Under certain conditions, logical devices can be made using present-day circuit techniques which have mean times between failure of several years in continuous operation.

48.5. Majority Gate Logic for Improved Digital Reliability

G. Buzzell, W. Nutting, and R. Wasserman, *Hermes Electronics Co., Div. of Itek, Cambridge, Mass.*

Physical devices used for switching logic have a finite probability of failure. The application of redundancy to circuits is presented as a means for improving computer reliability in the face of such failures. The present paper shows various redundant configurations considered and the results that led to the development of a majority gate module.

The module developed implements a "two-out-of-three" majority decision. The majority gate function is accomplished by the summation of magnetic fields produced by current pulses applied to input windings on a core. When the total field exceeds a preselected threshold, the core changes its remanent state. By varying the threshold level, a variety of logical functions are obtained from the module.

This design technique is incorporated in a small general-purpose digital computer for demonstrating the reliability of a redundant system as compared to a nonredundant system. The computer also demonstrates the ease of maintenance during actual operation and shows that redundant design can be economical.

48.6. Tunnel Diode Threshold Logic

G. P. Sarrafian, *Texas Instruments Inc., Dallas, Tex.*

Some advantages of tunnel diodes as computer elements are discussed, along with their applicability to systems of threshold logic. Specific circuits are given which perform complex logic functions. Logic applications which are discussed include 1) novel circuits performing conventional computer functions, 2) techniques for achieving reliability through redundancy, and 3) simulation of neuron-like elements and nerve nets.

SESSION 49*

Thurs. **2:30–5:00 P.M.**

Waldorf-Astoria Astor Gallery

SYMPOSIUM ON TIME-VARYING NETWORKS

Chairman: S. DARLINGTON, *Bell Telephone Labs., Inc., Murray Hill, N. J.*

49.1. Time-Varying Networks—Past and Present

L. A. ZADEH, *University of California, Berkeley, Calif.*

Prior to the beginning of the past decade, papers on time-varying networks were few and far between. Indeed, most of the literature on linear time-varying systems consisted essentially of papers which dealt with linear differential equations resulting from perturbation analyses of the motion of nonlinear time-invariant dynamical systems.

In recent years, the advent of Wiener's theory, missile guidance techniques, parametric amplification, scatter communication, and other technological developments have given rise to a host of new problems involving the analysis and synthesis of time-varying systems and have stimulated search for effective methods of dealing not only with deterministic but also with probabilistic systems. The present paper surveys the progress made during the past decade and sketches the present status of the theory of linear time-varying networks.

49.2. Analysis of Time-Varying Networks

B. K. KINARIWALA, *Bell Telephone Labs., Inc., Murray Hill, N. J.*

Several systematic methods for obtaining solutions on linear time-varying networks are presented. A major objective of the paper is to determine the classes of networks for which the solutions can be obtained in closed form. These classes are characterized in many different ways, *viz.*, the number of time-dependent elements, the functions defining the variation of elements, and special relations between all or some of the elements. Simple examples are used to illustrate the various methods.

49.3. Some Techniques for the Analysis and Synthesis of Nonstationary Networks

JOSÉ B. CRUZ, JR., *University of Illinois, Urbana, Ill.*

A class of nonstationary or time-variable networks which are realizable as cascades of fixed multi-output networks and multi-input time-varying gain amplifiers is studied. It is shown that if the time-varying gain functions are expressible as finite sums of exponentials or sinusoids, then a cascade of several of these is equivalent to one fixed network in cascade with one time-varying gain amplifier. Time-domain and frequency-domain behavior of these networks are examined.

Sampled networks are also considered. Using Friedland's transmission matrix to characterize the network elements, Mason's signal flow graph theory for a system of matrix equations applies directly. A sensitivity function is defined which is applicable for time-domain analysis and synthesis of a network where an element transmission matrix is perturbed.

49.4. Some Models for Linear Time-Variant Filters and their Use in Communications Problems

T. KAILATH, *M.I.T., Cambridge, Mass.*

A large class of communication channels can be represented by linear time-variant filters. Different constraints, *e.g.*, finite duration or finite bandwidth of channel input or output signals, can be imposed on these filters in order to simulate the actual operating conditions of such channels. The constraints permit the original filter to be replaced by another (simpler) filter that imitates the original filter under the operating constraints. These new filters need not resemble the physical channel at all, and need not be equivalent to the actual channel, except under the given constraints. In this paper, methods of characterizing linear time-variant filters are investigated in order to determine the most convenient descriptions for the different constraints. These descriptions are used to obtain sampling theorems and models for the filter under the various constraints. The theorems are used to find the conditions under which a linear time-variant filter can be determined by input-output measurements only. Some other applications of this model are also discussed.

* Sponsored by the Professional Group on Circuit Theory. To be published in Part 4 of the 1961 IRE INTERNATIONAL CONVENTION RECORD.

SESSION 50*

Thurs. **2:30–5:00 P.M.**

Waldorf-Astoria Jade Room

ULTRASONICS ENGINEERING—II

Chairman: ROBERT L. ROD, *Acoustica Associates, Inc., Los Angeles, Calif.*

* Sponsored by the Professional Group on Ultrasonics Engineering. To be published in Part 6 of the 1961 IRE INTERNATIONAL CONVENTION RECORD.

50.1. Automatic Ultrasonic Examination of Large Rotor Forgings

M. E. AUGER AND R. G. GOLDMAN, *Large Steam Turbine-Generator Dept., GE Co., Schenectady, N. Y.*

The ultrasonic examination of large turbine-generator forgings for discontinuities and flaws has heretofore been carried out by skilled operators who must observe a cathode ray-tube screen for periods of up to eight hours and note down by hand the size and location of any echoes encountered.

Apparatus is described which, once set, performs this examination entirely automatically, producing a written record showing the amplitude, apparent depth, circumferential and longitudinal location of any echo and presenting this information in the form of *A*, *B*, and *C* scan representation for ease of interpretation by the examining engineer.

50.2. Application of Theory of Elastic Waves in Plates to the Design of Ultrasonic Dispersive Delay Lines

T. R. MEEKER, *Bell Telephone Labs., Inc., Whippany, N. J.*

Numerical solutions of the frequency equation for symmetrical and antisymmetrical elastic wave motions in the infinite plate are presented graphically in a form useful for the design of delay lines using these modes. For the lowest longitudinal mode, the dependence of several specific properties, such as inflection frequency, on the various parameters of the material are presented. Experimental data demonstrate the kind of performance to be expected from a dispersive delay line operating in the first longitudinal mode. The essential validity of the infinite plate theory for the case of the strip of finite length and width is demonstrated experimentally.

50.3. Transmission Characteristics of Longitudinal-Mode Strip Delay Lines Having Asymmetrically Tapered Widths

ALLEN H. MEITZLER, *Bell Telephone Labs., Inc., Whippany, N. J.*

A novel form of ultrasonic delay line has been developed which has two characteristic electrical properties: 1) a delay that is approximately a linear function of frequency, and 2) a band-pass loss characteristic which is centered on the linear region of the delay curve. The delay medium of the line is a thin strip having an asymmetrically tapered width. The novelty of the line lies in the fact that by arranging the transducers to that a longitudinal wave motion interacts with one minor surface as well as the two major surfaces of the strip, a band-pass loss characteristic is obtained which is independent of the transducers and terminating circuits. Thus, the delay line structure alone is one having properties of both a mechanical filter and a dispersive delay line.

50.4. Discussion of Time Delay in Reference to Electrical Waves

E. HOWARD YOUNG, JR., *Bell Telephone Labs., Inc., Whippany, N. J.*

The time delay of an electrical signal through an ultrasonic delay line may be uniquely expressed by either of the two terms, "phase delay" or "group delay." There have been devised numerous ways of determining both of these values for use in the field of ultrasonics. Many of the measuring systems do not determine these constants directly, but arrive at a value by using what appears to be, in certain instances, a close approximation to the mathematical definition. The purpose of this paper is to discuss some of these measuring systems as to the degree of the approximation involved. In doing so, the measuring system itself is analyzed together with the type of phase vs frequency curve for the delay line under measurement.

50.5. A Review of Some Russian Papers in Ultrasonics Engineering

R. N. THURSTON, *Bell Telephone Labs., Inc., Murray Hill, N. J.*

Several Russian papers of interest to the PGUE will be reviewed. While it is hoped to include more recent papers, topics available in November include ultrasonic machining, effect of transducer seal on delay-line characteristics, high-intensity ultrasound, and the properties of magnetostrictive ferrite transducers.

SESSION 51*

Thurs. 2:30–5:00 P.M.

Waldorf-Astoria
Sert Room

MILITARY ELECTRONICS

Chairman: R. L. CLARK, *Defense Res. and Engrg. (Communications), Dept. of Defense, Washington, D. C.*

* Sponsored by the Professional Group on Military Electronics. To be published in Part 5 of the 1961 IRE INTERNATIONAL CONVENTION RECORD.

51.1. The Photoscan Reconnaissance System

RENVILLE H. MCMANN, JR., *Military and Industrial Systems, CBS Labs., Stamford, Conn.*

Military Aerial Reconnaissance Systems employing television techniques have in the past been hampered by the relatively low resolution of TV camera tubes, and require real-time transmission is unwieldly airborne video recording equipment is to be avoided. CBS Laboratories' Photoscan was developed to overcome these problems; it combines the latest aerial photographic techniques with a specialized electronic scanning system. It is based on a unique cathode-ray tube having a rotating phosphor screen within the evacuated envelope.

In order to make maximum use of the Photoscan tube's capabilities, a considerable amount of signal enhancement including both vertical and horizontal aperture compensation is employed.

51.2. Micromodules in Avionics—Applicable, Practical

G. SIEVERS, *RCA Missile Electronics and Controls Div., Burlington, Mass.*

The micromodule is an improved component packaging concept. Among its many advantages the most outstanding are simplicity, minimum weight, minimum size, and uniformity.

The micromodule was developed by RCA/SurfCom for the Army. As an equipment manufacturer it behooved RCA/MECD to demonstrate the practical applications of the micromodule concept to avionic equipments.

MECD has demonstrated that micromodules can be integrated with standard components in existing equipment requiring a change of scope without a change of configuration. The micromodule is also being used as much as possible in equipment under development.

Where products of the future demand the use of a reliable "next generation" component concept, MECD has determined that the micromodule is most applicable and practical.

51.3. A Static Electronic Frequency Changer

D. C. GRIFFITH AND R. M. ULMER, *Elec. Product Dev., Tapco Group, Thompson Ramo Wooldridge Inc., Cleveland, Ohio.*

A power frequency changer using solid-state devices capable of operating from either fixed or variable supply voltage and frequency can be made to produce a single-phase or polyphase variable output frequency and voltage, each independently controllable over a wide range. This device operates in the positive and negative rectification and inversion modes to accomodate any load power factor. The load presented to the supply source of this device appears as a balanced high-power factor load regardless of the power factor or unbalance of the load on the frequency changer. The output waveform can be any desired shape as determined by the signal reference.

51.4. A Missile-Borne Sun-Position Indicator

NICHOLAS K. MARSHALL, *Solid State Electronics, Lockheed Missiles and Space Div., Palo Alto, Calif.*

This paper describes a versatile optical-electronic sun-angle sensing device being successfully used in missile testing for determination and telemetering of spin, roll, pitch and yaw motions, and known as a "Sun-position indicator" (SPI) unit.

The SPI is a completely self-contained end-instrument consisting of quartz optics, a solid-state sensor and a small, rugged, transistorized phase-shift subcarrier oscillator (for FM/FM telemetry) which has been specially compensated for short-term exposure to high temperatures. A ruggedized mercury battery provides power for several days of continuous operation.

The complete assembly occupies less than $2\frac{1}{2}$ cubic inches of space and weighs less than $1\frac{1}{2}$ ounces.

Field units have withstood more than 1000 G's of impact shock without damage and have continued to operate within tolerance limits.

Special features of this device include a fail-safe characteristic built into the circuit to prevent subcarrier channel drift or overlap, a "sense" circuit and optical configuration to determine clockwise or counterclockwise spin or rotation. Provisions are also made for dual outputs and secondary functions such as tell-tale information or multiplexing of another data channel.

51.5 The Theory of Pulsed Signal Measurements

GLENN W. PRESTON, *General Atronics Corp., Bala-Cynwd, Pa.*

The fundamental theory of pulsed signal demodulation has been extended and a general procedure has been evolved for determining the design of electrical measuring networks which give approximately optimum estimates of various pulse modulation parameters.

By way of illustration, this procedure has been applied to the measurements by radar or sonar of target velocity, target acceleration, target multiplicity (the measurement of the number of targets present at approximately the same range but having different velocities and cross sections) and target spin. The measuring networks in these cases consist of a set of parallel filters at IF—the first member of which is the familiar matched filter. This "matched filter set" is followed by balanced mixers and static real-time noniterative video arithmetic matrix operations. The set of IF measuring filters can be constructed using state-of-the-art components for comparatively complex "coded" pulse structures having usefully large time bandwidth products. Only four parallel IF filters are needed for the measurement of target amplitude, target range, target Doppler, target acceleration, target spin, and target multiplicity. The surprising mathematical simplicity of this theoretical method has a counterpart in the physical simplicity of the embodiment, thus accounting for the ability to measure coherently six target parameters with only four parallel IF channels.

An interesting possibility is noted for using the pulse measuring network to compensate those variations in the transmitter pulse form which would otherwise affect the measurements of the target parameters, thus relieving the stability requirements on the transmitter.

These general theoretical results are considered to have important implications not only in modification of existing radars and the design of future radars, but also in the design of new pulse communication systems.

SESSION 52*

Thurs. 2:30–5:00 P.M.

Coliseum Faraday Hall

VEHICULAR COMMUNICATIONS

Chairman: DONALD S. DEWIRE, *New York State Thruway Authority, Albany, N. Y.*

52.1. Tone Signaling Increases Mobile Radio Efficiency

T. G. HUMPHREYS, JR., *Alabama Gas Corp., Birmingham, Ala.*

Virtually every electric and gas utility, along with many water companies, now use mobile radio communications in their operations. The value of such systems can now be increased by the use of new devices employing audio tones.

Recently proposed rulemaking by the Federal Communications Commission will allow this technique to be employed in lieu of voice communications for many purposes, such as alarm signaling, valve and regulator operations, power line phase identification, etc. Some tone devices are presently being utilized for the above purposes on a limited scale, but it is anticipated that there will be tremendous growth in the field in the relatively near future.

The proposed end uses and the techniques to be employed will be discussed in some detail in this paper.

52.2. A New Approach to Transistorization of Mobile Radio-Telephone Equipment

I. TEOSE, *International Systcoms Ltd., Montreal, Canada.*

An equipment design is described in which transistors are employed in both receiver and transmitter to reduce power drain and increase reliability. The following design objectives are believed successfully met:

1) Low power drain in receive condition.
2) Tuning adjustments minimized by use of lumped ferrite filters for both first and second IF selectivity of receiver.
3) Transmitter up to full power one second after switching on.
4) All components easily and quickly accessible for maintenance.
5) Up to 11 RF channels available within a 1-Mc band for both receiver and transmitter, thus particularly adaptable to Maritime VHF.
6) Manufacturing cost of same order as vacuum-tube designs of similar RF power output.

A detailed description is given of a compact unit suitable for either underdash or trunk mounting in vehicular installations.

52.3. A 150-Mc Personal Radio Signaling System

D. MITCHELL AND K. G. VAN WYNEN, *Bell Telephone Labs., Inc., New York, N. Y.*

An experimental 150-Mc Personal Signaling System has been set up in New York City to evaluate over-all technical performance and explore subscriber reactions to the system. The system includes pocket receivers equipped with tuned reeds and central office arrangements adapted for direct customer dialing. The paper describes the system in over-all terms and tells how it was engineered. It also compares this system with the 35-Mc system now in service and briefly discusses traffic and radio transmission problems.

52.4. 15-kc Split Channel for the 150 Mc Land Mobile Service

R. T. MYERS, *Mobile Design Engrg., GE Co., Lynchburg, Va.*

This paper considers the use of "tertiary" (15-kc split) channels in the 150-Mc Land Mobile radio services to alleviate channel loading problems.

The questions of how satisfactory are tertiary frequencies and whether to choose a tertiary frequency or share a channel with other systems are considered. Engineering information on the transmitters and receivers indicates the expected behavior at various geographical separations. The results of practical field operations support the conclusion that tertiary channels can provide additional spectrum utilization.

52.5. Splitting the 450-Mc Channels

C. J. SCHULTZ, *Motorola, Inc., Chicago, Ill.*

Subdivision of existing 450-Mc land mobile channels will provide additional frequencies for the multitude of new public safety and industrial organizations who have found that two-way radio communication is an indispensable part of their operations.

Reduction of existing channel bandwidths presents a number of problems which must be considered if communication system performance, comparable to that presently achieved, is to be maintained on the new "split" channels. Significant reduction in *reliable* communication range cannot be tolerated.

A number of factors influence *reliable* communication range. Radio equipment performance degradation caused by automotive ignition interference, ambient RF noise, receiver desentization, transmitter and/or receiver frequency in stability, adjacent channel splatter, intermodulation product interference and transmitter spurious and harmonic radiation can cause a serious reduction in communication range and reliability.

With the possible exception of ambient RF noise, the communication systems engineer and the equipment design engineer can control the degradation caused by the various factors noted above. Adapting present interference reduction techniques to the new 450-Mc split channels will require further improvement of existing equipment designs and careful planning of communication systems prior to installation.

SESSION 53*

Thurs. 2:30–5:00 P.M.

Coliseum Marconi Hall

ANTENNAS

Chairman: DELMER C. PORTS, *Jansky & Bailey, Washington, D. C.*

53.1. Optimizing the Performance of Very High-Gain Low-Noise Antenna Systems

R. CALDECOTT, J. W. EBERLE AND T. G. HAME, *Antenna Lab., Dept. of Elec. Engrg., The Ohio State University, Columbus, Ohio.*

The concept of antenna signal-to-noise ratio is introduced and it is shown that this is a more indicative parameter than antenna gain or antenna noise temperature when the antenna is to be used in conjunction with a low-noise amplifying system. It is shown that in certain cases, by increasing the gain of an antenna, the noise temperature is increased at a much greater rate so that antenna signal-to-noise ratio is lowered. Also by considering noise temperature only, it is shown that the signal-to-noise ratio can possibly be lowered. An "ideal" antenna is defined and various ways are described which an actual antenna can be made to approach the ideal.

53.2. Far-Field Properties or Wide-Band Planar Arrays with Nonlinear Processing

EDWIN D. BANTA, *General Atronics Corp., Bala-Cynwyd, Pa.*

A planar array consists of a collection of transducers, arranged in a pattern on a plane, whose outputs are combined, after suitable processing, in a linear summation. This paper is concerned with the directionality and sensitivity of a planar array which listens to one or more broad-band sources and which employs linear or nonlinear processing at the array elements. Particular attention is paid to the effect of the source spectrum upon the beam pattern, the effect of perturbations in array weighting and position upon asymptotic side-lobe level, and the effects of nonlinear processing upon

* Sponsored by the Professional Group on Vehicular Communications. To be published in Part 8 of the 1961 IRE INTERNATIONAL CONVENTION RECORD.

* Sponsored by the Professional Group on Antennas and Propagation. To be published in Part 1 of the 1961 IRE INTERNATIONAL CONVENTION RECORD.

main-lobe sensitivity, upon sidelobes and upon angular estimation when more than a single source is present.

53.3. Frequency Scanning Antennas

A. Ishimaru and H.-S. Tuan, *Dept. of Elect. Engrg., University of Washington, Seattle, Wash.*

This paper presents the theory of 180° scanning by frequency variation and discusses the relationships between the linear array theory and the ω-β diagram of periodic structures. Each element is excited by an equivalent slow wave structure which is either nondispersive or dispersive. At a center frequency, the spacing is an integral multiple of guide wavelength $M\lambda_g$. It is shown that this is in fact the $-M$th space harmonic in the so-called forbidden region, and all the other harmonics are slow. For a given frequency range, the necessary phase velocity and other parameters are determined in order to obtain 180° scanning without causing the other main beams, and the example is carried out for the X-band frequency range.

53.4. A Critical Study of Linear Arrays with Equal Side Lobes

M. T. Ma and D. K. Cheng, *Dept. of Elec. Engrg., Syracuse University, Syracuse, N. Y.*

New and generalized expressions for the array factor of all physically realizable linear antenna arrays with progressive phase shifts are introduced. Based on these generalized expressions, a new way of synthesizing arrays with equal side lobes is available. It applies equally well to both broadside and endfire arrays, which may have either even or odd number of elements with unrestricted element spacing. No manipulations with transcendental functions are necessary, and the final expressions show a clear relationship between element excitations and null locations in the radiation pattern. Directive gain can be calculated directly from the array factor. Pattern optimization and sensitivity problems are discussed and typical examples are presented.

53.5. Maintaining Fixed Phase Differences Between Microwave Signals Generated at Remote Sites

S. B. Boor and R. J. Wohlers, *Res. Div., Radiation Inc., Orlando, Fla.*

The system described is used to maintain a fixed phase difference between microwave signals generated at widely separated stations. The method, a unique phase-lock technique, provides closed-loop compensation for perturbations occurring in the transmission medium, which may be air, waveguide, or cable. The system is not restricted to a particular frequency range, the ultimate accuracy being principally a function of the number of wavelengths between sites. Errors of less than one electrical degree are possible at separations of 10^5 wavelengths and can be easily realized using conventional circuitry. The technique is particularly applicable to the fields of satellite tracking and radio interferometry.

SESSION 54*

Thurs. 2:30–5:00 P.M.

Coliseum
Morse Hall

ADVANCES IN INSTRUMENTATION TECHNIQUES AND SYSTEMS

Chairman: P. S. Christaldi, *G-V Controls, Inc., Livingston, N. J.*

54.1. A Ferrite Piezomagnetic Stress Transducer

C. E. Land, *Sandia Corp., Sandia Base, Albuquerque, N. Mex.*

The permeability of a ferromagnetic or ferrimagnetic material is changed when the material is subjected to a unidirectional mechanical stress. This phenomenon (piezomagnetic effect) has been investigated in certain ferrites. The results of the investigation have been used in the development of a ferrite piezomagnetic stress transducer. This device produces a dc output voltage proportional to the stress in a ferrite sensor. The relationship between output voltage and stress can be made either linear or logarithmic to best fit the requirements of a particular instrumentation problem. The transducer is smaller and more sensitive (by at least an order of magnitude) than similar devices utilizing semiconductor strain gauges.

This paper presents a description and analysis of the piezomagnetic stress transducer. The Weiss domain theory is used to explain piezomagnetic effect and to develop a quantitative relationship between permeability and internal stress in the ferrite sensor. Several possible transducer applications involving the measurement of physical quantities such as pressure, force, acceleration, vibration, and shock are discussed.

54.2. Metastable Helium Sensitive Magnetometer

J. A. Rice, Jr., *Central Res. Labs., Texas Instruments Inc., Dallas, Tex.*

The principal features of typical Zeeman resonance experiments in bulk materials are reviewed.

The use of optical pumping in the Zeeman resonance of metastable helium and the properties of the resonance signal obtained are described.

A lead sulfide optical detector senses the resonance signal, a modulated 1μ emission from a helium discharge. The slope of the helium resonance line is used in a frequency control feedback arrangement to construct a magnetometer in which the external magnetic field strength is a linear function of frequency output.

Field test results on prototype magnetometers are used in the discussion of the over-all characteristics and limitations.

* Sponsored by the Professional Group on Instrumentation. To be published in Part 9 of the 1961 IRE International Convention Record.

54.3. Hysteresis Curve Tracer for Thin Magnetic Films

T. F. Bryzinski and D. R. Sahba, *Stromberg-Carlson Co., A Div. of General Dynamics Corp., Rochester, N. Y.*

The Magnetic Hysteresis Curve Tracer is an instrument that was developed to determine the static hysteresis characteristics of thin-magnetic-film sample elements. The instrument uses a unique method to obtain the more uniform longitudinal magnetic field necessary to switch thin magnetic films uniformly.

Another unusual characteristic is the method used to vary the induced voltage of the cancelling coil.

The Magnetic Hysteresis Curve Tracer also allows the sample element to be rotated to determine the Skew of the magnetic anisotropy of the film; and to study the static hysteresis characteristics when the longitudinal field and cross fields are applied at various angles relative to the Easy axis of the thin magnetic film.

54.4. A New Method for Automatic Measurement and Display of Amplitude/Frequency Characteristics in the VHF/UHF Range

H. Lucius, *Rohde & Schwarz, Munich, Germany.*

This is an investigation into the possibility of making swept-frequency measurements of frequency-responsive quantities with a high sensitivity and direct logarithmic representation. A survey of the present state of the art is followed by a discussion of a method which permits RF voltages swept in frequency to be amplified and measured with logarithmic or linear response.

For an example, an actual, automatic, selective vacuum-tube voltmeter is cited which operates in the frequency range 30 to 400 Mc. This instrument automatically tunes to the input frequency and follows it also in the case of rapid frequency changes. It offers considerable advantages, both for the swept frequency and for the point-by-point methods, due to its high sensitivity and logarithmic or linear indication.

54.5. Precision Measurement System for Large Antennas

W. C. Espenlaub, *Airborne Instruments Lab., Deer Park, L. I., N. Y.*

A facility for the precision measurement of large, multiple-beam, monopulse antennas is described. Accuracies of 0.35 db in gain and 0.1 mr in bearing have been achieved. The facility uses as a source a light, fixed-wing aircraft carrying a transmitter and radar beacon. A tracking radar, receivers, and signal processing and recording systems are contained in portable vans. Both relative and absolute gains are recorded as functions of azimuth and elevation angle. Patterns are recorded in both linear and logarithmic scales by an analog-type photo-optical recorder, which permits immediate access to the data and immediate determination of the completeness and accuracy of the recorded data.

Books

Statistical Theory of Communication, by Y. W. Lee

Published (1960) by John Wiley and Sons, Inc., 440 Fourth Ave., N. Y. 16, N. Y. 501 pages+7 index pages+xvii pages. Illus. 6×9¼. $16.75.

This text is intended as an introduction to communication theory for first year graduate students and some undergraduates. The book contains several basic chapters on probability and generalized harmonic analysis, followed by an exposition of Wiener's smoothing and prediction theory, and concludes with special topics in optimum systems.

The writing is very fine, with a heuristic argument or experimental result being added wherever necessary or useful. The author is evidently a dedicated and able teacher. For example, he is able to anticipate difficulties which might arise in early chapters when the student has not been introduced to material which appears in the later chapters.

One might complain of the fact that only stationary random processes with rational spectra are considered, that there is no mention of finite sample smoothing, and that detection is treated as though only signal-to-noise ratios are important. It may be argued, of course, that these complaints are unfairly applied to an introductory book. A more serious omission, though easily supplied by a teacher, is the absence of the Shannon-Bode interpretation of smoothing and prediction which should be quite useful to the student.

Professor Lee's lucid text should certainly be considered by a teacher planning a a course in this subject.

T. M. Burford
Bell Telephone Labs., Inc.
Murray Hill, N. J.

Electrical Engineering Problems, by E. M. Williams and F. J. Young

Published (1960) by McGraw-Hill Book Co., Inc., 330 W. 42 St., N. Y. 36, N. Y. 287 pages+6 index pages+xiv pages. Illus. 6¼×9¼. $7.75.

This is a rather unusual book, and is, as the name suggests, a collection of engineering problems. It is not a textbook in any conventional sense of the term. According to the authors, this book is the outgrowth of their teaching philosophy and experience in which problem solving, often requiring laboratory work, is an essential part of the educational experience of the student. The problems have been so written that the solutions "require professional skill in the application of electrical science, and particularly skill in the planning and conduct of electrical laboratory work."

The authors feel that a "problem centered" laboratory has a number of advantages both as a teaching medium and as a valuable engineering experience. The advantages of the educational method can be exploited if the student laboratory work is conducted with emphasis on: 1) learning to use the laboratory as a tool in problem solving; 2) enhancement of a responsible attitude (self-direction) in problem solving; 3) development of an understanding of the role of simplifications and derived concepts in relation to problem solving and basic science, and, consequently, reinforcing of the student's comprehension of basic science; and 4) encouraging initiative and inventiveness.

The book is derived into fourteen chapters, all of which are without chapter headings. The chapters serve principally to separate classes of problems. The problems range from the intermediate to the advanced, and include such subjects as linear and nonlinear dc and ac circuits, electromechanical devices, transformers, magnetic core switching circuits, rotating machines, and vacuum and semiconductor electronic circuits. The problems are presented in "professional" style—the form in which problems typically appear to an engineer in practice.

The authors make no effort to relate the problems to particular courses. Nor do they indicate the extent to which the work supplements or replaces laboratory work of the conventional types. However, they do discuss the conduct of the problem solving laboratory work at their home institution, and mention some of the pitfalls to be guarded against in conducting such a program.

The book will be a very valuable one to electrical engineering educators. It can serve in providing direction in the establishment of laboratory-centered workshops to supplement analytic courses. It can also provide a valuable source of interesting and instructive problems. For the non-educator, it provides interesting and challenging reading, and can provide many problems for pastime and pleasure.

Samuel Seely
Case Inst. Tech.
Cleveland, Ohio

Field Theory of Guided Waves, by Robert E. Collin

Published (1960) by McGraw-Hill Book Co., Inc., 330 W. 42 St., N. Y. 36, N. Y. 551 pages+13 index pages+xiii pages+40 appendix pages. Illus. 6¼×9¼. $16.50.

The author has provided a graduate-level textbook on applied electromagnetic theory, with particular emphasis on waves in various types of media. The treatment assumes a prior course at a level such as Ramo and Whinnery's "Fields and Waves in Modern Radio," as well as considerable mathematical sophistication. The author's objective was to bridge the gap between the usual senior-year or first-year graduate course in electromagnetic theory and the advanced periodical literature describing modern research. In this reviewer's opinion the objective has been achieved very well, with the book meeting a definite need in the advanced education of radio engineers.

After a review of basic electromagnetic theory, the author develops various methods of solving wave problems in free space and waveguides. Then he treats propagation in transmission lines and waveguides, periodic structures, surface waveguides, and artificial dielectrics. Many interesting problems are worked out in detail, some of which are the computation of strip-line characteristic impedance by Schwarz-Christoffel and variational methods, dielectric-slab loading of waveguides, probe, loop and aperture couplings in waveguides, capacitive and inductive windows, excitation of surface waves, and the interaction effects between obstacles in artificial-dielectric media.

The principal mathematical tools of present-day research are explained clearly, and illustrated by examples. Included are excellent introductions to Green's functions, and to variation, Rayleigh-Ritz, and Wiener-Hopf techniques. A forty-page mathematical appendix aids the reader by summarizing the required background in vector and dyadic analysis, matrices, calculus of variations, and infinite products and series.

In addition to its primary function as a textbook, this volume should also be a worthwhile addition to the library of practicing engineers who are working close to the frontier of research. Such engineers will find this a helpful reference for understanding the advanced papers on electromagnetic-theory applications that have been appearing in the literature in recent years.

Seymour B. Cohn
Rantec Corp.
Calabasas, Calif.

Computer Logic, by Ivan Flores

Published (1960) by Prentice-Hall, Inc., Englewood Cliffs, N. J. 394 pages+6 index pages+xii pages+57 appendix pages. Illus. 6¼×9¼. $12.00.

The purpose of this text is to carry a novice to the field through to a good comprehension of the functional design of digital computers. It is the opinion of this reviewer that the author succeeds rather nicely in this regard.

After several well-written introductory chapters, the author describes the broad outlines of computer system organization. Subsequently, he considers such topics as the flow and control of information, coding, machine arithmetic, number systems and counting, machine languages, logic, logical construction, functional units, the logic of arithmetic, memory devices and their logic, the control unit, and input and output equipment. The author concludes the main body of the text with a chapter on the application of digital computers to problem solving.

The appendix contains a very good glossary of computer terms. The text contains nothing on computer circuitry design details but this, of course, does not detract from the author's purpose for this text.

On the whole this reviewer found the author's presentation very good and a pleasure to read. This book is well worth recommending as an introductory text.

C. T. Leonde
University of California
Los Angeles

Foundations of Electrodynamics, by Parry Moon and Domina Eberle Spencer

Published (1960) by D. Van Nostrand Co., Inc., 120 Alexander St., Princeton, N. J. 293 pages+6 index pages+vii pages+14 appendix pages. Illus. 6¼×9¼. $9.75.

This book is an intermediate-level book on electrodynamics that could serve as text for a short university course at the advanced undergraduate level or beginning graduate level. Approximately the first twenty per cent of the book is concerned with reviewing ideas of fields and vectors, and with deriving the basic laws (Maxwell's equations) from a novel postulational basis. The middle two-thirds of the book applies these equations to static electric and magnetic fields, to skin effect, to wave propagation, to waveguides, and to antennas. Finally, there are two chapters concerned with moving systems which introduce the concepts of special relativity. Each chapter has a good number of problems, some quite imaginative, a well-chosen list of references, and a summary in text or tabular form, or both. The appendixes are on notation, units, coordinate systems, and solutions to a number of standard differential equations.

The middle portion of the book, as described above, is the most conventional part. The treatments of the several items are short, but do derive the basic ideas and include interesting examples. More could well have been included on resonant wave systems, since these are basic to communication and scientific use of wave phenomena.

The chapters on moving systems, which are not found in many books at this level, do as much as could be hoped in the space allowed to introduce the reader to the relativistic concept of moving systems. Most valuable is the tie to nonrelativistic ideas of moving systems in the section called "common-sense transformations."

Perhaps the most controversial as well as most novel section of the book is the first part, which arrives at Maxwell's equations from five postulates and a number of defined quantities, with the concept of retardation being taken as a basic postulate, and the retarded potentials as basic defined quantities. This reviewer found the treatment refreshing as a new look at an old subject, but was not convinced that it is indeed most basic, or best for the student to have as a primary point of view. Certainly the historic method, although overworked, gives insight into one side of the scientific method. The most common alternative is to set down Maxwell's equations in their most general form as experimental laws. The authors state that such treatments are usually imprecise in definitions. However, the treatment given here is limited to homogeneous, isotropic, linear media—limitations which seem unnecessary for a derivation at this level of sophistication.

The notation is generally good, although the use of the asterisk to denote all complex quantities seems unfortunate, as so much of the literature reserves this for conjugates. A few misleading arguments were noted, such as the one of Section 6-06, which states that electric and magnetic fields in all time-varying systems are orthogonal. Since the proof sets derivatives of two of the electric field components zero at the point of consideration when only the components themselves are given as zero, it is a proof for a plane-polarized wave.

J. R. Whinnery
University of California
Berkeley

Space Research, H. K. Kallmann Bijl, Ed.

Published (1960) by Interscience Publishers, Inc., 250 Fifth Ave., N. Y. 1, N. Y. 1188 pages+3 index pages+xvi pages+bibliography by chapter. Illus. 7×9¾. $24.00.

This book contains the papers presented at the First International Space Science Symposium, which was sponsored by the Committee on Space Research (COSPAR) of the International Council of Scientific Unions. Held at Nice, France, January 11–16, 1960, the Symposium brought together "space" scientists from all the countries active in upper atmosphere and space research. The papers concentrated on the scientific results achieved between the launching of Sputnik I in October, 1957, through the preliminary results obtained from Explorer VI and Lunik III. The subjects discussed were limited to the earth's atmosphere, the ionosphere, tracking and telemetry, solar radiation, cosmic radiation, interplanetary dust, and the characteristics of the moon and planets.

Of the nearly 100 papers, about half were devoted to sounding rocket measurements of the upper atmosphere and of the ionosphere, and a fourth to the measurements of the particles and fields associated with the Van Allen belts. In particular, the papers on the earth's atmosphere range from the meteorological significance of cloud formations photographed from outside the atmosphere, through the measurements of winds and atmospheric stratification using sodium vapor and grenade explosions, to density variations determined by sounding rockets and from satellite drag measurements. The papers on the ionosphere report both propagation measurements and the results of direct probing of particle, density and energy. The section on tracking and telemetry ranges from the description of equipment, a special camera, as well as several Doppler systems for determining satellite orbits through the determination of the earth's gravitational field from these orbits, to the observation of the impact of Lunik II by means of the Doppler shift in its transmitted frequency. Part IV is devoted to sounding rocket measurements of x-ray and ultra-violet solar radiation and to measurements on the earth of cosmic rays and of auroral changes related to solar activity. Part V deals with satellite measurements of the Van Allen radiation belts and of the related magnetic field and with some tentative theories of their formation. Papers in the section on interplanetary dust detail satellite micrometeorite measurements and attempt to correlate these with observations of the total meteoric influx on the earth. The last section brings together some papers on the surface and atmosphere of the moon and on the possibility of life on other planets.

Although an attempt was made to present a summary paper at the beginning of each section, the juxtaposition of papers reporting on observations made at quite different times and consequently with quite different techniques leads to some problems of understanding for the reader who may not be familiar with the very rapidly changing field of space science. The editing of the manuscripts is exceptionally good, as is the printing and art work. Finally, one must join President van de Hulst in saying that . . . "the over-all impression (from the symposium) is that of a magnificent advance in many scientific fields of practical and theoretical importance."

G. E. Mueller
Space Technology Labs.
Los Angeles, Calif.

Electronic Circuit Analysis, Vol. 1, Passive Networks, by Phillip Cutler

Published (1960) by McGraw-Hill Book Co., Inc., 330 W. 42 St., N. Y. 36, N. Y. 446 pages+6 index pages+x pages+2 bibliography pages. Illus. 6¼×9¼. $8.00.

The stated purpose of this book, the first of a projected series, is "to build a solid foundation in the basic concepts and techniques essential to mastering problems of analysis, design, and maintenance of electronic equipment" and "to narrow the gap between the technician's and engineer's viewpoints." It is aimed toward increasing the theoretical competence of those having technician level training and requires only a working knowledge of algebra and basic electronics.

To implement the stated purpose the book is divided into five chapters: "Network Analysis and Theorems," (67 pages); "A-C Circuit Analysis," (107 pages); "Transient Analysis," (85 pages); "Transformers," (67 pages); and "Graphic Analysis of Vacuum-Tube Circuits," (110 pages). Each chapter contains an unusual number of worked-out examples and a generous number of problems to be solved. The entire book stresses practical application of the theoretical principles discussed.

A double-subscript notation is used to denote voltages in which E_{ab} means the voltage at point b with respect to point a. Current direction is considered to be the same as direction of electron-flow. Since these notations are the reverse of conventions prevalently used elsewhere, the reader with prior knowledge of network analysis may experience some initial confusion.

The discussion of determinant solution of simultaneous equations is unduly limited by restricting it to two unknowns. That a determinant solution with more unknowns is possible is not mentioned.

An equation is given for "decibels" but no explanation of the meaning or significance of the decibel appears. The definition "Q" loosely refers to reactive volt-amperes as reactive *power*.

Examples showing graphical determination of μ, g_m, and r_p from the plate characteristic curve show each being determined at a different operating point. The fact that these must be computed at the same point for the interrelation equation $\mu = g_m r_p$ to be valid is not emphasized

The lack of mathematical sophistication required of the reader leads to some labored and restricted procedures. In a few places, concepts are applied prior to their introduction in the exploratory material. Where this occurs the explanation usually follows within a few pages. A few typographical errors were noted, but no more than in most first printings.

This book does an excellent job explaining theoretical concepts and illustrating practical applications within the background restrictions imposed. It should find widespread use in courses for technicians and as a ready reference for those seeking simple explanations and worked-out examples. It should also prove valuable for graduate engineers wishing to review areas in which they have become rusty or whose education was so highly theoretical that a need is felt for increased competence in making practical applications.

I. O. Ebert
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East Lansing

Dictionary of Electronics, by Harley Carter

Published (1960) by Pitman Publishing Corp., 2 W. 45 St., N. Y., N. Y. 358 pages+vi pages+18 appendix pages. Illus. 5×7½. $8.50.

This volume of British usages is intended to be "helpful to many engineers, technicians, apprentices and students." It treats, in some cases lightly, branches of electronics, including atomic physics, audio, communications, computers, electricity and magnetism, industrial electronics, instrumentation, radar, radio, radio navigation, and television. It is as up to date as *Tunnel Diode* and as historical as *Aether*. It appears to be as authentic as the author can make it without any citation of authority or any reference to already-published definitions.

"Dictionary of Electronics" contains some 2200 terms and definitions, illustrated by 233 figures, plus a list of units and abbreviations, lists of letter symbols and graphical symbols, color codes for components, decibel conversion tables, a classification of the electromagnetic spectrum, a frequency-wavelength conversion table, drawings of tube-base arrangements, and a table of rationalized MKS units. The definitions range in length from 3 to 830 words, and tend to be tutorial rather than definitive.

Your reviewer has selected the following quotations to indicate the flavor of the treatment:

> "*Amplification*—Process by which a comparatively small signal is applied to the input of an amplifier and appears at the output in greatly magnified form."
> "*High Fidelity*—The sound output of an amplifier and loudspeaker combination is said to be of high fidelity when it is a reasonably faithful reproduction of the original sound."
> "*Temperature*—The degree of hotness or intensity of heat, expressed in arbitrary units."

"Dictionary of Electronics" contains a wealth of useful information. The book will be somewhat less than satisfying for those who must be discriminating in their use of technical words.

Millard W. Baldwin, Jr
Bell Telephone Labs., Inc.
Murray Hill, N. J.

Statistical Theory and Methodology in Science and Engineering, by K. A. Brownlee

Published (1960) by John Wiley and Sons, Inc., 440 Fourth Ave., N. Y. 16, N. Y. 543 pages+4 index pages+xv pages+18 appendix pages. Illus. 6×9¼. $16.75.

This remarkably self-sufficient book covers the basic repertoire of the modern professional statistician. It begins with a summary of fundamental probability theory in a 63-page chapter such as that which practically every author in the field must give, because it cannot yet be assumed that the reader has learned these things elsewhere. There follows a 40-page introductory chapter on the subject of statistics proper, showing by definition and example what is meant by estimation, hypothesis testing, and confidence limits. The remaining 17 chapters show how such problems are solved in specific situations. The generous lists of accompanying exercises are interesting, up-to-date, and down-to-earth. Tables of the useful statistical functions are furnished.

Specifically, the topics treated include the standard distributions, such as binomial, hypergeometric, Poisson, chi-square, multinomial, and bivariate normal. There is also a chapter on so-called nonparametric tests in which one does not attempt to guess what the distribution is. Tests for randomness and for equality of variances and means have their individual chapters. The analysis of variance (one- to four-way inclusive) is given extensive attention. Linear regression is treated for both the single and multiple variable cases. There are two chapters dealing with the design of experiments. There is no mention of spectral density, but its mates, correlation and covariance, do appear. In this respect, it should be made clear that the reader will have to look elsewhere for a development of the time series point of view in statistics.

The book would make a good undergraduate text for engineers and scientists. It should also be useful in a self-taught study program and as a handy reference for much useful statistical knowledge.

W. R. Bennett
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Scanning the Transactions

Autopsy is not a word one normally associates with engineering, yet it accurately describes one of the important jobs being done by reliability engineers. Valuable information about the causes of death can be obtained by examining components that have expired. In this way the engineering "pathologist" can determine if the component died a natural death or if its demise was violent. In many cases a visual examination is all that is required. In the case of hermetically-sealed devices such as transistors and relays, however, external examination is not very helpful. In such cases it is desirable to actually open the case (autopsy) to see what caused the failure. Unfortunately, opening a transistor case mechanically often disturbs the delicate junction wires, particularly when the case is filled with a silicone grease mixture affectionately known in the trade as "moose gunk." Post-mortem specialists should therefore welcome the new autopsy technique that has recently been perfected which uses an electrochemical process to remove the case without disturbing the internal transistor and relay elements. (C. B. Clark and E. F. Duffek, "New autopsy techniques for transistors and relays," IRE TRANS. ON RELIABILITY AND QUALITY CONTROL, December, 1960.)

The importance of adequate training is probably nowhere more clearly demonstrated than in the field of bio-medical electronics. This fledgeling field has so far been made up largely of workers whose formal training has been only in biology or medicine or only in engineering. With the exception of biophysicists, who, it should be noted, have contributed much to this field, few can be found who have been formally trained in both the physical and life sciences. It is not unlikely that bio-medical electronics will some day become a separate and distinct discipline in its own right, or at least will form a part of a broader new discipline that would fill the void that lies between engineering and science on the one hand and medicine and biology on the other. Consequently, there is an urgent need now for the establishment of adequate courses of instruction in this new area. The numbers of such programs at present are few. Nor is there even agreement as to what form such programs should take. Considerable encouragement, however, can be taken from the experience of an older, closely allied field—biophysics. A recent survey of biophysics teaching programs has shown that no less than 68 educational institutions in the U. S. and Canada now offer such programs. Even more striking is the fact that, despite the diversity of these programs, there is a remarkable degree of agreement on the requirements of biophysics as a discipline. (N. A. Coulter, Jr., and R. W. Stacy, "Biophysics teaching programs available in the United States and Canada," IRE TRANS. ON MEDICAL ELECTRONICS, October, 1960.)

How much do you sweat? An answer to this personal question might well provide a reliable measure of the amount of stress you are under. There are two distinct groups of sweating: thermal and mental. Thermal sweating occurs over most of the body surface with the exception of areas such as the palms of the hands and soles of the feet. Mental or emotional sweating, on the other hand, is usually restricted to the palms, soles and armpits. Simple indexes of stress, such as respiration rate, heart rate, and deep body temperature, have proved somewhat unreliable. Considerable research has shown that if there is any single index of stress, it is to be found in the sweat rate. The question posed at the start can indeed be answered. An ingenious electronic device has been developed which will continuously measure and record sweat rate. The sweat rate is determined by measuring the change in resistance of a sensing element which, in turn, reflects the change in moisture content of the air within a small chamber which is fastened against the skin. The question of whether, as is likely, as much sweat went into the development of this novel device as is now coming out of it will have to remain unanswered. However, the question of whether sweat rate is indeed a good measure of stress will in all probability be answered by this important new tool. (O. Z. Roy, "An electronic device for the measurement of sweat rates," IRE TRANS. ON MEDICAL ELECTRONICS, October, 1960.)

Rendezvous in space. The propulsion and guidance problems associated with placing satellites in orbit have been resolved to the point where attention can now be directed to space flight and guidance problems of a more advanced nature. One such problem is that of satellite rendezvous. In recent months there has been a great amount of interest in terminal guidance schemes that yield a soft landing. This end condition would usually be necessary for the successful completion of certain space missions of the future, such as inspecting a hostile satellite, assembling or repairing a space station, supplying or ferrying personnel to a space station, and rescuing astronauts. The basic ideas behind a terminal guidance technique for satellite rendezvous have now been worked out. The simple system can be mechanized with a constant thrust rocket, a small computer, and attitude control. (A. L. Passera, "Conditional-switching terminal guidance (A terminal guidance technique for satellite rendezvous)", IRE TRANS. ON AERONAUTICAL AND NAVIGATIONAL ELECTRONICS, December, 1960.)

Pocket-size personal radio receivers, a commonplace sight with respect to the AM broadcast band, are now making their appearance in the VHF band. Two papers at the Vehicular Communications sessions of the 1960 WESCON meeting were devoted to personal radio paging and two-way communication systems which used pocket-size FM receivers operating in the 145–175 Mc band. The receivers weighed about one pound, employed 25 to 26 transistors and diodes, and needless to say featured modular construction. (T. H. Yaffe, "A personal two-way radio communication system featuring modular construction"; also J. F. Mitchell, "Personal radio paging in the VHF band," IRE TRANS. ON VEHICULAR COMMUNICATIONS, December, 1960.)

Conference publications, despite the dissenting views held by members of the SPPCP (Society for the Prevention of the Publication of Conference Proceedings), provide a picture of the state of the art and an indication of important unsolved problems which can be very useful to the specialist. To the nonspecialist, they frequently serve as weather vanes, pointing to oncoming centers of activity that may soon have a significant effect on the general technical climate. With this in mind, we should like to call attention to three conference reports that have recently appeared. Only the conference titles, since they are self-explanatory, need be listed here, with the reminder that a full listing of individual papers and their abstracts appears in the following section of this issue: Conference on Diagnostic Data Processing (IRE TRANS. ON MEDICAL ELECTRONICS, October, 1960); Conference on Solid State Radiation Detectors (IRE TRANS. ON NUCLEAR SCIENCE, January, 1961); Conference on Standards and Electronic Measurements (IRE TRANS. ON INSTRUMENTATION, September, 1960.)

Abstracts of IRE Transactions

The following issues of TRANSACTIONS have recently been published, and are now available from the Institute of Radio Engineers, Inc., 1 East 79th Street, New York 21, N. Y. at the following prices. The contents of each issue and, where available, abstracts of technical papers are given below.

Sponsoring Group	Publication	IRE Members	Libraries and Colleges	Non Members
Aeronautical and Navigational Electronics	ANE-7, No. 4	$2.25	$3.25	$ 4.50
Audio	AU-8, No. 6	2.25	3.25	4.50
Broadcasting	BC-7, No. 1	2.25	3.25	4.50
Communications Systems	CS-8, No. 4	2.25	3.25	4.50
Information Theory	IT-6, No. 3	2.25	3.25	4.50
Instrumentation	I-9, Nos. 2–3	3.60	9.45	12.60
Medical Electronics	ME-7, No. 4	2.25	3.25	4.50
Nuclear Science	RQC-9, No. 3	2.25	3.25	4.50
Reliability and Quality Control	NS-8, No. 1	2.25	3.25	4.50
Vehicular Communications	VC-9, No. 3	2.25	3.25	4.50

Aeronautical and Navigational Electronics

Vol. ANE-7, No. 4, December, 1960

Conditional-Switching Terminal Guidance (A Terminal Guidance Technique for Satellite Rendezvous)—Anthony L. Passera (p. 110)

This is a terminal guidance technique for satellite rendezvous utilizing a constant thrust rocket motor, a computer, and attitude control. For any given thrust level, this technique can reduce the relative range to any desired value in a minimum of time for an interceptor on a collision course. A terminal guidance law is formulated and mechanized. The generalized range performance trajectories and system errors are presented.

Radio Frequency Noise from Environment of Hypersonic Vehicles—Mahendra Singh Sodha (p. 119)

The author has reviewed the state of art in estimating the radio frequency noise from the environment of a hypersonic vehicle and has pointed out areas requiring considerable effort. It can be safely said that the radiation due to the incoherent processes is less than that due to a corresponding black body. The possible mechanisms for excitation of and radiation by plasma oscillations need further investigation before anything conclusive can be stated regarding their role in the emission of RF noise. A conjecture has also been made about mechanisms for coherent radiation.

Theoretical Accuracy of Radar Measurements—Merrill I. Skolnik (p. 123)

The theoretical rms error in measuring time delay (range) and Doppler frequency (relative velocity) are determined for representative radar waveforms, including rectangular-, trapezoidal-, triangular-, and Gaussian-shaped pulses as well as the linear FM pulse compression waveform. The so-called "uncertainty" relationship of radar is interpreted in terms of measurement errors and the difference between the radar and the quantum mechanical uncertainty principles is discussed. Mention is also made of the theoretical error involved in measuring the angle of arrival with an antenna aperture.

Addendum to "A Flush-Mounted Runway Antenna for Use with the FAA Directional Glide-Path System"—J. R. Baechle and R. H. McFarland (p. 130)

Abstracts (p. 131)

PGANE News (p. 132)

Contributors (p. 133)

Annual Index, 1960 (follows p. 133)

Audio

Vol. AU-8, No. 6, November-December, 1960

The Editor's Corner—Marvin Camras (p. 189)

PGA News (p. 190)

Transistor Power Amplifiers With Negative Output Impedance—Werner Steiger (p. 195)

The response of electromechanical transducers can often be greatly improved by proper electrical termination that compensates for their coil impedance.

The results of a detailed analysis are presented for two practical transistor amplifier configurations which produce negative output impedance.

A push-pull power amplifier, based on this analysis, uses the bias stabilizing elements of the output stage to obtain the necessary positive current feedback. The three-stage circuit delivers, without a transformer, 12 watts into 8 ohms or 8 watts into 16 ohms. The output impedance is adjustable from plus 1 ohm to either minus 7 or minus 14 ohms.

This amplifier has been used successfully in an all-transistor stereophonic high-fidelity system.

A Transistor Push-Pull Amplifier Without Transformers—J. H. Caldwell (p. 202)

A push-pull transistor amplifier has been developed using a matched pair in the output stage, with a minimum number of components and requiring no transformers.

Automatic Spectral Compensation of an Audio System Operating with a Random Noise Input—Charles E. Maki (p. 206)

A set of 80 filters is used to divide a random noise input spectrum of an audio system into 25 cps increments. An identical set operating as a spectrum analyzer provides a similar function on the system output. By means of an automatic regulating system using solid-state electronics, each of the 80 loops is closed independently, thus providing a unique control system compensating the audio system spectrum and equalizing disturbing resonance phenomena. This method has been successfully applied to the control of a vibration system spectrum where mechanical resonances at the exciter table produce high Q peaks and notches. The degree of spectral flatness reveals that adequate compensation is possible for typical resonance phenomena occurring over a wide frequency range.

A New Cardioid-Line Microphone—Robert C. Ramsey (p. 219)

A new microphone, the Electro-Voice Model 642, is described. Designed particularly for television and motion picture applications where the usable microphone working distance must be a maximum, the model 642 has improved directivity and high sensitivity. The improved directivity is achieved by functioning as a first-order gradient microphone at bass frequencies and as a line microphone at higher frequencies. A detailed description of the directional characteristics is included.

Choice of Base Signals in Speech Signal Analysis—Ladislav Dolanský (p. 221)

Fourier series is generally considered to be one of the most basic mathematical tools of the communications engineers; when experimental support is sought for the theoretical conclusions obtained, it has the advantage of having readily available source equipment in the form of sine-wave generators. In many cases, however, due to the characteristics of the signals under study, the analysis into other base functions would result in a reduction of expression complexity and a better insight into the problem. This is demonstrated on a specific example, in which the damped-oscillatory voiced speech sounds are expressed by means of complex-exponential base functions. The method of measuring the pertinent coefficients is given; the nature of the analyzing equipment, which is also used for synthesis, is described briefly, and experimental results, including synthetically obtained approximations of the original signals, are presented.

While speech signals are used to illustrate the method, the latter is applicable to other signals as well.

The Use of Pole-Zero Concepts in Loudspeaker Feedback Compensation—William H. Pierce (p. 229)

Pole-zero concepts, with the associated techniques of signal flow graphs and root locus plots, are introduced and used in the analysis and synthesis of integrated loudspeaker-amplifier systems in the lower-frequency region. The case of the infinite baffle system is treated in detail, and formulas are developed for general voltage and current feedback. This is then simplified into a design method using only RC elements, and the compensation of the high-efficiency woofer in an undersized enclosure illustrates the method.

Correspondence (p. 235)
Contributors (p. 236)
Annual Index (follows p. 236)

Broadcasting

VOL. BC-7, NO 1, JANUARY, 1961

Tenth Annual Fall Symposium—The Editor (p. 1)

Planning and Erecting a 1619 Foot Tower for Television Broadcasting—R. W. Hodgkins (p. 4)

An Automatic Program Logging System—Robert W. Flanders (p. 11)

Design Criteria: Transmitter High Voltage Solid State Rectifiers—Lynn R. Zellmer (p. 15)

A Further Analysis of TASO Panel 6 Data on Signal to Interference Ratios and Their Application to Description of Television Service—Harry Fine (p. 22)

Television Program Automation—James B. Tharpe (p. 39)

Automation of TV station operations is going to be essential for stations to keep competitive and to produce the efficiency required to maintain proper earnings from gross revenues. The Chief Engineer is going to be the key man in automation planning due to the fact that the end result of the automation is his on air operation in the technical department. This automation of the on air operation will be found to act as the catalyst which will affect work flow—department to department throughout the organization. When properly organized the information handling and scheduling in the Sales, Program, Traffic, Technical and Accounting Departments will be integrated to provide over-all efficiencies far exceeding those which may be immediately expected in the technical area. Consider the automation system units as (a) the active storage display located in the technical department which can be operated manually, or by simple control room tape punch and reader and (b) separately the large capacity prestorage facility. Plan that any unit installed should allow for gradual growth and change of systems in the station's other departments. It is essential, therefore, that the on air automation system have the capability of being integrated with all data processing systems, which over the next decade will be the order of the day for all businesses of any size.

Errata and Letters to the Editor (p. 42)

Communications Systems

VOL. CS-8, NO. 4, DECEMBER, 1960

Military Radio Communications Equipment Cost-Design Relationships—D. C. Ports, E. E. Reinhart, J. J. Crenca, and K. G. Heisler, Jr. (p. 203)

A method is presented for determining the relationships between the "costs" (size, weight, dollars) and the electrical characteristics (frequency, bandwidth, input power, output power, antenna gain) of radio equipment used in military communications systems. The compilation of pertinent data is described, and a series of empirical "trade-off" curves displaying cost-design relationships as they exist in various classes of current and developmental military equipment is shown. Separate sets of curves are included to illustrate the dependence of the trade-offs on such factors as the type of installation for which the equipment was designed, the type of modulation employed and developmental status.

Communication Networks for Digital Information—J. M. Unk (p. 207)

Considerable advance has been made in the automation of clerical work over the last ten years, and the movement continues unabated. There is thus an ever-increasing need for means of telecommunication suitable for the exchange of information between computers and remote input and output equipment (*i.e.*, data transmission). As soon as large organizations, or organizations spread over a large geographic area, adopt automation of clerical work, a need arises for a system comprising one or more computers which have to be linked to numerous sets of input and output equipment.

This necessitates a telecommunication network for digital information, and this network must be perfectly matched to, and form an integral whole with, the system. An excellent example of such an arrangement is an airline space reservation system. This system is examined in detail, and its operational and technical requirements are discussed, as well as the means of realizing them.

Particular attention is paid to the question of reliability, speed and efficiency, and it is shown that these three factors are closely interrelated. When traffic is heavily concentrated, it will be necessary to employ high signalling speeds, though these will not be economically justified where traffic is light.

Propagation, Noise, and General Systems Considerations in Earth-Space Communications—Harold J. Pratt, Jr. (p. 214)

As man's ability to escape the attraction of the earth's gravitational field increases, the science of earth-space communications becomes more and more important. In this paper, an attempt is made to analyze the relevant propagation, noise and general system aspects of earth-space systems and to predict the operating frequencies for maximum range.

The earth's atmosphere is shown to be nearly transparent to the transmission of radio frequencies (RF) between 80 and 15,000 megacycles. The various sources of noise both internal and external to the earth-space communications system are investigated and a spectrum of system sensitivity is plotted. Maximum available transmitter power and practical antenna parameters are predicted for the 1965–1970 era.

All of these factors are then combined and weighted according to the "beacon" or "radar" equations, and the optimum operating frequencies for maximum range one-way and two-way earth-space communications systems are shown to lie in the microwave region of the spectrum.

Analysis of a Phase-Modulation Communications System—Robert L. Choate (p. 221)

A communication system is analyzed which utilizes phase modulation (PM) and phase detection. The analysis shows that when the total radio frequency (RF) power level is significantly above the receiver threshold, a margin of safety exists which may be traded for additional signal-to-noise ratio (SNR) at the demodulated output of the receiver. In this respect the PM system is similar to FM communication systems which utilize an "FM improvement factor." Several examples are presented to indicate the magnitude of the PM improvement factor when the signal is a sine wave variable throughout the audio band. A novel type of closed-loop phase detector is suggested which is linear over a very wide range of phase angles.

Distortion of Angle-Modulated Signals in Misaligned Linear Filters—Janis Galejs (p. 228)

Differences in distortion are calculated for sinusoidally phase modulated signals that are passed through dissimilar single-tuned RLC filters. The differences in distortion of two identical signals are related to filter tolerances. A two-tone phase modulated signal is shown to experience significant distortions relative to a single-tone phase modulated signal, although the difference tone is hardly distorted, if passed alone.

Performance of Combined Amplitude and Phase-Modulated Communication Systems—J. C. Hancock and R. W. Lucky (p. 232)

The performance of two types of digital phase- and amplitude-modulated systems is investigated for the high signal-to-noise ratio region. Approximate expressions for the probability of error and channel capacity of the the more optimum of these two systems are compared with corresponding expressions for probability of error and channel capacity for a digital phase-modulated system. It is shown that the phase- and amplitude-modulated systems show a definite power advantage over the phase-only system when the information content per transmitted symbol must be greater than 3 bits. From a channel capacity standpoint, the phase- and amplitude-modulated systems make more efficient use of the channel for signal-to-noise ratios greater than 11 db. The more optimum of the two phase and amplitude systems has only a 3-db advantage over the less optimum and is considerably more difficult to instrument.

Digital Phase Control Techniques—Philip R. Westlake (p. 237)

An analysis of a *partially digitized* phase-locked loop using Z-transform sampled data theory is presented. Responses are obtained at various junctions of the loop for both a step frequency input and for a sinusoidal frequency input. These responses are compared with the corresponding responses for an analog phase-locked loop. Stability criterion and root locus are determined. Effects of quantization are studied. It is concluded that over most of the range of operation the behavior of the digital phase-locked loop is nearly identical to the corresponding analog phase-locked loop, but that in addition, certain possible advantages may occur as a result of the digitization.

Simplified Baseband Diversity Combiner—R. T. Adams (p. 247)

In conventional FM receivers, the gain of the limiters rises during a fade to maintain constant output. The resulting sharp rise in noise complicates the problem of diversity combining, requiring the combiner to provide a very high degree of suppression of noisy signals. By suitable limiter design, the necessary AM suppression can be obtained without affecting average receiver gain, permitting the use of simple linear addition at baseband for diversity combining. Cross coupling between limiters of a set of receivers maintains constant combined output.

Receivers are simply connected in parallel to provide any degree of diversity. No additional circuits or components are used for the combining function, since operation does not depend on measurement of out-of-band noise. For the same reason, the system is not disabled by loss of pilot tones or by multipath distortion products of interference appearing as excess out-of-space noise. The performance of this combiner compares favorably with other presently used combining methods.

Communication by a Polar-Orbit Satellite Relay—William K. Hagan (p. 250)

Aircraft on transpolar flights do not have highly reliable noise-free communications. By the use of polar-orbiting satellite repeaters, UHF communications can be utilized. Active, wideband repeaters are proposed in the satellite, using equipment similar to existing hardware. A system is discussed for a 5000-mile altitude satellite orbit and a 3500-mile ground distance separation. Complete system parameters are described. The satellite receiver, noise figure, satellite transmitter power output, and satellite solar power generation system are discussed in greater detail. It is concluded that the system is feasible and practical and could be implemented immediately to provide high probability noise-free communications.

A Slope-Feedback Method for Speech Compression—M. P. Beddoes (p. 254)

This paper deals with a slope-feedback method for compressing the bandwidth of speech signals. The maximum amount of compression is estimated from a quantity called the speech detail factor. This is analogous to the familiar picture detail factor. Measurements of the former show that the following compression ratios are possible:

1) a two-fold compression of "telephone" quality speech,
2) almost five-fold compression of band-filtered speech which has a syllable articulation of 60 per cent.

A special feature of the coder is a variable-delay unit and the experimental version is described.

Improved Multiplex Voice Frequency Carrier Systems Using New Audio Filters—B. Tennent (p. 258)

Using resonators built with high "Q" ferrite-cored inductors and suitably selected plastic film capacitors, improved band-pass and band-elimination filters have been designed which allow the accommodation of duplex high-speed telegraphy channels in a mid-band-speech carrier circuit, with small degradation in voice quality and with negligible cross-talk. It is shown that in such a circuit, the removal of a 400-cps frequency band from the voice spectrum, from about 1100 to 1500 cps, offers the best compromise as far as intelligibility of speech is concerned. The basic elements of a complete system are described.

The improved tone channel filters accept, with small distortion and ringing, frequency shifts of ±42.5 cps and allow: 1) the reduction of the usual 170-cps channel spacing to 145 cps, without increase in cross-talk, and 2) the location of 145-cps spaced tones up to 6000 cps in suitable links. For systems with frequency shifts of ±30 cps, similar units with a narrower acceptance band reduce the required channel spacing to only 85 cps.

A Thin-Route Beyond-the-Horizon VHF System in the Middle East—J. D. Hoffman (p. 263)

The application of thin-route technique in an economical integrated small-scale VHF system in the 156-174-Mc band is described. The system provides point-to-point multi-channel voice, teletype and mobile communications between the main office of the Trans-Arabian Pipe Line Company in Beirut, Lebanon, and pumping stations and mobile units along the route of the pipeline through Lebanon, Syria, Jordan and Saudi Arabia. In addition, supervisory control and telemetering of 5000-HP combustion gas turbine pumping installations over portions of the system including a 120-mile long link, is described. The terminals of this link and others, 90 to 105 miles long, are well beyond the horizon. Dual frequency diversity is employed. Several 250-watt transmitters and dual diversity receivers are duplexed on large arrays mounted on 200-foot self-supporting towers. Two remote unattended relay stations are employed. System parameters, over-all propagation reliability, and plans for expansion as well as the economic attractiveness of a thin-route design for use in remote areas, are discussed.

Correction to "Comparison of PSK vs FSK and PSK-AM vs FSK-AM Binary-Coded Transmission Systems"—A. B. Glenn (p. 272)

Contributors (p. 273)

Annual Index (follows p. 273)

Information Theory

Vol. IT-6, No. 3, December, 1960

Information Rate in a Continuous Channel for Regular-Simplex Codes—C. A. Stutt (p. 516)

M equally probable symbols may be encoded as continuous waveforms whose sample values are the coordinates of the vertices of a regular simplex in N dimensions. These vertices or code points, therefore, are equally spaced, and the resulting waveforms are adapted particularly to low signal-to-noise communication systems. An upper bound for the information rate in an additive Gaussian noise channel, based on the use of regular-simplex coded waveforms, has been calculated. The results indicate that for signal-to-noise energy ratios less than approximately unity and for error probabilities ranging from 10^{-2} to 10^{-8}, this rate is a sizable percentage of the ideal rate which has been derived by Shannon and Tuller.

Construction of Relatively Maximal, Systematic Codes of Specified Minimum Distance From Recurring Sequences of Maximal Period—C. N. Campopiano (p. 523)

Relative to a distance function which is both translation-invariant and expressible as the sum of the distances between coordinates, an upper bound is obtained for the size of certain (n, d) systematic codes. This bound is closely related to a result of M. Plotkin. It is shown that certain (n, d), systematic codes obtainable from linear recurring sequences are of maximal size in an appropriate class of systematic (n, d) codes when the distance function is translation-invariant and the sum of the corresponding coordinate distances. The results are specialized to the Hamming distance and to the cyclic distance of C. Y. Lee. Relative to the Hamming distance, the results are valid for an arbitrary Galois field $GF(q)$. For the cyclic distance, however, the results are valid only for prime Galois fields and for $GF(4)$. Moreover, it is shown that for the latter distance, it is impossible to set up a "translation-invariant, coordinate-sum" distance which is also cyclic for any nonprime Galois field except $GF(4)$.

A Partial Ordering for Binary Channels—N. Abramson (p. 529)

The properties of iterated binary channels are investigated. An ordering (defined by the symbol $\supset$) of communication channels with two possible inputs and any number of possible outputs is defined. For any two such channels C_1 and C_2, this ordering has the property that if the $C_1 \supset C_2$, the minimum average loss when using C_1 will be less than the minimum average loss using C_2, *independent of the losses assigned to the various errors, and independent of the statistics of the source*. This ordering is applied to 1) the general binary channel, 2) the iterated binary symmetric channel, and 3) the unreliable binary symmetric channel when used with many iterations. Curves allowing one to to use the ordering are given, and an example using these curves is worked out.

On the Probability Density of the Output of a Low-Pass System When the Input is a Markov Step Process—W. M. Wonham (p. 539)

Forward equations are derived for the $(N+1)$-dimensional Markov process generated when a Markov step signal $\{s(t)\}$ is the input to an N^{th}-order system of the form $dX/dt = U(X; s)$. As examples, the joint probability densities of input and output are found for a symmetric three-level signal smoothed by an RC low-pass filter, and partial results are obtained for a doubly integrated Rice telegraph signal.

Generation of a Sampled Gaussian Time Series Having a Specified Correlation Function—Morris J. Levin (p. 545)

A computationally convenient method is presented for simulating a sequence of sampled values of a stationary Gaussian process having a specified correlation function or power spectrum. Z-transform theory is applied to provide a simple recursive formula for generating the values from a set of independent Gaussian random variables.

A Note on the Local Structure of Shot Noise—Richard A. Silverman (p. 548)

It is shown how to construct shot noise which, like the turbulent velocity field, is quite accurately univariate normal, but exhibits marked departures from bivariate normality at close ranges.

Maximum-Weight Group Codes for the Balanced *M*-ary Channel—Carl W. Helstrom (p. 550)

The construction of (n, k) group alphabets is discussed for the balanced M-ary channel, where M is the power of a prime. In this channel all M digits are equally likely to be in error, and an incorrect digit is equally likely to be any digit besides the one sent. The alphabets are formed by taking n columns of the modular representation table of the Abelian group of k-tuples of elements from the Galois field $GF(M)$ under digitwise addition. The formation and properties of that table are described. Attention is focused on alphabets in which all letters except the n-tuple of 0's have the maximum number of non-null elements. Tables of such alphabets are given for $M=2$, $k=2, 3, 4$; $M=3$, $k=2, 3$; and $M=4$, $k=2, 3$.

Correction to "Quaternary Codes for Pulsed Radar"—George Welti (p. 555)

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The 1960 Conference on Standards and Electronic Measurements—Ivan Easton (p. 70)

Abstracts—(p. 71)

A New Space Age Challenge—Standards and Electronic Measurements—Lloyd B. Wilson (p. 75)

The design and development of advanced military weapon systems have resulted in rapid developments in our technology during the past few years. In turn these developments have resulted in needs for increased accuracies greater ranges and new categories of measurement. These needs were confirmed last year by several calibration surveys one of the most prominent of which was conducted by the Aerospace Industries Association. The papers presented at this Conference described some of the steps being taken to meet these needs.

Calibration Requirements of Aerospace Vehicles—Richard Stolle (p. 81)

This paper offers a presentation of an orderly approach to determining the precision measurement requirements of an aerospace system through research and development. Discussion also covers the steps necessary to maintain the integrity of measurement requirements throughout the production and operational phase, by utilization of proper calibration equipment and methods. The approach proposed is applied in general terms to a hypothetical space research system. The relation of measurement accuracies to the reliability programs and some traceability of calibration factors is also considered.

Effect of Tracking Accuracy Requirements on Design of Minitrack Satellite Tracking System—J. H. Berbert (p. 84)

The Minitrack satellite tracking system is a radiointerferometer angular-tracking system designed to have a tracking accuracy of 0.1 milliradian under optimum conditions. The system and component requirements imposed by this system accuracy will be discussed. The Minitrack system makes extensive use of techniques which minimize the effects of component inaccuracies. However, notwithstanding these techniques, some precision components are necessary; for example, the Minitrack time standard is designed to have an accuracy of 1 part in 10^8 or 1 msec per day. The system provides valuable geophysical data in addition to acquiring and tracking the IGY satellites.

Results based on two and one half years of tracking experiences will be given.

Current Notes on Problems in Standards and Electronic Measurements—DEWLine— W. G. Donaldson (p. 89)

This paper is concerned with problems in standards and electronic measurements, as related to the operation and maintenance of the DEWLine. The complex radar and communications systems are kept operating within specified tolerances by more than 80 different types of test equipment. The development of an integrated calibration system that would insure the accuracy and reliability of this test equipment are discussed. The function and operation of our standards laboratory and its associated mobile calibration team are described. The standards used by our laboratory are certified by the U. S. National Bureau of Standards and the National Research Council of Canada. The problems encountered in developing valid calibration procedures are outlined. Recommendations to test equipment manufacturers are included.

The Nation's Electronic Standards Program: Where Do We Now Stand?—Harvey W. Lance (p. 94)

Recently increased standards activities throughout the nation have resulted in a large increase in the calibration services requested from the National Bureau of Standards and in a number of related problems. Several of these are discussed, including desirable criteria for the staffing and instrumentation of electronic standards laboratories, the choice of interlaboratory standards to be submitted to NBS, and the use of these standards before and after after calibration. An attempt is made to clarify the concept of "traceability of calibrations to NBS," and conditions under which a calibration may be called traceable are discussed. Suggestions are made regarding the use of available calibration services and the action to be taken when needed calibration services are not available. The need for an association of standards laboratories is pointed out, and many areas are noted in which such an association could make valuable contributions.

Propagation of Error in a Chain of Standards—A. G. McNish and J. M. Cameron (p. 101)

There is a widespread belief that in a chain of standards traceable back to a central laboratory, each standard must be calibrated in terms of a standard 10 times as accurate. Conversely, this implies a 10-fold degradation in accuracy in each successive calibration. If this were true, accuracy would be intolerably degraded at the working level. A more realistic view is that accuracy in a chain of standards is as good as its weakest link. This can be demonstrated by experimental data on the errors obtained in calibrations and can be explained by examining the factors which affect accuracy in calibration.

An Analysis of the Accumulated Error in a Hierarchy of Calibrations—Edwin L. Crow (p. 105)

Calibrations of many types are performed in a hierarchy of calibration laboratories fanning out from a national standard. Often the statement is made that the accuracy of each echelon of the hierarchy should be 10 times the accuracy of the immediately following echelon. The validity of such statements is examined by deriving formulas for the total error accumulated over the entire sequence when systematic and random errors may occur in each echelon, and by determining how a given total error may be achieved at minimum total cost under reasonable assumptions for the form of the cost-error functions.

Vendor Calibration Program Coordination and Control—E. F. Peebles (p. 114)

Today we find that a prime defense contract is subdivided between many subcontractors and vendors. These firms must supply components whose interrelating tolerances are ever narrowing. To assure compatibility, it has become necessary for the prime contractor to coordinate the calibration programs of his suppliers. Direct traceability to the national standards is a necessity. Care must be taken to see that the proper ratios of accuracy are maintained between each level of calibration, and that control to assure adequate frequency of calibration is maintained. In addition, it is necessary to review the procedural administration of each supplier's program.

Frequency and Time Standards—A Status Report—F. G. Merrill (p. 117)

A review of the fundamental reference standards for time, their history, distribution and uses. Frequency standard accuracies and stabilities have increased about two orders of magnitude in the past decade. Reproducibility is a few parts in 10^{10}, but accuracies are a magnitude or more below this. Increased ability to transmit time and frequency standards accurately has made it possible for all countries on the globe to have the same standard.

Atomic Beam Frequency Standards—R. C. Mockler, R. E. Beehler, and C. S. Snider (p. 120)

A general qualitative description of atomic beam devices is given, with particular emphasis upon cesium atomic frequency standards.

The various uncertainties in frequency measurements are discussed including the effects of the uniform C field, the effect of a phase difference between the two oscillating fields that excite the atomic transition, and the effect of exciting an atomic transition with signals that are not monochromatic.

The two cesium beam devices constructed at the National Bureau of Standards are described in some detail. The various tests are described for determining the uncertainties in the frequency measurements. The results of these tests are given.

The accuracy of these rather dissimilar machines is considered to be $\pm 1.5 \times 10^{-11}$, and the precision of measurement is 2×10^{-12}. The latter figure represents the standard deviation of the mean for measurement times of a few hours, or, about 100 separate measurements.

A Prototype Rubidium Vapor Frequency Standard—R. J. Carpenter, E. C. Beaty, P. L. Bender, S. Saito, and R. O. Stone (p. 132)

A prototype rubidium vapor frequency standard has been developed for possible use in a satellite measurement of the gravitational frequency shift predicted by the Theory of Relativity. The relative transition frequencies of several optically pumped rubidium vapor absorption cells have been shown to remain stable to one part in 10^{11} or better for a period of one month. A crystal-controlled oscillator is corrected to a subharmonic of the rubidium transition frequency by a fully electronic servo system. The standard is transistorized, small in size, low in weight, and requires less than 10 watts to operate.

Crystal-Controlled Primary Frequency Standards: Latest Advances for Long-Term Stability—T. C. Anderson and F. G. Merrill (p. 136)

The modified Pierce-oscillator circuit employing the new AT-cut contoured crystal unit, thoroughly analyzed and tested under rigorous conditions, has gained widespread use since it was introduced about seven years ago. However, the deceptive simplicity of the circuit hides the numerous problems encountered in designing a suitable production unit. A balanced design to achieve fractional part-per-billion frequency stability, using precise commercial components, takes into account all reactance variations, crystal-current stability, tube and component-aging margins, and rugged environmental conditions. This paper will give the solutions to these problems embodied in 2.5- and 5-Mc military oscillators which provide these high-frequency stabilities.

Miniature Transistorized Crystal-Controlled Precision Oscillators—W. L. Smith (p. 141)

Crystal-controlled transistor oscillator circuits employing precision AT-cut quartz resonators provide frequency stability comparable to vacuum-tube frequency-standard oscillators. These transistor oscillators are considerably reduced in size and in power drain, and possess excellent short-time stability. Oscillators, suitable for fixed-station applications, capable of operating in widely varying ambient conditions, will be described. Other oscillators, designed for very low power drain and capable of withstanding the extreme mechanical environments of satellite and missile-borne applications, will also be discussed. Performance test results will be given for operation during quiet conditions and during vibration, shock, and static acceleration.

The Power Spectrum and Its Importance in Precise Frequency Measurements—J. A. Barnes and R. C. Mockler (p. 149)

The power spectral density functions of a frequency multiplier chain, driven by several different crystal oscillators, were obtained by comparing the output with a second chain which was stabilized with an ammonia maser. The frequency of the maser stabilized chain was demonstrated to be relatively fixed; the power spectrum of the other chain was determined by two different methods. The results are compared. Possible errors and uncertainties introduced by the methods are discussed. An analysis is made that relates the instantaneous frequency fluctuations of a signal with the power spectral density function.

Analysis predicts that when frequency modulation occurs in the first stages of frequency multiplication or in the primary frequency oscillator, the output power spectrum is, in general, not symmetrical. Furthermore, the sidebands are increased in intensity by the multiplication process. This is, in fact, observed to be the case. It is shown that a frequency counter will measure the frequency of the center of gravity of the power spectrum.

If signals having a complex power spectrum are used in precise frequency measurements, errors may result.

Time and Frequency Synchronization of Navy VLF Transmissions—R. R. Stone, Jr., W. Markowitz, and R. G. Hall (p. 155)

Precision instrumentation has been developed by the Naval Research Laboratory for use in the synchronization of time and frequency throughout the U. S. Navy utilizing transmissions from existing VLF naval communication transmitters in the 15- to 25-kc range. Time, as determined by astronomical observations of the U. S. Naval Observatory, is currently being transmitted from radio station NBA in the Canal Zone on a carrier frequency of 18 kc controlled by reference to the atomic resonance of cesium. Note must be taken of the systems of time used. The Naval Observatory determines Universal Time (UT) in various forms, Ephemeris Time (ET), and atomic time (A.1). Absolute frequency is based on ET, which is obtained from observations of the moon. The adopted frequency of cesium for the system A.1, derived from these observations, is 9 192 631 770 cps. Transmissions of time and frequency from NBA, GBR, MSF, WWV, and WWVH have been coordinated. The frequency transmitted is constant during each year, but is offset from A.1 so that the time pulses will be nearly in accord with UT2. The frequency of NBA is maintained constant to about 1 part in 10^{10} with respect to about five cesium resonators located in the U. S. and United Kingdom. Even at great distances from the transmitting station, frequency may be synchronized to the transmitted frequency to within one part in 10^{10}, and time may be set to closer than 1 msec. The techniques employed will be described, and the results of monitoring the transmissions from December, 1959, to date reported.

Determination of Nonlinear Characteristics of Ferroelectric Ceramics—P. N. Wolfe (p. 161)

Analysis of the behavior of devices employing low-dissipation-factor ferroelectric ceramics as nonlinear dielectrics requires a simple method of specifying numerically the relation between electric displacement and field. A technique will be given for reducing experimental data to three parameters, descriptive of the nonlinear material behavior over a large electrical operating range. Preparation of standard samples and experimental precautions to be observed will be discussed.

Measurement of the Wave-Propagation Properties of Plasma in the Microwave Region—F. J. Tischer (p. 167)

A measurement method is described for the determination of plasma data in the test section of a waveguide in a microwave circuit. Electron density, plasma frequency, and collision frequency can be determined by measurement of the phase shift and attenuation introduced in the presence of the plasma. Rigorous equations are derived for the evaluation of the measured values of phase shift and attenuation.

Standards and Measurements of Microwave Surface Impedance, Skin Depth, Conductivity and Q—Howard E. Bussey (p. 171)

The metal walls of a cavity resonator becomes standards of skin depth when the internal Q is determined, if the walls are uniform and if contact loss is eliminated as in the circular TE_{01} mode. An end plate standardized in this way may be replaced by another flat piece of material and its unknown skin depth easily determined. A copper cavity in use has 94 per cent of theoretical Q. Deoxidization of the surface raises the value to 97 per cent. Surface roughness and mode conversion may account for the remaining Q departure. Accuracy of Q measurement (± 3 per cent) will be discussed and preliminary results on several metals will be given.

Resistivity Measurements of Semiconductors at 9000 Mc—G. L. Allerton and J. R. Seifert (p. 175)

A very important measurement in the manufacture of semiconductor material is the volume resistivity of material. Presently, this is measured by sending a direct current through a sample of the material and measuring the voltage drop across two points on the surface of the material. A new approach has been made by conducting this measurement with a high-frequency test signal, and using test samples to load the transmission system. The resistivity of limited areas and depths of material is determined.

A Radio-Frequency Permittimeter—R. C. Powell and A. L. Rasmussen (p. 179)

A coaxial RF impedance transformer in which the secondary is a single turn of the material to be measured is used with two-terminal impedance bridges to determine the complex permittivity or complex conductivity of low-impedance materials. No electrodes are needed, and many conductors, semiconductors, electrolytes and high-permittivity materials can be evaluated to about 1 per cent, since errors due to electrode impedance and interaction as well as first-order series inductance are eliminated. The design, calibration, range, and accuracy are given along with measured values of such materials as ferrites and strong electrolytic solutions, showing complex conductivities differing considerably from those previously observed by other methods.

The Measurement of Microwave Resistivity by Eddy Current Loss in Small Spheres—T. Kohane (p. 184)

A cavity perturbation method for measuring the resistivity at microwave frequencies of small spherical polycrystalline samples will be described. The sample is placed in the cavity at a region of maximum magnetic field and zero electric field. The eddy currents induced in the sample result in losses which may be measured, permitting determination of the sample resistivity. No assumption is made regarding the depth of penetration of fields, the influence of skin effect being taken into account in an exact manner. Measurements have been carried out both above and below room temperatures.

Measurement of Microwave Ferrites at High Signal Levels—J. F. Ollom and W. H. von Aulock (p. 187)

The study of large-signal effects in ferrites is concerned with 1) determination of the critical internal RF magnet field h_c at which the loss characteristics of the ferrite become nonlinear, 2) measurement of the loss characteristic as a function of the biasing dc magnet field at a given RF signal level, 3) observation of deterioration of the transmitted pulse, and 4) measurement of high-power effects as a function of material composition, sample shape and size. This paper discusses waveguide configurations suitable for these measurements. Instrumentation for measurements at peak-power levels up to several hundred kilowatts is described, and experimental results are compared with H. Suhl's theoretical predictions.

A Vibrating Sample Magnetometer—Nolan V. Frederick (p. 194)

A vibrating sample magnetometer has been designed and constructed. The instrument combines the advantages of the techniques employed by Smith and Foner. The instrument employs the pickup coil and sample geometry of Smith's instrument and a vibration and measurement technique similar to that used by Foner. This combination of techniques makes unnecessary any modifications of the magnet employed and yet provides a system which is self-calibrating.

The sample is mounted at the end of a "Vycor" glass rod which is mounted in the plane of the magnet gap. The rod is vibrated in its gravest flexural mode. The vibration frequency and amplitude are controlled by feedback circuitry. The glass rod acts as a stable frequency source. The sample is vibrated parallel to the magnetic field and normal to the plane of the pickup coils which are mounted upon the magnet pole pieces. The voltage induced in the pickup coils is measured by a feedback amplifier-voltmeter which allows accuracy of approximately one per cent.

Rapid Broad-Band Directional Coupler Directivity Measurements—T. Mukaihata, M. F. Bottjer, and H. J. Tondreau (p. 196)

A rapid broad-band technique (over a 40 per cent frequency band) which finds its application in directivity measurements has been developed. The technique is applicable to waveguide or coaxial couplers with directivities from 10 db to more than 60 db. The method minimizes measuring time, is simple in operation, and features precision accuracy. A direct readout presentation of the directivity function will be offered and system analysis presented. Inherent errors and flange effects will be treated. A tabulation of the directivity function and its application to the solution of related vector phasor problems will be included. Advance techniques for automatic plotting of directivity vs frequency will also be discussed.

A Transfer Instrument for the Intercomparison of Microwave Power Meters—G. F. Engen (p. 202)

In the intercomparison of two microwave power standards, or in the calibration of a microwave power meter by means of a second or "standard" power meter, the measurement of microwave impedance has played a major role.

Through an extension of the reflectometer concept, it is now possible to devise a four-arm junction which, when properly adjusted, makes possible the intercomparison or calibration of such power meters with little or no regard for their impedance characteristics. In addition, the method is substantially independent of the impedance discontinuity which may be present at the input flange or connector. This latter result is of particular value in coaxial systems.

Absolute Measurement of Temperatures of Microwave Noise Sources—A. J. Estin, C. L. Trembath, J. S. Wells, and W. C. Daywitt (p. 209)

In recent years, the requirement for noise-figure measurements of low-noise devices has led to a need for more precise knowledge of temperatures of noise sources. A system has been developed which is capable of measuring the absolute noise temperature of a gas discharge tube in WR-90 waveguide to within 0.01 db. The comparison circuit is a modified Dicke radiometer. The standard noise source is a black body radiator at approximately 1000°C. Preliminary measurements of noise temperatures of a set of nine laboratory equivalents of a commonly used argon discharge tube indicate an excess noise temperature of 15.90 db at 200 ma discharge current with a variation between tubes of 0.03 db.

The Waveguide Spark Gap as a Standard for Microwave High Voltages—Robert D. Wengenroth (p. 214)

A means of determining microwave high voltage is provided by a waveguide spark gap. Its application is similar to that of the sphere gap employed at dc and power frequencies. The waveguide spark gap may take the form of hemicylinders, cylinders, hemispheres, spheres, or posts in a rectangular waveguide section. The voltage required for breakdown of the gap is computable, by the techniques of electrostatics, as a fraction of that required for the uniform waveguide. The waveguide spark gap has already proved valuable as a reference standard in pulsed-power tests of microwave components. It is therefore recommended as a standard for microwave high voltages, which are not easily determined by other means.

A Modulated Subcarrier Technique of Measuring Microwave Phase Shifts—G. E. Schafer (p. 217)

This paper describes a technique for comparing phases of two microwave signals which employs amplitude modulation in one channel of a two-channel system. This modulated subcarrier technique produces a null response in a two-channel system for all ratios of the amplitudes of the waves traversing the separate channels. Therefore, high precision is maintained for all ratios of amplitudes. A practical application of this technique using readily available components achieved a precision of phase measurements of a tenth of a degree for a change of attenuation of 50 db of component under test.

Measurement of Reflections and Losses of Waveguide Joints and Connectors Using Microwave Reflectometer Techniques—R. W. Beatty, G. F. Engen, and W. J. Anson (p. 219)

The reflection and loss of a waveguide joint are quantified by its VSWR and efficiency, respectively. These are conveniently and accurately determined by techniques which employ a reflectometer with auxiliary tuners and an adjustable sliding termination. Depending upon the stability and gain of the associated apparatus, measurements of VSWR's of 1.001 and lower, and of efficiencies of 99.99 per cent and higher may be obtained. The attenuations of short lengths of waveguide may be determined at the same time that the efficiency measurement is made.

An Investigation of Long-Term Stability of Zener Voltage References—R. P. Baker and J. Nagy, Jr. (p. 226)

A wide range of environmental conditions could preclude the use of conventional standard cells as references for precise electrical measurements. As a solution to this problem, silicon junction ("Zener") diodes were investigated for use as a voltage reference in a militarized test set capable of operating many months in adverse environments without restandardization. It was found that diodes can be selected with respect to temperature coefficient, noise, and long-term stability, which have sufficient stability to replace unsaturated standard cells. The average standard deviation observed for 11 selected diodes tested for four months is 3.1 PPM.

A Standard Current Transformer and Comparison Method—A Basis for Establishing Ratios of Currents at Audio Frequencies—Bernadine L. Dunfee (p. 231)

Prompted by recent demands of science and technology, the Electricity Division of the National Bureau of Standards has entered a program for the accurate measurement of ratio and phase angle of current transformers at frequencies up to 10 kc. The present paper will deal with the first phase of this work. It will describe a 5/5 ampere-standard transformer having very small corrections, designed to operate up to 100 per cent overload from 60 cps to 10 kc, and a versatile test method capable of measuring ratio and phase angle to better than 5 PPM and 5 microradians. The direction of further steps in the proposed program will be briefly outlined.

Calibration of a Kelvin-Varley Standard Divider—M. Morgan and J. Riley (p. 237)

The linearity deviation of a multiple decade Kelvin-Varley voltage divider can be calibrated by comparing it decade by decade with a ten-step standard divider. The standard divider can be calibrated by precisely measuring its resistors and calculating its linearity. The basis for both of these techniques is derived mathematically. The procedure for measuring each decade, and the method of combining the contributions of all the decades to find the linearity deviation of a given setting will be presented. The expected accuracy of the measurements will be analyzed. Contributions of resistor accuracy, resistor and contact stability, lead resistance, temperature variations, analytical simplifications, and power dissipation will be discussed.

The Precision Measurement of Transformer Ratios—R. D. Cutkosky and J. Q. Shields (p. 243)

A procedure for measuring the voltage ratio between the two secondary windings of a three-winding transformer is described.

The application of this procedure to the calibration of transformers with ten-to-one ratios is discussed in detail. Explicit formulas are developed which correct for the finite lead impedances and load admittances associated with the measuring system, and yield a value for the open-circuit transformer ratio. Detailed calculations are presented for measurements performed on a given transformer with results to be accurate to a few parts in 10^9.

A Ratio Transformer Bridge for Standardization of Inductors and Capacitors—D. L. Hillhouse and H. W. Kline (p. 251)

A ratio transformer bridge for comparing inductors and capacitors with NBS certified standards to well within certified values will be described. Comparison precisions of a few thousandths per cent for 1 mh to 10 henries, a few hundredths per cent for 100 μh, about 0.001 per cent for 0.01 to 10 μf, and better than 0.01 per cent for 10 to 1000 pf are obtained at 1000 cycles. The effective series resistance of inductors within a few tenths per cent are obtained. Factors affecting accuracy will be analyzed and results presented. The effects of stray and lead capacitances, inductances, and resistances will be considered. The integral construction allows two- or three-terminal measurements.

A 0–180 Degree Phase Angle Master Standard for 400 CPS (Abstract only)—J. H. Parke and H. N. Cones (p. 74)

A continuously variable, 0 to 180° phase-shift standard for 400 cps is described in detail. It consists of a π-section line made up of twelve 14.6° and three 4.3 sections to provide for two sizes of coarse steps and an RC circuit at the input to the line to provide for fine steps and a continuous fine control. A method for accurately adjusting the characteristic impedance of all π-sections to the same value, which is used as the termination, was devised. Under these conditions, it will be shown that the phase shift introduced by each π-section can be accurately computed from a measured value of inductance. The phase shift of each π-section was also determined by an experimental procedure dependent upon a 180° phase shift introduced by a toroidal transformer. The values obtained by these two independent methods agree to within 0.01. (Presented at the 1960 Conference on Standards and Electronic Measurements as paper 5–6. This paper is published in the *NBS J. of Res.*, vol. 64C, July–September, 1960.)

Admittance Standardization and Measurement in Relation to Coaxial Systems—D. Woods (p. 258)

To bring about an over-all improvement in the accuracy of measurement of electrical quantities at radio frequency, it is first necessary to devise means for more accurate immittance measurement. Reference is made to a precision dual-admittance bridge and associated standards which were designed for this purpose for the HF and VHF bands. A description will be given of a universal coaxial connector system compatible with the increased accuracy, and suitable for all frequencies at which coaxial systems are normally used. Good matching techniques will be discussed in relation to the design and utilization of extremely wide band measuring instruments.

A Precision RF Attenuation Calibration System—C. M. Allred and C. C. Cook (p. 268)

A new precision attenuation calibrating system with greatly increased sensitivity, stability, and measurement range has been completed at the National Bureau of Standards, Boulder Laboratories. The increased stability and sensitivity are achieved by the use of a highly accurate piston attenuator and precision phase shifter combined into a null system. The extended attenuation measurement range has been obtained by using a new mode launching system which is excited by essentially a constant current source of very high magnitude. The padding necessary for correct impedance matching is kept at a minimum by use of a special noninteractive combining network.

Techniques and Errors in High Frequency Voltage Calibration—E. Uiga and W. F. White (p. 274)

A group of high-frequency voltage standards has been developed by the National Bureau of Standards to serve as transfer devices between NBS standards and working instruments. The series consists of AT voltmeters, thermal voltage converters, and micropotentiometers.

This paper discusses the techniques and errors involved in applying these devices to typical problems such as the calibration of electronic voltmeters. Possible sources of errors included are human error, loading effects, voltage drop in connecting leads, stray field pickup, effect of ground currents of signal and power frequencies, transmission-line effects, response and waveform errors.

A Precision RF Power Transfer Standard—P. A. Hudson (p. 280)

A fast-reading, precision RF power transfer standard is described which is usable at fixed frequencies in the range 10 Mc to 1000 Mc. The dynamic range is 1 watt to 1000 watts with a resolution of 0.1 per cent to 0.01 per cent. Stability is 0.1 per cent per year. The standard consists of three directional couplers to cover the frequency range and a series of vacuum thermoelement detectors matched to 50 ohms at each frequency interest. The thermoelements are connected to the secondary line of the appropriate coupler and provide a dc output voltage which is calibrated in terms of RF power in the coupler main line.

A series of small, portable wattmeters employing vacuum thermoelements are also described.

A Subtle Error in RF Power Measurements—S. J. Raff and G. U. Sorger (p. 284)

In the measurement of RF power by dc or AF substitution, using balanced-bridge methods, there is generally a systematic error because of the very small variation of the bolometer resistance over the AF cycle. For a barretter in a typical bridge circuit using a 10-kc audio frequency, this error is shown to be of the order of 5 per cent. For thermistors, the error is generally smaller, but because of the complex thermal behavior of the thermistor, the error is not accurately calculable. The nature and origin of this error will be discussed and data presented from which its magnitude and direction can be calculated as a function of the bridge circuit parameter, the AF and the bolometer time constant, whenever the latter is unique.

Temperature-Compensated Microwatt Power-Meter—Edward E. Aslan (p. 291)

A new microwave microwatt power meter is described which permits full scale measurements from 0.01 mw to 3 mw in six ranges over a frequency range from 0.01 kMc to 40 kMc. The power meter functions on the principle of substitution of audio power for radio frequency power. It utilizes a special thermistor mount containing two identical thermistor elements; one element is positioned inside the radio frequency field and one element outside the radio frequency field, but they are in close proximity to each other. The temperature compensation reduces the effect of temperature change to 1 per cent of what it would be without compensation. The instrument is accurate to ± 1.3 per cent at full scale on each range exclusive to the thermistor mount. The calibration factor of a typical X-band mount is 0.98 ± 1 per cent. Absolute power measurements can be made to a minimum accuracy of ± 2.3 per cent when using a calibrated mount. Once calibrated, the power meter may be switched from range to range without requiring recalibration.

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Medical Electronics

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Proceedings of Conference on Diagnostic Data Processing:

Recapitulation of Conference—Murray Eden (p. 232)

Welcome—Introduction to the Conference—V. K. Zworykin (p. 239)

The Mechanical Conservation of Experience, Especially in Medicine—F. A. Nash (p. 240)

Books are no longer adequate means for storing clinical data in a form which can make retrieval sufficiently flexible. It is suggested that a Grouped Symbol Associator is the equipment of choice for relating an individual case to generalized accounts of many similar illnesses. It is further suggested that mechanical aids will provide the physician with precise knowledge in a systematic way and permit him to devote his time to a study of the individual peculiarities of a case.

Correlation of Data with a Digital Computer in the Differential Diagnosis of Hematological Diseases—Martin Lipkin (p. 243)

With the aid of a digital computer, comparison was made of hospital case data and data characteristic of hematologic disease. The differential diagnoses of the hospital cases were tabulated in written form. Conclusions were also stated regarding whether enough hospital case data were present to establish a diagnosis, or whether additional data were needed.

An Analog Approach to Computer Diagnosis—Leo J. Brannick (p. 247)

The problem of diagnostic computation has been approached by defining each disease in terms of its symptoms and their relative significance in the characterization of that particular disease. These "definitions" were then converted into analogous resistive networks and were used as standards against which a group of symptoms representing an unknown disease could be compared. The specialized computer constructed for this purpose compares the unknown with each of the standards stored in the machine, and if there is a match it indicates with which standard or disease there is a match and to what extent a correlation exists between them. The machine compares the unknown with all of the standards even if a match is found early in the process so that if two or more possibilities exist they will all be indicated.

Computers and Clinical Psychiatry—Peter G. S. Beckett (p. 248)

Psychiatrists collect a vast amount of clinical information in lengthy interviews with patients. It is proposed that this information can be reliably recorded on a series of scales in a form suitable for high-speed data processing. A method of recording currently in use in a Michigan hospital is presented and its advantages and disadvantages discussed.

Diagnostic Aspects of Computer Applications in Medical Research at the University of Pennsylvania—Maxine L. Rockoff (p. 250)

The diagnostic implications of medical research utilizing a digital computer are discussed according to the type of mathematical analysis and/or computer technique employed. Illustrative examples include the solution of differential equations in anesthesiology, the use of Fourier analysis in ballistocardiology, and the use of multiple regression analysis in neoplastic chemotherapy.

Major Problems in the Use of Computing Machines—Richard Taylor (p. 253)

1) Medical histories recorded by machine. How will these records be used by medical people and medical institutions? The answer to this is important because at the moment no one has told us of a real bona fide use for these records, and consequently, having them in machine form is of no clear-cut advantage. 2) Machine-aided diagnoses. We feel that the computing machine can be of real service in this area, but it is not at all clear exactly how the medical profession can take advantage of the capabilities of the machinery. The real problem here is to use the computer to aid the doctor, not to replace him. 3) Laboratory data. Laboratory data can be fed into computers perhaps more easily than can any other data. However, it is probably going to be important to use laboratory analyzing equipment which can make records in machine-readable form if full advantage is to be taken of the computing machine. 4) The handling of graphical and pictorial information such as "EKG, EEG, and X-ray pictures." EKG's and EEG's can probably be made to yield to mathematical analysis, but the question of machine-digested X rays is still open. 5) Communication between doctor and computer. The question of how a doctor can introduce data into the computer without having to resort to the usual transscription of handwritten data to punch-card form is one that I feel we must settle if there is to be any progress at all in this area.

Computer Programming of Diagnostic Tests—Lee B. Lusted (p. 255)

A great many medical diagnostic tests have been developed to supplement the patient information obtained from history and physical examination. These tests vary greatly in amount of discomfort to the patient, complexity, and cost. It is obvious that diagnostic tests should be kept to a minimum. Logical consideration to help determine the minimum additional medical tests needed in a specific case will be discussed.

Use of a Digital Computer in the Analysis of Intestinal Motility Records—John T. Farrar (p. 259)

Methods do not exist for the rapid, quantitative analysis of complex phasic patterns such as are seen on records of intraluminal gastrointestinal pressure or other parameters of motility. In an attempt to develop a more satisfactory method, these wave forms have been converted into digital form and then analyzed by the Whirlwind I digital computer at M.I.T. Generation of the autocorrelation function and the power density spectrum of these records has permitted a numerical quantitative expression of certain information contained in these curves.

Computers and Psychophysiology in Medical Diagnosis—Albert F. Ax (p. 263)

Apparatus has been designed to sample, digitize, and magnetically record for computer input up to 29 physiological variables as recorded on the intact human. Specialized procedures have been worked out for computing independently on continuous variables the four aspects of correlation—lag, coincidence, amplitude, and slope.

Storage and Retrieval of the Results of Clinical Research—Murray Eden (p. 265)

The problem of retrieval of information from the large volume of clinical literature has received increasing attention in the last few years. The methods of structural linguistics are being applied to this problem and may ultimately provide for machine indexing and abstracting and for the flexible retrieval of data pertinent to specific clinical problems.

The Use of Computers in Physiologic Diagnosis—Donald L. Fry (p. 269)

The major activity of this laboratory is to establish mathematical models that approximately describe the various parts of the cardiovascular and pulmonary systems. With this knowledge descriptive equations can be derived that are suitable for solution by computer techniques. These solutions are of potential diagnostic value. Two examples will be cited in which 1) blood velocity is computed from a measured pressure gradient and 2) the physical properties of certain intrathoracic pulmonary structures may be deduced from air flow measurement.

Diagnosis of Arterial Disease with Analog Computers—Ralph W. Stacy (p. 269)

Using an analog computer to simulate the behavior of the arterial system, it is possible to compute a peripheral pulse wave which closely approximates the peripheral pulse wave recorded from a patient, when the central pulse wave recorded from that patient is used as a forcing function. A second-order differential equation is used, describing primarily the vibratory behavior of the system. When behavior duplication is verified, the equation parameters may be analyzed to provide data on arterial elasticity and blood viscosity and mass.

There is every reason to believe that this approach, utilizing analog simulation of a physiological system, is applicable to many such systems. Thus, heretofore unavailable data on the condition of such systems may be made available for diagnostic use.

Digital Electronic Methods for Infrared Spectroanalysis—R. H. Taplin (p. 273)

With the advent of modern, high-speed electronic digital techniques, new tools and new approaches to the problem of spectral analysis become possible. These can be used to develop methods for extracting this hitherto unused information from analytical systems. The resulting procedures which become available by the digital manipulation of spectral information provide a powerful extension of the analyst's ability and enhance judgment and intuitive knowledge built up by past analytical experience.

Using Electronic Computers in Medical Diagnosis—Robert S. Ledley (p. 274)

It is becoming increasingly recognized that electronic computers can aid certain aspects of medical diagnosis. But to use the computer for such purposes, the mathematical foundation of the medical diagnostic processes must first be well understood. Three mathematical disciplines are inherently involved in the diagnostic processes: logic, probability, and value theory.

IBM Type 704 Medical Diagnosis Program—Taffee Tanimoto (p. 280)

The basic input to the type 704 computer is simply the presence or absence of those characteristics (symptoms or results of a laboratory test) of a set of medical cases which are considered to be pertinent by an expert in that particular field. Pairwise and over-all similarity of both the cases and the symptoms are defined so that geometrically the cases, considered as points in a suitable space, form several clumps, thus establishing a natural classification. The mathematical model is based on the assumption of equal-likeliness of the characteristics or symptoms so that in order that the final results be significant, a sufficiently large number of characteristics are initially assumed and the system is reduced by repetitively deleting the least significant characteristic, thus inducing weighting of the characteristics, since more emphasis is placed on those characteristics which comprehend one another. When the set of characteristics is fixed, the computer is able to determine the case or cases which in an over-all sense best represent the characteristics. By interpreting pairwise similarity as probabilities, it is possible to predict how likely it is for a case with given symptoms (or tests) to exist on the basis of the classification the computer produces.

Digital Computers and Medical Logic—R. Ebald and R. Lane (p. 283)

This paper discusses the logical structure of a computer program designed to analyze and determine significant relationships between sets of symptoms drawn from actual case histories and a "classical" set in a group of hematological diseases.

Diagnosis, Therapeutics, Prognosis, and Computers—François Paycha (p. 288)

Doctor-Machine Symbiosis—Jordan J. Baruch (p. 290)

In machine-aided diagnosis, the problem of dividing the diagnostician's task sensibly between the doctor and the machine will be a major part of any successful solution. In this division, a major problem to be faced will be facilitation of communication between the doctor and his mechanical aide. To study methods of communication to match "communication rates," and to establish those parts of the diagnostic problem for which the doctor and machine are individually most suited, are probably the most important part of machine-aided diagnosis. On the solution of these problems rests not only the best realization of the potentials of the team, but, even more important, a full acceptance by the medical profession of the diagnostic machine as a welcome assistant.

Diagnostic Video Data Processing—Lee B. Lusted (p. 293)

Computers have been built which can handle spatial problems. A particularly interesting application of the spatially oriented computer is to "read" chest X-ray photofluorograms and to separate the obviously abnormal chest films from the normal chest films. Preliminary studies of such a computer will be described.

Electronic Data Processing of National Vital Statistics—Halbert L. Dunn (p. 295)

At the present time, national vital statistics are tabulated on electric accounting machines. During the past two years, the National Office of Vital Statistics has been engaged in a study of the feasibility of electronic data processing equipment. In terms of possible applications of electronic data processing systems within the National Office of Vital Statistics, the NOVS program falls into two areas:

1) The annual cycle of the collection, processing, analysis, and dissemination of

vital statistics (births, deaths, fetal deaths, marriages, divorces, and notifiable diseases.)

2) The conduct and processing of special statistical studies in the field of health and demography.

The experiences of other large statistical agencies have shown that EDPM can contribute greatly to the speed of data processing and to the efficient handling of complex tabulations and computations. It may well be the same in the case of national vital statistics processing. In any case, the examination of present procedures required in a feasibility study will contribute greatly to the over-all efficiency of the organization.

Digitation of Clinical and Research Data in Serial Evaluation of Disease Processes—W. A. Spencer and C. Vallbona (p. 296)

There is an urgent need to quantify if possible the complex phenomena emerging out of the changeable nature and variability of disease processes and resulting from the interactions of man, disease agents, and his environment. Comprehensive care and individualization of treatment is formulated by the physician logically or empirically or intuitively. Methods that can increase the variety, frequency and depth of our observations should assist us. Information flow between the patient and the physician has been scrutinized to develop extensive application of EDP for clinical use and research in chronic disease. A variety of digitation formats is being investigated and used. The assumptions of this experiment and the problems and advantages of present experience with EDP will be considered. Practical technical problems that have been identified will be discussed.

Some Reflections on Medical Diagnosis by Electronic Data Processing Machines—George R. Meneely (p. 309)

The Vanderbilt University School of Medicine study of the feasibility of electronic data processing in medical diagnosis emphasizes a coordinated engineering and medical scientific effort. All needed technical modalities exist. Decisions have to be made about obtaining and encoding input patient information, size of memory, nature of access, the organization of data stored in it, the arithmetic of comparison, the format of a useful output. Diagnosis of health is a worthwhile long-term objective. Government services, large industries, and major medical centers are primary sites. Administrative, personnel and financing problems are difficult but not insurmountable.

Possible Application of EDP in Daily Practice—William A. Kelly (p. 314)

Once certain standards are agreed upon, we may obtain and record maximum information from patients with minimum expenditure of a doctor's time and eliminate entirely certain human factors peculiar to both doctor and patient which sometimes lead to delay or confusion in diagnosis. This information will be permanently recorded and readily available at all times and in all places to subsequent physicians. The record can be kept continuously up to date. Classification and analysis of the material obtained by electronic data processing (EDP) will suggest diagnoses, further tests, and possible lines of treatment. The collection of material from millions of cases will present opportunities for EDP to study association of diseases, constitutional factors in disease, environmental factors, etc. (*cf.* german measles, cancer of lung) and will afford opportunities for unbiased study of methods of treatment.

This seems to promise an "industrial revolution" in the practice of medicine.

Some Comments on the Usefulness of Electronic Data Processing in Medical Practice—Thomas P. Almy (p. 315)

Many of the time-consuming activities performed by a practicing physician can be performed expeditiously by electronic data processing. Permanent records on patients could be made available in a very short time to any hospital in the country. However, the meeting of patient and physician must be regarded as a therapeutic phenomenon from the start. The importance of the thinking, reasoning, and listening process on the part of the physician cannot be diminished without affecting the over-all therapeutic value of the physician to the patient.

Resolution (p. 316)

Roster of Conference Attendees (p. 317)

Contributions:

Primate Bio-Instrumentation for Two Jupiter Ballistic Flights—W. C. Hixson, C. T. Paludan, and S. W. Downs, Jr. (p. 318)

A description is given of the bio-instrumentation phase of two related Army Jupiter ballistic missile flights involving squirrel monkey passengers, one of which was recovered alive and in good physical condition. These flights marked the initial entry into space, and successful return, of a primate under ballistic flight conditions comparable to those to be encountered by man.

The paper describes the relationship of the instrumentation program to the biocapsule design in terms of the telemetered measurements. An outline is presented of the signal conditioning circuitry and associated transducers used for the in-flight telemetry recording of the primate's electrocardiogram, respiration rate, chest sounds, and axilla body temperature. Instrumentation related to the recording of the ambient temperature and pressure of the biocapsule, flash temperatures, and cosmic ray particle tracks is also described.

An Electronic Device for the Measurement of Sweat Rates—O. Z. Roy (p. 326)

A new method for the continous measurement and recording of sweat rate has been developed. The sweat rate is determined by continuously measuring the change in resistance of a sensing element which, in turn, reflects the change in moisture content of a small volume of air. In operation, a chamber containing the element is fastened against the skin. Dry air is passed through the chamber at a sufficient rate to maintain an arbitrarily predetermined level of humidity within the chamber. A variation in sweat rate produces a change in the moisture content of the air and, consequently, a change in the resistance of the element. This change is nullified by means of a servo system which adjusts the flow of dry air so as to restore the original level of moisture. Thus, the air flow across the element at any time is a measure of the sweat rate.

Microliter Oxygen Detection in Medical Research—Victor W. Bolie (p. 330)

Many problems in medical research concerning the transmembrane diffusion, transport, and metabolism of oxygen require its detection with microliter accuracy. The paper describes the construction and operating characteristics of an electronic polarograph sensing system with a membrane-covered gold electrode having a sensing error of less than 0.5 microliter of oxygen at atmospheric pressure.

FM Receiving System for Endoradiosonde Techniques—B. Jacobson and B. Lindberg (p. 334)

The receiver detects FM signals with frequency deviations up to 30 kc in the 300–400-kc band. The drift is less than ± 20 cps per day. The receiver operates satisfactorily with field strength variations of 1:30,000. To prevent erroneous recordings when the signal strength varies abruptly with changes in the mutual direction of the transmitting and receiving antennas, a nondirectional receiving antenna circuit has been developed. Also, an output clamp circuit prevents the recorded values from changing during occasionally low field strength periods.

Micromanipulator Techniques—T. C. Helvey (p. 340)

Similarities between micromanipulation in molectronics and in biology are demonstrated. The author describes different types of micromanipulators, including that of his own design, and lists also a few typical applications of micromanipulation in biology, from his own experience. The intention of the paper is to stimulate interest in the design of tools needed in the development of microminiature and molecular electronic modules and subsystems.

Panel Discussion: Human Factors in Circuitry Design—Edited by T. C. Helvey (p. 345)

Zero Frequency Response from AC Transducers—C. C. Collins and R. S. Mackay (p. 349)

Piezoelectric and certain other transducers are not suitable as displacement monitors for very-low-frequency phenomena because the sustained signal resulting from a steady input dies away. The gradual disappearance of the generated voltage essentially partially differentiates a signal. Good low-frequency response down to zero frequency is reconstituted by mixing with a signal some of its own integral. The detailed conditions and circuits are given. A relevant theorem on the possible perfection of diodes in integrators is demonstrated. Drift limits response to a few minutes, and static pressure or displacement measurements are presently limited to this period. Experiments on simultaneously cancelling several cascaded time constants, *e.g.*, pneumatic and electric, are cited.

Biophysics Teaching Programs Available in the United States and Canada—N. A. Coulter, Jr., and R. W. Stacy (p. 351)

A survey of biophysics teaching programs shows that at least 68 institutions in the United States and Canada now offer such programs, and more will be started in the near future. A classification of types of program is given, together with pertinent statistics. Despite a wide diversity of interests and administrative organization, a remarkable degree of agreement on the requirements of biophysics as a discipline is disclosed.

A Computer Solution for Determination of Thermal Tissue Damage Integrals from Experimental Data—Alice M. Stoll (p. 355)

In the course of a study on the relationship between tissue damage and pain sensation due to thermal stimulation, a computer method was developed for the analysis of the experimental data. Considerable interest in the details of this method has been expressed by various investigators who encountered similar data analysis problems. This report is written, therefore, to state the problem and its solution as an indication of some of the possibilities computer methods offer the biological investigator having little or no previous experience in the use of computers. The rationale, physiological observations, and results of the study itself have been reported elsewhere so that only those facts necessary to an understanding of the computer solution are noted here.

Data Processing Considerations in the Handling of Medical Data—Edgar C. Smith, Jr., (p. 359)

This paper examines the growing interest in data processing of medical data, exploring problems of machine design, problem formulation, and analysis. In addition, it discusses data-processing systems in relation to four basic medical-data-handling problem areas and their relation and interaction with equipment design, and reports that these problem areas are: clinical patient data, basic research, diagnosis, and medical-document retrieval. It also reports that any failure of the computer, at the present time, to provide required information is due to inability to feed it precise instructions on what it should do, and that results of further study will be reflected in improved equipment design. Finally, it concludes that the greatest problem is that of education—the necessity for engineers to understand medical problems better in order to design better equipment, and the necessity for the physician to know about the techniques and equipment of data processing.

Analyzing Medical Data—Some Statistical Considerations—John E. Walsh (p. 362)

Noting that the heterogeneous and complicated nature of medical data places severe restrictions on its analysis, a discussion of the feasibility of establishing standard procedures for this analysis follows.

It is pointed out that computational difficulties can be overcome by the use of a high-speed, large-memory computer; principles of mathematical statistics and their application to investigation of medical data are outlined, and the extent of medical data needed to furnish various levels of clinical information is discussed.

Correction to "The Use of Television and Scanning Techniques for Ultraviolet Irradiation Studies of Living Cells"—P. O'B. Montgomery, L. L. Hundley, and W. A. Bonner (p. 366)

Abstracts of Current Bio-Medical Electronics Research Projects (p. 367)

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Nuclear Science

Vol. NS-8, No. 1, January, 1961

Foreword—R. F. Shea

Introduction to Semiconductor Particle Detectors—W. L. Brown (p. 2)

This paper considers the physical processes which govern the operation of semiconductor particle detectors. It contains a discussion of: the production of hole-electron pairs by energetic particles in solids; the motion of the pairs under the influence of an electric field and in the presence of trapping and recombination; the current wave shape resulting from transport of these carriers; the production of high electric fields to facilitate transport in single conductivity and junction devices; and the influence of high densities of holes and electrons along particle tracks on the transport processes.

Experience at Harwell with Surface-Barrier Detectors—G. Dearnaley (p. 11)

A simple and reliable technique for the construction of surface barrier detectors in silicon and germanium will be described. Results will be presented on their characteristics, sensitive depth, working life, and damage by radiation. Various structures of detector have been investigated, and their applications to nuclear physics will be discussed.

Performance of Silicon Surface Barrier Detectors with Charge Sensitive Amplifiers—J. L. Blankenship and C. J. Borkowski (p. 17)

Silicon surface barrier diode detectors of 1 cm² and 25 mm² sensitive area have given pulse height spectral resolutions of 17 kev and 13½ kev (FWHM) respectively, for 5.5 mev alpha particles. Reverse currents at 500 volts bias were less than 1×10^{-6} amps/cm² with breakdown in excess of 1000 volts. A charge sensitive amplifier contributes 3½ and 10 kev noise (FWHM) with an input capacitive loading of 20 and 180 pf respectively.

High Resolution Study of Nuclear Reactions by p-n Junction Detectors—G. Amsel, P. Baruch, and O. Smulkowski (p. 21)

The specific problems which arise from the use of p-n junctions for the detection of particles emitted in nuclear reactions are studied.

The mechanism which allows the distinction between particles of different nature emitted in nuclear reactions like (d, p), (d, α), (d, d) is explained. Behind the barrier there is a "diffusion zone" which furnishes a slow component to the pulse. Pulse shape selection technics permit elimination of pulses due to long range particles. The diffusion zone is then used as an anticoincidence detector. Manufacturing of detectors in low resistivity material is necessary for the detection of short range particles.

Inverse current rapidly increases with the ionic bombardment induced by the beam on the target. A simple electrostatic deflection system can protect the junction.

The energy of the emitted particles rapidly varies with the angle of observation. This leads to the use of slit shaped detectors for maximum resolution. On the other hand several detectors can be connected in parallel to the input of the same amplifier: well resolved peaks are obtained if the difference in angle between the detectors is sufficient.

Typical spectra obtained in course of the study of the reactions O^{16} (d, d) O^{16}, O^{16}(d, α) N^{14}, O^{18}(d, α)N^{16}, O^{18}(p, α)N^{15} are presented. α ray groups 70 kev apart have been separated.

Improvements in Encapsulated Silicon Junction Alpha Detectors—R. W. Jackson, P. P. Webb, and R. L. Williams (p. 29)

Encapsulated silicon junction alpha detectors made with material of resistivity 1000 ohm-cm and with front layer depth of 2 microns have been available for some time now in window areas of 5, 20, and 200 square mm. Recent measurements on the best of these units have given resolutions of 0.6 per cent, 0.9 per cent and 4 per cent for 5.5 Mev alpha particles.

For wider application, similar units have been made with front layer depth of 0.2 micron and using material of resistivity up to 30,000 ohm-cm. Excitation of carriers by radiation of optical wavelengths shows that the effective dead layer is less than 0.03 micron. The necessity of making a solder contact and seal to the extremely thin front layer raises problems in the achievement of high stability, low leakage, and low noise at high voltages. Thus the depletion layer depths obtainable in encapsulated units with high resistivity material do not yet approach those obtainable in unencapsulated units in vacuum. A representative measurement obtained recently gave a resolution of 0.6 per cent with a window area of 5 square mm. (junction area 20 square mm.) and depletion layer depth 180 microns.

Transistor Form of Nuclear Particle Detector—R. L. Williams and P. P. Webb (p. 35)

A transistor form a nuclear particle detector has been fabricated using 20,000 ohm-cm p-type silicon. With such high-resistivity silicon and a wafer 10 mils thick, a bias voltage of 30 to 40 volts extends the depletion layer almost completely through the wafer, leaving a thin p region so that the whole wafer becomes a transistor. A particle entering the device through the collector depletion layer produces ionization in this layer which is quickly swept out. The charge separation is such that the emitter is forward biased and a transistor pulse current flows subsequent to the collector diode current.

The current time characteristics of the device will be shown and the gain of the device will be considered both for light radiation and particle pulse signals. From a detailed consideration of the gain-bias characteristics the lifetime in the base of the transistor can be calculated. This will be compared to the response time of the unit.

The detector surface has been shown to have sensitivity variations by comparing the gain of the device obtained with a small light beam at several points on the surface. Variations in sensitivity are indicated by the shape of the resolution curves.

Signal-to-noise ratios obtained are comparable to those realized with good amplifiers and similar area diodes. This, combined with noise and gain data, indicates that the device is amplifying the signal and the collector junction noise current by the same factor. Typical gain figures are 200 to 300.

The transistor impedance has been shown to be resistive having a value near 10 kilohms.

Operation at CO_2 and liquid air temperature does not appear to give any gain in signal-to-noise ratio.

The performance of the transistor device will be discussed in terms of possible improvement and present limitations.

NIP Silicon Junctions Detectors—Lydie Koch, Jean Messier, and Jean Valin (p. 43)

NIP silicon junctions have been studied as particle detectors. They consist of a 1.000 Ω.cm silicon plate on each side of which respectively a P and N layer have been diffused in order to have a NIP structure. The incident particles, 9 to 40 Mev alpha, are parallel with the junctions planes, and strike the detector in the I region. An energy resolution of 2 per cent and a good linearity of pulse height vs particle energy up to 40 Mev have been obtained. In addition, gamma rays have been detected with NIP junctions, and pulse height distribution of Co^{60}, Cs^{137} and Hg^{203} have been studied. The average amount of energy expended by a photoelectric electron in creating one electron-hole pair in silicon has been measured and is found to be:

$E=3{,}53\pm0{,}07$ eV for 279 keV electrons,

$E=3{,}55\pm0{,}1$ eV for 660 keV electrons.

Semiconductor Electron Detectors—J. M. McKenzie and G. T. Evans (p. 50)

The properties of p-n junctions made by phosphorus diffusion in 12,000Ω cm p-type silicon have been examined using the Chalk River $\pi\sqrt{2}\beta$-ray spectrometer as a source of monoenergetic electrons. With 200-volt reverse bias the depletion layer is thick enough to absorb totally 350 Kev electrons. Up to 1200 Kev some of the electrons are scattered sufficiently to deposit all their energy in the junction. This results in a total absorption peak up to electron energies of 1.2 Mev. However, at this energy most of the electrons act like minimum ionizing particles and deposit 180 Kev of energy in the junction.

Energy Spectra of Correlated Fragment Pairs from the Spontaneous Fission of CF^{252}—W. T. Joyner, H. W. Schmitt, J. H. Neiler, and R. J. Silva (p. 54)

Silicon surface barrier counters have been used in conjunction with specially-designed low noise amplifiers to measure the energies of correlated fragment pairs from the spontaneous fission of Cf^{252}. The silicon counters, ¼ inch × ¼ inch in size and prepared from 3600-ohm-cm material, exhibit rise times for fission pulses of a few nanoseconds; the pulse height resolution obtained for natural alpha particles is 0.5 per cent. The energy response of the present counters to fission fragments appears to be slightly nonlinear. Pulses from coincident fragment pairs are analyzed and recorded in a 100×100 channel coordinate recorder. Approximately 3×10^{5} events have been recorded on punched paper tape and sorted on the ORACLE. Preliminary results including the deduced relative mass yields are shown, as well as pulse-height and energy spectra.

The Application of Silicon Detectors to Alpha Particle Spectroscopy—A. Chetham-Strode, J. R. Tarrant, and R. J. Silva (p. 59)

The sensitivity for detection of low abundance groups in an alpha spectrum was found to be limited primarily by a low-energy tail in the pulse height distribution. The effects of scattering and source preparation on the magnitude of this tail were experimentally investigated. A theoretical lower limit of sensitivity for low abundance groups was calculated from consideration of scattering process in the crystal.

Background contamination in new detectors and the increase in background due to the collection of recoil nuclei was studied. Methods for minimizing the increase in background are suggested.

A chamber, designed from a consideration of the above results, was constructed and used for the detection and measurement of low abundance groups in the alpha spectra of U^{234} and the actinium decay series.

A Gold-Silicon Surface-Barrier Proton Range Telescope—R. Takaki, M. Perkins, and A. Tuzzolino (p. 64)

Of interest in cosmic-ray studies is the proton energy spectrum. The recent development of the Au-Si semiconductor particle detector affords a convenient means for studying the proton spectrum for low energies. The small size, stability, energy resolution, and relative insensitivity to β and λ radiation of these diodes suggest their usefulness as proton detectors on space vehicles. Gold-silicon detectors are presently being made at the Laboratories for Applied Sciences of The University of Chicago using the fabrication technique developed at the Oak Ridge National Laboratory. An apparatus is described which employs two detectors forming a proton range telescope. This has been made possible by fabricating silicon wafers as thin as 0.004 inch. This apparatus provides information concerning the proton flux lying in the energy intervals from $\approx$0.5 to 5 Mev and 5 to 10 Mev, without the use of pulse-height analysis. This principle can be extended to additional energy intervals.

Application of Solid-State Detectors to High Energy Physics—G. L. Miller, B. M. Foreman, and Luke C. L. Yuan (p. 73)

All charged particles exhibit a minimum in their—dE/dX vs E behavior. This minimum occurs at relativistic velocities, *i.e.*, high energies, and corresponds to an energy loss of approximately 1.7 Mev gm^{-1} cm^2 for all particles. The application of solid state detectors at high energies depends on obtaining good signals from these minimum ionizing events.

Detectors for this application should be large in area, have reasonably thick depletion layers, and a low series resistance to insure fast rise time. Low noise is not a prime requirement however, since the Landau effect in any case limits the resolution to a low value.

Using an analyzing magnet and counter telescope at the Brookhaven Cosmotron, diffused silicon junctions of up to 1.5 cm diameter have been investigated using minimum ionizing particles. The signal-to-noise ratio obtained is $\sim$10 1 and the resolution $\sim$30 per cent.

Semiconductor Particle Counters at Low Temperatures—F. J. Walter, J. W. T. Dabbs, and L. D. Roberts (p. 79)

Studies of the behavior of semiconductor surface-barrier counters have been made in the temperature range 0.2°K 300°K. A simple model which appears to describe the observed behavior is presented. Mountings suitable for low temperature applications are described.

Nuclear Method of Measurement of Diffusion Length in P-N Junctions—Lydie Koch and J. Messier (p. 83)

A *p-n* germanium junction has been irradiated with 4, 8 Mev, 6 Mev, 8,7 Mev alpha particles and 5 Mev, 10 Mev and 11 Mev protons; the incident particles penetrate into the crystal perpendicularly to the junction plane. The depletion region is 0, 7 micron wide and is located at a distance of 5, 3 μ from the crystal surface.

The variation of the charge collection efficiency vs incident particle range in the material gives an accurate means of calculating the diffusion length of the minority carriers in the base material.

The Use of Surface-Barrier Diodes for Fast-Neuron Spectroscopy—T. A. Love and R. B. Murray (p. 91)

A neutron-sensitive semiconductor counter has been constructed by depositing a thin layer of Li^{6}F between two silicon surface-barrier counters. Neutrons are detected by observing the $\alpha+T$ pair resulting from the Li^6(n, α)T reaction; pulses from the two counters are added and the sum pulse is amplified and recorded on a multichannel analyzer. Since the sandwich geometry permits simultaneous detection of both reaction products, the magnitude of the sum pulse is proportional to the energy of the incoming neutron. A coincidence circuit was used to reduce background counts. Pulse-height spectra from slow neutrons and from monoenergetic fast neutrons, in the energy region 0.6 to 15 Mev, have been recorded from several counters of this type using sensitive areas of about 0.7 to 0.8 cm^2, with a Li^{6}F layer of order 150 μ gm/cm^2 thick. In all cases a well defined neutron peak was observed in the pulse-height spectra. The full width at half maximum of the fast-neutron peak was about 300 kev approximately independent of neutron energy. [Counters of this type seem relatively insensitive to gamma-ray background but at the higher energies (8 Mev and up) background from (n, charged particle) reactions in materials other than the Li^6 is quite high.]

Fast Neutron Damage to Silicon Junction Particle Detectors—R. V. Babcock (p. 98)

Two silicon junction charged-particle detectors were irradiated with fast neutrons distributed in energy from $\frac{1}{2}$ to 6 Mev.

Reverse current and pulse height spectra of U-234 α particles were observed at several bias voltages as functions of neutron dosage. The reverse current of both detectors increased roughly five fold during exposure to 1.2×10^{13} fast neutrons per cm^2. From the α pulse heights the capacitance (at some fixed bias) of one detector was found to increase roughly 25 per cent per 10^{12} nvt. Approximately 50 per cent of this change was restored by 1000 hours of annealing at room temperature.

In the other detector, the α pulse height decreased at a similar rate, but the data was obscured by the development of unusually large pulse rise times.

dE/dx and E Semiconductor Detector Systems for 25-Mev He^3 and Alpha Particles—H. E. Wegner (p. 103)

Thin semiconductor detectors have been constructed in which the space-charge region completely fills the volume of the detector. These detectors can be used to measure low-energy alpha particles in the usual way and can also be used for high-energy particles to measure dE/dx, the fractional energy lost in traversing a given amount of matter. A combination detector which measures both dE/dx and the total energy, E, of a particle is described, and performance with 21- and 25-Mev He^3 and alpha particles is shown. This combination allows various mass particles produced in a high-energy reaction to be completely separated. The manner of construction for these thin (0.002 inch) counters is described, and the advantages in terms of required size, signal-to-noise ratio, and rise time are discussed. Energy resolution characteristics for NaI scintillation detectors and semiconductor detectors are compared for high-energy He^3 and alpha particles.

The Effect of a High Radiation Environment on Gold-Silicon Charged Particle Detectors—R. W. Klingensmith (p. 112)

A study was conducted to determine the effect of a high radiation environment on the response of gold-silicon surface-barrier detectors to plutonium-239 alpha particles. The controlling damage was due to fast neutrons although the detectors were exposed to a mixed gamma-neutron field. After an exposure of 1000 rads the low energy side of the response peak showed a definite but broad secondary peak. With increasing dose the original peak broadened but retained its pulse height and the secondary peak dropped in pulse height and became very broad. The total number of counts remained constant being shared between the tween the two peaks. After 5000 rads exposure the original single peak response was no longer evident. Thermal annealing at 180 C for several hours yielded only slight recovery.

Temperature Behavior of *P-N* Junction Detectors—R. J. Grainger, J. W. Mayer, and J. W. Oliver (p. 116)

For practical considerations improved resolution together with higher operating limits can be realized for shallow-diffused junction detectors operated in the temperature range from approximately 0°C to -70°C. Detectors used above 50°C will usually show large amounts of deterioration of resolution. Detector noise generally governs the resolution that may be achieved. It appears that noise may arise from both surface and bulk currents, but the degree of contribution by each has yet to be determined.

Homogeneous Solid State Ionization Detector—J. D. van Putten and J. C. Vander Velde (p. 124)

A gold-doped silicon crystal was used to measure the most probable energy loss and energy-loss distribution of π^- mesons at 1.50 Bev/c and 2.55 Bev/c. The crystal used was 2 cm in diameter and .25 cm thick. The preparation of the detector is discussed. The results confirm the existence of a density effect in the relations describing the dependence of the most probable energy loss on particle momentum. The energy-loss distribution appears to be broader than the predicted width.

Considerations in the Design of Pulse Amplifiers for Use with Solid State Radiation Detectors—Edward Fairstein (p. 129)

The definition of amplifier noise in terms of equivalent charge or equivalent electrons and the technique for its measurement in these terms is discussed in detail.

Some of the theory which relates to the design of low noise, highly stable pulse amplifiers is reviewed. Tubes and other circuit elements suitable for use in low noise amplifiers are discussed.

The effect of the pulse shaping networks on the s/n ratio (shot noise and grid-current noise components) is described and data are given for the relative merits of single and double RC and delay line clippers in association with 1 to 5 RC integrators. It is shown, for example, that the noise performance of the double delay line clipper is noticeably inferior to that of the single RC clipper, although it is very much better with regard to permissible counting rate.

Low Noise Transistor Amplifiers for Solid State Detectors—T. L. Emmer (p. 140)

Amplifiers for Use with *P-N* Junction Radiation Detectors—R. L. Chase, W. A. Higinbotham and G. L. Miller (p. 147)

The signal on radiation pulse detectors is in the form of a charge on a capacitor. An ionizing particle produces a charge pair for each 3.6 ev dissipated in silicon. The capacitance of a *p-n* junction is proportional to the area and inversely proportional to the square root of the bias potential. Three similar preamplifier circuits are described. Negative charge feedback is employed so that the output amplitude is essentially independent of the value of the detector capacitance. The amplifiers have a high open loop gain, a fast response ,and show little tendency to oscillate. Best over-all performance, a noise line width of 5 kv, is achieved using WE417A or equivalent tubes in cascode at the input. RCA 7586 tubes give a line width of 8–10 kv with low capacitance detectors. The line width with transistors is 20–30 kv.

Pulse Rise Time for Charged Particles in *P-N* Junctions—H. M. Mann, J. W. Haslett, and G. P. Lietz (p. 151)

The rise time of pulses from charged particles entering *p-n* junctions is of importance in the use of these devices for fast counting. For this application coincidence resolving times of the order of 10 nsec are presently useful. Measurements of rise time for alpha particles at energy 6 Mev have been made using a system with limiting rise time 7.5 nsec. Surface barrier and diffused junction detectors show a dependence of rise time t upon reverse bias V of the form to α 1/V^x where $0.4\leq X\leq0.9$. The rise time was determined by the lifetime of minority carriers for some detectors, and for others, by the base resistivity. The results show no limitation in application of these detectors to 10 nsec coincidence resolving time, since the depletion layer can be extended to reduce the effective RC time constant of the detector below 10 nsec.

Transient Response of *P-N* Junction Detectors—C. T. Raymo and J. W. Mayer (p. 157)

Conference on Semiconductor Nuclear Particle Detectors (p. 162)

Reliability and Quality Control

Vol. RQC-9, No. 3, December, 1960

Military System Reliability: Department of Defense Contributions—J. Spiegel and E. M. Bennett (p. 1)

This report describes the Defense Department's increasing concern regarding electronic equipment reliability during the period 1942–1959. It discusses the establishment of the joint Army-Navy Vacuum Tube Development Committee (VTDC) in June, 1943, and VTDC's successor, the Panel on Electron Tubes (PET) in October, 1946. Also described is the formation of the Ad Hoc Group on Reliability of Electronic Equipment in December, 1950, the Advisory Group on Reliability of Electronic Equipment (AGREE) in August, 1952, the Advisory Group on Electron Tubes (AGET) in March, 1954, the Advisory Group on Electron Parts (AGEP) in June, 1954, and the Ad Hoc Committee for Guided Missile Reliability (ACGMR) in March, 1957. The interrelation of the tasks and findings of these organizations are discussed.

Breaking Even on Failure Rate Reduction—J. B. Heyne (p. 9)

Optimal Diagnostic Procedures—B. B. Winter (p. 13)

In recent papers, optimal diagnostic procedures are presented for some special cases. In this paper, we present an optimal diagnostic procedure under a different restriction, *i.e.*, we consider equipment in which elements can only be tested one at a time, or all at once. Optimality is in the sense of minimum expected cost.

New Autopsy Techniques for Transistors and Relays—C. B. Clark and E. F. Duffeck (p. 20)

A new method for opening hermetically-sealed metal cases is described. Instead of mechanically sawing or cutting the metal, an electrochemical process is used. Two methods are described, static electrolysis (anodic dissolution) and jet electrolysis. Examples of the application of these methods to the "autopsy" of failed transistors with 6-mil Kovar shells and relays with 15-mil brass shells is shown.

On Prediction of System Behavior—Joan R. Rosenblatt (p. 23)

An Application of the Information Theory Approach to Failure Diagnosis—E. J. Kletsky (p. 29)

Brulé, Johnson, and Kletsky have developed a technique based on information theory which leads to highly efficient procedures for diagnosing equipment failures. This paper demonstrates by means of a practical example the validity of this technique. In addition, the feasibility of the approach is shown and the procedure to be used in its implementation is outlined in detail. The paper concludes with a general discussion including comments on the generality of the technique, the possibility of machine computation, and possible areas of application.

Back Issues of Reliability Proceedings Now Available (p. 40)

Vehicular Communications

Vol. VC-9, No. 3, December, 1960

Linear Cancellation Technique for Suppressing Impulse Noise—Elie J. Baghdady (p. 1)

Theory and Performance of Vehicular Center-Fed Whip Antenna—Helmut Brueckmann (p. 10)

The design considerations and results of extensive performance tests of a novel antenna for vehicular communication in the frequency range 30 to 76 mc are given together with applicable theory. The principal features of the antenna include feeding a whip antenna at its center through a coaxial cable, terminating it at its base into a variable reactor with different settings for each one of ten bands, providing separate built-in fixed-tuned matching networks for each band and switching them by means of automatic remote control which is activated by the frequency dial of the radio set. The design of the base reactor comprising a transmission line wound on a ferrite core having a tapped coil connected in parallel with it, and of the transmission line inside the whip are discussed in detail. Measured current distributions, radiation patterns, impedance plots and other performance data are presented.

A Broadband 160-Mc Colinear Array—R. F. H. Yang and L. H. Hansen (p. 21)

The design of a 3-element colinear array is described. Over the 152–162 MC band, the array has a minimum gain of 4 db over a half-wavelength dipole and VSWR less than 1.5. The circularity of its horizontal pattern is $\pm\frac{1}{4}$ db. The array elements are covered and supported by a Fiberglas tube. DC grounds are provided for these radiating elements for lightning protection and reduction in static noise.

Effects of Tower and Guys on Performance of Side-Mounted Vertical Antennas—R. F. H. Yang and F. R. Willis (p. 24)

The omni-directional pattern of a vertical antenna when side-mounted on a mast or tower, is distorted as a function of tower diameter and separation in wavelength. The pattern is further affected by obstruction of metallic tower guys. Laboratory and field measurements of these effects are analyzed. Possibility of taking advantage of these effects for special coverage is suggested. Tower effect on antenna impedance is briefly discussed.

System Performance, Compatibility, and Standards—R. T. Buesing and N. H. Shepherd (p. 32)

There are two prime purposes of Industry Standards for 2-Way Land Mobile Radio Equipment. They are: 1) To assure high standards of customer performance and 2) to assure system compatibility. Examples are g ven of standards written for both purposes. For example, the logic behind receiver sensitivity and selectivity standards are discussed. Similarly, the importance of standards which assure compatibility between Tone-Coded Squelch Systems, standards for frequency stability, and standards for interference protection between systems are discussed.

A Personal Two-Way VHF Radio Communication System Featuring Modular Construction—T. H. Yaffe (p. 44)

This paper describes a VHF "personal" communications receiver assembled entirely from individual circuit modules, which are constructed with standard, commercially available, subminiature components. Defective modules can be rapidly replaced, and later repaired or modified. Other receiver features include 1 microvolt sensitivity, double conversion, a crystal filter selectivity package at the high I. F. frequency, and a novel squelch gating circuit.

The companion transmitter, more conventional in construction, also is subminiaturized. It features a 1 watt power output, a transistorized modulator, and a DC-DC converter type of power supply with rechargeable nickel cadmium batteries. The shirt pocket size receiver and the transmitter occupy a combined volume of less than 85 cubic inches and together weigh less than $4\frac{1}{2}$ pounds.

Personal Radio Paging in the VHF Band—John F. Mitchell (p. 48)

This paper is a discussion of a complete VHF Radio Paging System designed to operate in the 25 to 50 mc band and 144 to 175 mc bands. The system includes small light weight receivers which are worn by the users. The receivers can be selectively called up to many thousands on the same RF channel. When the receiver is called, the user hears an alerting tone. He then presses the listen button and the voice message is received. The base station is a standard land mobile FM transmitter. This transmitter is tone modulated by the encoding equipment to send the page alerting call. It is then voice modulated to send the message. The base encoding equipment may take several forms from the simplest which can call 90 different receivers to the most complex which can call up to 7500 receivers. The base station RF equipment may take many forms and may also service two-way radios on the same channel.

Police and Fire Department Communications Centers—A Systems Approach to the Control Console and Related Facilities—George A. Brookes (p. 58)

Police departments and similar organizations which require communication with mobile units are confronted with similar problems. The equipment provision for a typical installation is discussed with particular emphasis on the facilities which are provided in the communications console.

A description is given of the modular units such as amplifiers, control units, display units and signal actuated recorder which have been developed for this application.

System Concepts for Address Communication Systems—Donald H. Hamsher (p. 72)

Pushbutton Dial Mobile Radiotelephone—An Advanced Concept in Common Carrier Mobile Service—J. Russell Stewart (p. 77)

A real need has developed for common-carrier mobile radiotelephone service which can be connected directly into dial telephone exchanges. Many exchanges are now unattended and the mobile subscriber must be able to dial his calls and receive calls in the same manner as with his office or home dial telephone.

The transmission of the dialing information from a moving vehicle into the exchange, with the accuracy required to meet telephone standards, has presented an interesting challenge in view of various radio propagation characteristics often experienced, particularly from weak signal or fringe areas.

The pushbutton type of dialing described in this paper provides a digital signalling system employing tones of sufficient duration to ride over the numerous signal drop-outs sometimes lasting more than 100 milliseconds. Extensive field experience has proven this approach to be highly reliable and consistent in dialing from a mobile unit. A unique application of counter tubes and transistor switching circuits is employed in the conversion of the tones into dial pulses at the base station terminal. The use of pushbuttons has been found to be very convenient for mobile service.

A number of the various features incorporated in mobile dial systems are described in this paper.

Guarded Tone Signalling—William B. Smith, Jr. (p. 87)

A method of audio frequency tone signalling which utilizes the maximum number of combinations of a given number of tone channels is described. The principal feature of this method is the use of all tones present as a positive space. Several typical applications of this method to selective calling are described. These include selective party-line telephone ringing, and aircraft selective call.

15 Kc Splits—A Source of Channels in the 150 Mc Band—J. A. McCormick (p. 94)

Abstracts and References

Compiled by the Radio Research Organization of the Department of Scientific and Industrial Research, London, England, and Published by Arrangement with that Department and the *Electronic Technology* (incorporating *Wireless Engineer* and *Electronic and Radio Engineer*) London, England

NOTE: The Institute of Radio Engineers does not have available copies of the publications mentioned in these pages, nor does it have reprints of the articles abstracted. Correspondence regarding these articles and requests for their procurement should be addressed to the individual publications, not to the IRE

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The number in heavy type at the upper left of each Abstract is its Universal Decimal Classification number. The number in heavy type at the top right is the serial number of the Abstract. DC numbers marked with a dagger (†) must be regarded as provisional.

UDC NUMBERS

Certain changes and extensions in UDC numbers, as published in PE Notes up to and including PE 666, will be introduced in this and subsequent issues. The main changes are:

Artificial satellites:	551.507.362.2	(PE 657)
Semiconductor devices:	621.382	(PE 657)
Velocity-control tubes, klystrons, etc.:	621.385.6	(PE 634)
Quality of received signal, propagation conditions, etc.:	621.391.8	(PE 651)
Color television:	621.397.132	(PE 650)

The "Extensions and Corrections to the UDC," Ser. 3, No. 6, August, 1959, contains details of PE Notes 598–658. This and other UDC publications, including individual PE Notes, are obtainable from The International Federation for Documentation, Willem Witsenplein 6, The Hague, Netherlands, or from The British Standards Institution, 2 Park Street, London, W.1, England.

ACOUSTICS AND AUDIO FREQUENCIES

534.21-14 **381**
Sound Source near a Velocity Discontinuity—P. Gottlieb. (*J. Acoust. Soc. Am.*, vol. 32, pp. 1117–1122; September, 1960.) The far-field solution for a line and a point source near a tangential velocity discontinuity has been calculated by summing the plane waves that make up the source.

A list of organizations which have available English translations of Russian journals in the electronics and allied fields appears at the end of the Abstracts and References section.

The Index to the Abstracts and References published in the PROC. IRE from February, 1959, through January, 1960, is published by the PROC. IRE, June, 1960, Part II. It is also published by *Electronic Technology* (incorporating *Wireless Engineer* and *Electronic and Radio Engineer*) and included in the April, 1960, issue of that Journal. Included with the Index is a selected list of journals scanned for abstracting with publishers' addresses.

534.23-14 **382**
Underwater Explosions as Acoustic Sources—D. E. Weston. (*Proc. Phys. Soc.*, vol. 76, pp. 233–249; August 1, 1960.) The special nature of the underwater explosion as an acoustic source is considered, and some absolute charge source levels and measured differences between the acoustic source levels of charges of various size are given in tabular form.

534.26+[538.566:535.42 **383**
Diffraction of a Pulse by a Resistive Half-Plane—Papadopoulos. (*See* 503.)

534.26 **384**
Acoustic Forces and Torques on a System of Strips—K. Saermark. (*Appl. Sci. Res.*, vol. B8, No. 1, pp. 13–28; 1959.) In continuation of earlier theoretical work on the scattering of EM waves by strips, the acoustic forces are calculated for the diffraction of a plane acoustic wave at a system of two rigid coplanar strips. *See* 510.

534.286-8 **385**
Ultrasonic Absorption and Velocity in Molten Salts—R. W. Higgs and T. A. Litovitz. (*J. Acoust. Soc. Am.*, vol. 32, pp. 1108–1115; September, 1960.) Measurements made on a series of molten nitrate salts indicate a structural viscosity similar to that found in water and associated organic liquids.

534.614-8-14 **386**
Measurement of the Speed of Sound across Thin Sheets of Plastic Material. Use for the Interferential Determination of the Speed of Sound in Liquids—G. Laville and J. Maillet. (*C.R. Acad. Sci., Paris*, vol. 250, pp. 1206–1207; February 15, 1960.)

534.75 **387**
Theory of Signal Detectability as an Interpretive Tool for Psychophysical Data—W. P. Tanner, Jr. (*J. Acoust. Soc. Am.*, vol. 32, pp. 1140–1147; September, 1960.)

534.76 **388**
An Energy Theory of Directional Hearing and its Applications in Stereophony—H. Mertens. (*EBU Rev.*, No. 59A, pp. 22–33; February, 1960.) A general formula for the transfer function of any two-channel system of stereophony is derived and applied to two practical systems.

534.76:061.3 **389**
Conference on Problems of Stereophony, held at the Institut für Rundfunktechnik in Hamburg, 8th and 9th April 1959—(*Rundfunktech. Mitt.*, vol. 3, pp. 151–173; August, 1959.) The abridged text is given of papers dealing with stereophonic and pseudostereophonic systems, stereophonic recording and reproduction methods, and related broadcasting problems.

534.76:621.396.97 **390**
Perspectives for "Room-Related" Broadcast Transmission—L. Keibs. (*Tech. Mitt. BRF, Berlin*, vol. 4, pp. 2–20; March, 1960.) The subjective and objective parameters which affect auditory perspective are discussed with particular reference to the simulation of concert hall or studio listening conditions at the receiver. Stereophonic broadcasting and recording techniques are reviewed. 85 references.

534.793 **391**
The Usual and Necessary Dynamic Characteristics of Objective Loudness Meters—H. Niese. (*Hochfrequenztech. u. Elektroakust.*, vol. 69, pp. 17–29; February, 1960.)

534.833.4:621.372.51 **392**
Determining Component Variation for Gradual Transition between Dissimilar Impedances—Becker, Bruer, and Turner. (*See* 454.)

534.84 **393**
A New Large Anechoic Chamber for Sound Waves—W. Kraak, G. Jahn, and W. Fasold. (*Hochfrequenztech. u. Elektroakust.*, vol. 69, pp. 1–7; February, 1960.) The dimensions of the chamber are 23 m×11 m×8m high; special precautions to exclude external noise have been taken, and the reflection factor does not exceed 10 per cent in the frequency range 300 cps to 12 kc.

621.395.625.3:538.221 **394**
The Anhysteretic Remanence of Magnetic Recording Types—Wohlfarth. (*See* 655).

ANTENNAS AND TRANSMISSION LINES

621.315.212:537.312.62 **395**
Nanosecond Response and Attenuation Characteristics of a Superconductive Coaxial Line—N. S. Nahman and G. M. Gooch. (PROC. IRE, vol. 48, pp. 1852–1856; November, 1960.) A description is given of a miniature superconducting line which transmits nanosecond pulses without measurable change in rise time. Data on temperature dependence over a wide range are also given.

621.372.2 **396**
A Variational Integral for Propagation Constant of Lossy Transmission Lines—R. E. Collin. (IRE TRANS. ON MICROWAVE THEORY

AND TECHNIQUES, vol. MTT-8, pp. 339–342; May, 1960. Abstract, PROC. IRE, vol. 48, p. 1515; August, 1960.)

621.372.2:621.3.018.756 397
Analysis of Certain Transmission-Line Networks in the Time Domain—W. J. Getsinger. (IRE TRANS. ON MICROWAVE THEORY AND TECHNIQUES, vol. MTT-8, pp. 301–309; May, 1960. Abstract, PROC. IRE, vol. 48, p. 1515; August, 1960.)

621.372.2:621.372.5 398
Reactance Circuits consisting of Electromagnetically Coupled Lines in Decimetre-Wave Applications—O. Gold. (*Nachrichtentech. Z.*, vol. 13, pp. 15–23; January, 1960.) The circuit equations of coupled transmission-line systems and their equivalent circuits are derived, and parameters are tabulated. The design of coupled strip- and coaxial-line filters and directional couplers is described.

621.372.2:621.372.51 399
A Printed-Circuit Balun for Use with Spiral Antennas—R. Bawer and J. J. Wolfe. (IRE TRANS. ON MICROWAVE THEORY AND TECHNIQUES, vol. MTT-8, pp. 319–325; May, 1960. Abstract, PROC. IRE, vol. 48 p. 1515; August, 1960.)

621.372.8:534.29 400
Microphony in Waveguide—I. Goldstein and S. Soorsoorian. (IRE TRANS. ON MICROWAVE THEORY AND TECHNIQUES, vol. MTT-8, pp. 372–375; May, 1960. Abstract, PROC. IRE, vol. 48, p. 1516; August, 1960.)

621.372.8.002.2 401
Electroformed Copper Waveguides—L. E. Hall and B. H. Meggs. (*Metal Ind., Lond.*, vol. 97, pp. 435–438; November 25, 1960.) The process of electroforming and its advantages are outlined.

621.372.821 402
Radiation from Discontinuities in Strip-Line—L. Lewin. (*Proc. IEE*, vol. 107, pt. C, pp. 163–170; September, 1960.) The calculations for strip lines of small spacing include the effects due to open and short circuits, coaxial terminations, posts, and corners.

621.372.821 403
Discontinuities in the Centre Conductor of Symmetric Strip Transmission Line—H. M. Altschuler and A. A. Oliner. (IRE TRANS. ON MICROWAVE THEORY AND TECHNIQUES, vol. MTT-8, pp. 328–339; May, 1960. Abstract, PROC. IRE, vol. 48, p. 1515; August, 1960.)

621.372.821:621.372.832.8 404
A Y-Junction Strip-Line Circulator—U. Milano, J. H. Saunders, and L. Davis, Jr. (IRE TRANS. ON MICROWAVE THEORY AND TECHNIQUES, vol. MTT-8, pp. 346–351; May, 1960. Abstract, PROC. IRE, vol. 48, p. 1516; August, 1960.)

621.372.823:621.372.831 405
A Method for the Evaluation of Equivalent-Circuit Parameters of an Asymmetric Waveguide Junction—J. K. Sinha. (*Proc. IEE*, vol. 107, pt. C, pp. 324–329; September, 1960.) Parameters derived by considering only the first few evanescent modes agree very well with those obtained experimentally using a cavity system partially filled with coaxial dielectric rod.

621.372.826:537.226 406
Power Flow and Negative Wave Impedance in the Dielectric-Rod Waveguide—E. F. F. Gillespie. (*Proc. IEE*, vol. 107, pt. C, pp. 198–201; September, 1960.) A general theory of power flow is derived for a hybrid mode.

621.372.831.11 407
Nonreflecting Waveguide Tapers—H. E. M. Barlow. (*Proc. IEE*, vol. 107, pt. B, pp. 515–521; November, 1960.) An exact match is theoretically possible if a change in position of the wall of a waveguide is accompanied by an appropriate change of surface impedance. The idea is developed in detail for a linear taper.

621.372.832.4 408
Some Observations on Waveguide Coupling through Medium-Sized Slots—L. Lewin. (*Proc. IEE*, vol. 107, pt. C, pp. 171–178; September, 1960.) A quasistatic method is used, taking radiation damping into account. Details are given for axially-coupled waveguides, and for waveguides coupled through crossed slots in the broad face.

621.372.832.4 409
Two Capacitive Windows in a Rectangular Waveguide—H. Bosma. (*Appl. Sci. Res.*, vol. B7, no. 2, pp. 131–144; 1958.) An investigation is made of the behavior of two apertures located a small distance apart in relation to wavelength, and with their edges parallel to the long side of the waveguide. Expressions for the reflection and transmission coefficients are given and absolute values of the transmission coefficient are obtained both theoretically and experimentally.

621.372.832.4 410
Transmission in a Rectangular Waveguide with an Arbitrary Number of Capacitive Screens—F. A. W. van den Burg. (*Appl. Sci. Res.* vol. B7, no. 3, pp. 153–183; 1958.) Conditions for a full transmission of EM waves in a loaded waveguide are derived as a natural extension of Bosma's investigations (*see* 409). Some applications of the filter properties of the system are discussed, and theoretical results are compared with measurements.

621.372.852.323 411
The Physical Mode of Operation and the Theory of Ferrite Resonance Isolators—R. Steinhart. (*Nachrichtentech. Z.*, vol. 13, pp. 119–128; March, 1960.) The principle of ferrimagnetic resonance absorption is interpreted with the aid of a model. Maxwell's equations are used in calculating directional attenuation and phase shift of isolators.

621.372.852.5 412
A New H_{10}-to-H_{20} Mode Transducer—C. C. Eaglesfield, Y. Klinger, and L. Solymar. (*Proc. IEE*, vol. 107, pt. B, pp. 512–514; November, 1960.) The H_{01} mode of a circular waveguide can be excited from the H_{10} mode of a rectangular waveguide, via a transducer for the H_{20} rectangular-waveguide mode. Construction of the latter is described, based on a general method given by Barlow (*ibid.*, 1959, vol. 106, Suppl. 13, pp. 1–8).

621.396.67 413
Communal Aerials—K. E. Müller and G. Martin. (*Nachrichtentech Z.*, vol. 10, pp. 14–21; January, 1960.) Continuation of 2227 of 1960 (Düniss and Müller) with details of measurements of reflection coefficient and voltage distribution on antenna installations.

621.396.67:621.317.3 414
Practical Aerial Measurements—F. C. Judd. *Wireless World*, vol. 66, pp. 580–584; December, 1960.) A scale model for plotting vertical and horizontal aerial radiation patterns is described. Circuit diagrams of a suitable 3-Gc oscillator and receiver are given, with the radiation patterns obtained for various types of antennas.

621.396.67:621.391.81.029.63 415
The Height Gain of Receiving Aerials for Band IV with Horizontal Polarization—P. Thiessen. *Rundfunktech. Mitt.*, vol. 3, pp. 196–202; August, 1959.) The relation between the height-gain function and the type of terrain is established on the basis of measurements. The results obtained enable field-strength values measured at any height between 3 and 10 m to be converted to the standard height of 10 m.

621.396.67.095.1:530.17 416
On Determining the Polarization Orientation Angle of a Linearly Polarized Source by Analogue Techniques—R. E. Franks and R. L. Bell. PROC. IRE, vol. 48, pp. 1919–1920; November, 1960.) Three 120° spaced probes in a conical horn antenna are used to indicate polarization angle of a source on the rotor of a torque generator.

621.396.674.3 417
Transients in Cylindrical Antennae—H. J. Schmitt. (*Proc. IEE*, vol. 107, pt. C, pp. 292–298; September, 1960.) An analysis is given of the transient response of the radiation field for step-function excitation, with experimental confirmation.

621.396.676:621.3.015.5 418
Voltage Breakdown of Antennas at High Altitude—W. E. Scharfman and T. Morita. (PROC. IRE, vol. 48, pp. 1881–1887; November, 1960.) A consideration of the mechanism responsible for breakdown is followed by the presentation of experimental data illustrating breakdown power as a function of altitude for different antennas under both CW and pulse conditions. Methods of increasing power-handling capacity are also discussed.

621.396.677:621.372.825 419
The Resonance Excitation of a Corregated-Cylinder Antenna—J. R. Wait and A. M. Conda. (*Proc. IEE*, vol. 107, pt. C, pp. 362–366; September, 1960.) Radiation from an axial magnetic line or slot source on the surface of a corrugated cylinder is considered. The analysis is extended to an elliptic cylinder with a special azimuthal variation of surface reactance, which can be adapted to study a corrugated panel on a flat metallic ground plane excited by a parallel slot source.

621.396.677:621.372.826 420
The Surface-Wave Aerial—W. Hersch. (*Proc. IEE*, vol. 107, pt. C, pp. 202–212; September, 1960.) Surface-waveguide theory is extended to include higher-order hybrid modes and applied to the design of a high-gain end-fire antenna small compared with the wavelength.

621.396.677.43 421
Rhombic Aerials with Optimum Operating Characteristics—P. Miram and E. Palm. (*Nachrichtentech. Z.*, vol. 13, pp. 82–91; February, 1960.) Improved design formulas are derived, and antenna parameters are given as a function of input impedance in tabular and graphical form. The design of a wide-band rhombic with changing angle of taper (exponential rhombic) is discussed.

621.396.677.5 422
Extension of the Range of Validity of a Calibration Method for Frame Aerials—E. Zühlke. (*Nachrichtentech. Z.*, vol. 10, pp. 21–23; January, 1960.) Swinyard's equation is modified by a correction factor to make it applicable for any ratio l/λ where l is the distance between transmitter and receiver antennas.

621.396.677.71 423
An Experimental Study of the Slot Aerial and the Three-Element Collinear Array of Slot Aerials—R. King and G. H. Owyang. (*Proc. IEE*, vol. 107, pt. C, pp. 216–227; September, 1960.) The circuit properties of slot antennas centre-fed by two-slot transmission lines are

investigated; the results are compared with the theoretically derived complementary quantities for a cylindrical dipole antenna.

621.396.677.83 424

The Backfire Antenna—E. Weissberg. (Proc. IRE, vol. 48, pp. 1911–1912; November, 1960.) A new explanation is advanced for the increased directivity of backfire Yagi antennas.

621.396.677.833 425

A New Design Method for Phase-Corrected Reflectors at Microwave Frequencies—S. Cornbleet. (*Proc. IEE*, vol. 107, pt. C, pp. 179–189; September, 1960.) The aberrations are reduced by coating the reflector surface with a dielectric, which may be an array of metal plates or waveguides. Experimental results are given for 9.3 Gc.

621.396.677.833.2 426

Paraboloidal Reflectors with Axial Excitation—A. R. Donaldson, I. P. French, and D. Midgley. (*Proc. IEE*, vol. 107, pt. B, pp. 547–552; November, 1960.) An analysis, applicable to deep paraboloids, is given for a dipole placed at the focus along the axis of rotation. The field null along the axis is not important when two similar systems are coupled at close range.

621.396.677.833.2 427

Wide-Band Paraboloidal Aerials with Helices as Radiators for Decimetre Waves—R. Herz. (*Nachrichtentech. Z.*, vol. 13, pp. 109–114; March, 1960.) Investigations were made on 2-m and 3-m paraboloidal reflectors illuminated by helix radiators with a special matching arrangement. Gain and radiation patterns are given for circular polarization at frequencies in the range 610–960 Mc.

621.396.677.833.2 428

Monitoring Paraboloidal Reflector Antennas—G. Swarup and K. S. Yang. (Proc. IRE, vol. 48, pp. 1918–1919; November, 1960.) A method is described for monitoring surface distortions.

621.396.677.75 429

Phase Change on Transmission of Microwaves through Metal Disc Delay Dielectrics—C. Dhanalakshmi and S. K. Chatterjee. (*Z. Phys.*, vol. 158, pp. 196–203; February 18, 1960. In English.) The theoretical phase change is derived for microwave transmission through an artificial dielectric composed of metal disks arranged in a three-dimensional array. Experimental values obtained on arrays with disk spacings of 1.91 and 2.22 cm are given for comparison.

621.396.677.85 430

The Electromagnetic Theory of the Spherical Luneberg Lens—C. T. Tai. (*Appl. Sci. Res.*, vol. B7, no. 2, pp. 113–130; 1958.) A solution is obtained for the spherical or three-dimensional Luneberg lens.

621.396.677.85:621.396.933.2 431

The Design of Cylindrical Metal-Plate Microwave Lenses fed by Nonresonant Slotted Waveguide Arrays—J. W. Crompton. (*Proc. IEE*, vol. 107, pt. C, pp. 330–333; September, 1960.) "The use of a suitably modified refractive index enables cylindrical lenses with squinting linear feeds to be designed by the usual 2-dimensional methods applicable to lenses with nonsquinting feeds. An example is given of the design of a typical lens fed by a nonresonant slotted waveguide having a 20° squint angle."

AUTOMATIC COMPUTERS

681.142 432

High-Speed Adding System—N. Kuroyanagi. (*Rev. Elect. Commun. Lab., Japan*, vol. 8, pp. 175–188; March/April, 1960.) A new system is described which increases the adding speed by obtaining the "carriers" of all digits in a one-step operation.

681.142 433

A Digital Computer Store with Very Short Read Time—T. Kilburn and R. L. Grimsdale. (*Proc. IEE*, vol. 107, pt. B, pp. 567–572; November, 1960. Discussion, pp. 605–607.) Each binary cell is formed by two sets of windings coupled, or not coupled, by a linear ferrite. A 200,000-unit store has been constructed.

681.142 434

A Parallel Arithmetic Unit using a Saturated-Transistor Fast-Carry Circuit—T. Kilburn, D. B. G. Edwards, and D. Aspinall. (*Proc. IEE*, vol. 107, pt. B, pp. 573–584; November, 1960. Discussion, pp. 605–607.) An addition time over 24 digits of 200 nanoseconds is achieved.

621.142 435

Multipliers and Dividers in A.C. Computers—C. H. Smith and A. Prabhakar. (*Electronic Engrg.*, vol. 32, pp. 714–716; November, 1960.) Thermionic-tube and transistor dividers and multipliers are described, in which the exponential shape of the small-signal characteristic is used to combine a dc and an ac signal.

681.142 436

The Differential Analyser and its Realization in Digital Form—P. L. Owen, M. F. Partridge, and T. R. H. Sizer. (*Electronic Engrg.*, vol. 32, pp. 614–617, 700–704; October, November, 1960.)

681.142:537.376 437

High-Speed Light Output Signals from Electroluminescent Storage Systems—G. R. Hoffman, D. H. Smith, and D. C. Jeffreys. (*Proc. IEE*, vol. 107, pt. B, pp. 599–605; November, 1960. Discussion, pp. 605–607.) The effect of phosphor afterglow (25–30 μsec per digit) on read-out time appears to limit the number of matrices to about 32×32.

681.142:538.221:539.23 438

A Computer Storage Matrix using Ferromagnetic Thin Films—E. M. Bradley. (*J. Brit. IRE*, vol. 20, pp. 765–784; October, 1960.) Details are given of the construction and performance of a storage system using the coherent rotational mode of magnetization reversal in thin films of a newly developed alloy on an Al substrate.

681.142:621.318.134 439

A 1-Mc/s Magnetic-Core Buffer Store for Use with a Card Punch or Line Printer—J. B. James. (*Electronic Engrg.*, vol. 32, pp. 689–695; November, 1960.) The store accepts data from a computer and provides a series of parallel outputs suitable for a printer or card punch. Square-loop magnetic cores are used, and the decoding and parity-check circuits are described.

681.142:621.318.134 440

Ferrite-Core Memory Systems with Rapid Cycle Times—D. B. G. Edwards, M. J. Lanigan, and T. Kilburn. (*Proc. IEE*, vol. 107, pt. B, pp. 585–598; November, 1960. Discussion, pp. 605–607.) The normal cycle time of 6–10 μsec. for square-loop ferrite cores is reduced to 2 μsec. A system suitable for a store of 1024 words of 52 digits with a cycle time of 1.6 μsec is developed.

681.142:621.318.134:621.318.57 441

A Class of Optimal Noiseless Load-Sharing Matrix Switches—R. T. Chien. (*IBM J. Res. and Dev.*, vol. 4, pp. 414–417; October, 1960.) A scheme for constructing a matrix switch with a reduced number of input wires is given. *See also* 442.

681.142:621.318.134:621.318.57 442

New Developments in Load-Sharing Matrix Switches—G. Constantine, Jr. (*IBM. J. Res. and Dev.*, vol. 4, pp. 418–422; October, 1960.) See also 3712 of 1958.

681.142:621.372.44 443

The Parametron and its Application in Data Processing Systems—E. Schmitt. (*Elektron. Rundschau*, vol. 14, pp. 41–46; February, 1960.) Ferrite-core and diode parametrons are reviewed and applications are discussed.

681.142:621.374.5:538.652 444

Transistorized Magnetostrictive Delay-Line Stores—H. A. Showell, C. W. M. Barrow, and R. E. Collis. (*AEI Engrg. Rev.*, vol. 1, pp. 58–67; July, 1960.) Two types of storage system for operation at 1 Mc are described; their delay times are 100 μsec and 1 Msec respectively. See also *Proc. IEE*, vol. 106, pt. B, Suppl. 18, pp. 1267–1276; April, 1960.

681.142:621.395.625.3 445

The Assessment of the Reliability of Magnetic Tape for Data Processing—R. Noble. (*J. Brit. IRE*, vol. 20, pp. 737–743; October, 1960.) A method of tape testing based on a theory of the origin of observed signal drop-out distribution permits batch testing and assists in the design of tape-handling systems and in the calculation of reliability.

681.142:621.395.625.3 446

A Magnetic Read Head with Output Signal Independent of Tape Speed—D. Kerr and E. J. M. Quirk. (*J. Brit. IRE*, vol. 20, pp. 743–748; October, 1960.) Each head is double, consisting of a variable-reluctance reading head and a conventional writing head. One unit comprises eight double heads and can be used with standard ½-inch tape in computer output and editing equipments. The reading head is adequate for normal packing densities over a wide range of tape speeds down to zero.

CIRCUITS AND CIRCUIT ELEMENTS

621.319.4 447

Self-Resonance of Ceramic Miniature Capacitors—K. H. Olbricht. (*Bull. schweiz. elektroteck. Ver.*, vol. 51, pp. 142–147; February 27, 1960.) Methods of measuring the resonance frequency are discussed, and the characteristics of various types of miniature ceramic capacitor at frequencies in the range 10–1000 Mc are investigated. See also 3362 of 1958 (Bork.).

621.372.4/.5 448

A Review of the Present State of Network Synthesis: Part 1—G. Wunsch. (*Frequenz*, vol. 14, pp. 47–55; February, 1960.) A comprehensive review is given of synthesis methods. 40 references.

621.372.4 449

Two-Terminal RC Networks and Theoretically Related Topics—O. P. D. Cutteridge. (*Proc. IEE*, vol. 107, pt. C, pp. 275–282; September, 1960.) A derivation of the properties of the principal minors of successive orders of the modal determinant of a lumped linear RC network. *See also* 661.

621.372.413 450

Perturbation Theory of Resonant Cavities—R. A. Waldron. (*Proc. IEE*, vol. 107, pt. C, pp. 272–274; September, 1960.) A detailed derivation is given of the perturbation formula for the frequency shift on introducing a sample of ferrite or dielectric material into a resonant cavity.

621.372.413 451

On the Theory of Strongly Coupled Cavity Chains—M. A. Allen and G. S. Kino. (IRE Trans. on Microwave Theory and Techniques, vol. MTT-8, pp. 362–372; May, 1960.

Abstract, Proc. IRE, vol. 48, p. 1516; August, 1960.)

621.372.413:546.824.31 452
The Rutile Microwave Resonator—A. Okaya. (Proc. IRE, vol. 48, p. 1921 (Correspondence); November, 1961.) The use of a rutile crystal as a microwave resonant cavity is described. This is of a much smaller size than the equivalent metal-walled cavity.

631.372.413:621.317.61 453
Measurement of Bandwidth of Microwave Resonator by Phase Shift of Signal Modulation—D. S. Lerner and H. A. Wheeler. (IRE Trans. on Microwave Theory and Techniques, Vol. MTT-8, pp. 343–345; May, 1960. Abstract, Proc. IRE, vol. 48, pp. 1515–1516; August, 1960.)

621.372.51:534.833.4 454
Determining Component Variation for Gradual Transition between Dissimilar Impedances—C. Becker, C. M. Bruen, and R. B. Turner. (*IBM J. Res. and Dev.*, vol. 4, pp. 430–438; October, 1960 . The problem is attacked by a recursive method needing a minimum of numerical precision. The application to an acoustic absorption system is considered. [See also 2013 of 1957 (Becker).

621.372.54 455
Remarks on and Additions to Küpfmüller's Transient Formula—G. Wunsch. (*Hochfrequenztech. u. Elektroakust.*, vol. 69, pp. 35–39; February, 1960.) Küpfmüller's formula for low-pass filters is generalized, and an analogous formula valid for all-pass delay circuits with optimally flat response is derived.

621.372.54 456
The Performance of Filter Networks consisting of *n* Equal Half-Sections—W. Herzog. (*Nachrichtentech. Z.*, vol. 13, pp. 137–146; March, 1960.) Formulas are given for the open-circuit impedance of an *n*-section network from which the transmission characteristics can be derived. Calculations for various simple filters are included.

621.372.54:534.1 457
A 400-CPS Tuning-Fork Filter—J. J. O'Connor. (Proc. IRE, vol. 48, pp. 1857–1865; November, 1960). An introduction is given to the use of a tuning-fork filter as a circuit element, and a complete description is given of a particular unit, its derivation, and the correlation between theory and measurement.

621.372.54:621.374.5 458
Linear-Slope Delay Filters for Compression—T. R. O'Meara. (Proc. IRE, vol. 48, pp. 1916–1918; November, 1960.) Design considerations are summarized for filters having linear change of delay time with frequency over a narrow band.

621.372.57:681.142 459
The Normalization of Electrical Integrating and Differentiating Circuits—K. H. Kerber. (*Elektronische Rundschau*, vol. 14, pp. 49–50; February, 1960). See also 3401 of 1960.

621.373:621.372.444 460
On the Switching Time of Subharmonic Oscillators—A. H. Nethercot, Jr. (*IBM J. Res. and Dev.*, vol. 4, pp. 402–406; October, 1960.) The time necessary to change the phase of an idealized subharmonic parametric oscillator by 180° is calculated for various values of pump power and switching power.

621.373.4 461
Qualitative Investigation of a New Oscillator Circuit—S. Vojtášek and K. Janáč. (*Hochfrequenztech. u. Elektroakust.*, vol. 69, pp. 11–17; February, 1960.) Analysis of a triode oscillator circuit with good frequency stability by 1) mathematical treatment and 2) an analog differential analyzer.

621.373.52 462
Transistor Beta-Phase-Shift Oscillator—A. R. Saha. (*J. Electronics Control.*, vol. 9, pp. 113–125; August, 1960.) A new oscillator circuit is described whose performance is analyzed theoretically and confirmed by experiment.

621.374:621.372.44:621.382.23 463
Pulse Shaping with Variable-Capacitance Diodes—D. P. Schulz. (Proc. IRE, vol. 48, p. 1918 (Correspondence); November, 1960.) Small-signal analysis is carried out for variable-capacitance integrating and differentiating circuits.

621.374.32 464
Multiple Coincidence Circuit—R. L. Chase. (*Rev. Sci. Instr.*, vol. 31, pp. 945–949; September, 1960.) A general-purpose transistor coincidence circuit accepting up to five input signals with three simultaneous outputs is described. It features a special discriminator which operates on the leading edge of the input signals or the passage through zero on the trailing edge; the discriminator bias can be varied over a wide range without affecting the circuit recovery time.

621.374.32 465
High-Speed Counter requiring No Carry Propagation—W. N. Carroll. (*IBM J. Res. and Dev.*, vol. 4, pp. 432–425; October, 1960.) The method depends on forming complements, but the need for complementing the entire register is eliminated.

621.374.5:621.382.3 466
Highly Accurate Phantastron Delay Circuit—S. R. Parris and D. A. Staar. (*Electronics*, vol. 33, pp. 72–74; October 21, 1960.) A transistor circuit incorporates compensating arrangements to cancel sources of timing error. The final circuit provides a delay of 220 μsec with an accuracy within -1 per cent.

621.375.018.756 467
The Laws of Summation for Tilt, Rise Time and Overshoot, particularly in Amplifier Circuits—H. Dobesch and H. Sulanke. (*Nachrichtentech. Z.*, vol. 10, pp. 3–14; January, 1960.) The time-function parameters of pulses applied to cascade-connected quadripoles are calculated. An improved summation law for the rise time is derived.

621.375.018.756 468
The Representation in Pulse Form of the Noise of Amplifiers—H. Maier-Leibnitz. (*Z. angew. Phys.*, vol. 12, pp. 97–99; March, 1960.) The noise characteristics of pulse amplifiers are derived, without reference to the frequency spectrum, as a function of the pulse response of the amplifier.

621.375.132 469
Amplifiers with Quasi-constant Gain—J. T. Allanson. (*Electronic Technol.*, vol. 37, pp. 462–466; December, 1960.) Various methods are considered whereby the over-all gain of an amplifying system may be held approximately constant despite variations in the parameters of the amplifying units incorporated in the system.

621.375.232.3 470
Ultralinear Cathode Follower—P. L. Read. (*Rev. Sci. Instr.*, vol. 31, pp. 979–982; September, 1960.) Six tubes are used in a modified White follower circuit to give unity gain, an output impedance of $2\times10^{-3}\,\Omega$ and intermodulation distortion 2×10^{-5} per cent.

621.375.3 471
Flux Resetting Characteristics of Full-Wave Magnetic Amplifier affected by the Metallic Rectifier—K. Murakami and T. Kikuchi. (*Sci. Rep. Res. Inst. Tohoku Univ., Ser. B*, vol. 11, no. 1, pp. 23–44; 1959.) Quantitative relations between rectifier and flux resetting characteristics are investigated by a technique in which the effects of nonlinear forward and reverse characteristics of the rectifier are separated by means of mechanical synchronous contacts.

621.375.3.024:621.375.4 472
A High-Power Transistor-Magnetic D.C. Amplifier—G. Sarkar. (*Electronic Engrg.*, vol. 32, pp. 705–711; November, 1960.) The amplifier uses a transistor chopper, two transistor amplifiers, and a magnetic amplifier. The circuits described give a high gain, high-power output, and high-input impedance.

621.375.421 473
Transistor Wide-Band Amplifiers—A. I. Fischer. (*Nachrichtentech. Z.*, vol. 10, pp. 83–87; February, 1960.) The design of RC-coupled multistage amplifiers is considered; only the earthed-emitter configuration is suitable for this application.

621.375.9:538.569.4 474
Atomic Hydrogen Maser—H. M. Goldenberg, D. Kleppner, and N. F. Ramsey. (*Phys. Rev. Lett.*, vol. 5, pp. 361–362; October 15, 1960.) Self-sustained emission at the atomic-hydrogen hyperfine transition frequency has been observed. Increased interaction times with the radiation field (mean values up to 0.3 second) and correspondingly narrowed resonance widths have been obtained by retaining the atoms in a storage box with suitable walls. Stimulated emission has also been recorded and the magnetic-field-independent hyperfine transition used to observe field-dependent Zeeman transitions by a double resonance method.

621.375.9:621.372.44 475
Parametric Amplifiers—R. Elsner, L. Pungs and K. H. Steiner. (*Frequenz*, vol. 14, pp. 59–67; February, 1960.) A review of nonlinear reactance circuits; amplifier characteristics are calculated and compared with experimental results.

621.375.9:621.372.44 476
An Analysis of Four-Frequency Nonlinear Reactance Circuits—D. K. Adams. (IRE Trans. on Microwave Theory and Techniques, vol. MTT-8, pp. 274–283; May, 1960. Abstract, Proc. IRE, vol. 48, p. 1515; August, 1960.)

621.375.9:621.372.44:621.372.2 477
Shock Waves in Nonlinear Transmission Lines and their Effect on Parametric Amplification—R. Landauer. (*IBM J. Res. and Dev.*, vol. 4, pp. 391–401; October, 1960.) The propagation of a periodic signal on a transmission line with a nonlinearity in the distributed capacitance is examined. The signal is deformed during its propagation and EM shock waves are generated. The subsequent growth and decay of the shock are analyzed. See also 2275 of 1960.

621.375.9:621.372.44:621.372.2 478
A Wide-Band U.H.F. Travelling-Wave Variable-Reactance Amplifier—R. C. Honey and E. M. T. Jones. (IRE Trans. on Microwave Theory and Techniques, vol. MTT-8, pp. 351–361; May, 1960. Abstract, Proc. IRE, vol. 48, p. 1516; August, 1960.)

621.375.9:621.372.44:621.385.6 479
Low-Noise Electron-Beam Amplifier—Labus. (See 744).

621.375.9:621.372.44:621.385.6 480
New Microwave Tube Devices "Fawshmotron" using the Fast Electron Waves—Matsuo. (*See* 745.)

621.375.9:621.382.23 481
Negative-Resistance Amplifier Design—Schultz and Yin. (*See* 725.)

621.375.921.2 482
Negative-Resistance Distributed Amplifier—C. A. Saklski. (Proc. IRE, vol. 48, pp. 1909–1910; November, 1960.) Operation of the amplifier is described in terms of iterative sections.

621.376.22 483
The Properties and Design of Ring Modulators—H. Bley. (*Nachrichtentech. Z.*, vol. 13, pp. 129–136, 196–201; March, April, 1960.) This is a treatment, on the basis of quasilinear quadrupole theory, of experimentally determined characteristics and design parameters of ring modulators.

621.376.22:621.396.933.23 484
Mechanical Modulator uses Variable Capacitance—Habra. (*See* 577.)

621.376.22.029.65:621.382 485
The *p-i-n* Modulator, an Electrically Controlled Attenuator for mm and Sub-mm Waves—F. C. de Ronde, H. J. G. Meyer, and O. W. Memelink. (IRE Trans. on Microwave Theory and Techniques, vol. MTT-8, pp. 325–327; May, 1960. Abstract, Proc. IRE, vol. 48, p. 1515; August, 1960.)

621.376.3 486
Explicit Form of F.M. Distortion Products with White-Noise Modulation—R. G. Medhurst and J. H. Roberts. (*Proc. IEE*, vol. 107, pt. C, pp. 367–369; September, 1960.) An extension and correction to 2281 of 1960 (Medhurst).

GENERAL PHYSICS

530.112:530.12 487
First-Order Terrestrial Ether-Drift Experiment using the Mössbauer Radiation—M. Ruderfer. (*Phys. Rev. Lett.*, vol. 5, pp. 191–192; September 1, 1960.) A one-way test of the special relativity and contraction theories is proposed, which would obviate the cancellation of first-order terms observed in two-way tests.

537.2:621.396.677.85 488
Electric Polarizability of a Short Right Circular Conducting Cylinder—T. T. Taylor. (*J. Res. NBS*, vol. 64B, pp. 135–143; July–September, 1960.) Calculations to an accuracy of approximately five significant figures are carried out for cylinders with radius/half-length ratios of $\frac{1}{4}$, $\frac{1}{2}$, 1, 2, and 4. The results are applicable to the design of artificial dielectrics.

537.213:621.385.833 489
Method of Solving a Class of Axially Symmetric Problems in the Theory of Potential and Application to the Design of Electron-Optical Lenses—G. A. Grinberg and I. A. Skukeilo. (*Z. Tekh. Fiz.*, vol. 29, pp. 1293–1303; November, 1959.) A class of problems arising in the calculation of electrostatic fields with rotational symmetry is considered. If the systems satisfy certain conditions, they can be treated by a method of successive approximations which are obtained by solving a plane electrostatic problem.

537.311.33 490
A Note on the Theory of Space-Charge-Limited Currents—C. Rhys-Roberts and R. H. Tredgold. (*Proc. Phys. Soc.*, vol. 76, pp. 497–501; October 1, 1960.) The experimental results of Branwood and Tredgold (219 of January, 1961) with $BaTiO_3$ are explained by a simple model in which there are thin layers of uncharged traps at the surface of the dielectric, which are uniformly distributed in space and of one energy depth; the bulk of the material contains no traps.

537.525 491
The Role of Cold Electron Emission due to Field Effect in the Maintenance at the Cathode of an Electric Discharge in a Highly Rarified Gas—H. Doucet. (*C. R. Acad. Sci., Paris*, vol. 250, pp. 1007–1009; February 8, 1960.) The hypothesis of electron emission at the cathode under the influence of the space charge due to positive ions is proposed, and supported by preliminary experimental results.

537.525:538.56 492
Oscillation caused by Electron Sheath Breakdown—S. Ohara and K. Takayama. (*Rev. Elec. Commun. Lab., Japan*, vol. 8, pp. 7–11; January/February, 1960.) Relaxation oscillations of frequency 50–3000 cps were investigated by inserting a highly charged probe into the dark plasma of a hot-cathode gas-discharge tube.

537.56:538.614 493
Electron Energy Distributions in Plasmas: Part 2—Hydrogen—R. L. F. Boyd and N. D. Twiddy. (*Proc. Roy. Soc. A*, vol. 259, pp. 145–158; December 6, 1960.) The method given in Part 1 (3260 of 1959) is applied to the study of the mechanism of striation structure in hydrogen discharges.

537.56:538.614 494
Rotary Magnetic Polarization in Plasmas. Application to the Measurement of Electron Density—T. Consoli and M. Dagai. (*C. R. Acad. Sci., Paris*, vol. 250, pp. 1010–1012; February 8, 1960.)

537.56:538.614 495
Measurement of the Electron Density of a Plasma in Evolution. Experimental Apparatus—T. Consoli and M. Dagai. (*C. R. Acad. Sci., Paris*, vol. 250, pp. 1223–1225; February 15, 1960.) A general description is given of apparatus for measuring electron density in the range 10^{16}–10^{20} electrons/m³.

537.56:538.63 496
Investigation of a Plasma Column Continuously Fed and Subjected to an Electromagnetic Field: Conditions for the Existence of Non-centred Maxwellian Solutions: Equations of Density—J. M. Dolique. (*C. R. Acad. Sci., Paris*, vol. 250, pp. 1221–1222; February 15, 1960.)

537.583:537.213 497
Potential Distribution between Two Plane Emitting Electrodes: Part 2—Thermionic Engines—P. A. Lindsay and F. W. Parker. (*J. Electronics Control*, vol. 9, pp. 81–111; August, 1960.) All potential distributions can be represented by a two-parameter family of curves, the parameters depending on the electrode temperatures, potentials and work functions; the computed results show clearly the relative influence of these quantities on the potential minimum between the electrodes. (Part 1: 2306 of 1960.)

538.114 498
Equivalence of the Critical Concentrations in the Ising and Heisenberg Models of Ferromagnetism—R. J. Elliott, B. R. Heap, D. J. Morgan and G. S. Rushbrooke. (*Phys. Rev. Lett.*, vol. 5, pp. 366–367; October 15, 1960.)

538.221:621.318.134:538.569.4 499
Ferrimagnetic Resonance in Three-Sublattice Systems—R. K. Wangsness. (*Phys. Rev.*, vol. 119, pp. 1496–1500; September 1, 1960.)

538.56:621.372.413 500
Sets of Eigenvectors for Volumes of Revolution—J. Van Bladel. (IRE Trans. on Microwave Theory and Techniques, vol. MTT-8, pp. 309–319; May, 1960. Abstract, Proc. IRE, vol. 48, p. 1515; August, 1960.)

538.561:537.122 501
On the Cherenkov Effect for a Charge Moving above an Interface—A. G. Sitenke and V. S. Tkalich. (*Z. Tekh. Fiz.*, vol. 29, pp. 1074–1085; September, 1959.) Mathematical analysis relating to the EM radiation due to the movement of a charged particle and a modulated beam of charged particles in the proximitiy of a dielectric.

538.561:537.122 502
On the Cherenkov Radiation of Dipole Moments Moving along an Axial Channel in a Dielectric—L. S. Bogdankevich. (*Z. Tekh. Fiz.*, vol. 29, pp. 1086–1089; September, 1959.) The radiation field is calculated for a magnetic and electric dipole moving in a dielectric. If the radius of the channel $a \ll \lambda$, then the radiation of the electric dipole moving perpendicularly to the axis increases by a factor of $4\epsilon^2/(\epsilon+1)^2$ compared with the radiation in the dense medium of the dielectric.

538.566:535.42]+534.26 503
Diffraction of a Pulse by a Resistive Half-Plane—V. M. Papadopoulos. (*Proc. Roy. Soc. (London) A*, vol. 255, pp. 538–557; May 10, 1960.) The two-dimensional diffraction problem, acoustic or EM, in which the incident pulse front is parallel to the edge of a half-plane, is solved by assuming dynamic similarity in the solution. Relations between this problem and the three-dimensional problem which arises when a plane pulse is incident obliquely at the edge of a resistive half-plane are discussed.

538.566:535.42 504
The Diffraction of Electromagnetic Waves—R. King. (*Z. angew. Phys.*, vol. 12, pp. 88–95; February, 1960.) Mathematical treatment of diffraction and scattering at the surface of a conducting circular cylinder is given.

538.566:535.42 505
Diffraction of Electromagnetic Waves at a Paraboloidal Screen of Finite Dimensions (Axially-Symmetric Fields)—Yu. N. Kuz'min. (*Z. tekh. Fiz.*, vol. 29, pp. 1304–1311; November, 1959.) A theoretical treatment is given of diffraction at a thin ideally-conducting paraboloidal segment.

538.566:535.42 506
Diffraction by an Imperfectly Conducting Half-Plane at Oblique Incidence—T. B. A. Senior. (*Appl. Sci. Res.*, vol. B8, no. 1, pp. 35–61; 1959.) The exact solution has been obtained for the problem of a plane wave incident at an oblique angle on a metallic half-plane. The analysis requires the solution of coupled Wiener-Hopf integral equations for the electric and magnetic current distributions excited on the surface of the half-plane.

538.566:535.42 507
Diffraction of an Electromagnetic Plane Wave by a Metallic Sheet—W. E. Williams. (*Proc. Roy. Soc. (London) A*, vol. 257, pp. 413–419; September 20, 1960.) A new generalized technique is developed for the solution of the problem of the diffraction of an *E*-polarized plane wave incident at an oblique angle on an imperfectly conducting half-plane. The solution obtained shows complete agreement with that of Senior. (*See* 506.)

538.566:535.42 508
Aperture Fields in the Diffraction by a Slit—H. P. Hsu. (*J. Appl. Phys.*, vol. 31, pp.

1742–1746; October, 1960.) A description of measurements at 3.2 cm λ, using a parallel-plate device, of the field distribution over apertures of width 1.27, 2.21, 3, and 3.5 λ.

538.566:535.42:621.396.677 509
The Various Statements of Kirchhoff's Principle and their Application to the Diffraction Diagrams of Electromagnetic Waves—G. F. Koch. (*Arch. elekt. Übertragung*, vol. 14, pp. 77–98, 132–153; February, March, 1960.) The various approximation methods based on Kirchhoff's principle are applied to the case of microwave diffraction at a diaphragm and a reflector disk, particularly for oblique incidence. Comparisons are made with experimental results. Reflection at mirrors with dimensions of the order of a few wavelengths is considered with regard to the calculation of surface utilization and reflection cross sections. 53 references.

538.566:535.43 510
Transmission Coefficient for a System of Parallel Slits in a Thin, Plane Screen—K. Saermark. (*Appl. Sci. Res.*, vol. B8, no. 1, pp. 29–34; 1959.) An extension of earlier work on the scattering of EM waves (*ibid.*, vol. B7, no. 6, pp. 417–440; 1959.) to include more than two parallel slits in a perfectly conducting screen.

538.566:537.56 511
Dielectric Constant of a Dense Electron Gas—T. Pradhan and P. Misra. (*Phys. Rev.*, vol. 119, pp. 1878–1881; September 15, 1960.) Theoretical investigation of dispersion and absorption of EM waves in a dense electron gas.

538.566:537.56 512
Propagation Constants for Electromagnetic Waves in Weakly Ionized, Dry Air—A. V. Phelps. (*J. Appl. Phys.*, vol. 31, pp. 1723–1729; October, 1960.) Data are given for dry air at ionospheric temperatures in the presence of a magnetic field. The magnitude and energy dependence of the electron collision frequency are also derived.

538.566:621.396.67 513
Electromagnetic Fields of Axial Symmetry Bounded by a Cone and a Sphere—H. Buchholz. (*Arch. Elektrotech.*, vol. 45, pp. 27–48; February 17, 1960.) The radiation field of a floating magnetic current ring in a space enclosed by spheres and cones is calculated. This solution is extended to certain limiting conditions of direct bearing on EM radiation from antennas in free space.

538.567:[621.372.8+621.385.6 514
Some Properties of Three Coupled Waves—L. Solymar. (IRE TRANS. ON MICROWAVE THEORY AND TECHNIQUES, vol. MTT-8, pp. 284–291; May, 1960. Abstract, PROC. IRE, vol. 48, p. 1515; August, 1960.)

538.569:539.2 515
Induced and Spontaneous Emission in a Coherent Field: Part 3—I. R. Senitzky. (*Phys. Rev.*, vol. 119, pp. 1807–1815; September 15, 1960.) Theory, developed in Parts 1 and 2 (3777 of 1958 and 462 of 1960), dealing with the interaction between the EM field in a cavity resonator and a number of two-level molecules, is generalized to include a Gaussian spread in the molecular frequency.

538.569.4 516
Microwave Emission from an Optically Pumped Atomic System—V. E. Derr, J. J. Gallagher, R. E. Johnson, and A. P. Sheppard. (*Phys. Rev. Lett.*, vol. 5, pp. 316–318; October 1, 1960.) Preliminary results are reported of an experiment in which the microwave emission at about 9192 Mc from an optically pumped Cs cell has been directly detected.

538.569.4:535.853 517
Recording R.F. Spectrometer for Nuclear Quadrupole Zeeman Spectra—C. Dean. (*Rev. Sci. Instr.*, vol. 31, pp. 934–941; September, 1960.) Circuit details are given of semiautomatic apparatus in continuous operation for recording chlorine resonances in the 30–40-Mc region.

538.569.4:538.222:535.853 518
A Simple Spectrograph for Nuclear Paramagnetic Resonance—R. Becherer. (*C. R. Acad. Sci., Paris*, vol. 250, pp. 1037–1039; February 8, 1960.) A description is given of modifications to the Bloch spectrograph which simplify decoupling problems.

538.569.4:535.853:621.375.9 519
Sensitivity of Microwave Spectrometers using Maser Techniques—C. H. Townes. (*Phys. Rev. Lett.*, vol. 5, pp. 428–430; November 1, 1960.) Expressions are derived for the reduction in the coefficient minimum detectable absorption in a microwave waveguide when molecules in an excited state are added along the waveguide. The application of this principle to a cavity spectrometer is discussed.

538.569.4:621.375.9 520
Atomic Hydrogen Maser—Goldenberg, Kleppner, and Ramsey. (*See* 474).

GEOPHYSICAL AND EXTRATERRESTRIAL PHENOMENA

523.16:551.507.362.1 521
An Instrument for the Investigation of Interplanetary Plasma—H. S. Bridge, C. Dilworth, B. Rossi, and F. Scherb. (*J. Geophys. Res.*, vol. 65, pp. 3053–3055; October, 1960.) A Faraday cup is described, for use on a deep probe, to measure the density and the magnitude and direction of the bulk velocity of the positive ions.

523.164.3 522
Amplitude Scintillation of Radio Star at Ultra-High Frequency—H. C. Ko. (PROC. IRE, vol. 48, pp. 1871–1880; November, 1960.) Observations of Cygnus-A at 915 Mc over a 12-month period are described; they show fluctuations of scintillation rate, short-term and seasonal, as well as some correlation with geomagnetic effects.

523.164.3 523
Evidence for the Solar Corpuscular Origin of the Decametre-Wavelength Radiation from Jupiter—T. D. Carr, A. G. Smith, and H. Bollhagen. (*Phys. Rev. Lett.*, vol. 5, pp. 418–420; November 1, 1960.) Some correlation was found between 10-Mc and 18-Mc emissions from Jupiter between April and August, 1960, and the occurrence of geomagnetic disturbance about nine days earlier. Some events were associated with solar flares.

523.164.3 524
New Limits to the Diameters of some Radio Sources—L. R. Allen, H. P. Palmer, and B. Rowson. (*Nature, London*, vol. 188, pp. 731–732; November 26, 1960.) Observations using a base line of 32,000 λ have shown that at least seven sources have major features smaller than three seconds of arc, with extremely high surface brightness.

523.164.32 525
Relation between the Position and the Sense of Polarization of Solar Radio Storms—A. M. Malinge. (*C. R. Acad. Sci., Paris*, vol. 250, pp. 1186–1188; February 15, 1960.) Observations of the positions of solar storm centers made with the great interferometer at Nançay at 169 Mc have been related to measurements of polarization made at Néra, Netherlands, at 200 Mc. Results show that the radiation from storm centers in the northern solar hemisphere has a predominantly right-hand polarization, and that from the southern, a left-hand polarization.

523.164.32:523.75 526
Solar Bursts of Type III and their Relation to Flares—H. H. Rabben. (*Z. Astrophys.*, vol. 49, pp. 95–110; January 26, 1960.) Recordings of bursts made by radiometer and radio spectrograph at Freiburg and other observatories are analyzed, and their relation to flares observed in the same period is studied.

523.165 527
The Radiation Belt produced by Neutrons Leaking out of the Atmosphere of the Earth—W. N. Hess. (*J. Geophys. Res.*, vol. 65, pp. 3107–3115; October, 1960.) The composition of the radiation belts is compared with that expected for a neutron decay source. It seems that the inner belt is produced only by neutron decay. In the outer belt the electrons of energy greater than 200 Kev are probably produced by neutron decay, but those of lower energy probably come from outside the belt.

523.165 528
The Solar Daily Variation of the Cosmic Radiation: World-Wide Neutron Monitor Observations during the International Geophysical Year—G. Schwachheim. (*J. Geophys. Res.*, vol. 65, pp. 3149–3157; October, 1960.)

523.165 529
Effects of Short-Term World-Wide Modulation of the Primary Cosmic Radiation on Observed Daily Intensity Variations—N. R. Parsons. (*J. Geophys. Res.*, vol. 65, pp. 3159–3161; October, 1960.)

523.165 530
Observations of the Van Allen Radiation Regions during August and September 1959: Part 1—A. J. Dessler. (*J. Geophys. Res.*, vol. 65, pp. 3487–3490; October, 1960.) [Discussion of 3474 of 1960 (Arnoldy, *et al.*).]

523.165 531
Latitude and Altitude Distribution of Geomagnetically Trapped Protons—S. F. Singer. (*Phys. Rev. Lett.*, vol. 5, pp. 300–303; October 1, 1960.) A theory is derived for a geometrical injection coefficient of trapped protons of cosmic-ray origin. Calculated distributions resemble contours obtained experimentally.

523.165 532
Diffusion of Particles in the Earth's Radiation Belts—N. Herlofson. (*Phys. Rev. Lett.*, vol. 5, pp. 414–416; November 1, 1960.) Fluctuations in the geomagnetic field may cause diffusion of particles across the field. The distribution of particles predicted by a theoretical study of diffusion is compared with observations using Pioneer IV.

523.165:550.385.4 533
Geomagnetic Fluctuations and the Form of the Outer Zone of the Van Allen Radiation Belt—E. N. Parker. (*J. Geophys. Res.*, vol. 65, pp. 3117–3130; October, 1960.) The sudden compression of the geomagnetic field, associated with the initial phase of a magnetic storm, causes electrons to diffuse radially across the geomagnetic field. It is estimated that a particle at $r = 3.5\ R_E$ will diffuse a distance R_E in about 5 years.

523.165:550.385.4 534
Charged-Particle Variations in the Outer Van Allen Zone during a Geomagnetic Storm—T. A. Farley and A. Rosen. (*J. Geophys. Res.*, vol. 65; pp. 3494–3496; October, 1960.) Fluctuations in the particle fluxes and local magnetic field were observed by Explorer VI at 44,000 km during the geomagnetic storm of

August 16, 1959, and were found to be correlated. The numbers of low-energy particles decreased and high-energy particles increased. The results are consistent with the theories of Dessler and Parker (1586 of 1960).

523.165:551.507.362.2 535

A Study of Variations of Corpuscular Radiation Observed by Satellite 1958 Epsilon near Japan—M. Hirono and H. Akima. (*Rep. Ionosph. Space Res. Japan*, vol. 14, pp. 41–68; March, 1960.) Observations in August and September, 1958, are related to the electron shell of the Argus I explosion. The lowering of mirror points by Coulomb scattering and the influence of corpuscular radiation on the ionosphere are examined.

523.3:621.396.96 536

Radar Methods of Measuring the Cislunar Electron Density—V. R. Eshleman, P. B. Gallagher, and R. C. Barthle. (*J. Geophys. Res.*, vol. 65, pp. 3079–3086; October, 1960.) Six related techniques for measuring the integrated electron density between the earth and the moon are discussed. These are based on the determination of the group retardation suffered by low-frequency radar echoes. Very high peak power (pulse technique) or very high equipment stability (CW technique) would be required to measure absolute radar range, but this difficulty can be avoided by sending a reference signal with the measuring signal. The effects of path splitting, electron "blobs," and lunar surface irregularities are considered.

523.3:621.396.96 537

A Lunar and Planetary Echo Theory—W. E. Brown, Jr. (*J. Geophys. Res.*, vol. 65, pp. 3087–3095; October, 1960.) A lunar radio echo is divided into a specular component and a Lambert scatter component based on a model of the lunar surface. The theory is compared with experimental data on the shape and frequency spectrum of reflected pulses.

523.75:550.385.4 538

Propagation of Solar Cosmic Rays through Interplanetary Magnetic Field—T. Obayashi and Y. Hakura. (*J. Geophys. Res.*, vol. 65, pp. 3143–3148; October, 1960.) Type III polar blackouts are closely associated with solar flares which are accompanied by type IV noise outbursts. The delay before the commencement of the type III blackout is about 18 hours for flares in the east sector of the sun and about 4 hours for flares in the west. The difference is ascribed to a regular distortion of the outer solar magnetic field. The commencement of the geomagnetic storm is not dependent on the solar longitude of the flare.

550.38:523.16 539

The Gross Character of the Geomagnetic Field in the Solar Wind—F. S. Johnson. (*J. Geophys. Res.*, vol. 65, pp. 3049–3051; October, 1960.) The field may be deformed into a tear-drop shape by the interplanetary plasma. It is emphasized that the asymmetry of the deformed field ought to be considered in space investigations.

550.382:621.391.812.63 540

Note on the Geometry of the Earth Magnetic Field useful to Faraday-Effect Experiments—K. C. Yeh and V. H. Gonzalez. (*J. Geophys. Res.*, vol. 65, pp. 3209–3214; October, 1960.) A study of the factor $H \cos \phi \sec i$ where ϕ and i are the angles between a ray and, respectively, the earth's field and the vertical.

550.385:551.594.2 541

Audio-Frequency Fluctuations in the Geomagnetic Field—J. B. Wilcox and E. Maple. (*J. Geophys. Res.*, vol. 65, pp. 3261–3271; October, 1960.) An examination of recordings at three locations widely spaced in latitude indicates that equatorial thunderstorms are the major sources of fluctuations in the frequency range 40–16,000 cps.

550.386(99) 542

Geomagnetic Observations at Halley Bay—J. MacDowall. (*Proc. Roy. Soc. A*, vol. 256, pp. 219–221; June 21, 1960.)

551.507.362 543

Results of Scientific Investigations made by Soviet Sputniks and Cosmic Rockets—V. I. Krassovsky (Krasovskii). (*Astronaut. Acta*, vol. 6, no. 1, pp. 32–47; 1960.) Report presented at a meeting of the American Rocket Society, Washington, D. C.; November, 1959.

551.507.362:523.3 544

Payload Design for a Lunar Satellite—P. F. Glazer and E. R. Spangler. (*Electronics*, vol. 33, pp. 63–67; October 28, 1960.) A description is given of the experiments planned and the equipment and methods used in the Able-5 vehicle.

551.507.362.1 545

On Geomagnetic Observations with the Aid of the First Soviet Cosmic Rocket—M. G. Antsilevich and A. D. Shevnin. (*Dokl. Akad. Nauk SSSR*, vol. 135, pp. 298–300; November 11, 1960.) The results of the investigation show that the rate at which the intensity of the magnetic field decreases with height is greater than the calculated one. A graph indicates this variation for heights between 15,000 km and 34,000 km.

551.507.362.2 546

Osculating Elements Derived from the Modified Hansen Theory for the Motion of an Artificial Satellite—A. Bailie and R. Bryant. (*Astrophys. J.*, vol. 65, pp. 451–453; October, 1960.) Musen's development of the Hansen theory for the motion of an artificial satellite can also lead to an expression for the velocity vector and osculating elements, as well as for the gravitational perturbations.

551.507.362.2 547

An Algorithm Applicable to Numerical Integration of Orbits in Multirevolution Steps—C. J. Cohen and E. C. Hubbard. (*Astrophys. J.*, vol. 65, pp. 454–456; October, 1960.)

551.507.362.2 548

Variations in the Orbit of the Echo Satellite—R. Jastrow and R. Bryant. (*J. Geophys. Res.*, vol. 65, pp. 3512–3513; October, 1960.) Minitrack observations of the Echo satellite show that, owing to the sun's radiation pressure, the perigee distance and eccentricity of the orbit are varying at rates which are in good agreement with the theoretical rates. The observations also lead to a value for atmospheric density at a height of 1500 km.

551.507.362.2:621.391.812.6 549

Evidence of Satellite-Induced Ionization Effects between Hemispheres—J. D. Kraus. (PROC. IRE, vol. 48, pp. 1913–1914; November, 1960.) Signal enhancement over a 330-mile path is correlated with reflection from ionization caused by Sputnik III. This occurred when the satellite was in both the northern and the southern auroral zones, and an explanation for this is advanced.

551.510.535 550

Some Studies of Bifurcation of the Ionospheric F Layer into F_1 and F_2—C. S. G. K. Setty. (*J. Atmos. Terrest. Phys.*, vol. 19, pp. 82–87; October, 1960.) Ionograms recorded at frequent intervals at Cambridge in 1954 and 1955 show how the F layers develop at sunrise, on quiet and disturbed days, and at different seasons.

551.510.535 551

A Pre-sunrise Phenomenon and the Presence of Negative Ions in the F Region of the Ionosphere—C. S. G. K. Setty. (*J. Atmos. Terrest. Phys.*, vol. 19, pp. 88–94; October, 1960.) Increases of F-layer electron density, which occur about two hours before ground sunrise, might be due to photodetachment of electrons from negative ions.

551.510.535 552

A Test of a Procedure for Easy Estimation of Representative Monthly Electron Density Profiles for the Ionosphere—J. W. Wright. (*J. Geophys. Res.*, vol. 65, pp. 3215–3217; October, 1960.) The profile produced from the mean of the daily virtual-height curves is well within one standard deviation of the mean of the individual profiles.

551.510.535 553

A Study of Observed Spread-F—J. Renau. (*J. Geophys. Res.*, vol. 65, pp. 3219–3240; October, 1960.) Examination of a large number of ionograms shows the effect of using different receiver gain settings, and reveals a "night-F_1" phenomenon. The degree of spreading varies with magnetic dip.

551.510.535 554

The Possible Importance of Nitric Oxide Formation during Polar-Cap Ionospheric Absorption Events—L. Herzberg. (*J. Geophys. Res.*, vol. 65, pp. 3505–3508; October, 1960.) Polar-cap absorption is attributed to an increase in abundance of NO, the probable ionizable constituent of the D region. A possible mechanism depends on the production of N atoms by cosmic-ray particles. The ionization of NO must occur above 70 km; alternative theories of polar-cap absorption, involving photodetachment of electrons from O_2 ions, require the ionization to be much lower.

551.510.535:523.75 555

Ionospheric Disturbances following a Solar Flare—G. E. Hill. (*J. Geophys. Res.*, vol. 65, pp. 3183–3207; October, 1960.) The perturbations of $f_{\min}$, f_0E_s and f_0F_2 following the great flare on September 11, 1957, are shown on polar projection maps. The $f_{\min}$ charts differ significantly from those of Obayashi and Hakura (2376 of 1960) for the same period. The $f_{\min}$ disturbance during the geomagnetic storm forms an elliptic ring with the E_s concentrated in crescent-shaped areas inside it. The results are discussed theoretically.

551.510.535:523.78 556

Back-Scatter Experiments during the Total Eclipse of October 2, 1959—C. Malik, J. Aarons, and H. Poeverlein. (*J. Geophys. Res.*, vol. 65, pp. 3241–3247; October, 1960.) The eclipse perturbations could not be clearly separated from those due to other disturbances.

551.510.535:523.78 557

Eclipse Effects on the F Layer at Sunrise—C. S. G. K. Setty. (*J. Atmos. Terrest. Phys.*, vol. 19, pp. 73–81; October, 1960.) An analysis of electron-density variations during the solar eclipse of September, 1951, which took place near sunrise in Maryland, U. S. About 30 per cent of the ionizing radiation may have originated outside the solar disk.

551.510.535:523.78 558

Eclipse Effects on the F_1 Layer Observed at Cambridge on 30 June 1954—C. S. G. K. Setty (*J. Atmos. Terrest. Phys.*, vol. 19, pp. 95–101; October, 1960.) Variations of f_0F_1 during the solar eclipse of June, 1954, are discussed. About 10 per cent of the ionizing radiation may have originated outside the solar disk.

551.510.535:550.385.37 559

A Connexion between P_c and the F Region.—H. J. Duffus. (*Nature, London*, vol. 188, pp.

719–721; November 26, 1960.) The diurnal variation of geomagnetic micropulsations of the P_c type near the equator is inversely related to the diurnal variation of the true electron density at 280 km. The interpretation of this result is that the source of P_c oscillations lies above the ionosphere.

551.510.535:551.507.362.1 560

Determination of Electron Density in the Ionosphere from the Rotation of the Plane of Polarization of Radio Waves Emitted by a Rocket—K. I. Gringauz and V. A. Rudakov. (*Dokl. Akad. Nauk SSSR*, vol. 132, pp. 1311–1313; June 21, 1960.) Rocket investigations on August 27, 1958, at heights up to 450 km and at frequencies of 24, 48, and 144 Mc are reported. A graph shows the variation of electron density with altitude.

551.510.535:621.3.087.4 561

Reducing Interference in Ionospheric Sounding—K. Perry. (*Electronics*, vol. 33, pp. 118–120; May 27, 1960.) A special circuit is described for separating the desired pulses from interfering CW signals.

551.510.535(98):523.75 562

Solar Corpuscular Radiation and Polar Ionospheric Disturbances—T. Obayashi and Y. Hakura. (*J. Geophys. Res.*, vol. 65, pp. 3131–3142; October, 1960.) Typical examples of abnormal absorption at high latitudes are described and compared for 1) low-energy cosmic ray events, 2) geomagnetic storms, and 3) combined cosmic-ray events and storms. The energy spectra of the solar particles involved are discussed and summarized.

551.510.535(99) 563

The Ionosphere over Halley Bay—W. H. Bellchambers and W. R. Piggott. (*Proc. Roy. Soc. A*, vol. 256, pp. 200–218; June 21, 1960. Discussion.) "The ionospheric phenomena observed at Halley Bay are briefly described and the influence of the Weddell Sea magnetic dip anomaly stressed. Some ionization is generated in the lower ionosphere by solar photo-ionization processes at solar zenith angles up to about 100°. The F_2-layer variations appear to be dominated by movements of ionization which can also be seen near the maximum of the F_1 layer. Ionization drift velocities in the E region reverse with season and are greater in winter than in summer. Other features of drift and absorption are generally consistent with those expected."

551.510.535(99):523.164 564

Ionospheric Drifts determined from Radio Star Scintillation Observations—P. M. Brenan. (*Proc. Roy. Soc. A*, vol. 256, pp. 222–229; June 21, 1960.) Spaced-receiver observations have been made at Halley Bay, and ionospheric velocities have been deduced from the motion of the diffraction pattern over the ground. Both the time of midnight reversal and the drift speed correlate well with Evans' measurements of motions of auroral forms (*See* 568.)

551.594.5 565

Spiral Patterns in Geophysics—V. Agy. (*J. Atmos. Terrest. Phys.*, vol. 19, pp. 136–140; October, 1960.) The spiral patterns found in recent analyses of magnetic and ionospheric data are incompatible with Störmer theory.

551.594.5 566

Latitude Distribution and Seasonal Variation of Aurora over the British Isles during 1957 and 1958—B. McInnes and K. A. Robertson. (*J. Atmos. Terrest. Phys.*, vol. 19, pp. 115–125; October, 1960.)

551.594.5:621.396.96 567

On the Origin of Radar Echoes associated with Auroral Activity—J. Meos and S. Olving. (*Chalmers Tekn. Högsk. Handl.*, no. 196, 20 pp.; 1958. In English.) Observations at Kiruna, Sweden, at 30 Mc indicate that the predominant echo mechanism is closely connected with ionized and often invisible auroral forms which are directed along the geomagnetic field.

551.594.5(99) 568

Systematic Movements of Aurorae at Halley Bay—S. Evans. (*Proc. Roy. Soc. A*, vol. 256, pp. 234–240; June 21, 1960.) All-sky photographs have been used to determine the movement of individual auroral features, on the assumption of a fixed height of occurrence. (See also 518 of 1960.)

551.594.5(99) 569

Auroral Results from Halley Bay during the International Geophysical Year—G. M. Thomas. (*Proc. Roy. Soc. A*, vol. 256, pp. 241–244; June 21, 1960. Discussion.)

551.594.5(99):621.396.96 570

Auroral Radio Echoes at Halley Bay—D. P. Harrison. (*Proc. Roy. Soc. A*, vol. 256, pp. 229–234; June 21, 1960.) The echoes observed are shown to fit closely the case of specular reflection from columns of ionization aligned along the local magnetic field at a height of about 100 km.

551.594.6 571

The Effect of Proton Gyration in the Outer Atmosphere represented on the Dispersion Curve of Whistler—T. Ondoh and S. Hashizume. (*J. Geomag. Geoelect.*, vol. 12, no. 1, pp. 32–37; 1960.) Whistlers observed at Kyoto, geomagnetic latitude 24.7°N, reach a height of 1350 km. The dispersion of a very pure whistler at Kyoto in 1958 was measured from 10 kc to less than 1 kc and compared with that calculated using the complete dispersion law. It is concluded that the dispersion was influenced by the effect of proton gyration.

551.594.6 572

Propagation of Whistlers to Polar Latitudes—G. McK. Allcock. (*Nature, London*, vol. 188, pp. 732–733; November 26, 1960.) An analysis of observations made in New Zealand, North America, and Antarctica of the dispersion characteristics of a whistler associated with a depression which occurred in the area of the Tasman Sea at 0836 UT on April 7, 1949. Reception of this whistler in the Antarctic would imply a final stage of propagation under the ionosphere for more than 2800 km.

551.594.6:621.391.82 573

Observations of Earth-Ionosphere Cavity Resonances—Balser and Wagner. (*See* 688.)

LOCATION AND AIDS TO NAVIGATION

534.88:621.396.962.25/3 574

An Experimental Comparison between a Pulse and a Frequency-Modulation Echo-Ranging System—L. Kay. (*J. Brit. IRE*, vol. 20, pp. 785–796; October, 1960.) A wide-band pulse system provides higher range resolution than the FM system, which in turn is superior to a pulse system of limited bandwidth. (See also 1893 of 1959.)

621.396.663 575

The Wave Analyser: Equipment for the Simultaneous Direction-Finding of Several Incident Wave Trains—K. Baur. (*Frequenz*, vol. 14, pp. 41–46; February, 1960.) To overcome problems arising from multipath propagation a system of analyzing the interference pattern at the aerial array is proposed which makes use of computer circuitry. Examples are discussed of single-, two-, and three-wave direction finders.

621.396.932.2 576

A Microwave Position-Fixing System—H. R. Smyth. (*J. Inst. Nav.*, vol. 13, pp. 164–172; April, 1960.) A narrow-beam rotating aerial on board ship operates in conjunction with shore-based beacon transmitters. The bearings of the beacons relative to north are displayed in digital form with a discrimination of 0.02°. Field tests on the system are described.

621.396.933.23:621.376.22 577

Mechanical Modulator uses Variable Capacitance—J. Habra. (*Electronics*, vol. 33, pp. 68–69; October 28, 1960.) Description of a modulator for a landing guidance system using a mechanically rotated capacitor and a hybrid ring to give a constant characteristic impedance and modulation depth.

621.396.96:629.13.052 578

Electrical Measurement of Altitude: Part 1—Physical Fundamentals—H. J. Zetzmann. (*Arch. tech. Messen*, no. 289, pp. 21–34; February, 1960.) Operating principles of terrain-clearance and radar-type altimeters are outlined. 43 references.

621.396.962.2:621.373.421.13 579

The Importance of Constant Frequencies for C.W. Radar Techniques and the Achievement of High Frequency Stability—W. Herzog. (*Nachrichtentech. Z.*, vol. 13, pp. 29–33; January, 1960.) Circuit and performance data are given for highly-stable crystal oscillators of simple construction.

621.396.962.3 580

Getting High Range Resolution with Pulse-Compression Radar—G. P. Ohman. (*Electronics*, vol. 33, pp. 53–57; October 7, 1960.) [See also 2023 of 1960 (Cook).]

MATERIALS AND SUBSIDIARY TECHNIQUES

535.215 581

Grain-Boundary Photoresponse—W. W. Lindemann and R. K. Mueller. (*J. Appl. Phys.*, vol. 31, pp. 1746–1751; October, 1960.) A discussion of measurements indicating the limitations to the sensitivity of grain-boundary photocapacitors and spectral response data showing absorption-edge irregularities.

535.215 582

Measurements on Multi-alkali Photocathodes—G. Frischmuth-Hoffmann, P. Görlich, H. Hora, W. Heimann, and H. Marseille. (*Z. Naturf.*, vol. 15a, pp. 648–650; July, 1960.) A (Cs-Na-K)Sb cathode, similar to that studied by Spicer (825 of 1959), is investigated and the quantum yield determined. Comparisons are made with results of measurements on Cs_3Sb cathodes [3838 of 1958 (Görlich and Hora)].

535.215 583

Photoelectric Properties of Anodically Produced Titanium and Niobium Oxide Layers—J. Rupprecht. (*Naturwiss.*, vol. 47, pp. 127–128; March, 1960.)

535.215:546.48'221 584

The Problem of Space-Charge-Limited Currents in CdS Crystals—E. Schnürer. (*Z. Naturforsch.*, vol. 15a, pp. 645–647; July, 1960.) Measurements of photocurrent/voltage characteristics were made on CdS cells with Au electrodes after X-ray bombardment. The mechanism governing the changes in photocurrent is discussed on the basis of these results. [See also 1622 of 1959 (Wright).]

535.215:546.48'221 585

An Improved Method of Growing CdS Crystals from the Vapour Phase—P. D. Fochs. (*J. Appl. Phys.*, vol. 31, pp. 1733–1734; October, 1960.)

535.215:546.681'221'241 586
Photoconductivity in Gallium Sulphoselenide Solid Solutions—R. H. Bube and E. L. Lind. (*Phys. Rev.*, vol. 119, pp. 1535–1547; September 1, 1960.) The photoconductivity characteristics of solid solutions of GaSe and GaS have been investigated for proportions of GaS between 10 and 50 per cent. The results indicate that the photocurrent is carried primarily by holes.

535.215:546.817–31 587
On the Photoconductive Properties of Lead Monoxide—M. Wada, T. Takahashi, and T. Seki. (*Sci. Rep. Res. Inst. Tohoku Univ., B*, vol. 11, no. 1, pp. 55–61; 1959.)

535.215:548.0 588
Toroidal Energy Surfaces in Crystals with Wurtzite Symmetry—R. C. Casella. (*Phys. Rev. Lett.*, vol. 5, pp. 371–373; October 15, 1960.)

535.37:546.48'221 589
Change in Structure of Blue and Green Fluorescence in Cadmium Sulphide at Low Temperatures—L. S. Pedrotti and D. C. Reynolds. (*Phys. Rev.*, vol. 119, pp. 1897–1898; September 15, 1960.)

535.376:546.47'221 590
The influence of the Excitation Wavelength of Electrophotoluminescence—H. Gobrecht and H. E. Gumlich. (*Z. Phys.*, vol. 158, pp. 226–241; February 18, 1960.) Investigation of the electrophotoluminescence of ZnS-Mn as a function of the wavelength of the ultraviolet light used for excitation. A model of the field enhancement and quenching of luminescence is derived which is in agreement with earlier results. (3894 of 1960.)

537.227 591
Ferroelectricity in Potassium Ferrocyanide Trihydrate and its Isomorphous Substances—S. Waku, K. Masuno, T. Tanaka, and H. Iwasaki. (*J. Phys. Soc. Japan*, vol. 15, pp. 1185–1189; July, 1960.)

537.227:546.431'824–31 592
Measurements of the Dielectric Constant of $BaTiO_3$ Single Crystals in the Paraelectric Region at *X* Band—A. Lurio and E. Stern. (*J. Appl. Phys.*, vol. 31, pp. 1805–1809; October, 1960.)

537.228.1:549.514.51 593
V.H.F. Crystal Polishing and the Nature of Polished Quartz Surfaces—I. Ida and Y. Arai. (*Rev. Elect. Commun. Lab., Japan*, vol. 8, pp. 119–174; March/April, 1960.)

537.311.33 594
The Theory of Ion Motion in Semiconductors—F. Ollendorff. (*Arch. Elektrotech.*, vol. 45, pp. 10–26; February 17, 1960.) Phenomenological description of ion motion in an homogeneous isotropic semiconductor. The shortcomings of the theoretical results are discussed with the aid of a numerical example.

537.311.33 595
Note on the Field Dependence of the Mobility in Semiconductors—M. Hattori and H. Sato. (*J. Phys. Soc. Japan*, vol. 15, pp. 1237–1242; July, 1960.) By assuming that the mobility μ can be expanded in powers of the field field strength F as $\mu=\mu_0(1-\nu F^2)$, ν is calculated for nonpolar and polar semiconductors, neglecting collisions between electrons. [See also 1284 of 1960 (Sato).]

537.311.33 596
Surface Space-Charge Calculations for Semiconductors—D. R. Frankl. (*J. Appl. Phys.*, vol. 31, pp. 1752–1754, October, 1960.) "Approximation formulas for the surface excesses of carriers at large values of the reduced surface and bulk potentials are derived, and computed results are presented."

537.311.33 597
Solubility of Flaws in Heavily Doped Semiconductors—W. Shockley and J. L. Moll. (*Phys. Rev.*, vol. 119, pp. 1480–1482; September 1, 1960.) A simple model is presented which shows how the solubility of a charged impurity in a semiconductor depends upon the Fermi level.

537.311.33 598
Cascade Capture of Electrons in Solids—M. Lax. (*Phys. Rev.*, vol. 119, pp. 1502–1523; September 1, 1960.) Giant trapping cross-sections associated with Coulomb attractive centers are explained in terms of a high rate of capture into highly excited states, followed by a cascade process in which a certain fraction of the captured electrons reach the ground state.

537.311.33 599
Theory of Hot-Electron Effects in Many-Valley Semiconductors in the Region of High Electric Field—H. G. Reik, H. Risken, and G. Finger. (*Phys. Rev. Lett.*, vol. 5, pp. 423–425; November 1, 1960.)

537.311.33:061.3 600
Physics of Semiconductors—R. A. Smith. (*Nature, Lond.*, vol. 188, pp. 632–633; November 19, 1960.) Report of a conference held in Prague, August 29 through September 2, 1960.

537.311.33:534.28 601
Interaction of Conduction Electrons with Acoustic Waves in Many-Valley Semiconductors—N. Mikoshiba. (*J. Phys. Soc. Japan*, vol. 15, pp. 1189–1199; July, 1960.) A self-consistent semiclassical method is applied to many-valley semiconductors such as *n*-type Ge to clarify the characteristic features of the interaction of conduction electrons with acoustic waves.

537.311.33:536.21.083 602
Measurement of Thermal Conductivity in Semiconductors—R. Nii. (*Rev. Elect. Commun. Lab., Japan*, vol. 8, pp. 99–104; March/April, 1960.) Measurements on single crystals of Bi_2Te_2, PbTe, and InSb in the temperature range 100°–600°K.

537.311.33:538.632 603
Hall Field Relaxation in Semiconductors at High Frequency—K. S. Champlin. (*J. Appl. Phys.*, vol. 31, pp. 1770–1771; October, 1960.) "Using a simple extension of standard magnetoionic theory, the frequency dependence of the complex Hall field is calculated for samples with rectangular, cylindrical, and spherical geometry. The result has application to "open-circuit" Hall effect measurements on semiconductors at microwave frequencies."

537.311.33:546.28 604
Resonant Spin-Spin Interaction between Donors and Acceptors in Silicon—R. A. Levy. (*Phys. Rev. Lett.*, vol. 5, pp. 425–427; November 1, 1960.)

537.311.33:546.28 605
Valence Band Parameters in Silicon from Cyclotron Resonances in Crystals subjected to Uniaxial Stress—J. C. Hensel and G. Feher. (*Phys. Rev. Lett.*, vol. 5, pp. 307–309; October 1, 1960.)

537.311.33:546.28 606
Paramagnetic Resonance Absorption from Acceptors in Silicon—G. Feher, J. C. Hensel, and E. A. Gere. (*Phys. Rev. Lett.*, vol. 5, pp. 309–311; October 1, 1960.) The resonance signal is observed after the removal of the degeneracy of the valence band by subjecting *p*-type Si to uniaxial stress.

537.311.33:546.28 607
Note on the Treatment of Impurity Scattering in Optical Absorption in Semiconductors—B. Donovan. (*Proc. Phys. Soc.*, vol. 76, pp. 574–577; October 1, 1960.)

537.311.33:546.28 608
Metal Precipitates in Silicon *p-n* Junctions—A. Goetzberger and W. Shockley. (*J. Appl. Phys.*, vol. 31, pp. 1821–1824; October, 1960.) The precipitates were found to cause excess reverse current below the avalanche breakdown. This current varies as V^n where $4<n<7$. "Gettering" can be used to remove the precipitates.

537.311.33:546.28:535.215 609
Anomalous Surface Channels on Silicon *p-n* Junctions—R. Solomon. (*J. Appl. Phys.*, vol. 31, pp. 1791–1799; October, 1960.) Evidence is offered to show that multiple trapping of injected carriers occurs at surface interface states. A chopped monochromatic light source was directed on to the surface and the change of phase of the output current with movement of the surface compared against a reference source.

537.311.33: [546.289+546.28 610
Measurement of the Coefficient of Photoelasticity of Germanium—C. Grandjean and F. Desvignes. (*C. R. Acad. Sci., Paris*, vol. 250, pp. 1183–1185; February 15, 1960.) Description of a mounting used for studying the optical properties of Si and Ge.

537.311.33:546.289 611
Oscillations in Germanium with an Applied Pulsed Electric Field—M. Cardona and W. Ruppel. (*J. Appl. Phys.*, vol. 31, pp. 1826–1827; October, 1960.) A report of current oscillations were observed in uniformly doped *p*-type Ge with rectifying contacts in the absence of a magnetic field. Voltages were measured across a 50-Ω load in series with the sample. A minimum of 30 v was required to produce oscillations and the frequency varied between 5 kc and 5 Mc, depending on the position of the contacts.

537.311.33:546.289 612
Low-Temperature Impurity Conduction and Magnetoresistivity in *n*-Type Germanium—P. Csavinszky. (*Phys. Rev.*, vol. 119, pp. 1605–1609; September 1, 1960.) The resistivity of several lightly Sb-doped *n*-type Ge samples has been calculated and compared with values measured at 2.5°K. An order-of-magnitude agreement has been obtained. Similar agreement has been obtained for the magnetoresistive ratio.

537.311.33:546.289 613
Effect of Shear on Impurity Conduction in *n*-Type Germanium—H. Fritzsche. (*Phys. Rev.*, vol. 119, pp. 1899–1900; September 15, 1960.) A method is described of studying the shape of the donor wave functions at large distances from the donor atom by means of the effect of shear stress on impurity conduction.

537.311.33:546.289 614
Absorption Spectra and Zeeman Effect of Copper and Zinc Impurities in Germanium—P. Fisher and H. Y. Fan. (*Phys. Rev. Lett.*, vol. 5, pp. 195–197; September 1, 1960.)

537.311.33:546.289 615
Interaction of High-Energy Phonons in Germanium—G. Ascarelli. (*Phys. Rev. Lett.*, vol. 5, pp. 367–369; October 15, 1960.) Transport of energy by phonons excited by hot electrons is observed experimentally. An average phonon energy and an average phonon mean free path are evaluated.

537.311.33:546.289 616
A Reversed Carrier Transport Effect in Germanium—A. C. Prior. (*Proc. Phys. Soc.*,

vol. 76, pp. 465–480; October 1, 1960.) The variation of the electron/hole mobility ratio with electric field is theoretically and experimentally shown to influence substantially the motion of a density distribution in near intrinsic material at high fields. In *n*-type Ge the normal motion can be reversed, and the possibility of injection or extraction from the negative end of an *n*-type specimen should be considered. An apparent negative resistance has been observed and a tentative explanation is given. Changes in mobility ratio with mechanical stress at high field levels have been investigated.

537.311.33:546.289:535.215 617
Interband Photoconductivity in Germanium—T. S. Moss and T. D. H. Hawkins. (*Proc. Phys. Soc.*, vol. 76, pp. 565–566; October 1, 1960.) Interband photoconductivity has been observed by recording and comparing spectral sensitivity curves for specimens at room and at liquid-nitrogen temperatures. The time spent by a carrier in the split-off band before returning to the heavy-hole band is estimated to be 4 to 14×10^{-12} second.

537.311.33:546.289:538.214 618
The Magnetic Susceptibility of Iron- and Zinc-Doped Germanium—D. Geist. (*Z. Phys.*, vol. 158, pp. 123–132; February 18, 1960.) The shift in diamagnetic susceptibility observed in Fe-doped single-crystal Ge is caused by ferromagnetic precipitates and is independent of the field. The suspected temperature dependence of susceptibility of Zn-doped material could not be measured owing to the low solubility of Zn. (See also 232 of January.)

537.311.33:546.289:538.569.4 619
New Electron Spin Resonance Spectrum in Antimony-Doped Germanium—R. E. Pontinen and T. M. Sanders, Jr. (*Phys. Rev. Lett.*, vol. 5, pp. 311–313; October 1, 1960.)

537.311.33:546.289:541.135 620
The Role of Subsidiary Electric Charge Carriers in the Anodic Dissolution of a Germanium Electrode—Yu. V. Pleskov. (*Dokl. Akad. Nauk SSSR*, vol. 132, pp. 1360–1363; June 21, 1960.) Results of experiments show that for the passage of one Ge atom from the crystal lattice into solution, the ratio of holes used is 2.4 and the ratio of electrons migrating to the conduction band is 1.6. Graphs show the variation of current multiplication in the *p-n* junction with illumination.

537.311.33:546.47–31 621
Pressure Dependence of the Resistivity of Zinc Oxide—A. R. Hutson, W. Paul, W. Howard, and R. B. Zetterstrom. (*Z. Phys.*, vol. 158, pp. 151–154; February 18, 1960. In English.) "The change of resistivity of *n*-type ZnO with hydrostatic pressure has been found to be 2.2×10^{-6}/kg cm^{-2} and is nearly linear for pressures up to 2800° kg/cm^2. This result can be shown to be incompatible with a simple model of electron mobility which assumes that the scattering due to acoustic modes arises from a deformation potential associated with lattice dilation."

537.311.33:546.682'86 622
Anomalous Barrier Capacitance in *p-n* Junctions of InSb.—C. A. Lee and G. Kaminsky. (*J. Appl. Phys.*, vol. 31, pp. 1717–1719; October, 1960.) Reverse-bias transition capacitance measurements on alloy diodes of InSb at 78°K give values three times those calculated from normal diode theory.

537.311.33:546.824–31 623
Anisotropic Conduction in Nonstoichiometric Rutile (TiO_2)—L. E. Hollander, Jr., and P. L. Castro. (*Phys. Rev.*, vol. 119, pp. 1882–1885; September 15, 1960.) Measurements are reported and discussed in relation to conflicting published results.

537.311.33:[546.873'241+546.873'241 624
Dislocation Nets in Bismuth and Antimony Tellurides—P. Delavignette and S. Amelinckx. (*Phil. Mag.*, vol. 5, pp. 729–744; July, 1960.)

537.311.33:546.873'241 625
Infrared Faraday Rotation and Free Carrier Absorption in Bi_2Te_3—I. G. Austin. (*Proc. Phys. Soc.*, vol. 76, pp. 169–179; August 1, 1960.)

537.312.62:539.23 626
Critical Fields of Thin Superconducting Films—W. B. Ittner III. (*Phys. Rev.*, vol. 119, pp. 1591–1596; September 1, 1960.) The critical fields of thin superconducting films have been calculated on the basis of the Bardeen-Cooper-Schrieffer theory (1386 of 1958).

537.583 627
Density of a Thorium Monolayer for Maximum Thermionic Emission—W. E. Danforth and D. L. Goldwater. (*J. Appl. Phys.*, vol. 31, pp. 1715–1717; October, 1960.) The surface density is measured by a high-sensitivity analytical balance.

538.221 628
Anisotropy of the Intrinsic Domain Magnetization of a Ferromagnet—S. H. Charap. (*Phys. Rev.*, vol. 119, pp. 1538–1542; September 1, 1960.)

538.221 629
Eddy-Current Effects in Rectangular Ferromagnetic Rods—E. W. Lee (*Proc. IEE*, vol. 107, pt C, pp. 257–264; September, 1960.) Theoretical investigation of eddy-current distributions and the resulting loss angles.

538.221 630
Internal Ferromagnetic Resonance and Magnetostatic Modes in Nickel-Iron Alloys—J. C. Anderson. (*Proc. Phys. Soc.*, vol. 76, pp. 273–281; August 1, 1960.) (See also 1705 of 1960.)

538.221 631
The Magnetization of Ferromagnetic Binary Alloys of Cobalt or Nickel with Elements of the Palladium and Platinum Groups—J. Crangle and D. Parsons. (*Proc. Roy. Soc. A*, vol. 255, pp. 509–519; May 10, 1960.)

538.221 632
Bloch Wall Spacing in Thin SiFe Specimens of Cubic Texture—R. Brenner. (*Z. angew Phys.*, vol. 12, pp. 107–111; March, 1960.)

538.221 633
The Ferromagnetism of the Compound γ-FeSn—M. Asanuma. (*J. Phys. Soc. Japan*, vol. 15, pp. 1343; July, 1960.)

538.221:537.312.62 634
Properties of Some Magnetic Superconductors—R. M. Bozorth, D. D. Davis, and A. J. Williams. (*Phys. Rev.*, vol. 119, pp. 1570–1576; September 1, 1960.) Solid solutions in the system $GdRu_2$-$CeRu_2$, in which both ferromagnetism and superconductivity have been observed, are studied by magnetic methods.

538.221:538.652 635
The Saturation Magnetostriction Constants of Nickel within the Temperature Range—1960 to 365°C—R. R. Bires and E. W. Lee. (*Proc. Phys. Soc.*, vol. 76, pp. 502–506; October 1, 1960.)

538.221:538.653.1 636
The Remanence Characteristics of Stretched Polycrystalline Nickel Wires—C. Schwink and G. Zankl. (*Z. Phys.*, vol. 158, pp. 181–195; February 18, 1960.) Remanence was measured as a function of previously applied and removed tensile stress.

538.221:539.23 637
Formation of Very Thin Films of Nickel. Action of an Electric Field. Results—A. Colombani and G. Goureaux. (*C. R. Acad. Sci., Paris* vol. 250, pp. 1264–1266; February 15, 1960.)

538.221:539.23 638
Oblique-Incidence Anisotropy in Evaporated Permalloy Films—D. O. Smith, M. S. Cohen, and G. P. Weiss. (*J. Appl. Phys.*, vol. 31, pp. 1755–1762; October, 1960.)

538.221:539.23 639
Magnetization Reversal of Thin Magnetic Films in the Nanosecond Range—W. Dietrich and W. E. Proebster. (*Elektron. Rundschau*, vol. 14, pp. 47–49; February, 1960.) [See 2843 of 1960 and also 3591 of 1960 (Dietrich, *et al.*).]

538.221:539.23:621.385.833 640
Domains in Thin Magnetic Films Observed by Electron Microscopy—H. W. Fuller and M. E. Hale. (*J. Appl. Phys.*, vol. 31, pp. 1699–1705; October, 1960.) A new method for observing full domains in thin films, using an off-center objective aperture diaphragm as a knife edge.

538.221:621.318.124 641
Ceramic Permanent Magnets—J. W. Bunn and J. Harrison. (*Wireless World*, vol. 66, pp. 595–598; December, 1960.) A comprehensive review of the magnetic properties of Ba ferrite, and the manufacture and design details for permanent magnets are given. Various practical applications are discussed.

538.221:621.318.134 642
The Ferrimagnetism of Nonstoichiometric Iron Sulphides—R. Perthel. (*Ann. Phys., Lpz.*, vol. 5, pp. 273–295; February 8, 1960.)

538.221:621.318.134 643
The $k\pi$ Walls in Ferrites—M. Paulus. (*C. R. Acad. Sci., Paris*, vol. 250, pp. 1213–1215; February 15, 1960.) Report of powder-pattern investigations of the magnetization of single-crystal Ni ferrite containing <0.05 per cent Co, relating to the formation of multiple domain walls.

538.221:621.318.134 644
Exchange Interaction and Cubic Crystal Field Splitting Parameter of Fe^{3+} in Spinel Structure—Y. Sugiura. (*J. Phys. Soc. Japan*, vol. 15, pp. 1217–1222; July, 1960.)

538.221:621.318.134 645
Classical Theory of Spin Configurations in the Cubic Spinel—T. A. Kaplan. (*Phys. Rev.*, vol. 119, pp. 1460–1470; September 1, 1960.)

538.221:621.318.134 646
Magnetic Properties of Mn_3O_4 and the Canted-Spin Problems—K. Dwight and N. Menyuk. (*Phys. Rev.*, vol. 119, pp. 1470–1479; September 1, 1960.)

538.221:621.318.134 647
Adiabatic Demagnetization and Specific Heat in Ferrimagnets—J. E. Kunzler, L. R. Walker, and J. K. Galt. (*Phys. Rev.*, vol. 119, pp. 1609–1614; September 1, 1960.)

538.221:621.318.134 648
Magnetic Properties and Ferrimagnetic Resonance in Polycrystalline $3Y_2O_3\cdot(5-x)$ $Fe_2O_3\cdot x$ In_2O_3—Y. Shichijo and T. Miyadai. (*Rev. Elec. Commun. Lab., Japan*, vol. 8, pp. 12–17; January/February, 1960.)

538.221:621.318.134 649
Measurement of the Complex Permittivity and the Permeability Tensor of Ferrites in the

Millimetre Wave Range—D. I. Mash and V. V. Nikol'skiĭ. (*Z. Tekh. Fiz.*, vol. 29, pp. 1070–1073; September, 1959.) Graphs show the dependence of the components of the permeability tensor on the intensity of the constant magnetic field.

538.221:621.318.134:538.569.4 650

Ferromagnetic Resonance in Polycrystalline Ferrites—J. Snieder. (*Appl. Sci. Res.*, vol. B7, no. 3, pp. 185–232; 1958.) An experimental and theoretical study is made of the propagation of TE_{11} waves of wavelength 3.2 cm in a circular waveguide containing a rod of Ferroxcube IV magnetized by a static magnetic field in a longitudinal direction.

538.221:621.318.134:538.569.4 651

Interaction between High-Power Microwave Losses and Magnetic Flux Reversal—E. M. Gyorgy and F. B. Hagedorn. (*J. Appl. Phys.*, vol. 31, pp. 1775–1778; October, 1960.) Experiments on polycrystalline ferrite show that the spin waves associated with high-power off-resonance microwave absorption have a negligible effect on the flux reversal process. The latter has a marked effect on the high-power microwave loss.

538.221:621.318.134:538.569.4 652

Anisotropic Ferromagnetic Resonance Line Width in Ferrites—H. B. Callen and E. Pittelli. (*Phys. Rev.*, vol. 119, pp. 1523–1531; September 1, 1960.) The source of resonance line width in disordered magnetic materials such as ferrites is discussed theoretically.

538.221:621.318.134:538.569.4 653

Magnetic Resonance and Magnetocrystalline Anisotropy in Ytterbium Iron Garnet—R. F. Pearson and R. W. Teale. (*Proc. Phys. Soc.*, vol. 76, pp. 308–310; August 1, 1960.) A note of anomalous anisotropic resonance behavior observed in measurements on $Yb_3Fe_5O_{12}$.

538.221:621.318.134:538.652 654

Ultrasonic Measurement of Magnetization in Mn-Ferrite Single Crystal—K. Husimi, K. Nishiguchi, and T. Suzuki. (*J. Phys. Soc. Japan*, vol. 15, pp. 1341; July, 1960.) An ultrasonic method [3857 of 1958 (Husimi and Kataoka)] is shown to be adequate for measurement of magnetization without disturbing the domain configuration.

538.221:621.395.625.3 655

The Anhysteretic Remanence of Magnetic Recording Tapes—E. P. Wohlfarth. (*Phil. Mag.*, vol. 5, pp. 717–722; July, 1960.) The anhysteretic properties are discussed by introducing the idea of internal demagnetization spectra.

538.222:538.569.4 656

Cross-Relaxation Effect of Chromium and Iron in K_3 (Co, Cr, Fe)$(CN)_6$—J. M. Minkowski. (*Phys. Rev.*, vol. 119, pp. 1577–1578; September 1, 1960.)

538.222:538.569.4:535.37 657

Coherence, Narrowing, Directionality, and Relaxation Oscillations in the Light Emission from Ruby—R. J. Collins, D. F. Nelson, A. L. Schawlow, W. Bond, C. G. B. Garrett, and W. Kaiser. (*Phys. Rev. Lett.*, vol. 5, pp. 303–305; October 1, 1960.) The coherence and directionality of the radiation are experimentally verified and the line width measured. Relaxation oscillation has been observed in the fluorescence.

548.0 658

On Dislocations Formed by the Collapse of Vacancy Discs—C. Elbaum. (*Phil. Mag.*, vol. 5, pp. 669–674; July, 1960.) The formation of dislocations by the collapsing-vacancy-disk mechanism is examined for Al, Cu, Si, and Ge.

621.791.76:537.322.1 659

Investigations of the Influence of the Peltier Effect on Resistance Welds—S. Scholz. (*Z. angew. Phys.*, vol. 12, pp. 111–117; March, 1960.) The strength of welds between metals which differ thermoelectrically depends on the direction of the welding current. The magnitude of this effect is calculated and confirmed by experimental results.

MATHEMATICS

512.8 660

Multiple Products of Matrices of General Form—M. Dreikorn and F. Stockinger. (*Arch. Elekt. Übertragung*, vol. 14, pp. 54–56; February, 1960.) A general scheme of calculation is illustrated by a numerical example.

517.524:621.372.4 661

Further Theory of a Certain Continued Fraction—O. P. D. Cutteridge. (*Proc. IEE*, vol. 107, pt. C, pp. 234–237; September, 1960.) An extension is given to the determination of the zeros of a polynomial, illustrated by a numerical example in linear-network theory.

MEASUREMENTS AND TEST GEAR

531.76:621.374.33:621.385 662

Time Analyzer using a Crystal-Controlled Trochotron Tube—T. Dobrowolski and J. Walker. (*J. Sci. Instr.*, vol. 37, pp. 289–291; August, 1960.) A nine-channel timing system is described in which the output of a crystal oscillator is switched by a starting signal and then applied to a beam-switching tube which produces impulses to control the circuits which gate the signals to be timed.

621.317.328.029.6 663

On Measurements of Microwave $\hat{E}$ and $\hat{H}$ Field Distributions by using Modulated Scattering Methods—M. K. Hu. (IRE Trans. on Microwave Theory and Techniques, vol. MTT-8, pp. 295–300; May, 1960. Abstract, Proc. IRE, vol. 48, p. 1515; August, 1960.)

621.317.335.3:621.372.413 664

A New Cavity-Resonator Method for Measuring Permittivity—J. K. Sinha and J. Brown. (*Proc. IEE*, vol. 107, pt. B, pp. 522–530; November, 1960.) A cylindrical-rod specimen is inserted into the cavity, and the permittivity is derived from a plot of cavity length at resonance against length of rod inserted. The advantages of the method are discussed.

621.317.335.3.029.6:621.372.826 665

Application of Slow Surface Waves for the Measurement of Dielectric Constants of Substances at Ultra High Frequencies: Part 2—V. P. Shestopalov and K. P. Yatsuk. (*Zh. Tekh. Fiz.*, vol. 29, pp. 1090–1099; September 1959.) An extension of the method described in Part 1 (3984 of 1960) to liquid dielectrics in the dm-λ range.

621.317.335.3.029.6:621.372.826 666

Application of Slow Surface Waves for the Measurement of Dielectric Constants of Substances at Ultra High Frequencies: Part 3—V. P. Shestopalov, K. P. Yatsuk, and I. P. Yakumenko. (*Z. Tekh. Fiz.*, vol. 29, pp. 1330–1338; November, 1959.) The method is generalized for application to dielectrics with small losses. Formulas are derived for determining the loss angle of solid cylindrical samples and liquids. (Part 2: *see* 665.)

621.317.42 667

Investigation of Plane-Parallel Fields by means of Analogue Electrical Flux Fields—E. Schütz. (*Arch. Tech. Messen*, pp. 25–26; February, 1960.) The distribution of current flow in a metal foil is used as an analog for the purpose of magnetic-field plotting.

621.317.44:537.525 668

Magnetic Probes of High Frequency Response—S. E. Segre and J. E. Allen (*J. Sci. Instr.*, vol. 37, pp. 369–371; October, 1960.) Magnetic field distributions in pulsed discharges can be measured by probes having a response which is uniform within 1 per cent, up to 20 Mc.

621.317.7:621.372.44 669

A **Theory of Steady Forces in Variable-Parameter Networks**—W. E. Smith. (*Proc. IEE*, vol. 107, pt. C, pp. 228–233; September, 1960.) The theory is applicable for the absolute calibration of square-law measuring instruments.

621.317.7:621.391.822.029.64:621.387 670

Noise Generators for Centimetre Waves—R. Saier. (*Frequenz*, vol. 14, pp. 68–70; February, 1960.) The use of gas-discharge tubes as noise sources is considered; two generators for use at 3.3–4.9 and 5.85–8.2 Gc, respectively, are described.

621.317.7.029.64:621.316.72 671

A Power Stabilizer for Frequency-Modulated Microwave Oscillators—H. A. Dijkerman, C. Huiszoon, and A. Dymanus. (*Appl. Sci. Res.*, vol. B8, no. 1, pp. 1–7; 1959.) A description is given of a power stabilizer for the 1.25-cm-λ region which uses a ferrite modulator of special design and has a time constant of 10^{-4} seconds.

621.317.723:551.508.94 672

A Double Field Mill or the Measurement of Potential Gradients in the Atmosphere—D. R. Currie and K. S. Kreielsheimer. (*J. Atmos. Terrest. Phys.*, vol. 19, pp. 126–135; October, 1960.) It is possible to measure either the atmospheric potential gradient or the self-charge of the equipment.

621.317.733 673

Two-Signal Bridges—G. W. Short. (*Electronic Tech.*, vol. 37, pp. 452–455; December, 1960.) The use of two oscillators of different frequencies enables the input and output of the bridge to have a common terminal.

621.317.74:621.372.4/.5 674

An Instrument for the Automatic Determination of the Imaginary Part from the Real Part, and *vice versa*, for Network Functions of the Minimum-Phase Type—V. Pollak. (*Hochfrequenz. u. Elektroakust.*, vol. 69, pp. 7–11; February, 1960.)

621.317.77 675

Ratiometer Phase Angle Indicator—K. L. Morphew. (*J. Sci. Instr.*, vol. 37, pp. 300–302; August, 1960.) The principles of operation of a moving-coil ratiometer and associated circuits are described, and performance, adjustment, and calibration details of the complete instrument are given.

OTHER APPLICATIONS OF RADIO AND ELECTRONICS

535.376.07 676

Increasing the Brightness-Voltage Nonlinearity of Electroluminescent Devices—J. A. O'Connell and B. Narken. (*IBM J. Res. and Dev.*, vol. 4, pp. 426–429; October, 1960.) Marked improvement in the brightness/voltage nonlinearity and greatly enhanced discrimination ratios can be obtained by the inclusion of SiC resistive layers in series with electroluminescent elements.

551.508.822 677

Meteorological Measurement Techniques in the Free Atmosphere—M. Hinzpeter. (*Elektrotech. Z.*, *Edn. B.*, vol. 12, pp. 73–77; February 22, 1960.) Details are given of the German radiosonde Type H50 and of radiosondes in use in other countries.

621.385.833 678

The Depth of Focus of Electron-Optical Images obtained by Electrostatic Immersion Objectives—G. Bartz. (*Optik, Stuttgart*, vol. 17, pp. 135–142; March, 1960.) An approximation formula is derived for the depth of focus. Illustrations show a fivefold improvement in depth of focus relative to an optical microscope when an electrostatic immersion objective is used in a secondary-electron microscope.

621.398:623.451–519 679

Miniaturized Autopilot System for Missiles—J. H. Porter. (*Electronics*, vol. 33, pp. 60–64; October 21, 1960.) A detailed description is given of the electronic system which provides a series of control conditions during a 2000-second launch period. A magnetic shift register is used for programming flight operations.

PROPAGATION OF WAVES

621.391.812.62.029.63 680

The Installation of a 1.3-Gc/s Link between Prague and Kolberg near Berlin—P. Beckmann and U. Kühn. (*Radio u. Fernsehen*, vol. 9, pp. 71–73; February, 1960.) Field-strength measurements at Kolberg for transmissions at 1215 Mc over a 240-km path are discussed. [See also 1753 of 1960 (Kühn).]

621.391.812.62.029.63 681

Note on Microwave Propagation just Beyond Horizon in the Torrid Zone—S. Uda. (*Sci. Rep. Res. Inst. Tohoku Univ., B.*, vol. 11, no. 1, pp. 11–12; 1959.) Microwave propagation tests in the 2-Gc region have been made between Landour and New Delhi, India, over a distance of 224 km. Very strong night-time signals are shown to be due to atmsospheric temperature inversion.

621.391.812.624.029.63 682

A Note on Scatter Propagation—S. J. Martin. (PROC. IRE, vol. 48, pp. 1915–1916; November, 1960.) Some results are given for a 156-mile, 400- and 800-Mc scatter link. These include data on frequency-selective fading, the effect of beam width on path multiplication and the variations of fading rates with aerial elevation.

621.391.812.624.029.64 683

Propagation Measurements at 3480 and 9640 Mc/s beyond the Radio Horizon—G. V. Geiger, N. D. La Frenais, and W. J. Lucas. (*Proc. IEE*, vol. 107, pt. B, pp. 531–546; November, 1960.) Long-term measurements of median level and fading characteristics, mainly over path lengths of 173 and 247 miles, are described. For a considerable time the *X*-band *S*-band transmissions were made simultaneously over the same link. Aerial siting tests were also made. [See also 2000r of 1959 (Angell, *et al.*).]

621.391.812.63 684

The Variation of the Rate of Fading with Frequency—B. N. Singh and O. P. Sinha. (*J. Atmos. Terrest. Phys.*, vol. 19, pp. 141–143; October, 1960.) The number of peaks per hour is given by $0.3f \cos i$, where f is the operating frequency and i the angle of incidence at the ionosphere.

621.391.812.63.029.51 685

The Fading of Low-Frequency Radio Waves Reflected from the Ionosphere—W. A. Cilliers. (*J. Atmos. Terrest. Phys.*, vol. 19, pp. 102–114; October, 1960.) On all frequencies between 70 and 200 kc there is evidence of a quasi-periodic fading component of period roughly 7.5 minutes. This seems to be due to a quasi-sinusoidal irregularity in the ionosphere having a spatial period of order 20 km and a speed of 35 m/s.

RECEPTION

621.391.812.63:621.3.018.41(083.74) 686

Continuous Recordings of the Frequency Variation of the WWV-20 Signal after Propagation over a 4000-km Path—R. C. Fenwick and O. G. Villard, Jr. (*J. Geophys. Res.*, vol. 65, pp. 3249–3260; October, 1960.) Shifts of 1 part in 10^7 were observed morning and evening. During magnetic disturbances shifts of 3 parts in 10^7 were found.

621.391.812.63.029.62 687

V.H.F. and Television Reception over Great Distances—J. Kornfeld and E. Schenner. (*Radioschau*, vol. 10, pp. 48–50, February/March, 1960.) Report on observations in Austria of transhorizon reception in the frequency range 30–100 Mc during the period 1958 through September, 1959.

621.391.82:551.594.6 688

Observations of Earth-Ionosphere Cavity Resonances—M. Balser and C. A. Wagner. (*Nature, London*, vol. 188, pp. 638–641; November 19, 1960.) A report is given of equipment used and results obtained from experiments to observe cavity effects in the region of the theoretical fundamental-mode frequency of 10.6 cps. Final results, produced by simulated spectrum analysis on a digital computer, give five resonance modes in the range 5–34 cps with a frequency of 7.8 cps for the first peak and $Q=4$ for the cavity. (See 4382 of 1960 for a report of earlier work.)

621.396.62.029.62:621.391.822 689

The Technique of Low-Noise Input Circuits in the 100-Mc/s Region—R. Cantz. (*Telefunken-Röhre*, no. 33a, pp. 105–146; January, 1960.) The relative importance of aerial noise and the low noise figure of an FM receiver input stage is discussed. Several modern input circuits are described, and the influence of aerial bandwidth on the noise figure of VHF receivers is considered.

STATIONS AND COMMUNICATION SYSTEMS

621.376:621.396:681.84.087.7 690

Interrelation and Combination of Various Types of Modulation—W. D. Meewezen. (PROC. IRE, vol. 48, pp. 1824–1832; November, 1960.) Reprint. (See 2157 of 1960).

621.376.3 691

R.F. Spectra of Waves Frequency-Modulated with White Noise—R. G. Medhurst. (*Proc. IEE*, vol. 107, pt. C, pp. 314–323; September, 1960.) Results of analyses are presented as curves covering the range of modulation parameters likely to be found in multi-channel radiotelephone systems using frequency-division multiplex. [See also 2546 of 1958 (Medhurst, *et al.*).]

621.391 692

Traffic Efficiencies in Congested Band-Radio Systems—J. H. Weber: J. P. Costas. (PROC. IRE, vol. 48, pp. 1910–1911; November, 1960.) Comment on 1011 of 1960 and author's reply.

621.391 693

Orthogonal Codes—H. F. Harmuth. (*Proc. IEE*, vol. 107, pt. C, pp. 242–248; September, 1960.) A discussion is given by the use of sine and cosine functions for nonbinary code alphabets.

621.396.65:621.396.43 694

Nonlinear Distortion due to Line Reflections in Radio-Link Multiplex Systems—W. Mansfeld. (*Nachrtech. Z.*, vol. 10, pp. 33–38; January, 1960.) Matching problems in radio-link muliichannel telephony systems are investigated. (See also 2232 of 1958.)

621.396.712 695

Planning and Installation of the Sound Broadcasting Headquarters for the B.B.C.'s Overseas and European Services—F. Axon and O. H. Barron. (*Proc. IEE*, vol. 107, pt. B, pp. 485–496; November, 1960. Discussion, pp. 496–498.)

621.396.722:551.5 696

The Radio Receiving Station of the German Meteorological Service in Offenbach a.M—K. Fischer and P. Wüsthoff. (*Elektrotech. Z., Edn. B*, vol. 12, pp. 78–82; February 22, 1960.) The design and equipment of the central receiving station for weather reports are discussed.

621.396.722:621.391.812.63 697

Improved Communications using Ground Scatter Propagation—R. T. Woltram. (*Electronics*, vol. 33, pp. 74–78; October 28, 1960.) Description of a "pin-wheel sounder" for propagation research giving a CRO display of signal azimuth.

621.396.934 698

Missile Communication during Re-entry Blackout—K. M. Baldwin, O. E. Bassett, E. I. Hawthorne, and E. Langberg. (*Elektronics*, vol. 33, pp. 105–109; May 27, 1960.) The choice of a sufficiently high communication frequency and other special features of the telemetry transmitting and receiving equipment, which are intended to overcome the blackout effect due to plasma sheath formation, are considered.

621.396.97 699

Methods of Obtaining an Optimum Monophonic Broadcast Transmission System—G. Steinke. (*Tech. Mitt. BRF, Berlin*, vol. 4, pp. 21–32; March, 1960.) Listening conditions in the home, the characteristics of monitoring installations, and broadcast recording techniques are discussed. 33 references.

621.396.97:534.76 700

Stereophonic Broadcasting using Pulse Amplitude Modulation—H. F. Mayer and F. Bath. (*Rundfunktech. Mitt.*, vol. 3, pp. 174–179; August, 1959.) A time-multiplex PAM method compatible with normal reception and requriin a single channel of slightly greater bandwidth is described. [See also 334 of January, 1961 (Janus).]

SUBSIDIARY APPARATUS

621–526 701

The Stabilization of Control Systems with Backlash using a High Frequency On-Off Loop—E. A. Freeman. (*Proc. IEE*, vol. 107, pt. C, pp. 150–157; September, 1960.) An auxiliary loop is used to drive the motor across backlash in the gears whenever the motor and load tend to separate.

621–526 702

The Effect of an Additional Nonlinearity on the Performance of Torque-Limited Control Systems Subjected to Random Inputs—J. L. Douce and R. E. King. (*Proc. IEE*, vol. 107, pt. C, pp. 190–197; September, 1960.) The addition of a nonlinear error detector gives an improved response.

621–526 703

A Calculation of Switching Functions as a Means of Minimizing Error in an On-Off Control System—R. F. Brown. (*Proc. IEE*, vol. 107, pt. C, pp. 249–256; September, 1960.) Adaptive switching functions are discussed, and the principles illustrated on a mathematical model of an ideal servomechanism.

621–526 704

Extension of the Dual Input Describing-Function Technique to Systems containing Re-

active Nonlinearity—R. M. Huey, O. Pawloff, and T. Glucharoff. (*Proc. IEE*, vol. 107, pt. C, pp. 334–341; September, 1960.) An extension of the work of Kochenburger (see 224 of 1951) and of West, *et al.* (3223 of 1956), enabling the nonlinear coefficient to be associated with any term in the differential equation.

621.316.722.078 705

The Stabilization of Direct-Voltage Supplies—E. Cassignol, G. Giralt, and Y. Sevely. (*C. R. Acad. Sci., Paris*, vol. 250, pp. 1218–1220; February 15, 1960.) A functional diagram is proposed for studying the control and stabilization of a dc supply system under load and no-load conditions.

621.318.57:621.314.63 706

Designing Solid-State Static Power Relays—R. F. Blake. (*Electronics*, vol. 33, pp. 114–117; May 27, 1960.) The performance and design of relay circuits using Si controlled rectifiers is considered.

621.362:621.387 707

Construction of a Thermionic Energy Converter—F. G. Block, F. H. Corregan, G. Y. Eastman, J. R. Fendley, K. G. Hernqvist, and E. J. Hills. (PROC. IRE, vol. 48, pp. 1846–1852; November, 1960.) A discussion is given of design data for a Cs-vapor type of energy converter. The construction and testing of a high-power unit is described.

TELEVISION AND PHOTOTELEGRAPHY

621.397:621.391.8 708

Observations of Television Reception in Band IV—U. Dietz, H. Hopf, and N. Mayer. (*Rundfunktech. Mitt.*, vol. 4, pp. 23–30; February, 1960.) Report on comparative tests in the Hamburg area using band III and band IV transmitters, and on experimental color-television transmissions in south-west Germany using a modified NTSC system. Band IV propagation appears satisfactory, apart from greater ground attenuation.

621.397.12 709

Cablefilm Equipment—S. N. Watson. (*J. Brit. IRE*, vol. 20, pp. 759–764; October, 1960.) Television-type techniques enable short lengths of 16-mm news film to be copied. The system described transmits in approximately one hour over a music circuit a length of film corresponding to about 30 seconds of television time.

621.397.132 710

Henri de France Colour Television System—R. Chaste and P. Cassagne. (*Proc. IEE*, vol. 107, pt. B, pp. 499–507; November, 1960. Discussion, pp. 507–511.) A description is given of the "Secam" system. The luminance-signal component is transmitted over a wide band for all scanning lines, but each of the two complementary chrominance-signal components is transmitted, in a narrow band, over alternate lines. An encoding system enabling signals to be transmitted over existing links is outlined, together with the design of a suitable compatible 625-line receiver incorporating a 64-μsec delay line for storing alternate chrominance scans: no synchronous detector is used, as in the NTSC system. The system was demonstrated by relaying a program from Paris to London over the existing Eurovision link. (See also 3660 of 1960).

621.397.132:535.62 711

Colour Television—with Two Primary Colours?—P. Neidhardt. (*Radio u. Fernsehen*, vol. 9, pp. 103–106; February, 1960.) Land's theory of colour vision and its unsuitability for practical application are discussed. (See also 341 of January, 1961.)

621.397.61 712

The Influence of the Camera Optical System on a Television Channel—D. Frenzel. (*Nachrichtentech. Z.*, vol. 13, pp. 1–8, January, 1960.) Measurements were made on several lens systems to determine the relation between optical parameters and the quality of television reproduction. (See also 3995 of 1958.) 24 references.

621.397.61 713

The Sync-Pulse Separator Stage in Monochrome Television Transmitters—G. Coldewey. (*Frequenz*, vol. 14, pp. 56–58; February, 1960.) Two diode pulse-separator circuits whose linearity can be improved by using a Ge diode instead of an oxide-cathode type are discussed.

621.397.62:621.396.669 714

Television Noise Limiting—H. D. Kitchin. (*Electronic Technol.*, vol. 37, pp. 406–414, 455–459; November, December, 1960.) The operation of two simple types of noise limiter for an AM sound channel is analyzed, and an improved circuit with variable bias is described. Design equations are given, and the influence of pulse shape and factors affecting over-all noise performance are discussed.

621.397.62.001.4:621.391.823 715

A Controlled Interference Generator—W. E. Matthews and P. L. Mothersole. (*Electronic Engrg.*, vol. 32, pp. 685–688; November, 1960.) Realistic interference signals used for investigating the performance of television receivers are generated from an electric motor and a motor-car ignition simulator. Details of the circuit and construction are given.

621.397.621 716

Theoretical Investigations of the Sync Separator Stage in Television Receivers—H. Reker. (*Nachrichtentech. Z.*, vol. 13. pp.147–154; March, 1960.) The importance of the coupling filter between video output stage and sync separator is d scussed. The designs of two types of filter are given.

621.397.74 717

Method for Planning Optimum Transmitter Networks for Television Coverage in Bands IV and V. (Description of the Method and Indications for its Use)—H. Eden, H. W. Fastert, and K. H. Kaltbeitzer. (*Rundfunktech. Mitt.*, vol. 4, pp. 4–22; February, 1960.) The method described is suitable for transmitters of equal or differing ERP. [For English versions, see *EBU Rev.*, no. 59A, pp. 6–21; February, 1960. See also 348 of January, 1961 (Eden and Kaltbeitzer).]

621.397.74 718

Technical Peculiarities of the Swiss Television Network—H. A. Laett. (*Rundfunktech. Mitt.*, vol. 4, pp. 31–34; February, 1960.) Problems aris ng from the trilingual culture and mountainous nature of the country are considered.

TRANSMISSION

621.396.61:621.395.665.1 719

A Compandor for Broadcast Transmission—W. von Guttenberg and H. Hochrath. (*Nachrichtentech. Z.*, vol. 13, pp. 9–15; January, 1960.) Several types of compandor are reviewed with reference to the CCITT requirements. A syllable compandor operating at carrier-frequency level has given satisfactory results under experimental conditions. (See 4055 of 1960.)

TUBES AND THERMIONICS

621.382.2/.3 720

Lumped-Model Analysis of Space-Charge Widening—J. F. Gibbons and D. A. Linden. [PROC. IRE (Correspondence), vol. 48, p. 1920; November, 1960.] Lumped constants are used to represent transistors and diodes in the analysis.

621.382.23 721

Pulse Characteristics of *p-n* Junctions—E. Köhler. (*Nachrichtentech Z.*, vol. 10, pp. 62–67; February, 1960.) Calculations of *p-n* junction performance under conditions of signal reversal are based on experimental investigations of current characteristics as a function of circuit parameters.

621.382.23 722

Estimation of High-Frequency Properties of the Thermal-Avalanche Negative-Resistance Diode—J. Nishizawa. (*Sci. Rep. Res. Inst. Tohoku Univ., Ser. B.* vol. 11, no. 1, pp. 1–9; 1959. Discussion is given of thermal effects and an equivalent-c rcuit analysis to determine the upper frequency limit of operation.

621.382.23:539.12.05 723

Fast Neutron Bombardment of Germanium and Silicon Esaki Diodes—J. W. Easley and R. R. Blair. (*J. Appl. Phys.*, vol. 31, pp. 1772–1774; October, 1960.) The main result of the bombardment is the increase in the "excess" current which is proportional to integrated neutron flux. Substantial changes also occur in the *I/V* characteristics for exposures between 10^{15} and 10^{17} fast neutrons/cm^2.

621.382.23:621.372.44 724

***P-N-P* Variable-Capacitance Diode Theory**—J. M. Early. (PROC. IRE, vol. 48, pp. 1905–1906; November, 1960.) An analysis is given of steady-state RF operation.

621.382.23:621.375.9 725

Negative-Resistance Amplifier Design—J. B. Schultz and H. B. Yin. (*Electronics*, vol. 33, pp. 110–112; May 27, 1960.) Design criteria are given for amplifiers using tunnel diodes or four-layer transistor diodes.

621.382.23:621.376.23 726

Esaki Diodes as Superregenerative Detectors—A. G. Jordan and R. Elco. [PROC. IRE, (Correspondence), vol. 48, p. 1902; November, 1960.] Preliminary circuit details and oscillograph waveforms are presented to illustrate operation with the diode biased in the negative-resistance region but quenched in the positive-resistance region.

621.382.23:621.391.822 727

Noise Performance of Tunnel Diodes—E. G. Nielsen. (PROC. IRE, vol. 48, pp. 1903–1904; November, 1960.) With thermal noise represented by a parasitic series resistance and shot noise by an equivalent conductance, a theoretical expression for noise factor as a function of frequency is deduced.

621.382.23:621.391.822.3 728

Theoretical Justification for Shot-Noise Smoothing in the Esaki Diode—R. La Rosa and C. R. Wilhelmsen. [PROC. IRE (Correspondence), vol. 48, p. 1903; November, 1960.] With the probability of conduction electrons tunnelling across a thin junction assumed equal to 0.5, an expression is derived for mean-square noise current.

621.382.333 729

Characteristics of Germanium *p-n* Junction with Irregular Structure—M. Tomono. (*J. Phys. Soc. Japan*, vol. 15, pp. 1223–1236; July, 1960.) Components of the current flowing into an imperfect emitter junction of irregular structure were studied. Explanations are given for *I/V* characteristics of the emitter differing greatly from the Shockley equation, the abnormally strong current dependence of the current amplification factor of the transistor, and the floating potential of the emitter.

621.382.333 730

The Frequency Response of Power Transistors in the LF. Range and its Effect on the

Gain of Transistor Output Stages—L. Hermsdorf and J. Meinhardt. (*Nachrichtentech. Z.*, vol. 10, pp. 80–83; February, 1960.)

621.382.333:621.318.57 731
Switching Transistors—J. N. Barry. (*Electronic Technol.*, vol. 37, pp. 442–449; December, 1960.) Departures from the behavior predicted by simple theory have been found, and a modified equivalent circuit is suggested.

621.382.333:621.372.57 732
Application of the Theory of Noise Quadripoles to Transistors at Low Frequencies—J. Schubert. (*Telefunken-Röhre*, No. 33a, pp. 5–42; January, 1960.) The noise characteristics of a transistor in common-emitter configuration are calculated from the internal noise sources of Giacoletto's equivalent circuit and compared with measured values in the region of white noise. Flicker noise is also cosidered and optimum operating conditions for minimum noise figure are stated. The transistor noise figure is compared with that of a vacuum triode.

621.382.333:681.142 733
The Frequency Response of Junction Transistors in Electronic Computers—G. Laskowski. (*Nachrichtentech. Z.*, vol. 10, pp. 68–72; February, 1960.) Simplified treatment of transistor and diode logic circuits for use in digital computers.

621.382.333.018.78 734
Harmonic Distortion Factor of Transistors—S. Kawaguchi and M. Hirai. (*Rev. Elect. Commun. Lab., Japan*, vol. 8, pp. 34–38; January/February, 1960.) An equation is derived for the second-harmonic distortion factor of an amplifier circuit at low frequencies. Variations of distortion factor with change of bias and frequency have been measured.

621.383:535.371.07 735
A Two-Colour-Input, Two-Colour-Output Image-Intensifier Panel—F. H. Nicoll and A. Sussman. (PROC. IRE, vol. 48, pp. 1842–1846; November, 1960.) The design and construction of a solid-state unit which can be separately excited by visible or infrared images is described. The characteristics of the unit are given.

621.383.292.001.4 736
Investigations of the Local Characteristics of Photomultipliers—P. Cachou. (*C. R. Acad. Sci., Paris*, vol. 259, pp. 1004–1006; February 8, 1960.) A technique is described for studying the characteristics of photomultiplier tubes under normal working conditions. The tube is illuminated by a succession of very short light pulses from a flying-spot scanner.

621.385.032.213.13 737
The Conductivity of Oxide Cathodes: Part 8—Current-Dependent Matrix Dissociation—G. H. Nelson and E. Macartney. (*Proc. IEE*, vol. 107, pt. C, pp. 158–162; September, 1960). A discussion of the dissociative action which accompanies the passage of a current through a Ba-Sr oxide matrix at 1020°K. (Part 7: 2561 of 1960.)

621.385.2 738
Transient Space-Charge Flow—R. J. Lomax. (*J. Electronics Control*, vol. 9, pp. 127–140; August, 1960.) A numerical analysis is given of the flow of space charge under non-steady-state conditions in a parallel-plane diode, showing how a steady or quasi-steady state is established.

621.385.3+621.385.5 739
The Noise of Grid-Controlled Mixer Valves—R. Cantz. (*Telefunken-Röhre*, No. 33a, pp. 63–104; January, 1960.) Application of the theory of noisy quadripoles (1695 of 1957) to the calculation of the total noise admittance and the noise figure of a mixer stage. Apparatus for the measurement of noise characteristics is described, and results obtained with it are discussed.

621.385.3 740
The Noise and Stability of a Non-neutralized Triode used as a High-Frequency Input Stage—R. Sittner. (*Telefunken-Röhre*, No. 33a, pp. 147–206; January, 1960.) The advantages of non-neutralized over neutralized triodes in earthed-cathode input stages of television receivers are outlined. The investigation of the noise characteristics of the input stages is based on the theory of noisy quadripoles (1695 of 1957) and on experimental results. Normalized curves of noise figure and power gain are given, and the design of a cascode stage for operation at 200 Mc is detailed as an example.

621.385.5 741
The Noise Characteristic of a Pentode in the V.H.F. Range—H. Bauer. (*Telefunken-Röhre*, no. 33a, pp. 43–62; January, 1960.) Calculations are based on the theory of noisy quadripoles considered earlier (1695 of 1957). The impedance of the cathode lead of the pentode is shown to have a great influence on the noise characteristics. By inserting a capacitance in this lead, the minimum noise factor of the pentode can be made to be nearly as good as that of a triode.

621.385.5:621.374.3 742
How to Use the Secondary-Emission Pentode—E. J. Martin, Jr. (*Electronics*, vol. 33, pp. 60–63; October 7, 1960.) Applications in high-speed short-duration pulse techniques are illustrated.

621.385.6 743
Experiments on a Helix Buncher Tube—N. T. Lavoo. (*J. Electronics Control*, vol. 9, pp. 1–29; July, 1960.) Results of experimental measurements are given and compared with theory for a tube containing a klystron buncher, a short helix buncher, and a catcher gap.

621.385.6:621.375.9:621.372.44 744
Low-Noise Electron-Beam Amplifier—J. Labus. (*Arch. elekt. Übertragung*, vol. 14, pp. 49–53; February, 1960.) Instead of a linearly polarized field, as in the quadrupole amplifier [361 of 1960 (Adler, *et al.*)], circular polarization is proposed at the amplifier input. Amplification takes place even when the signal frequency exceeds the cyclotron frequency. The introduction of delay in the output line enables the amplifier to be used as a frequency converter.

621.385.6:621.375.9:621.372.44 745
New Microwave Tube Devices "Fawshmotron" using the Fast Electron Waves—Y. Matsuo. [PROC. IRE (Correspondence), vol. 48, p. 1908; November, 1960. A brief description is given of proposed quadrupole amplifier, oscillator, and backward-wave oscillator systems.

621.385.623:621.316.726 746
Transistorized Lock-In for Klystron Automatic Frequency Control—A. J. George and D. T. Teaney. (*Rev. Sci. Instr.*, vol. 31, pp. 997–998; September, 1960.) Circuit details are given of a phase detector and dc amplifier using low-drain transistors and batteries, which provides +15 v in series with the klystron reflector.

621.385.623.5 747
Noise Figures of Reflex-Klystron Amplifiers—K. Ishii. (IRE TRANS. ON MICROWAVE THEORY AND TECHNIQUES, vol. MTT-8, pp. 291–294; May, 1960. Abstract, PROC. IRE, vol. 48, p. 1515; August, 1960.)

621.385.623.5.072.6 748
Frequency Stabilization of Klystrons—M. J. A. Smith. (*J. Sci. Instr.*, vol. 37, pp. 398–399; October, 1960.) An outline is given of a method which has advantages over existing techniques.

621.385.623.5.072.6 749
Transistorized Frequency Stabilization for Reflex Klystrons used in Magnetic Resonance—P. Jung. (*J. Sci. Instr.*, vol. 37, pp. 372–374; October, 1960.) A fully transistorized stabilizer is described in which the effect of ripple and drift of the power supply is reduced by a factor of 1000.

621.385.63 750
Electron Sheet Beam Focusing with Tape Ladder Lines—W. E. Waters. (*J. Appl. Phys.*, vol. 31, pp. 1814–1820; October, 1960.) Laplace's equation is solved approximately, to obtain the plasma frequency, beam stiffness, and average beam potential for a sheet electron beam. A numerical example is given for a typical system.

621.385.63 751
Tapering Travelling-Wave Tubes—G. M. Clarke. (*J. Electronics Control*, vol. 9, pp. 141–146; August, 1960.) A simplified analysis of the performance of a tapered travelling-wave valve. Results of more accurate calculations are indicated.

621.385.63:621.372.823 752
Interaction of Electrons with the H_{01}-Wave Field in a Circular Waveguide—I. A. Gilinskii. (*Dokl. Akad. Nauk. SSSR*, vol. 134, pp. 1055–1057; October 11, 1960., Mathematical analysis of the interaction of an electron beam with the field of nonretarded mm waves.

621.385.632 753
A Small-R.F.-Signal Theory for an Electrostatically Focused Travelling-Wave Tube—W. W. Siekanowicz. (PROC. IRE, vol. 48, pp. 1888–1901; November, 1960.) Using the Llewellyn-Peterson equations with correction factors derived by Pierce (2284 of 1947), consideration is given to the effect on the gain of large periodic variations of dc electron velocity. Comparison is made with measurements performed on an experimental system. 61 references.

621.385.632:621.376.4 754
Phase Modulation of T.W. Tubes—R. H. Wadie, M. T. Stockford, and M. Hutchinson. (*Electronic Technol.*, vol. 37, pp. 466–474; December, 1960.) The modulation products of a low-noise X-band travelling-wave tube have been studied when modulated by waveforms of variable amplitude at recurrence frequencies of 1 Mc and 1–10 kc.

621.385.632.12 755
Investigation of Helix/Anisotropic-Dielectric and Helix/Ribbed-Structure Slow-Wave Systems: Part 1—V. P. Shestopalov and V. A. Slyusarskii. (*Z. Tekh. Fiz.*, vol. 29, pp. 1317–1329; November, 1959.) Derivation of dispersion equations for a helix located in an anisotropic dielectric and determination of the distribution of power flux. The limiting case for transition to a helix/ribbed-structure is considered, and the possibility of using a helix with a periodic variation in a travelling-wave valve is examined.

621.385.633:538.569.4 756
The Cyclotron-Resonance Backward-Wave Oscillator—K. K. Chow and R. H. Pantell. (PROC. IRE, vol. 48, pp. 1865–1870; November, 1960.) The principle of cyclotron resonance interaction is applied to the construction of a backward-wave oscillator which requires no

slow-wave circuit. Operation in the mm-wave band enables power up to 15 watts to be obtained, and the unit tunes over a 2:1 frequency band.

621.385.633:621.372.22 757

Investigations on Inhomogeneous Delay Lines of Periodic Structure—H. Wehrig. (*Nachrichtentech. Z.*, vol. 13, pp. 71–81; February, 1960.) Measurements of dispersion and field strength were made on various types of three-dimensional grid structures, whose suitability for use in backward-wave oscillators is discussed.

621.385.64:621.376.23.029.63 758

Microwave Oscillation and Detection by a Smooth-Anode Coaxial Magnetron—R. M. Hill and F. A. Olson. (Proc. IRE, vol. 48, pp. 1906–1907; November, 1960.) Experiment confirms the theoretical analysis of Pease (1546 of 1960) which relates oscillator frequency to free-electron cyclotron frequency. Interaction with external powers is found to give a change in anode current proportional to the square root of signal power.

621.385.83:537.312.54 759

The Generation of *X* Rays in Valves—W. Reusse. (*Nachrichtentech. Z.*, vol. 13, pp. 53–57; February, 1960.) The process of X-ray generation in CR tubes and electron microscopes, and the resulting radiation hazards and their prevention, are considered.

621.385.832 760

General Investigation of Image Transformations on the Screen of Cathode-Ray Tubes caused by Constant Deflection Fields—C. G. Gassmann. (*Arch. Elekt. Übertragung*, vol. 14, pp. 71–76; February, 1960.) On the basis of calculations the possibility is considered of designing special CR tubes giving displays with arbitrary curvilinear orthogonal or skew coordinates.

621.387:621.362 761

Construction of a Thermionic Energy Converter—Block, Corregan, Eastman, Fendley, Hernqvist, and Hills. (*See* 707.)

621.387:621.391.822.029.64:621.317.7 762

Noise Generators for Centimetre Waves—Saier. (*See* 670.)

621.387.032.212 763

The Influence of the Rolling Texture on the Electron Emission of Cold Cathodes of Pure Metal—G. Purt. (*Z. angew. Phys.*, vol. 12. pp. 117–120; March, 1960.) A simple relation is established between the texture of polycrystalline Mo sheet and its cathodic properties in gas-discharge tubes.

MISCELLANEOUS

538.569.2.047+621.365.92 764

Industrial, Biological and Medical Aspects of Microwave Radiation—A. F. Harvey. (*Proc. IEE*, vol. 107, pt. B, pp. 557–566; November, 1960.) 108 references.

621.3.049.7:621.382 765

A Categorization of the Solid-State Device Aspects of Microsystems Electronics—J. A. Lesk, N. Holonyak, Jr., R. W. Aldrich, J. W. Brouillette, and S. K. Ghandi. (Proc. IRE, vol. 48, pp. 1833–1841; November, 1960.) 59 references.

Translations of Russian Technical Literature

Listed below is information on Russian technical literature in electronics and allied fields which is available in the U. S. in the English language. Further inquiries should be directed to the sources listed. In addition, general information on translation programs in the U. S. may be obtained from the Office of Science Information Service, National Science Foundation, Washington 25, D. C., and from the Office of Technical Services, U. S. Department of Commerce, Washington 25, D. C.

PUBLICATION	FREQUENCY	DESCRIPTION	SPONSOR	ORDER FROM:
Acoustics Journal (Akusticheskii Zhurnal)	Quarterly	Complete journal	National Science Foundation—AIP	American Institute of Physics 335 E. 45 St., New York 17, N. Y.
Automation and Remote Control (Avtomatika i Telemekhanika)	Monthly	Complete journal	National Science Foundation—MIT	Instrument Society of America 313 Sixth Ave., Pittsburgh 22, Pa.
	Monthly	Abstracts only		Office of Technical Services U. S. Dept of Commerce Washington 25, D. C.
Journal of Abstracts, Electrical Engineering (Reseratívnyy Zhurnal: Electronika)	Monthly	Abstracts of Russian and non-Russian literature		Office of Technical Services U. S. Dept. of Commerce Washington 25, D. C.
Journal of Experimental and Theoretical Physics (Zhurnal Eksperimentalnoi i Teoreticheskoi Fiziki)	Monthly	Complete journal	National Science Foundation—AIP	American Institute of Physics 335 E. 45 St., New York 17, N. Y.
Journal of Technical Physics (Zhurnal Tekhnicheskoi Fiziki)	Monthly	Complete journal	National Science Foundation—AIP	American Institute of Physics 335 E. 45 St., New York 17, N. Y.
Proceedings of the USSR Academy of Sciences: Applied Physics Section (Doklady Akademii Nauk SSSR: Otdel Prikladnoi Fiziki)	Bimonthly	Complete journal		Consultants Bureau, Inc. 227 W. 17 St., New York 22, N. Y.
Radio Engineering (Radiotekhnika)	Monthly	Complete journal	National Science Foundation—MIT	Pergamon Institute 122 E. 55 St., New York 22, N. Y.
	Monthly	Abstracts only		Office of Technical Services U. S. Dept. of Commerce Washington 25, D. C.
Radio Engineering and Electronics (Radiotekhnika i Elektronika)	Monthly	Complete journal	National Science Foundation—MIT	Pergamon Institute 122 E. 55 St., New York 22, N. Y.
	Monthly	Abstracts only		Office of Technical Services U. S. Dept. of Commerce Washington 25, D. C.
Solid State Physics (Fizika Tverdogo Tela)	Monthly	Complete journal	National Science Foundation—AIP	American Institute of Physics 335 E. 45 St., New York 17, N. Y.
Telecommunications (Elekprosviaz')	Monthly	Complete journal	National Science Foundation—MIT	Pergamon Institute 122 E. 55 St., New York 22, N. Y.
	Monthly	Abstracts only		Office of Technical Services U. S. Dept. of Commerce Washington 25, D. C.
Automation Express	10/year	A digest: abstracts, summaries, annotations of various journals		International Physical Index, Inc. 1909 Park Ave., New York 35, N. Y.
Electronics Express	10/year	A digest: abstracts, summaries, annotations of various journals		International Physical Index, Inc. 1909 Park Ave., New York 35, N. Y.
Physics Express	10/year	A digest: abstracts, summaries, annotations of various journals		International Physical Index, Inc. 1909 Park Ave., New York 35, N. Y.
Express Contents of Soviet Journals Currently being Translated into English	Monthly	Advance tables of contents of translated journals		Consultants Bureau, Inc. 227 W. 17 St., New York 22, N. Y.
Technical Translations	Twice a month	Central directory in the U. S. of translations available from all major sources in the U. S.	OTS and Special Libraries Assoc.	Superintendent of Documents U. S. Gov't Printing Office Washington 25, D. C.

Whom and What to See at the IRE Show

(*Continued from page 228A*)

Dymec, Div. of Hewlett-Packard Co., Booths 3019-3020
395 Page Mill Road
Palo Alto, Calif.

▲ Cort Van Rensselaer, ▲ Edward Morgan, ▲ Harry Schultheis, ▲ Joseph Rodgers, ▲ Richard Hughes, ▲ Wilbur Paul, ▲ Robert Grimm, ▲ Al Benjaminson

*Integrating Digital Voltmeter, *AC/Ohms to dc converter, *25 point input scanner; digital systems for data handling, component testing, automatic measurement and control; RF and microwave checkout equipment for production, maintenance, and field support; *H-Band test set for complete microwave communication link checkout.

Dyna-Empire, Inc., Booth 1716
1075 Stewart Ave.
Garden City, L.I., N.Y.

▲ H. B. Shaper, A. Bachran, C. Bates, L. Dubin, ▲ F. Eisenhauer, ▲ H. Fener, R. Saiya, E. Friedel, ▲ H. Horowitz, J. Litcher, P. Nachemson, J. Shannon, E. Toombs, C. Silipo

Electronic components and test equipment including *new hearing aid components, stereophonic high fidelity components, temperature testing systems components, *gaussmeters models *D-888, D-874, D-855, plategage, demagnetizers, transducers for underwater sound systems, D-315 underwater sound standard, sonar equipment.

Dyna-Magnetic Devices, Inc., Booth 3017
See: Guidance Controls Corp.

Dynacor Inc., Booth 4047
1016 Westmore Ave.
Rockville, Md.

John Cook, ▲ C. W. Lufcy, James Triplett, Robert Vollmer

Magnetic cores. Bobbin and tape wound for computers and controls. See also Sprague Electric Co.

Dynamics Corporation of America, Booths 1202, 1301-1309
See: American Transformer Div., Radio Engineering Laboratories, Inc., Reeves-Hoffman Div., Reeves Instrument Corp., Standard Electronics Div.

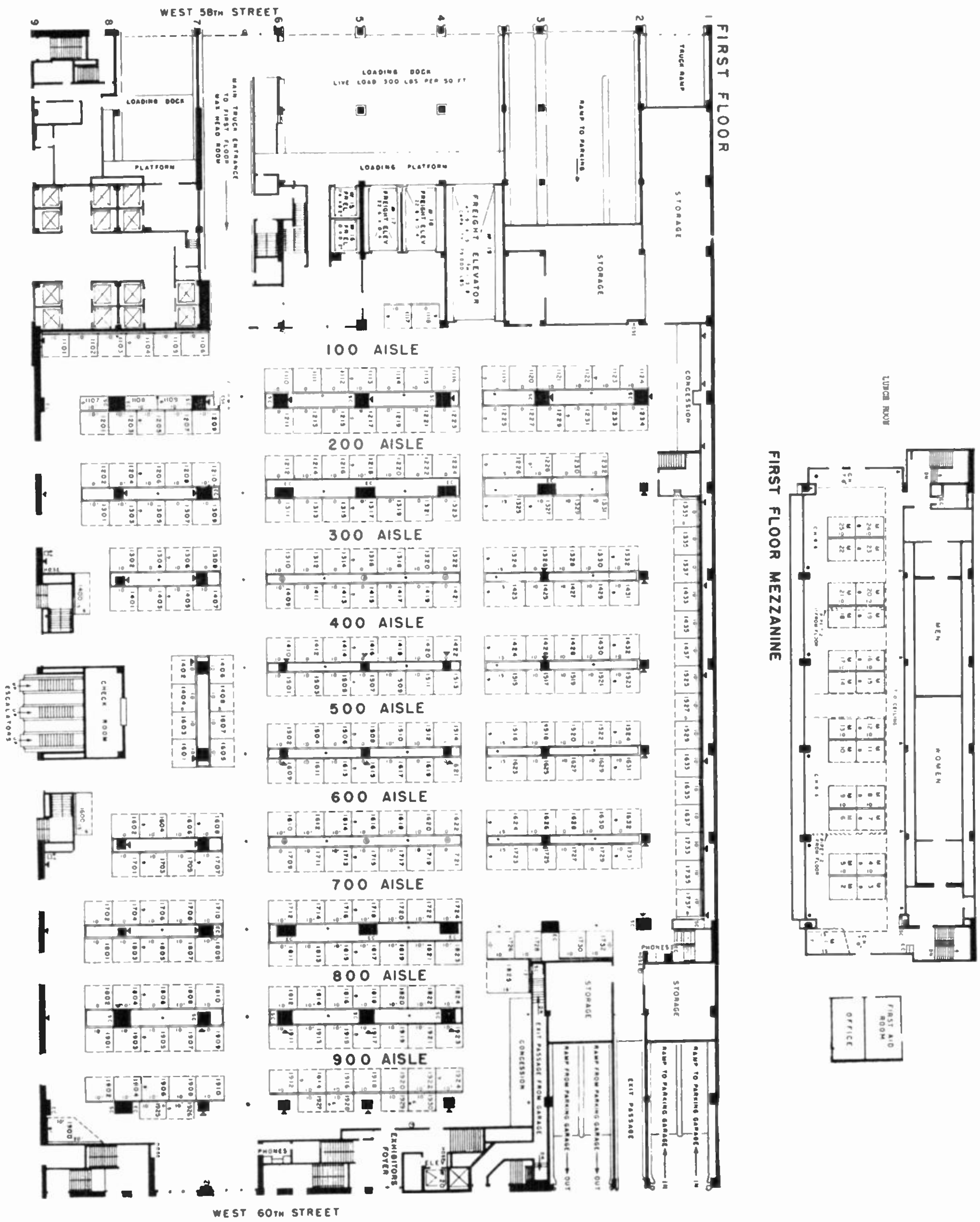
(*Continued on page 234A*)

Have you Considered the Advantages of IRE Membership?

If you are not a member of this fast-growing organization, we hope you will seriously consider turning the four-day advantages of the show into a year-round advantage through IRE membership. The advertising pages of the monthly "Proceedings of the IRE" and the annual "IRE Directory" will keep you up to date throughout the year on new products and developments, and through the editorial pages of "Proceedings of the IRE" and papers presented at Section and Professional Group meetings, you will learn about these new developments while they are still in the planning stage. You may join IRE at either the Waldorf-Astoria or the Coliseum lobby, or write for information to IRE Headquarters, 1 East 79th St., New York 21, N.Y.

Floor Plan—First Floor Components

First floor mezzanine is at right side of plan. Entrances to this area are next to booths 1333 and 1737.



Whom and What to See at the IRE Show

(Continued from page 232A)

Dynatran Electronics Corp. Booth 3014
178 Herricks Road
Mineola, N.Y.
▲ James R. Coleman, ▲ Roland C. Wittenberg, ▲ Erwin M. Wolf

100 mc and Gain Bandwidth Test Set

Dynatran Model 1818, 100 megacycle and gain bandwidth test set provides direct reading of 100 megacycle gain of transistors and gain bandwidth products to 1000 megacycles. This instrument is particularly useful for mesa, drift and surface barrier transistors and requires no auxiliary equipment.

Dytronics Company, Booth 3003
78 Sunnyside Lane, P.O. Box 3676
Columbus 14, Ohio
▲ P. A. Ryan, H. Shprentz, G. Obrist

Phase Meters, Phase Shifters, Phase Generators, Band Pass Filters.

EH Research Laboratories, Inc., Booth 3025
163 Adeline St.
Oakland, Calif.
W. D. Jordan, J. C. Hubbs

Pulse generators featuring very fast rise time and high rep rates. Transistor and diode tester for measuring switching time characteristics. Electrometers, coincidence circuits.

EICO, Booth 3509
See: Electronic Instrument Co., Inc.

ELIN Div., Booth 3018
See: International Electronic Research Corp.

E.M.I. Electronics Ltd., Booth 1518
See: EMI-US., Ltd.

E.M.I.—U.S., Ltd., Booth 1518
1750 North Vine St.
Los Angeles 28, Calif.
▲ Howard L. Hoffman, ▲ Robert Shevlot, Arthur Hoffman, Fred Belasco, Aldo Pulvirenti, ▲C. M. Morgan, ▲J. Sharpe, H. Clarke

Complete line of Klystrons, Photomultipliers, Traveling Wave Tubes, Orthicons, Vidicons, Magnetrons, Secondary Emission Tubes, Special Purpose Tubes, Cathode Ray Tubes, Wide Band Oscilloscopes, Waveguide Test Equipment, Sanders Microwave Instruments.

ESC Electronics Corp. Booth 2915
534 Bergen Blvd.
Palisades Park, N.J.
▲ Morton Fassberg, ▲ Stanley S. Packer, ▲ Bernard Brain, Rudolph E. Mottola, Raymond Grassi

Delay lines: Distributed constant, lumped constant, magnetostrictive, continuously variable, step variable, variable delay networks. Video transformers, filters of all types, pulse-forming networks, miniature plug-in encapsulated circuit assemblies.

† See PROCEEDINGS OF THE IRE—Jan. through Dec. (1960) for further information on our products.

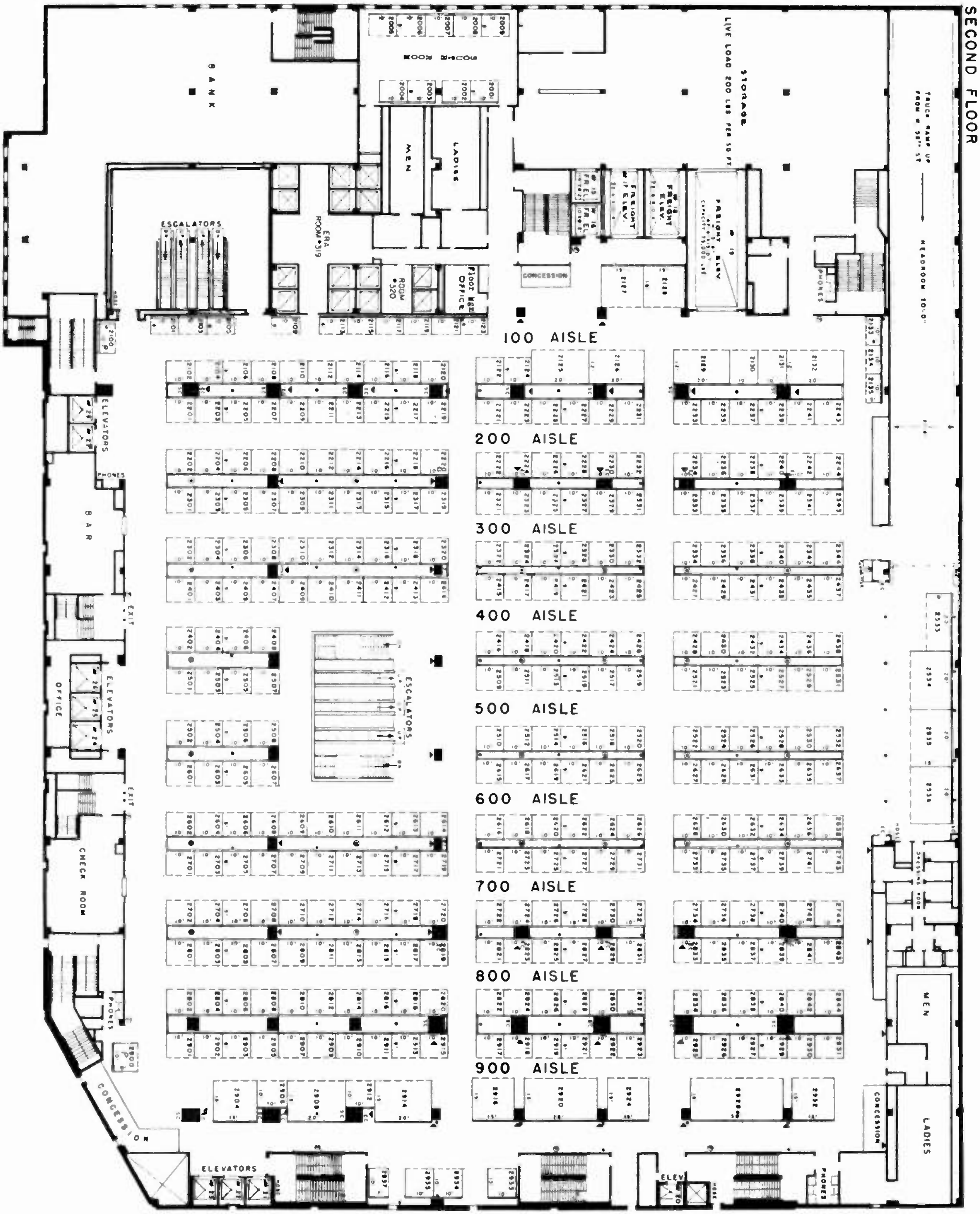
See 1961 IRE DIRECTORY, page 136, for complete information on our products.

Eastern Industries, Inc., Booths 2133-2134
100 Skiff St.
Hamden 14, Conn.
W. Schwanfelder, M. Engstrom, T. Mapes, F. Stone, H. Whitaker, T. Tenney, W. Haughey, R. Dixon, C. Noyes

Pressurization Units and Airborne Refrigeration Type Cooling Units for Electronic Equipment. Hydraulic Power Packs and Servo Mechanisms for Aircraft and Missiles. Pumps for Aircraft and Missiles. Servo Valves. Servo Systems. Actuators and Equalizer-Amplifiers.

(Continued on page 236A)

Floor Plan—Second Floor Components



Be sure to visit the South Room which is on the same level, 70 feet off the main floor in the center of the south wall.

Whom and What to See at the IRE Show

(Continued from page 234A)

Ebauches S.A., Booth 3027
(Neuchatel, Switzerland)
c/o Freeport Engineering Co.
350 Fifth Ave.
New York 1, N.Y.

Charles Friedman

Quartz crystal clocks; electronic test equipment; transistorized components.

Ecco Electronic Components Corp., Booth M-18
578 Nepperhan Ave.
Yonkers, N.Y.

Leon Weiss, S. L. Sack, Marjorie Woodward, Malcolm Beiner, Jean Taylor

RF connectors (BNC, TNC, N and C type). Coaxial to waveguide adapters. X-band antenna horns (microwave components). UHF-VHF fixed attenuators. Vacuum tube probes. Cable assemblies.

Eclipse-Pioneer Division, Booths 2222-2232 & 2329-2331

See: Bendix Corp.

Edgerton, Germeshausen & Grier, Inc., Booth 3244
160 Brookline Ave.
Boston 15, Mass.

Michael D. Altfillisch, Bernard F. Roberts, ▲ Jacques Murachver, John J. Mulrey, William A. Ward, ▲ Fred Gronberg, Daniel Riley

Model 707 Milli-mike oscilloscope. Model 850 integrated camera system. Ceramic-Metal hydrogen thyratrons. Ceramic-Metal hydrogen diodes. *Ceramic-Metal triggered spark gap. Glass-Metal triggered spark gap. Xenon flashtubes. Flash illuminator. *Microflash. FX-6A flash driver.

Thomas A. Edison Industries, Instrument Division, McGraw-Edison Co., Booths 2742-2744
West Orange, N.J.

Victor W. Rose, George V. Boselli, Joseph C. Emma, Joseph Zercoe, Jr., Edward J. Kerr, F. B. Morrison, Edward Hetsch, Don Alfred

*Model 292 miniature thermostat, *model 400 miniature circular chart recorder (tradenamed "Omnicorder"), model 250 miniature time delay relays, servo motors and motor generators, ultra-violet flame detector, aircraft pressure detectors and indicators, aircraft fire detection systems.

Eico Electronic Instrument Co., Booth 3509

See: Electronic Instrument Co., Inc.

Eitel-McCullough, Inc., Booths 2410-2412
301 Industrial Way
San Carlos, Calif.

F. A. Speaks, J. Quinn, G. Chambers, G. Badger, C. Warner

"Eimac" Electron Power Tubes: Power grid tubes, microwave tubes, amplifier klystrons.

†

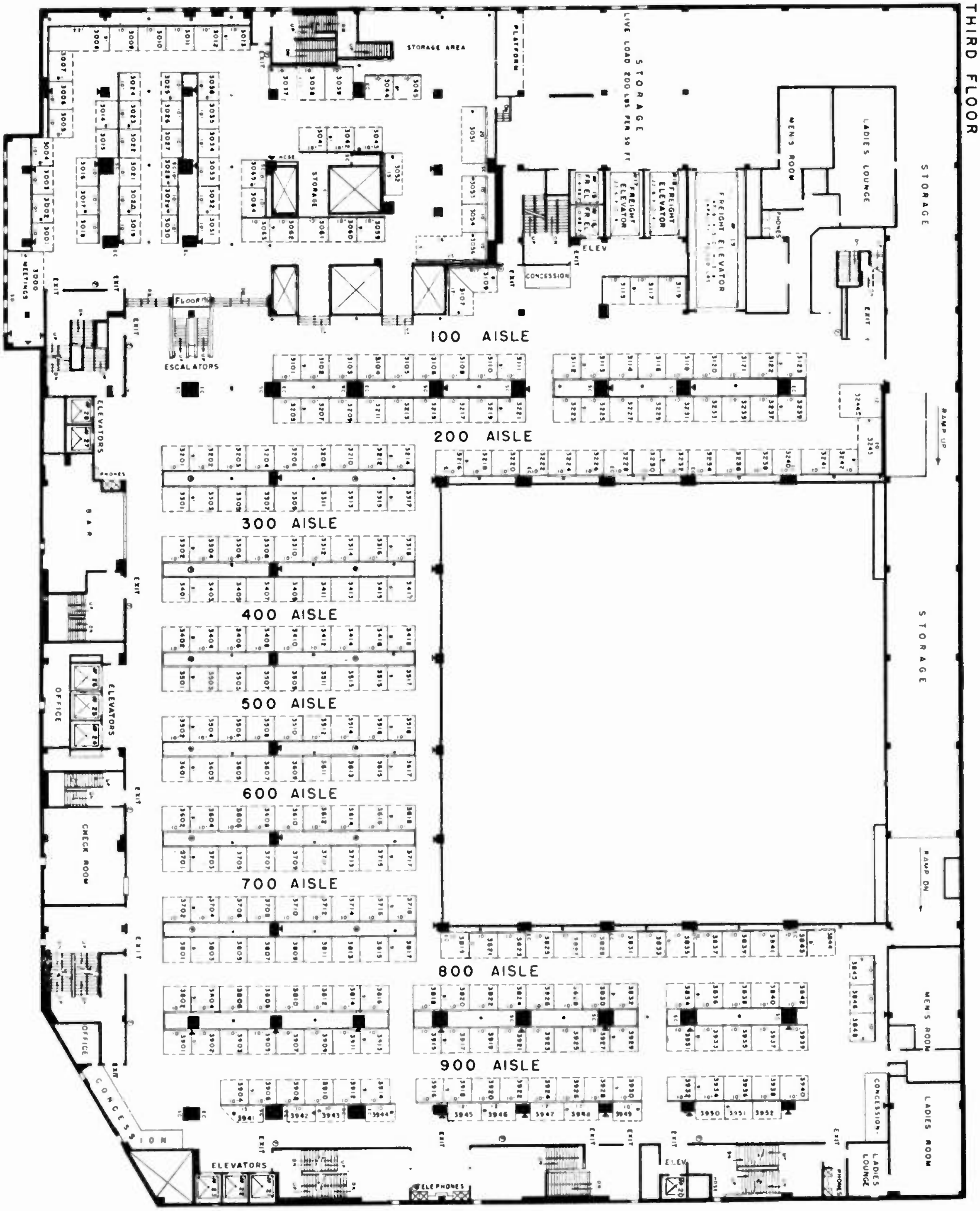
See PROCEEDINGS OF THE IRE—Jan. through Dec. (1960), Feb. (1961) for further information on our products.

See 1961 IRE DIRECTORY, pages 80 and 81, for complete information on our products.

(Continued on page 238A)

Floor Plan—Third Floor
Instruments & Complete Equipment

Communications Equipment & Systems, Computers, and Instruments for Test and Measurement, Microwave Equipment.



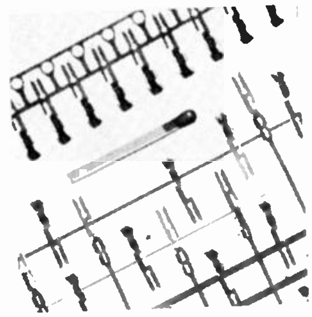
Escalators at the sound end of the main lobby take you direct to the third floor.
Be sure to see the booths in the "3000 Court" at the south-east corner of the floor.

Whom and What to See at the IRE Show

(Continued from page 236A)

Elastic Stop Nut Corp. of America, Booths 2341-3
See: Agastat Timing Instruments Div. & Buchanan Electrical Products Corp.

Elco Corp., Booths 1420-1422
"M" St. below Erie Ave.
Philadelphia 24, Pa.
▲Benjamin Fox, Leo Kagan, ▲ Herbert Ruehlemann, ▲ Sam Weiss, William McKay, Hershel Gordon, Robert Talamo, L. R. Travis



Elco "Varilok" Crimp-Type Contacts

Expansion of Elco's famous Varicon contact line now includes the *Varitwin Pin contact bifurcated taper pin termination) as well as the Varilok (crimp on and insert reliable contact)—plus *new Microcon (for sub-sub miniaturization). All feature Varicon reliability. *Advance design Varipak printed-circuit card enclosure. *New methodology for attaching connectors to flexible cable. Enlarged line of E-Z Mate sockets with self-locating design feature.

Elco Pacific Corp., Booths 1420-22
Audio connectors. See: Elco Corp.

Eldon Industries, Inc., Booth 4135
See: Ungar Electric Tools

Electra Manufacturing Co., Booths 2834-2836
4051 Broadway
Kansas City 11, Mo.
J. P. Wright, ▲ J. W. Sheriff, R. E. King, ▲ W. E. McLean
Manufacturers of precision film resistors, including deposited carbon and metal film types.

Electralab Printed Electronics Corp., Booth 2130
175 "A" St.
Needham Heights 94, Mass.
▲ Richard G. Zens, George V. McCarthy, ▲ H. Eugene Jones, Max R. Harvey, ▲ Robert Curran, Loring R. Litchfield, H. A. Bryant, L. B. Armstrong, ▲ William A. Campbell, Elliott L. Gessman

High temperature formed and flushed circuits on new Dielox Substrate. Beck Circuitry—embedded, layered, ideal for rotary switches. Electrolube—lubricant with negative-temperature coefficient for all electrical contacts, arcing and non-arcing. Protomaka—portable laboratory for processing prototype printed circuits.

Electric Hotpack Co., Inc., Booths 3846-3848
5019 Cottman Ave.
Philadelphia 35, Pa.
Arnold Mann, Douglas M. Bergen, Ira McFarland, Bart Conchar, George Wyman, Charley Jaynes, Wheeler Bishop, Fred Lucchesi, Bill Rariden, Ed Stansky, Phil Layne, Bob Shanberg, Al Jacobson
Environmental, controlled temperature equipment: Hot-Cold test chambers, −100° to 400°F; walk-in rooms, 0° to 40°C; bake-out ovens, 0° to 300°C; vacuum ovens, 0° to 300°C; *temperature and humidity cabinets, 0° to 100°C. chemical dehumidification, chambers to 31 cu. ft. for component stability tests.

Electrical Equipment Magazine, Booth 4415
See: Electronic Equipment Engineering

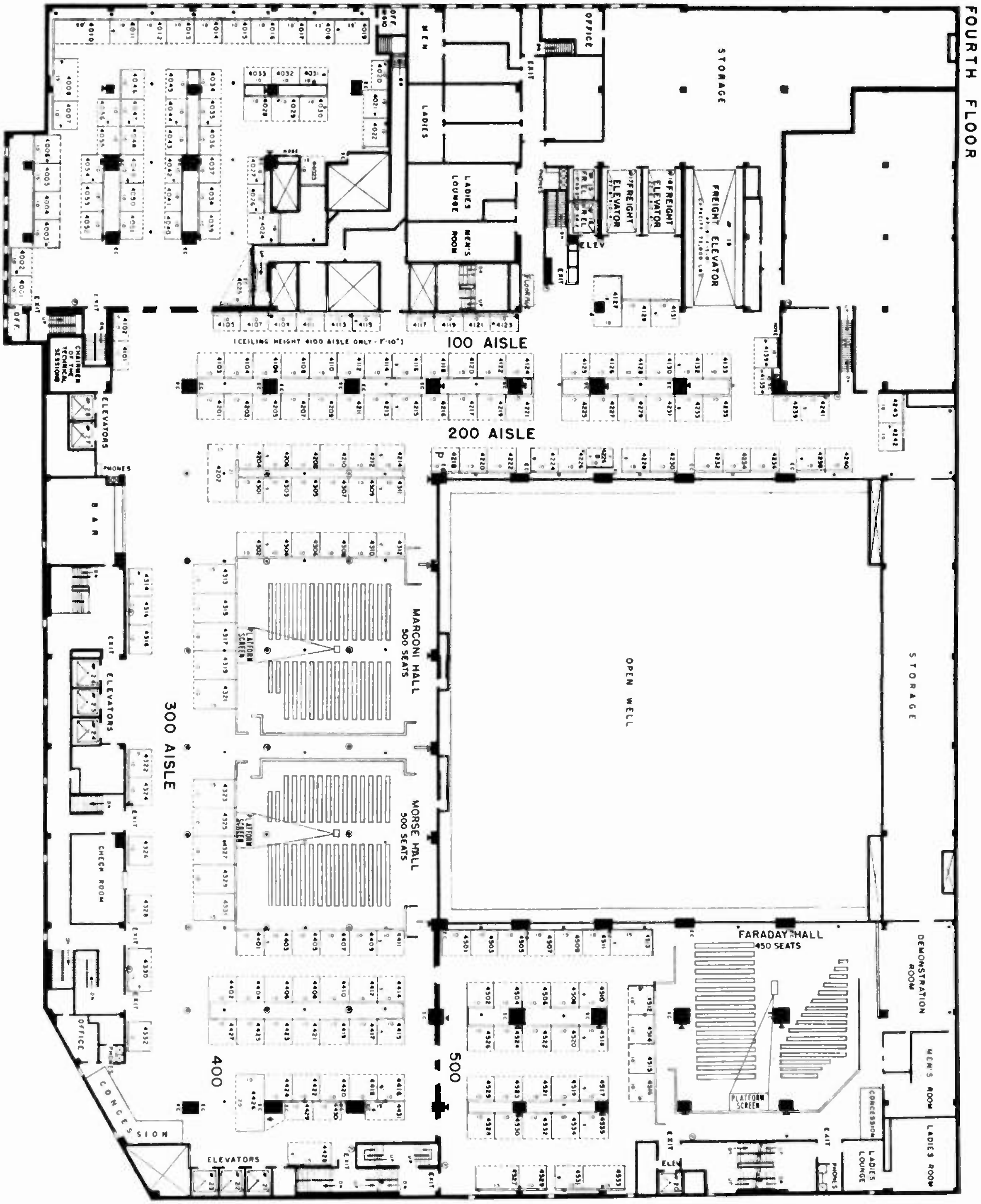
Electrical Industries, Booths 2526-2528
Murray Hill, N.J.
P. A. Muto, O. H. Brewster, K. F. Mayers, J. Jonassen, D. Wilson, C. W. Beach
Glass to metal seals for hermetically sealing electronic components. Complete line standard terminals, threaded seals, transistor and other miniature closures. Custom seals, custom sealing of components.

† See PROCEEDINGS OF THE IRE—Jan., March, May, July, Sept., Nov. (1960), March (1961) for further information on our products. See 1961 IRE DIRECTORY, page 180, for complete information on our products.

(Continued on page 240A)

Floor Plan—Fourth Floor
Production

Machinery, tools and raw materials; fabricators and services.



All lecture halls in the Coliseum are located on the fourth floor. Elevators at the east and north sides of the main lobby take you direct to this floor. Be sure not to miss the booths in the "4000 Court" at the southeast corner, and the "4500 Court," in the northwest corner.

Whom and What to See at the IRE Show

(Continued from page 238A)

Electro Devices Inc., Booth 4107
580 Main St.
Wilmington, Mass.

Paul J. Post, Fred F. Cain, Edward Gratto, A. A. Ryalls, F. Holst, A. Fox, R. F. Dacey, E. Moynahan, Joan Bakey, J. LeBrun, S. Sandler, F. Nappi

*New accessory featured by Electro Devices, combined with amazing versatility of patended toroidal coil winding machine, allows operator to wind to and measure inductance direct from the machine. Winding can be 360 degrees continuous. An invaluable time saver.

Electro Instruments, Inc., Booths 3912-3914
3540 Aero Court
San Diego 11, Calif.

▲ R. H. Applin, ▲ Joe Deavenport, B. Edelman, John Engelberger, Stanton East

All Electronic Analog-Digital and Digital-Analog Converters; Digital Voltmeters, Ratiometers, Ohmmeters; Wideband Transistorized Single Ended or Differential DC Amplifiers; Solid State X-Y Recorders and Accessories; Transistorized Counters and Timers; Counter Systems; Data Acquisition Processing and Recording Systems.

Electro-Measurements, Inc., Booths 3028-30

See: Electro Scientific Industries, Inc.

Electro-Mec Div. of Waltham Precision Instrument Co., Inc., Booth 2216
17-51 33rd Street
Long Island City 1, N.Y.

▲ Forbes Morse, ▲ Robert Wiener, Robert Bordewieck, ▲ R. P. Luce Jr., Carl Berntsen, Robert Ebert, George Boziwick, William Hees, Dann Neubauer, Jack Mott, Bruce Juell, F. M. Burmann

Ultra-low torque potentiometers of extreme precision, and digitometers.® Shaft encoders, featuring the D11-8 digitometer. This is an eight bit instrument 1.06" diameter. Also, the goniometer®, an instrument useful for test and calibration of all rotary type components. Additionally, the Waltham Precision Instrument Co. line of timing devices.

Electro-Mec Laboratory, Inc., Booth 2216

See: Electro-Mec Division, Waltham Precision Instrument Co., Inc.

Electro-Mechanical Instrument Co., Booth 1231
8th and Chestnut Sts.
Perkasie, Pa.

L. R. Void, Ray Jones, R. I. Dinlocker, Robert Gombert

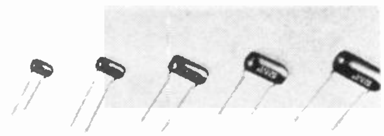
Ammeters, voltmeters, milliammeters, microammeters, and timing meters. 2 inch to 4½ inch.

First Aid Room

A nurse is in charge at all times. First aid room is located on the first floor mezzanine, northwest corner of the first floor. Take elevator 20.

Electro Motive Mfg. Co., Inc., Booth 2833
South Park & John Sts.
Willimantic, Conn.

▲ Arthur W. Evans, Joseph Regan, J. Kevin Foley, Milton Lauter, Charles Rueb, James Gilligan, Sherman Gruman, Peter Nichols, John Obsharsky, Robert Bell, Robert Miller



Mylar-Paper Dipped Capacitors

Manufacturers of quality capacitors with built-in reliability. Dipped mica, molded mica, silvered mica films, dipped mylar-paper, dipped paper, tubular paper, ceramic discs, ceramic feed-thrus, variable ceramics, trimmers, dual padders and single padders.

† See PROCEEDINGS OF THE IRE Jan., March, May, July, Sept., Nov. (1960), Jan., March (1961) for further information on our products.
See 1961 IRE DIRECTORY, page 168, for complete information on our products.

Electro-Pulse, Inc., Booth 3709
6711 South Sepulveda Blvd.
Culver City, Calif.

▲ B. G. Evans, ▲ R. J. Johnson, ▲ J. E. Niebuhr

General and special purpose pulse instrumentation, analog and digital; time delay generators; magnetic core testers; voltage and current calibrators; electronic counters. See also Servo Corp. of America, Booth 3707

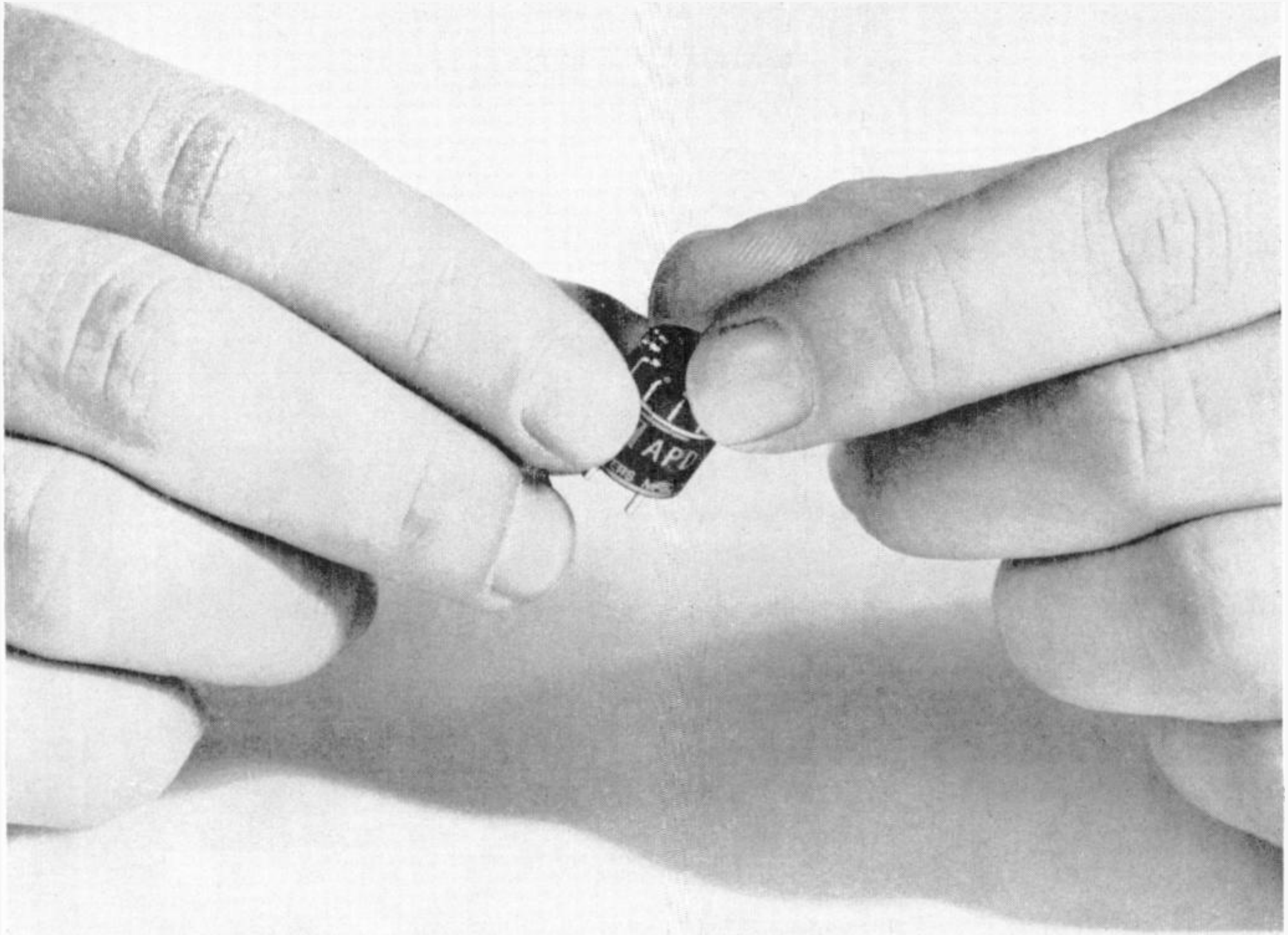
Electro Scientific Industries, Inc., Booths 3028-3030
7524 S. W. Macadam St.
Portland, Ore.

▲ D. C. Strain J. G. Kirwan, L. B. Keim, William Lyon, Paul Lintner

Bridges: Impedance, resistance, capacitance, comparison. Impedance measuring system. *Capacitance measuring system. Militarized voltage divider. Resistance transfer standard. Standard resistors. "In-line" Dekaboxes. Decade resistors and capacitors. Decade transformers. Decade voltage dividers: Computer.

(Continued on page 242A)

Be sure to see all four floors for a complete view of 800 new ideas!



Exclusive new subminiature DIALPOT© for printed circuitry gives instant answers to three basic questions

APD ½
½" dia.
Overall length ½" including dial, excluding terminals

At one quick glance, this plug-in subminiature pot answers the questions: Where is the slider? At what angle is the pot set? At what percent of voltage is the pot set? The dial is calibrated with equal graduations from 0 to 10 in the 300° winding angle. As an index, there is a scribe line on the base. Mechanical rotational stops are standard. The brush is phased so that the "0" graduation on the dial is in line with the scribe line at 0° functional rotation. Terminals are located on a standard .1 inch grid, as used in printed circuitry. Terminal numbers are clearly marked. Dissipates 1 watt at 40°C. Independent linearity (above 500 ohms.), ±3%. Meets MIL-R-19 and other specifications as applicable. Standard resistances: 50, 100, 500, 1K, 2K, 5K, 10K, 20K. Write for Bulletin APD-261.

WATERS MANUFACTURING, INC. · WAYLAND · MASS.

Waters

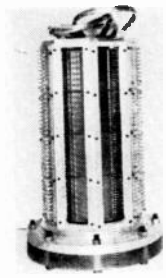
POTENTIOMETERS · COIL FORMS · POT HOOK® PANEL MOUNTS · TORQUE WATCH® GAUGES · TORQUE CALIBRATORS · OSCILLOSCOPES

Whom and What to See at the IRE Show

(Continued from page 240A)

Electro Tec Corp., Booth 1620
10 Romanelli Avenue
South Hackensack, N.J.

George Pandapas, Arthur Asch, Robert Kinsey, George Tubb, Robert McMillan, Philip Marshall, Tom Schober, Noel Siegel, William Endres, Peter Filipczak, George Merker, Remo Mariani, Leonard Buchoff, James DePalma



Slip Rings (0.035" diameter, to 16½' long)

Designers and manufacturers of precision miniature, subminiature and large slip rings and commutator assemblies, the Mark II wedge action relay, *telemetering switches, *and precision selector switches—all for systems requiring small units, low friction torque, high accuracy, with low electrical noise.

Electro-Voice, Inc., Booth 1510
Cecil & Carroll Sts.
Buchanan, Mich.

Don Kirkendall

Microphones, Cartridges.

Electrocraft, Inc., Booth 2337

Plugs, jacks, switches. See: GC Electronics Co.

Electron Corp., Booths 3802-3806

See: Ling-Temco Electronics, Inc.

Electronic Associates, Inc., Booths 3712-3718
Long Branch & Naberal Aves.
Long Branch, N.J.

C. J. Marsh, R. L. Yeager, J. D. Kennedy, W. Blodgett, W. O'Brien, G. Martin, R. Doelger, J. McCloskey, B. Johnson, P. Kaufmann, J. Beacon

"Pace" analog computer (231R) with associated read-out equipment. The transistorized desk-top analog computer TR-10. The 5000 Series transistorized digital voltmeter with "full-time" high impedance. *Also a complete line of precision capacitors.

Electronic Daily & Electronic Design, Booths 4403-05

See: Hayden Publishing Co.

Electronic Engineering Co. of California, Booth 1110

See: Engineered Electronics Co.

Electronic Engineers Master—eem, Booth 4424

See: United Catalog Publishers, Inc.

Electronic Equipment Engineering, Sutton Publishing Co., Inc., Booth 4415
172 South Broadway
White Plains, N.Y.

▲ Elmer Ebersol, ▲ Vin Zeluff, ▲ Wayne Williams, ▲ David Findlay, Glenn Sutton, Jr., R. A. Neubauer, R. H. Burke, John Iraci, N. C. Berro, A. Foustain, Don Fuller, Frank L. Ogilvie, Len C. Davis, George Yonan

"Electronic Equipment Engineering" serving 40,000 R & D engineers in the electronic original equipment market will present in special section of March Show Issue brief features covering IRE Show products in use.

Electronic Industries, Booth 4202
Chestnut & 56th Streets
Philadelphia 39, Pa.

Robert E. McKenna, ▲ Creighton M. Marcott, ▲ John E. Hickey, Jr., Elmer Dalton, Joseph Drucker, Menard Doswell, Gerald B. Pelissier, George Felt, Don May, Shelby A. McMillion, B. Wesley Olson, ▲ Bernard F. Osbahr, ▲ Richard G. Stranix, ▲ Christopher Celent, ▲ Donald J. Moran

"Electronic Industries"—Where Service to the Engineer Comes First. The industry's monthly magazine of applied electronic engineering and development. Editorial, business, and market research staffs at booth to swap ideas with registrants. Free subscriptions at booth for engineers only.

Electronic Instrument Co., Inc., Booth 3509
33-00 Northern Blvd.
Long Island City 1, N.Y.

▲ Harry R. Ashley, ▲ Richard Dugot, Sophie C. Ashley, Philip A. Portnoy, Robert Clark-Duff, Kent Springer, Mel Fink

EICO Model 460 Oscilloscope

Test equipment, stereo and monaural high fidelity components, citizen's band transceivers, amateur equipment, radios, both kit and factory-wired.

Electronic Measurements Company, Inc., Booths 2227-2229
Lewis St. and Maple Ave.
Eatontown, N.J.

D. K. Stevens, B. DeBlasio, J. Raczek, S. Norinsky, J. T. Allen, J. Baugher, H. Hamer

Regatran Half-Rack DC Power Supply

Regulated dc power supplies to 100 amperes, transistorized "Regatran" and tube-type "Regatron" models (chopper-stabilized for 0.01% regulation), rack-mounted, half-rack, table models, constant-current supplies, programmable (remote control) feature available. Precision calibrated supplies. AC voltage regulator for 115 or 230 volts.

(Continued on page 244A)

▲ Indicates IRE member.
* Indicates new product.
† Exhibitor is servicing IRE Engineers through the IRE Package Plan.

Don't go away mad

because you tired yourself out carrying a heavy stack of literature. Use the "Lead-Master" card, and the exhibitor will send his literature to you by mail.

POTENTIO-METERS

RELIABILITY

DIGITO-METERS

ROTARY SWITCHES

by

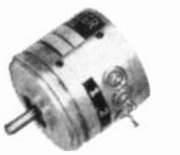
ELECTRO-MEC

All our instruments offer you design flexibility and long life.

Step up reliability.

Step down size of your system.

POTENTIOMETERS: A complete line of superprecision linear and non-linear potentiometers. Certified calibration data, including recordings of output function are supplied with each instrument. All AIA sizes from RR-09 to RR-30.



DIGITOMETERS: Four sizes are available in this shaft angle digitalizer, 1.06" to 3.00" Dia. When you operate under severe ambient conditions, always specify Electro-Mec Digitometers. They are designed to withstand the rigors of MIL (E) 5272 environmental tests.

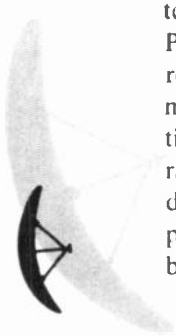
ROTARY SWITCHES: Our newest product with the same built-in reliability you have come to expect from Electro-Mec. .875" to 3.00" Dia., these Rotary Switches can be supplied singly or in combination with potentiometers. Current capacity up to 250 ma.

For further information or for data sheets, write or telephone our Engineering Department.
ST-6-3402 Teletype: NY-4-2126

ELECTRO-MEC DIVISION OF
WALTHAM PRECISION INSTRUMENT COMPANY, INC.
47-51 33 Street — Long Island City 1, N.Y.

"LEL'S NEW PARAMP"

SHORTENS THE MILES, BROADENS THE COVERAGE, STRENGTHENS THE SIGNALS



An outstanding state-of-the-art advancement in low-noise receiving systems, the new model RA-1 Telemetry Preamplifier is the first of a series of reactance amplifiers designed for telemetry, space and scatter communications, long range and early warning radar applications. Featuring a high degree of stability, the unit is completely weatherproofed for dependability in all outdoor environments . . .

PARAMETRIC Telemetry Preamplifier

SPECIFICATIONS:

Passband	225-260mc
Gain	25db
Noise Figure	1-2db
Load Impedance	50 ohms
Power Input	115v, 60cps

LEL INC. / **Akron Street Copiague, L. I., N. Y.** AMityville 4-2200

Whom and What to See at the IRE Show

(Continued from page 212A)

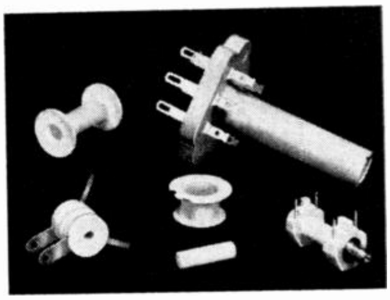
Electronic Measurements Corp., Booth 3941
625 Broadway
New York 12, N.Y.

M. Lieblich, L. Stans, J. Weber

Tube checkers, volt-ohm-milliammeters, vibrator checker, signal tracers, condenser checkers, oscilloscopes, signal generators, stereo amplifier, battery eliminators, vacuum tube voltmeters—all instruments available in wired or kit form. Also appliance checker in wired or kit form.

Electronic Mechanics, Inc., Booth 4201
101 Clifton Blvd.
Clifton, N.J.

D. Replogle, F. M. Grafton, K. Ivey, B. Replogle, J. Liker, R. Sachleben



"Mykroy" Coil Forms

Non-outgassing metallized tube components in "Mykroy." Printed circuits of glass-bonded mica. Hermetic seals of glass-bonded mica. "Mykroy"-glass-bonded mica custom molded, stock sheets, and machined pieces. A new 1740°F "Mykroy" for high thermal shock. Radiation resistant "Mykroy." "Thermica" tube spacers.

"Electronic News," Booths 4120-4122
7 East 12th St.
New York 3, N.Y.

W. Fairchild, D. Newman, H. Friedman, J. Chapman, H. Jefferbaum, I. Weiss, J. Damico, D. Jeppe, J. Tisch, D. Flora, M. Williams, J. Pintz, S. Deitch, J. Scunziano, W. O'Connor, H. Keller, J. Vigil

Newspaper (daily edition during IRE Show).

Electronic Products Magazine, Booth 4424

See: United Catalog Publishers, Inc.

Electronic Representatives Association (ERA), Room 319
600 South Michigan Ave.
Chicago 5, Ill.

William C. Weber, Jr., Ruth Perine, Wally Shulan, ▲ Harry Halinton, ▲ Philip Andress, ▲ R. Edward Stemm

The national trade association of electronic manufacturers' representatives. IRE headquarters features a "Lines Available" service for manufacturers seeking representation. 750 ERA member-firms will view this service and then contact manufacturers. Service available on no-charge basis. Also information on ERA activities.

See all the exhibits!

Don't miss these important locations—

Mezzanine at back of first floor. South Room at center of south wall, second floor. 3000 court at southeast corner of third floor. 4000 court at southeast corner of fourth floor. 4500 court in northwest corner of fourth floor.

Electronic Research Associates, Inc., Booths 2830-2832
67 Factory Place
Cedar Grove, N.J.

▲ D. D. Grieg, ▲ S. Moskowitz, ▲ N. J. Gottfried, L. Gottlieb, A. Cohen, A. Nichols

Transistorized power supplies, miniaturized packaged equipment, packaged transistor circuitry, Magitran transistor-magnetic power supplies, Transpac miniaturized power packs, Hypac high voltage power packs, Micropac subminiature supplies. Tunnel diode power source, multi-ampere miniaturized power packs, *power controllers utilizing controlled rectifiers.

Electronic Specialty Co., Booth 1218

See: Technicraft Division

Electronic Tube Corp., Booths 3112-3113
1200 East Mermaid Lane
Chestnut Hill
Philadelphia 18, Pa.

▲ Kenneth C. Meinken, ▲ Kenneth C. Meinken, Jr., ▲ Joseph Gordon, ▲ Richard Rude, ▲ Walter Hill, S. Ambrose

Oscilloscopes—dual channel—four channel. Single beam, plug in amplifier, sweep and "cali markers"—rack mounted—*5 mc completely transistorized miniaturized. Cameras—oscilloscope continuous recording Southern Instruments drum—Polaroid Land back— model SM-209—adapter for nine positions. Special designed camera cathode ray tubes.

Electronics International Co., Booth 3018

See: International Electronic Research Corp., ELIN Div.

Electrosnap Switch Div., Booths 1727-31

See: Control Switch Div.

Elgin-Advance Relays, Elgin National Watch Co., Booth 2233
2435 North Naomi St.
Burbank, Calif.

▲ Eric Firth, Duane Manning, John Kauwling, William Doty, Edward Scheibel, Charles Spevak, Joseph Schreiber

Military and commercial relays. Antenna, time delay, general purpose, power, sensitive, telephone, crystal, can styles, microminiature, featuring the world's smallest electromagnetic relay—the Elgin "Neomite." Elgin Micronics Div.: Timing devices. Elgin Abrasives Div.: Abrasives.

Elgin Laboratories, Inc., Booths 3210-12

Printed circuit board, Strip-Pack packaging. See: Erie Resistor Corp.

Elgin Metalformers Corp., Booths 4225-29

See: Emcor Ingersoll Products Div., Borg-Warner Corp.

Elin Div., Booth 3018

See: International Electronic Research Corp., ELIN Div.

(Continued on page 246A)

Both Portable and Stationary

FREQUENCY and TIME STANDARDS

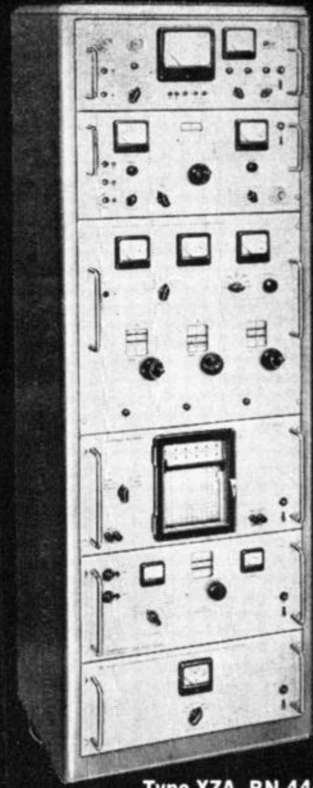
DECADE FREQUENCY SYSTEMS

Generate and Measure Frequencies from Zero to Kilomegacycles with Crystal Accuracy

FEATURES

- Frequency range from d.c. to 12.6 kilomegacycles.
- Accuracy and stability better than 1 x 10^{-9}/day, according to crystal oscillator used.
- Smallest crystal locked step 10 cps.
- Smallest frequency increment 5 millicycles.
- Crystal control steps rigidly locked to frequency standard.
- Continuous variable output voltage from less than 100μv to more than 1 volt.
- Simplicity of operation by small number of front panel controls.

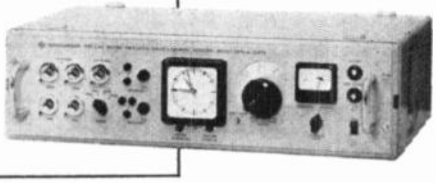
The decade frequency measuring system is based on the principle of the frequency synthesizer, which generates a continuously variable frequency with the accuracy of the driving standard oscillator. Unknown frequencies are measured by heterodyning with this variable reference frequency, and the difference frequency is measured on a precision meter with magnifier. Facilities for recording also are available.



Type XZA BN 444044

Type CAQ BN 7850

PORTABLE, FULLY TRANSISTORIZED FREQUENCY AND TIME STANDARD



STANDARD TIME SYSTEMS

Permits Measurement of Drift in Frequency Standards by means of Comparison of Time Signals

FEATURES

- This system embodies more than 20 years' experience in the field of time and frequency standards.
- Simplicity of operation obtained by completely integrated system.
- Special time-comparison oscilloscope for photographic logging.
- Emergency power supply prevents loss of calibration due to line failure.
- Special accessories, such as sidereal time converters, are available.

The standard time system generates a time signal, derived from the frequency standard, for comparison with time signals from WWV, etc., on a special time-comparison oscilloscope. Daily log without calculation may be kept by a photographic recording. The system provides frequency divider, motor-driven phase shifter, and all-wave receiver for time signals from 14 kc to 28 mc. Frequency standard has built-in servo system for remote control from VLF standard frequency by means of a phase comparator.

Type CAA BN 78012

ROHDE & SCHWARZ
111 Lexington Ave., Passaic, N. J. • PRescott 3-8010

Whom and What to See at the IRE Show

(Continued from page 244A)

Emcor Ingersoll Products Div., Borg-Warner Corporation, Booths 4225-4229
630 Congdon Ave.
Elgin, Ill.

B. L. Lucas, D. J. Jones, J. M. Votava, H. N. Bowen, Jr., C. W. Peterson, E. P. LaKaff, H. H. Wolfe, R. R. Green, D. L. Snow, M. D. Fitzgerald

The Emcor Modular Enclosure System: Including standard and *heavy duty vertical and sloped front frames—steel and aluminum panels —*chassis slides and other component parts for standard 19" and 24" wide enclosures used in commercial, industrial, and military applications.

Emerson & Cuming, Inc., Booth 3823
869 Washington St.
Canton, Mass.

C. L. Emerson, Jr., ▲ W. R. Cuming, ▲ H. A. Smith, ▲ C. I. Johnson, ▲ A. J. Giguere, J. R. Copley

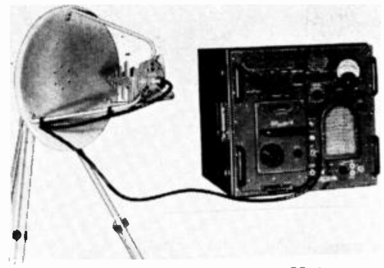
Introducing two new resin products for RF shielding applications. Eccoshield VX, a conductive caulking compound offering insertion loss equivalent to a welded point, and Eccocoat RF, a luminiscent paint to mark ground members. Eccomold CLE, a carbon loaded epoxy molding powder.

▲ Indicates IRE member.
* Indicates new product.
† Exhibitor is servicing IRE Engineers through the IRE Package Plan.

A complete listing of all registrants at the IRE Show and Convention, showing company affiliation and local hotel, is posted on the back wall of the mezzanine on the west side of the first floor.

Empire Devices Products Corp., Booths 3818-3820
37 Prospect St.
Amsterdam, N.Y.

▲ Michael T. Harges, ▲ Joseph Lorch, ▲ William S. Lambdin, Mark Epstein



Noise & Field Intensity Meter

Noise & field intensity meters, 14 kc to 10 kmc; power density meter; coaxial crystal mixers; microwave attenuators; terminations; microwave power attenuators; microwave attenuator panels; microwave step attenuators; ultra-sensitive receiver; radar interference blanker; variable frequency power supplies; microwave impulse generators; AM modulation meter; standard antennas; *preselector cavities.

†

See PROCEEDINGS OF THE IRE—Jan. through Dec. (1960), Jan., March (1961) for further information on our products.

See 1961 IRE DIRECTORY, pages 307, 309, 313, 315, 379, and 584, for complete information on our products.

Ender-Monarch Division, Booth 4129
See: Acoustica Associates, Inc.

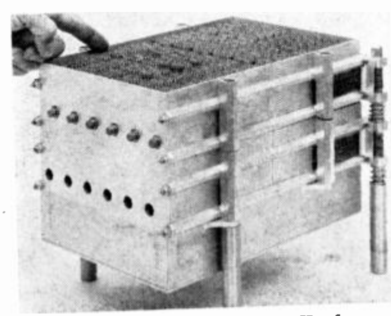
Engelhard Industries, Inc., Booths 1406-1414
113 Astor St.
Newark 2, N.J.

I. W. Sheppard, J. Derrig, T. Hartnett, A. Salomone, K. Walter, F. Wright, J. Vezza, R. Miller, G. Briechle, G. Shealy, R. Langley, A. Gautieri

Gas purifying and generating equipment. Precious metal plating solutions. Electrical contacts. Fused quartz and silica. Fine wire. Platinum clad. Relays. Raiselay. Slip-rings. Laminated metals. Luster gold coatings.

Engineered Electronics Co., Booth 1110
1441 East Chestnut Ave.
Santa Ana, Calif.

▲ T. W. Jarmie, ▲ F. J. Temple, ▲ A. B. Williams, ▲ W. O. Hedge, ▲ K. Goodman, ▲ R. Cepuch, ▲ J. W. Guthrie



Microminiature Circuit and Hardware

Plug-in circuit modules, vacuum tube and transistorized, transistorized indicators, transistorized decade and counters, *magnetic core circuits, *power supplies, digital breadboard equipment, microminiature circuit and hardware, *slide chassis assemblies.

(Continued on page 249A)

WRH

Whom and What to See at the IRE Show

(*Continued from page 246A*)

Epco Products, Inc., Booth 2239
Box 298
Wallkill, N.Y.

E. Mullin, Charles Abolin, David Unger, Nat Sperry, Ed Thomas, Charles Cutney

Transformers: Made to specification. Powers, audios, reactors, toroids, filters, transistor, pulse—for commercial or military standards. Encapsulated and high temperature types. *A new line of standard transformers.

Epsco, Incorporated, Booths 1216 & 3915
275 Massachusetts Ave.
Cambridge 39, Mass.

Bernard Gordon, Sam Bass, Don Deuitch, Pierre Cathou, Joe Bartholomew, Al Keane, Herb Karsh, Jack Gallagher, Bob Wright, William Shetter, Dick Ferrero

Component Div.: Digital circuitry, magnetics, logic trainer, logic panels. Instrument Div.: Data logger, high speed analog to digital converters, secondary voltage reference sources, multiplexers (electronic), digital voltmeters, amplifiers. Systems Div.: Computer Linkage systems, computer forcmat recording systems, portable data gathering systems, PCM telemetry systems, high speed, high accuracy instrumentation.

Era Dynamics Corp., Booths 2830-32

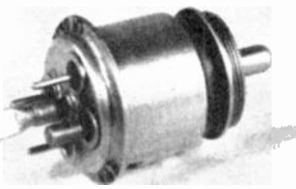
Electronic accessories. See: Electronic Research Assoc., Inc.

Ercona Corp., Booth 2110

See: Belling & Lee Ltd.

Ericsson Corp., Booth 2339
100 Park Ave.
New York 17, N.Y.

Larry Farrar, George Schindler, Nicholas J. DeSalvo, Irwin Feinstein, Gary Balsam



Ruggedized long life electronic tubes, featuring 416B, a microwave planar triode with high gm, low noise and superior figure of merit. Also, type 7150 amplifier tetrode with gm of 47,000 μmhos when triode (grounded grid) connected, as well as other premium tubes in this line.

L. M. Ericsson Telephone Co., Inc., Booths 2339 & 2125

See: Ericsson Corp. and North Electric Co.

Erie-Pacific Division, Booths 3210-12

Counters and timers. See: Erie Resistor Corp.

Erie Resistor Corporation, Booths 3210-3212
644 West 12th St.
Erie 6, Pa.

George P. Fryling II, Allen K. Shenk, ▲ J. D. Heibel, E. C. Titcomb, William R. Crotty, ▲ R. H. Anderson, ▲ Nello Coda, J. W. Schell, ▲ James Walsh, F. W. Deacon, F. J. Rich, T. O. Brown, ▲ B. A. Vizzier, F. R. Westphal, D. N. Sawtelle, E. S. Willis, ▲ F. R. Young, C. A. Slaterbeck, L. Palamara, L. Kopell, L. E. Shoot, R. H. Jones, H. C. Loller

Diodes, full-wave rectifier, pulse transformers, resistors, fixed and variable capacitors, *Blue-Chip® capacitor, *Wee Con capacitor, *style 538 miniature trimmer, Tantacon® capacitor, Transcap capacitor, *Econo-Grid printed circuit board, Strip-Pack board, *piezoelectric underwater transducer, technical ceramics, electronic counters, digital instruments, interval timers, control systems.

Ersin Multicore Solders, Booths 3406-3408

See: British Industries Corp.

Escon, Incorporated, Booths 1905 & 1928

See. Advanced Vacuum Products, Inc. & Glass-Tite Industries, Inc.

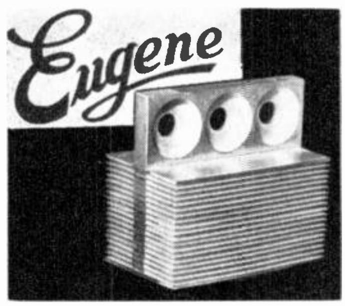
Eubanks Engineering Company, Booth 4036
260 North Allen Ave.
Pasadena, Calif.

▲ Floyd G. Eubanks, Murray Salit, William Brown, Ned Sheppard, Gerald Maloney

New model 810A automatic wire stripper with quick-change features to reduce set-up times, model 300-1 automatic wire prefeed.

Eugene Engineering Co., Inc., Booth 4525
1217 Hyde Park Ave.
Hyde Park 36, Mass.

Edward Doherty, Arthur Cook, Russell Blank



Mil Spec cases, heat sinks, electromechanical hardware, metal fabrication, complete electronic packaging, fiberglas molding, chassis, frames, complex forms. Featuring our design services available almost immediately through our unique Air Taxi Team.

(*Continued on page 250A*)

DON'T MISS THE FOURTH FLOOR!

Production engineering is rapidly becoming one of the most important facets of the radio-electronic industry. Fourth floor exhibits are devoted to this subject. On the fourth floor, you can find new machinery and tooling techniques, and discover ways to make your own product better, cheaper and faster. Don't pass up this opportunity to acquire new methods and knowledge on that all-important aspect of electronics—

PRODUCTION—FOURTH FLOOR

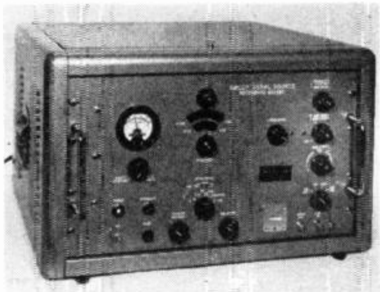
Whom and What to See at the IRE Show

(Continued from page 249A)

FXR Inc., Booths 3410-3414

25-26 50th Street
Woodside 77, N.Y.

Raymond Delcamp, William Fields, Peter Gilbody, James Lilly, Robert Gray, ▲ John Ebert, ▲ Lester Bertan, William Marshall, Paul Seckendorf, Donald Maguire, ▲ Edward Aslan



4-18 KMC Sweep Signal Sources

Sweep signal sources covering 5.85 to 18 kmc. Coaxial slide screw tuner. Trough slotted line. X Band high power load. *Electrically driven waveguide switches. 2-3 millimeter components. Direct reading attenuators and frequency meters. Temperature compensated power meters. Klystron power supplies. SWR indicator. Complete line precision microwave equipment and high power pulse modulators.

† See PROCEEDINGS OF THE IRE—Jan., March, Aug., Oct., Nov., Dec. (1960), Jan. through Dec. (1961) for further information on our products.

See 1961 IRE DIRECTORY, pages 125 through 128, for complete information on our products.

Fairchild Camera and Instrument Corp., Booths 2701-07

See: Fairchild Controls Corp. and Fairchild Semiconductor Corp.

Fairchild Controls Corp., Booths 2701-2703

Subsid. Fairchild Camera & Instrument Corp.
225 Park Ave.
Hicksville, L.I., N.Y.

T. F. D'Andrade, R. J. Feldheim, A. A. Budde, H. M. Avey, ▲ H. W. Cashman, R. M. Glueck, H. McCann

Complete line of precision potentiometers, and other sensing devices including rate gyros, accelerometers, pressure transducers and Mach and true air-speed transducers. RG-100 Sub-miniature Floated Rate Gyro for missile & aircraft applications as a control & stabilization element

Fairchild Publications, Inc., Booths 4120-22

See: Electronic News

Fairchild Semiconductor Corp., Booths 2705-2707

545 Whisman Road
Mountain View, Calif.

John W. Hall, ▲ Ransford J. Johnston, ▲ Robert M. Shultz, ▲ Donald M. Farina, Donald B. Rogers, Thomas H. Bay, Robert W. Dugan, Richard D. Day, Joseph DiMatteo, William P. O'Hara, James P. Paris, Joseph Gattuso

Planar-epitaxial version of Fairchild 2N708. *Complementary NPN and PNP high frequency transistors fT = 200 mc typical. Complete line of planar transistors, diodes, and special assemblies. 1 kmc planar transistors

† See PROCEEDINGS OF THE IRE—Jan. through Dec. (1960) and Jan. through Dec. (1961) for further information on our products.

See 1961 IRE DIRECTORY, pages 122-123, for complete information on our products.

Falcon Division, General Thermodynamics Corp., Booth 3037

209 Concord Turnpike
Cambridge, Mass.

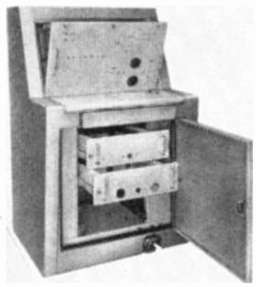
Arthur Blair, S. Leto

*Dynamic torque testing machine. Dynamometers. Miniature universal joints.

Falstrom Co., Booths 4315-4317

Falstrom Court
Passaic, N.J.

R. E. Hill, C. F. Lindholm II, H. P. Stuart, J. J. Olah, J. M. Ricker, P. W. Kievit, A. W. Lineholm, C. B. Constant, R. C. Ziegler, R. H. Colpitts



Control Console

Custom and standardized cabinets, consoles, racks, maintenance benches and chassis, frames, covers, housings for electronic industry. Welding facilities certified to meet latest military specifications. Qualified to handle prototype and production, fabricator of special items in aluminum, magnesium, stainless steel, steel, and other metals and alloys.

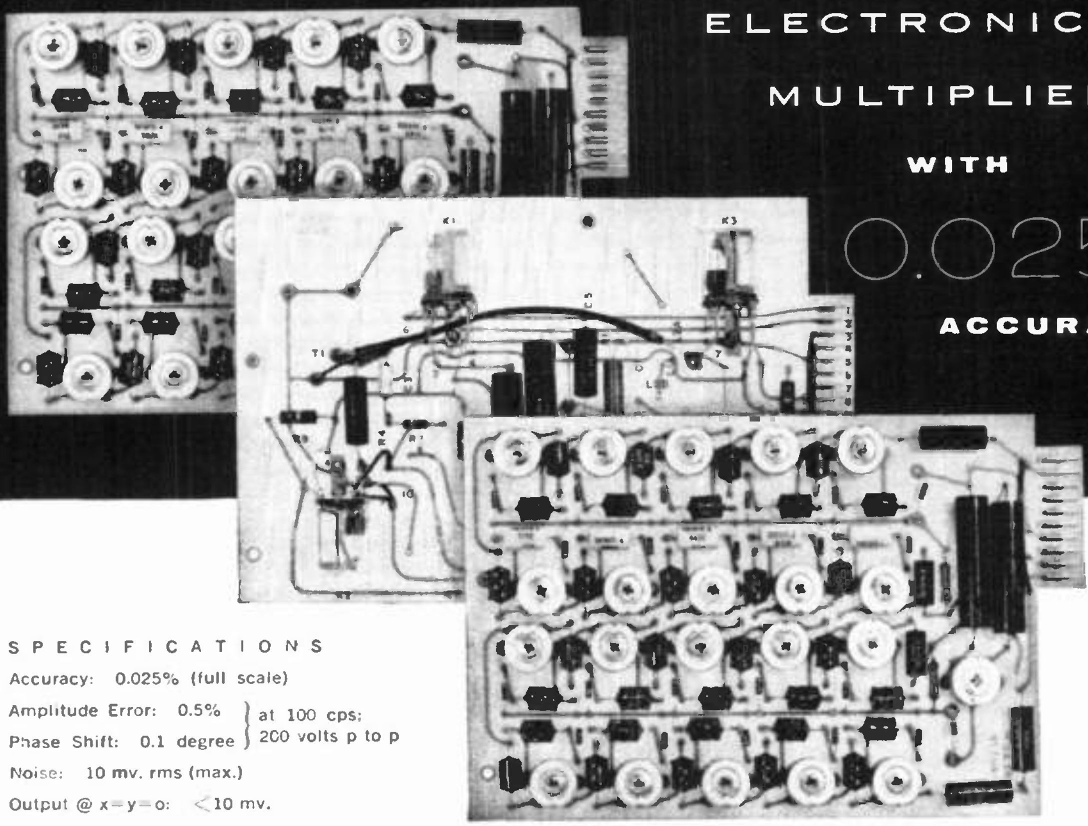
(Continued on page 252)

FIRST AID ROOM

A nurse is in charge at all times. First aid room is on the first mezzanine at the north side of the building. Take elevator 20 from any floor.

from the acknowledged leader in analog computer design

REAC® SOLID STATE ELECTRONIC MULTIPLIERS WITH 0.025% ACCURACY



SPECIFICATIONS

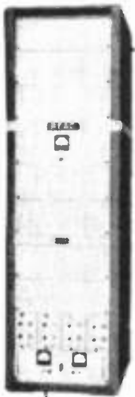
Accuracy: 0.025% (full scale)

Amplitude Error: 0.5% } at 100 cps; 200 volts p to p

Phase Shift: 0.1 degree } at 100 cps; 200 volts p to p

Noise: 10 mv. rms (max.)

Output @ x=y=o: < 10 mv.



MULTIPLIER CONSOLES

1. Eight Independent Products.
2. Expandable to 16 Products with adapter kit.
3. Adequate power for expansion to 16 products.
4. Operational Amplifier for each product.
5. Amplifier Balance Meter.
6. Standard Rack Mounting.

WITH THESE OUTSTANDING FEATURES:

- FOUR QUADRANT MULTIPLIER
- EXTREME DYNAMIC RANGE
- TEMPERATURE COMPENSATED
- FACTORY CALIBRATED, NO FIELD ADJUSTMENTS
- SILICON JUNCTION DIODE SHAPING NETWORKS
- PRINTED CIRCUIT PLUG-IN CARDS

For complete specifications, write for data file 103.

Qualified engineers seeking rewarding opportunities in these advanced fields are invited to get in touch with us.

Reeves

See our dynamic display at the I.R.E. Exhibit—Booths 1305—1307

REEVES INSTRUMENT CORPORATION

A Subsidiary of Dynamics Corporation of America • Roosevelt Field, Garden City, N. Y.

Whom and What to See at the IRE Show

(Continued from page 250A)

Fansteel Metallurgical Corp., Rectifier-Capacitor Div., Booths 1021-1022
North Chicago, Ill.
Glen Ramsey, ▲ H. Paul Weirich, Glen Iaggi, J. H. Hall, W. E. Bullock, H. P. Fieldman, J. V. Loftus, G. T. McElligott, J. V. DiMasi

FANSTEEL®

"Where Reliability Dictates Standards"

Tantalum capacitors, wet and solid of all types including "Gold-Cap" (certified reliability), PP, HP, "Blue-Cap," and STA (solids). Complete line silicon power rectifiers including *160 and *240 amp types. *Silicon zener regulator cells. *silicon zener diodes. Complete line silicon and selenium rectifier stacks. Chemical and Metallurgical Div.: Refractory metals. Electrical Contacts & Specialties Div.: Electrical contacts. Vascoloy-Ramet Div.: Carbide tools.

We'll be seeing you again at next year's show March 26-29, 1962

Faradyne Electronics Corp., Booth 2937
471 Cortlandt St.
Belleville 9, N.J.
J. W. Roy, R. A. Poyda, M. Brucker, S. Feldman, J. Webb, G. Evey, R. Gensheimer, J. Levine, J. Hutzler, A. Fraioli, M. Nelson, L. H. Wheeler, W. Richter
Mylar capacitors, tantalum capacitors, cores and core materials, ceramic beads, wire coils, aluminizing coils, tungsten wire, thread guides, precision bore tubing.

John E. Fast Co., Booths 2301-2303
See: Victoreen Instrument Co.

Federal Electric Corp., Booths 2510-20 & 2615-25
See: International Telephone & Telegraph Corp.

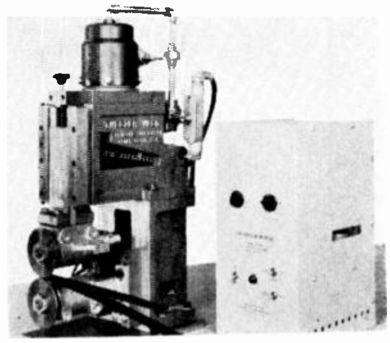
Federal Machine Tool Co., Booths 1217-1219
Precision machined metal components. See: Isotronics, Inc.

Federal Mfg. and Engineering, Booth 4112
See: Design Tool Co.

Federal Pacific Electric Co., Booths 2721-25
See: Cornell-Dubilier Electronics Div.

Federal Shock Mount Corp., Booth 1324
See: Korfund Company.

Federal Tool Engineering Co., Booth 4128
1384 Pompton Ave.
Cedar Grove, N.J.
R. H. Pityo, W. D. Pityo, E. L. Pityo, F. J. Rowe, R. J. Barry, A. J. Zetes, E. Pohle



Tweezer-Weld Seam Welder

Tweezer-Welders: complete line of bench-portable and automatic types—synchronous and stored energy welding controls— welding heads—*seam welders—*semiconductor equipment and components.

Fenwal Electronics, Inc., Booth 1204
51 Mellen St.
Framingham, Mass.
Robert S. Goodyear, Benjamin Wojeski, Al Wait, ▲ Harry (Bob) Andrews
Precision thermistors and thermistor probes of all types.

Ferris Instrument Co., Booth 3801
110 Cornelia Street
Boonton, N.J.
▲ H. J. Tyzzer, ▲ S. R. Montcalm, ▲ Thomas S. Leoser
Ferris has a new transistorized noise meter, FM and AM signal generators, and *new model 18-J microvolter with built-in RF amplifier. Additional features in several well-known instruments.

Ferroxcube Corp. of America, Booth 2530
235 East Bridge St.
Saugerties, N.Y.
▲ Carl J. Kunz, ▲ Ernest Slaney, Joseph L. Mondello, ▲ Ned W. Buoymaster, ▲ George Sawutz
Memory cores and memory planes; recording heads; toroids; pre-adjusted pot cores; bonded recording heads; E, U and I cores; negative temperature coefficient resistors; voltage dependent resistors. Other machined ferrite parts.

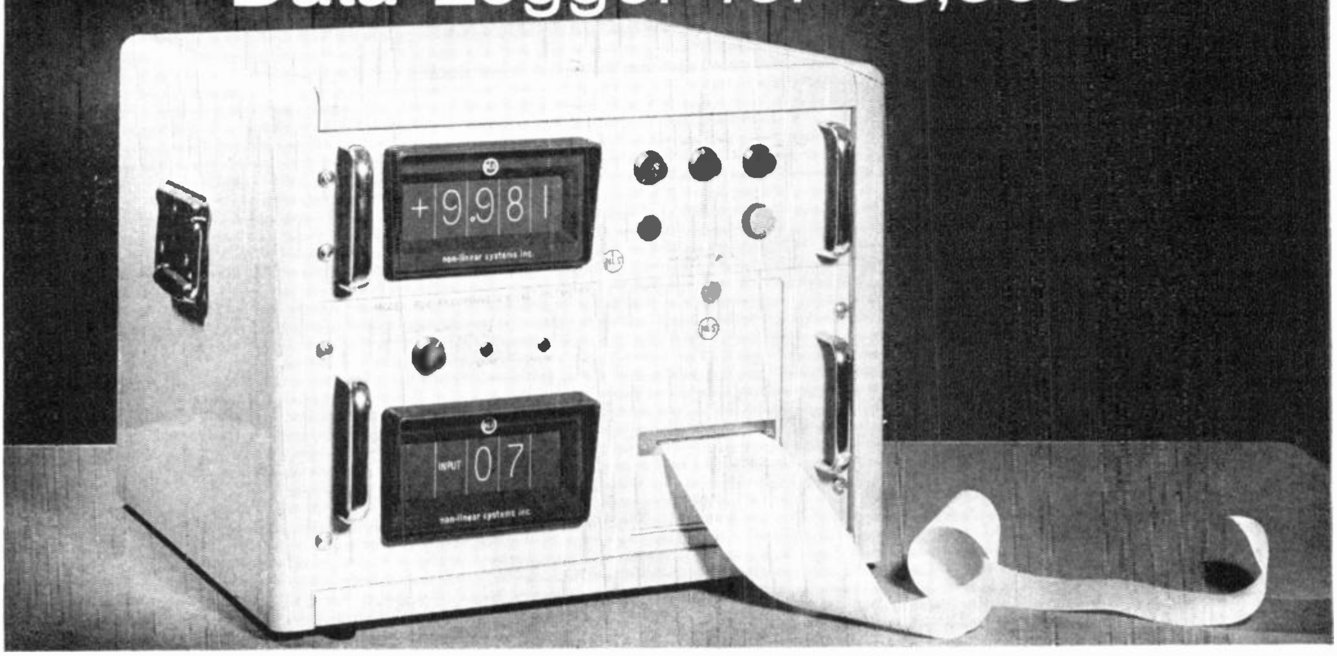
Fifty Avenue L, Inc., Booths 2721-25
See: Cornell-Dubilier Electronics.

Filmohm Corp., Booth 1806
48 West 25th St.
New York 10, New York
▲ Jack N. Popper, Charles A. Kossmann, Bob Latin, ▲ Bernie Gunshinan, Bert Aaron, Joe Reardon
Waveguide attenuator elements, N.B.S. pattern coaxial thermal voltmeters TDO D-8, filmcard metal film resistance card, *metal film mylar (DuPont mylar), microwave resistors—discs and rods, *crystal resistors, coaxial termination resistors, metallized mica attenuator elements, microsistors, metallized mica attenuator elements, microminiature module resistor, *flexible disc resistors.

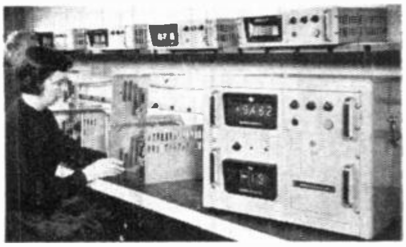
Filtors, Inc., Booth 2808
30 Sagamore Hill Drive
Port Washington, N.Y.
C. G. (Speck) Barker, Malcolm Pelton, Richard W. Walker, Louis D. Delalio, Edward Hill, Les Redding
Specialists in design and manufacture of hermetically sealed subminiature and microminiature relays. Producers of the "Golden G" premium quality microminiature relay. New this year: The Microlatch relay, the *Betamite relay series, and the *Miniwatt sensitive relay series.

(Continued on page 254A)

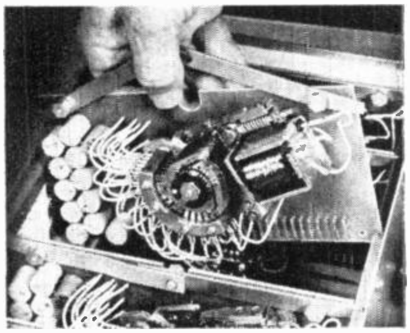
High Precision Data Logger for $3,600



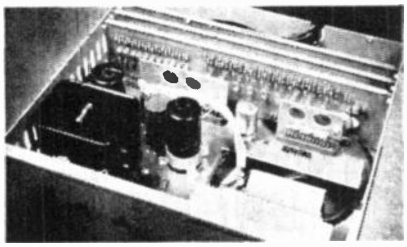
The RS2 Recording Digital Voltmeter — now in volume production at Non-Linear Systems, Inc. — scans up to 20 double-pole input channels . . . measures DC voltage from ±0.001 to ±999.9 with ±0.01% accuracy . . . and records input channel number and the 4-digit voltage measurement. Uses include research and development, quality control, environmental and reliability testing.



Volume production and simplified controls of the RS2 account for its low cost — half to a third less than custom-built units



Plug-in stepping switches in the digital voltmeter section of the RS2 permit replacement of all switches and decade resistors in minutes instead of days.



Note the compact, plug-in modular design of the scanner-printer section of the RS2.

NLS Reports on Low-Cost, Standard Data Logger

A low-cost automatic data logger built as an integrated scanning, measuring and printing system — the RS2 Recording Digital Voltmeter — is now in volume production at Non-Linear Systems, Inc.

This economy-priced NLS logger is designed for applications requiring high accuracy and low cost without need for the higher speed and greater input capacity of higher cost NLS systems. Simplified controls offer several automatic and manual modes of operation to meet the needs of a great number of applications.

While utilizing many circuits field-tested for six years in thousands of NLS digital voltmeters, the RS2 has undergone extensive testing as a standard, complete system. It is delivered ready to use, without need for additional engineering or complex interconnections.

Call your NLS regional office or representative for a demonstration, or write NLS.

RS2 BRIEF SPECIFICATIONS

Visual Indication: 4-digit voltage reading with correct polarity and range. 2 digits for input channel identification.

Range-Polarity Indication: automatic

Functions: scanning up to 20-double-pole channels; measuring DC voltage from ±0.001 to ±999.9 in ranges of ±9.999/99.99/999.9; printing channel number, 4-digit reading, polarity and decimal point placement.

Accuracy: ±0.01% of full scale on each range.

Speed: 2 seconds average for each data point scanned, measured and recorded.

Scanner Operation Modes: AUTO CYCLE — system continually repeats automatic scanning cycle from channel 00 to 19. ONE CYCLE — system automatically stops after scanning channel 19. PRINT — one input is measured without advancing scanner. Scanner may be manually advanced one channel at a time by depressing front panel ADVANCE button.

AC Voltage: Use NLS AC/DC Converter.

Low-Level DC: Use NLS Model 140 Preamplifier.

Input Impedance: 10 megs on all ranges.

Size: 14" high. 15¼" deep for 19" rack.

Delivery: From stock. 30 days, maximum, should stocks become depleted.

See the new RS2 at IRE, Booth 3041-42.

Originator of the Digital Voltmeter

NLS

non-linear systems, inc.

DEL MAR, CALIFORNIA

Whom and What to See at the IRE Show

(Continued from page 252A)

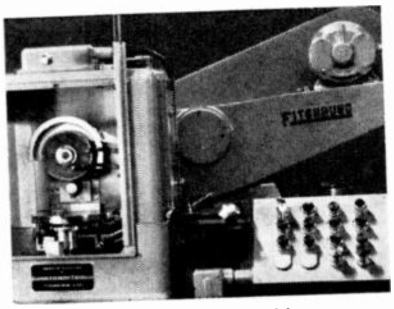
Filtron Co., Inc., Booth 1812-1814
131-15 Fowler Ave.
Flushing 55, L.I., N.Y.

▲S. Barry, ▲L. Milton, S. E. Perry, G. Barry, ▲J. Milton, J. Abrams, ▲M. First, ▲R. Klose, B. Burnett, ▲B. Jarva, ▲S. Burrano, ▲B. Birsten

RF interference filters, specialty capacitors, delay lines, *Attenuduct filters, *Attenu-Suit, radar pulse package, pulse forming networks, pulse transformers, pulse capacitors, energy storage capacitors, thermal circuit breakers, RF interference measurement services, systems engineering consultation services.

Fitchburg Engineering Corp., Booth 4535
Cleghorn St.
Fitchburg, Mass.

▲Garfield M. Arthur, William N. Forman, Robert N. Fickett, Samuel Testagrossa, Keijo Huhtala, Harold Buckman, Walter Sunne, Gerald Landry



Crystal Slicing Machine

The Fitchburg semiconductor crystal slicing machine.

John Fluke Mfg. Co., Inc., Booth 3237
7100-220th S.W.
Mountlake Terrace, Wash.

John Fluke, Roy Malm, Robert Hammond, John Zevenbergen, Leighton Rama, Richard May, Donald Hall

True RMS voltmeters, vacuum tube and transistorized general-purpose power supplies, meter calibrators, constant current supplies, high voltage power supplies.

Food Machinery and Chemical Corp., Dapon Dept., Booth 4011
161 East 42nd St.
New York 17, N.Y.

R. H. Malott, J. L. Shafer, F. Nostrand, J. M. Kreinik, J. L. Thomas

"Dapon" diallyl phthalate resins for molding electronic components. Dip coating—encapsulating—sealing—laminating. "Dapon" diallyl isophthalate resins for high temperature applications.

Ford Instrument Co., Booths 2733-39
See: Sperry Rand Corp., Sperry Gyroscope Div.

Forma Scientific, Inc., Booth 3946
Box 649
Marietta, Ohio

Richard L. Bergen, Harry F. Holmes, Thomas K. Decker, Roma H. Bergen, Ralph W. Bergen

*New designed high-temp vacuum oven with close temperature control over work load. Super-cold Frigid Midget, fast pull-down time to minus 100 deg. F. Dry boxes designed to give full view of work area with no glare or eye strain.

Foto-Video Electronics, Inc., Booths 3012-3013
36 Commerce Rd.
Cedar Grove, N.J.

▲A. J. Baracket, ▲T. R. Kennedy, Jr., ▲Robert D. Hamilton, ▲Hans Nord, ▲Herbert P. Michels, Angelo Dumont, Laurence Nagy, ▲Jess Dines, Paul Zucchino, ▲Rudiger Tietze, William Gerbert

Main product line: A) Regulated power supplies including *all-transistorized power supply system. B) Closed circuit TV cameras, monitors, television test equipment including monoscope camera, portable sync generator, video distribution amplifier. C) Radar-TV keyed video and window generator.

Franklin Electronics, Inc., Booth 3838
East Fourth St.
Bridgeport, Pa.

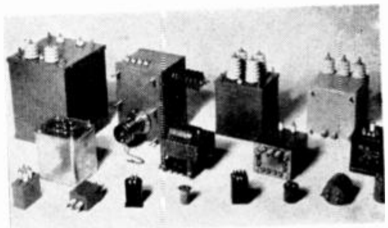
Philip P. Sharples, Thomas J. Keffer

*Model 550DC digital voltmeter—5 ranges—3.1 digits—0.1% accuracy. *Model 1450DC digital voltmeter—4.1 digits—0.05% accuracy. *Model 1350AD converter—3.1 digits—0.01% accuracy —60 readings per second. *Model 500B digital multimeter—3.1 digits—ac, dc ohms—5 ranges.

Keep this book for future reference, so you will be able to remember "Who made it?" and discover "Where can I reach them now?"

Freed Transformer Co., Inc., Booths 2509-2511
1720 Weirfield St.
Brooklyn 27, N.Y.

G. T. Dalrymple, M. Salzberg, L. Freed, ▲D. Gurevics, ▲S. Solzberg, ▲R. Freed, R. M. O'Dea, J. Solzberg, M. J. Solzberg



Transformers, reactors, toroid inductors, filters, magnetic amplifiers, saturable transformers, saturable reactors, transistor converters, constant voltage transformers, reference transformers, MIL-T-27A transformers and reactors, electronic counters, pulse transformers, molded and encapsulated transformers and reactors, laboratory test equipment.

† See PROCEEDINGS OF THE IRE—Jan. through Dec. (1960) and Jan. through Dec. (1961) for further information on our products. See 1961 IRE DIRECTORY, page 566, for complete information on our products.

Freeport Engineering Co., Booth 3027
See: Ebauches S. A.

Freon Div., Booths 4319-21
See: E. I. du Pont de Nemours & Co., Inc.

Frequency Standards, Div. Harvard Industries, Inc., Booth 3844
P.O. Box 504
Asbury Park, N.J.

Gil Ennes, Steve Bucher, ▲Jim Brough, ▲Lee Barret, George Gregory, ▲Bob Sleven, ▲Jack Cottingham

*High power microwave filter, 5 megawatt precision microwave wavemeters, filters, preselectors, discriminators, mixers.

Furane Plastics, Inc., Booth 4050
4516 Brazil St.
Los Angeles 39, Calif.

R. S. Pettigrew, Samuel Jeffries, Malcolm Bard, Vincent Chorusey, Leon Wynn

Epoxy and polyurethane electrical insulating materials. Potting and encapsulating compounds. Printed circuit board coatings. Adhesives, impregnants, etc.

GC Electronics Company, Div. of Textron Electronics Inc., Booth 2337
400 South Wyman St.
Rockford, Ill.

▲E. J. Naretta, Doug. Battin

Microphones, plugs, jacks, connectors, switches, electronic tools, cable ties, chemicals, wire strippers, rubber drives, tek titles, cable clamps, antennas and accessories, insulating materials, resistors.

GEMP Mfg. Corp., Booth 4115
See: Great Eastern Metal Products Co.

(Continued on page 256A)

▲ Indicates IRE member.
* Indicates new product.
† Exhibitor is servicing IRE Engineers through the IRE Package Plan.

STABILIZED MICROWAVE SIGNAL GENERATORS

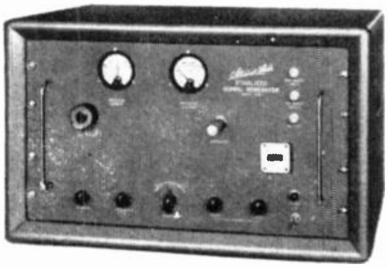
ULTRA STABLE
VARIABLE FREQUENCY
VERSATILE

Microwave signal sources with high rf stability... for test, research, inspection.

Model 300

INEXPENSIVE
Portable
Self-contained
Short-term stability —
1 part in 10^8.

10 mw power output for low power applications. Offers many features found only in much higher-priced instruments.



Model 500

EXTREME STABILITY
HIGH POWER
HIGH RELIABILITY
MODERATE COST

500 mw power output for maximum flexibility. The unexcelled frequency stability:
short-term deviation — 1 part in 10^8
long-term deviation — 1 part in 10^6
. . . is achieved with a high-gain dc amplifier, and patented AFC discriminator.

Models 300 & 500 operate at 8.5 to 9.6 Kmc/s. Also available — units at K, C and S-bands. Full year's warranty on all instruments. Write for complete information.

See us at IRE — Booth 3007

Strand Labs INC.

294 Centre Street • Newton 58, Mass. • Telephone WO 9-8890

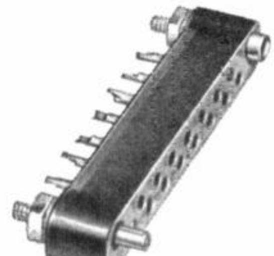
Representatives in principal cities of U.S. and overseas.

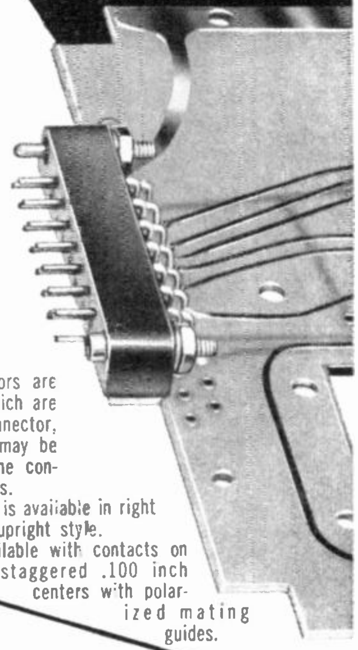
Methode Multiple Contact Connectors

Designed for aircraft, radar, and missile applications. Especially suitable for use with printed circuit boards or, Plyo-Duct, Methode's flat multi-conductor cabling.

TWO PART PRINTED CIRCUIT CONNECTOR
Series MD-1100 and SD-1100.

Exceed requirements of MIL-C-8384 and NAS 713, 714, 715 where applicable.

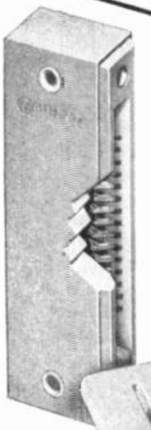




Methode Multiple Contact Connectors are designed to alleviate difficulties which are usually common with this type of connector, using closed entry sockets which may be inserted into and removed from the connector after wiring with simple tools.

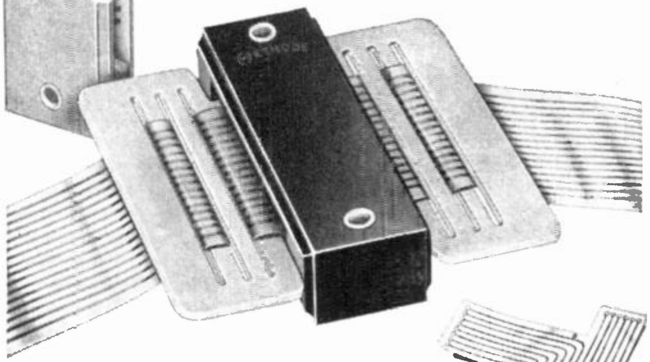
The male connector is available in right angle mounting or upright style.

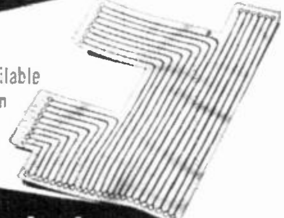
Available with contacts on staggered .100 inch centers with polarized mating guides.



RELI-ACON FEED-THRU STYLE CONNECTOR Series FTD 1500

These connectors employ a tri-furcated contact which withstands extreme vibration. Presently available in 15 contacts on .100 inch centers for a nominal card opening of .062 inch. Moisture seal is available about the board or cable entrance.





Flexible multi-conductor wiring is available in standard sizes from stock or custom patterned to your specifications.

COMPLETE information and data are available on both of above connector types . . . write today.

Methode manufacturing corp.
7447 W. Wilson Ave
Chicago 31, Ill.

Whom and What to See at the IRE Show

(Continued from page 254A)

G-L Electronics Co., Inc., Booth 1916
300 Harvard Ave.
Westville, N.J.

Stephen G. Lax, John C. Instone, Hugh L. Slough, ▲ Charles H. Fritz, Samuel E. Dansker, Frank J. Hayes, ▲ James R. Jaquet, Albert R. Pollack, Ed Bergen

Tape wound magnetic cores—uniformity and control of parameters. Nickel alloy bobbin cores. Nickel alloy transformer laminations featuring "Hi-Q" insulation. Head laminations. Custom carbide dies. Fiberglas radomes. Impregnated fiberglas instrument and computer front panels. Custom compression, transfer and injection molding.

G-M Laboratories, Inc., Booth 2105
4300 North Knox Ave.
Chicago 41, Illinois

Dr. K. Burian, Jerry Allyn, Jerry Borron, Warren Carnel, Ed. Gittleman, Jim Heffern, Harold Hill

Reliability—quality—delivery—competitive pricing. Specialists in producing to your exacting specifications. Servo motors, motor generators, rate generators. Size 18 through size 8.

GOE Engineering Co., Booth 4053
P.O. Box 22004
219 South Mednik Ave.
Los Angeles 22, Calif.

Robert L. Relly, Arvin Bell, ▲ S. W. Simberkoff, ▲ J. Simberkoff, ▲ Art Stangel, ▲ Harry Lewis

Terminals, feed thrus, insulated standoffs, threaded standoffs, handles, terminal boards, shaft locks, and allied hardware.

GPL Division, Booths 1501-1511

See General Precision, Inc.

Gabriel Electronics, Div. of The Gabriel Co., Booths 2635-2637
Main & Pleasant Streets
Millis, Mass.

▲ Robert Stewart, ▲ Jack Hamre, Peter Zitso

*New 2-12 kmc line of parabolic antennas up to 16 ft. dia.—radar antenna systems—rotary joints—airport surveillance antennas—dual polarized Cassegrainian antenna systems—beacon antennas and helical arrays—28' tracking antennas—R & D in microwave propagation.

Gamewell Company, Potentiometer Div., Booth 2837
1238 Chestnut St.
Newton Upper Falls 64, Mass.

C. J. Manning, W. Shannon, R. Beedle, W. Vossberg, T. Garrettston, Alex Fay, A. Lospinoso, N. Pukatch, C. McDonald, G. Kelly, R. Stalhunt

Potentiometers and miniature metal housed items, including trimmer, precision, differential, multiturn Rotary Switch, and other special potentiometers.

Gardner-Denver Company, Booths 4524-4526
Quincy, Ill.

D. P. Brouwer, W. L. Olds, G. W. Roth, W. H. Long, D. D. Bohon, D. F. Blondin, W. F. Bigony, G. P. Sheldon, B. V. Hayes, P. Meaden, R. Van Schelven, D. Schmitt, R. Campbell, J. James, J. Turner, D. Eveleth, G. Draper, J. R. Bos

Air and electric "Wire-Wrap" tools, mechanical "Wire-Wrap" tools for making solderless wrapped electrical connections. Also, manual service-type tools for wrapping and unwrapping, and wrapping bits and sleeves. Movie illustrating automatic "Wire-Wrap" machine.

Garlock Electronic Products, Booths 2814-2816
Garlock Inc.
Camden, N.J.

F. O. Dutton, F. Harned, C. Burgin, P. Byrne, J. Dearie, E. Budgis, F. Abbett, R. Crawford, R. A. Lyons, R. Morrow

Flexible printed circuitry. Teflon FEP encapsulated printed circuits offer greater design freedom with maximum reliability and labor savings. Etched copper circuit completely encapsulated in Teflon FEP. Also, tube and transistor sockets, stand-off and feed-thru insulators.

Garrett Corp., Booth 3841
9851-9951 S. Sepulveda Blvd.
Los Angeles 45, Calif.

R. Dale Moyer, Richard Callison, Karl Granlund, Peter Depp, Hilliard Davis, Charles Baugh, Gerald Rennerts

Electrical and electronic temperature controls, central air data computer systems, instruments, electrical motors, actuators and fans, electronic cooling units—all for aircraft, missile, and electronics industries. Infrared coolers.

Gates Radio Co., Booths 3608-3610
123 Hampshire St.
Quincy, Ill.

▲ L. J. Cervone, R. W. Kuhl, Abe Jacobowitz, W. T. Ayer

Gates IRE display includes *a complete line of transistorized amplifiers, the "Cartritape" cartridge tape system, the ST-101 spot tape recorder, *100W SSB transceiver, multiple geophysical amplifiers, and a special selection of Gates-manufactured coils.

General Aniline & Film Corp., Booth 4106

See: Ozalid Division

General Cement Mfg. Co., Booth 2337

See: GC Electronics Co.

General Ceramics Corp., Booths 1310-1316

See: Indiana General Corp.

General Chemical Div., Booth 4305

See: Allied Chemical Corp.

General Computers, Inc., Booth 3937
9000 West Pico Blvd.
Los Angeles 35, Calif.

R. A. Sinker, D. H. Sinker

Card programmed diode function generators, dc operational amplifiers, chopper amplifiers, general purpose and custom designed analog computers, industrial process control computers. All equipment modularized to facilitate assembly of units to meet any specifications from standard building blocks.

General Dispersions, Inc., Booth 4132

Nylon solutions and dispersions. See: General Plastics Corp.

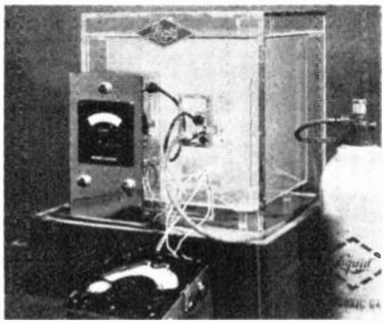
▲ Indicates IRE member.
* Indicates new product.
† Exhibitor is servicing IRE Engineers through the IRE Package Plan.

IRE MEMBERSHIP

The IRE membership booths at the Waldorf-Astoria Hotel and the Coliseum main lobby can provide you with information and application blanks for IRE membership and professional group membership. Also available here are membership cards and pins, IRE publications, and order blanks for the "Convention Record" which gives the complete text of all papers presented at the convention.

General Dynamics Corp., Liquid Carbonic Division, Booth 3011
135 South La Salle St.
Chicago 3, Ill.

W. Dickson, J. Rubin, E. Sweet, J. P. Antolak, C. Berntson, F. Knee, T. Gallagher, R. Wiesman



Plastic Low Temperature Chamber

Carbon dioxide used as a refrigerant and inert gas for environmental testing. Available as a solid or a liquid from high pressure cylinders, low pressure bulk storage tanks, or high pressure dry ice converters.

General Electric Company, Capacitor Department, Booth 2928
Hudson Falls, N.Y.

J. P. Holloway, J. L. Feininger, W. S. Stewart, ▲F. L. Johnson, T. Bisaha, R. Martin, D. Schmidt, D. H. Nichols, J. B. Maher, D. A. Donnolly

Capacitors, fixed, liquid, solid and film dielectric: Tantalum-*High reliability foil and solid, 85°C "A" case size cylindrical, high voltage—125°C foil cylindrical, porous-anode, king size rectangular; aluminum—computer-grade style; lectrofilm-B tubular, film-dielectric military and commercial equivalents; energy-storage and discharge; pulse-forming networks.

General Electric Co., Heavy Military Electronics Dept., Booths 2920-2924
Syracuse, N.Y.

M. DeLallo, M. Chacona, W. O. Johnson, Jr., N. R. Bibko

The Heavy Military Electronics Department will feature the Ballistic Missile Early Warning System (BMEWS) showing its broad capability and competence in the design and manufacture of defense electronic equipment ranging from the smallest components to the world's largest radar.

†

See PROCEEDINGS OF THE IRE—Jan., Feb., March, April, May, June, July, Sept., Oct., Dec. (1960), Jan., Feb., March (1961) for further information on our products.

See 1961 IRE DIRECTORY, pages 263, 267, 435, 437, 501, 621, for complete information on our products.

General Electric Company, Instrument Department, Booths 2904-2932
40 Federal St.
West Lynn, Mass.

C. Harris, Jr., W. E. Cornish, J. D. Henderson, W. J. Kearney, N. S. Stone, J. A. Peel, F. Haney, S. R. Sulis, M. W. Vittum, E. T. Finigan, J. J. Schimoler, E. R. Harrison

"Big Look" panel meters and time meters (indicating instruments)—2½, 3½ and 4½-inch ac, dc, and rectifier designs, all ratings, sealed and shielded. 4½-inch model has snap-on, snap-off cover. New, "Big Look" time meter to be introduced.

(Continued on page 258A)

Whom and What to See at the IRE Show

(Continued from page 257A)

General Electric Co., Laminated Products Dept., Booth 2914
Coshocton, Ohio

B. F. Brehl, R. Q. Dixon, F. J. McGroder, J. F. Tynan, G. S. Velimesis, R. M. Baril, R R. Regen

A host of new grades—*low-cost silicone/glass, *a melamine/glass with greatly reduced moisture absorption, *self-extinguishing copper clad grades FR-2, FR-4, FR-5, *epoxy glass with improved machineability.

General Electric Co., Lamp Division, Booth 2916
Nela Park
Cleveland 12, Ohio

Miniature Lamp Dept.: D. C. Miller, L. C. Newson, A. J. Nugent, E. C. O'Hara, D. T. Swertfager, J. W. Tuttle, J. H. van Es, J. F. Vercellotti, W. R. Walker

Lamp Glass Dept. (Quartz): N. G. Grafton, W. R. Becker, K. C. Field, W. D. Parker, R. Morrissey

Lamp Metals & Components Dept.: A. MacKenzie, R. W. Mouat, J. S. Petro, E. P. Kilroy, R. W. Schmies, I. O. Lisk, E. E. Kinney, R. J. Keyes, B. L. Corkum, E. H. Tucker, R. W. Hilbish, E. D. Smith

Tungsten and molybdenum metal products, electronic phosphors, lead wires and lamp bases. Pilot and indicator lamps, glow lamps and quartz glass products.

"Lead-Master" saves you time and trouble. To get exhibitors' literature sent direct to you by mail, circle the exhibitor's "Lead-Master" number, and leave your pocket card at the Coliseum Lobby.

General Electric Co., Magnetic Materials Section, Booth 2920
Edmore, Mich.

▲ E. E. George, M. E. Hartl, R. J. Studders, R. J. Parker, R. P. Smith, G. D. Barcus, G. J. Anderson, G. R. Laughlin, H. Schwartz, A. R. Kozlowski, R. G. Giffune, J. P. Young, J. C. Betts, A. Marquis, B. H. Fellows, J. E. Foy, F. G. Mussen

Complete line of Alnico permanent magnets for speakers, magnetos, motors and generators, electronic devices, communications, controls, and other specific applications. Thyrite® varistors for voltage surge suppression. Thermistors for temperature compensation, measurement, current surge suppression, time delay, and control.

General Electric Co., Missile and Space Vehicle Dept., Booth 2920
3198 Chestnut St.
Philadelphia 4, Pa.

William Hoese

Military Electronics

General Electric Co., Power Tube Dept., Booths 2912-2914
Schenectady 5, N.Y.

J. F. Callanan, E. A. DeMetre, ▲ H. W. Cole, L. G. Osterman, A. C. Rowe, R. H. Mack, C. D. Ahlstrom, K. E. Wilson, ▲ Dr. M. Weinstein, ▲ B. L. Pfefer, ▲ S. E. Webber, ▲ A. Michaelson, ▲ R. I. Reed, ▲ W. F. McKeehan, H. L. Tate, E. B. Martin, F. L. Miller, W. A. Babcock

Metal-ceramic tetrodes for military applications, multiple-beam klystrons, superpower gas tubes for electronic switching, broadband microwave oscillators and amplifiers, harmonic-suppression filters, research and development projects and capabilities.

General Electric Co., Receiving Tube Dept., Booths 2906-2908
Owensboro, Ky.

L. T. Bowles, J. W. Rush, Jr., J. R. Topper, J. E. Nelson, J. W. Gross, K. K. Krehbiel, L. G. Mumford, A. C. Gubitz, W. H. Clarke, S. E. McCallum

"Timm" (Thermionic Integrated Micro Modules) eliminate heat problems of miniaturization, prevent malfunction from radiation and heat. "Compactron"—a 12-pin vacuum device combining into one unit the functions now performed by several components.

General Electric Co., Semiconductor Products Dept. & Rectifier Components Dept., Booths 2901-2906
Electronics Park
Syracuse, N.Y.

J. Sweeney, H. Potter, A. Bassett, J. Walton, A. Woolaver, G. Curtiss, C. Goodman, W. Gebhardt, C. Ryder, J. Greene, P. Hahn, A. Barko, T. Loucas, W. Robusto, J. Teahan, J. Skelly, D. Louney, L. Mooney, R. Oliver, R. Schumaker, C. Huyette, J. Munson, C. Gallagher, H. Lupton, C. Barrie, R. Berry, R. Jay, W. Alexander, P. Burks, J. Bentley, J. Brady, T. McGough, J. Shea, W. Wroblicka, W. Halley, R. Bauman, J. Dempsey, E. Hookway, R. Rogers, J. Schuten, H. Hjermstad

Transistors: Unijunction, PNP low, NPN alloy, mesas. Diodes: Microdot, stripline, back, tunnel, thyrector. Rectifiers: High current, lead mounted SCR, fast turn-off inverter type SCR.

General Electric Company, Silicone Products Dept., Booths 2904-2932
Waterford, N.Y.

J. W. Hawkins, J. Scott Hurley, Jr., P. A. Goodwin, B. B. White, M. E. Groby, G. A. Darsie, A. J. Porter, G. E. Shepherd, J. J. Deasy, T. H. Reilly, R. V. Mackey, A. R. LaPaz, G. S. Glaser, J. S. J. Berray

Silicone varnishes, dielectric fluids and grease, silicone rubber for electrical tapes, wire and cable. RTV liquid silicone rubber, silicone potting, encapsulating, embedding compounds.

General Electric Company, Specialty Control Dept., Booths 2904-2932
Waynesboro, Virginia

D. F. Cross, R. D. Hawkins, H. E. Johnson, J. A. Krog

Sealed relays—miniaturized high performance, high reliability crystal can microminiature line; grid space microminiature 2-pole, 4-pole and featuring new polarized sensitive *2-pole unit, exclusive welded construction. "Unimite," world's smallest 1 amp relay offering high speed operation, isolated contact chamber. Meets MIL specs.

General Electric Company, Voltage Regulator Products Section, Booth 2924
Pittsfield, Mass.

R. A. Chatterley, H. R. Lumma, R. A. Prior, T. R. Shortelle, A. Terzano

Rack mounted Inductrol® and Sta-Vo-Trol voltage regulators for critical military and commercial applications. Sta-Vo-Trol static voltage regulator is a maintenance-free design that eliminates tubes, brushes, and moving parts—utilizes unique rate-feedback and industry-proven zener diode sensing.

General Electric Co., Ltd. of England, Booths 3406-08

Gold Lion tubes, Genalex special purpose tubes. See: British Industries Corp.

(Continued on page 260A)

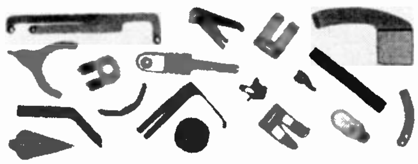
▲ Indicates IRE member.
* Indicates new product.
† Exhibitor is servicing IRE Engineers through the IRE Package Plan.


BANANA RIVER
ATLANTIC OCEAN

Whom and What to See at the IRE Show

(Continued from page 258A)

General Findings and Supply Co., Industrial Div., Booth 1051
Attleboro, Mass.
Gerald F. Tucci, Sam Greenbaum, Arthur O. Marcello, Fred Dole, J. Doescher



Miniature precious metal contacts and assemblies. Rivets, brushes, slip rings, contact blades, and special shapes. All standard contact alloys of gold, silver, platinum, and palladium. Also precision base metal fabrications and assemblies.

General Instrument Corporation, Booths 1101-1106
See: General Instrument Semiconductor Div., Harris Transducer Corp., Magne-Head Div., Micamold Electronics Mfg. Corp., Radio Receptor Co., F. W. Sickles Div.

General Instrument Corp., Semiconductor Division, Booths 1101-1106
65 Gouverneur St.
Newark 4, N.J.
R. Adler, ▲ J. Fishel, ▲ K. Moritz, H. Fialkov, M. Friedman, ▲ J. Evans, P. Frey, G. Cacavio, M. Klein, S. Young, H. Greenstone, H. Peaceman, R. Seifert, T. Liebfried, J. DeGroot, S. Spivak

*Silicon mesa transistors, *silicon mesa diodes, *25 amp. silicon rectifiers, *micro-ckt. packages, *microminiature diodes, special circuit encapsulations, complete line of germanium transistors, miniature glass silicon and germanium diodes, complete line JAN silicon power rectifiers, bobbinless resistors, complete line of zener voltage regulators, germanium tunnel diodes.

* Indicates new product.
▲ Indicates IRE member.

General Magnetic Corp., Booth 1904
10001 Erwin Ave.
Detroit 34, Mich.
Harold Mattes, ▲ W. E. Gilman, ▲ Ray Campbell, ▲ Ronald Hall, ▲ Robert Thompson
Permanent magnets (Alnico and Genox®) for microwave, meter, motor, instrument, aviation, automotive, electronic, radio, television, and communications industries.

General Mills, Inc., Booths 3830-3832
1620 Central Ave., N.E.
Minneapolis 13, Minn.
Paul Berglund, Carroll Skiba, George Schenck, Lloyd Pearson, ▲ Thomas Fay, ▲ Robert Snyder
*Transistorized digital clock—accurate ±0.5 millisecond per hour. Time increments of 1 millisecond presented in digital form. Has self contained WWV receiver. Readout directly to computer and/or through internal paper tape perforator. *Transistorized WWV receiver —rugged, compact, portable.

General Motors Corp., Booths 1325 & 2128
See: Delco Radio Div. and New Departure Div.

General Plastics Corp., Booth 4132
55 La France Ave.
Bloomfield, N.J.
Robert Goldsmith, M. Goldsmith, Edward W. Davidson, Walter Hassler, Jack Simon, Mel Nelson, Robert Gaunt, Raymond Goetz, Russell Baker, Harry Barto, Paul Farley, Paul Hess, Robert Logan, Al Thiel
Custom coating services—teflon, "Kel-F," nylon, epoxy, *"Penton," *"Rokide" ceramics, acrylics, phenolics. *"Genclad teflon"—glass printed circuit laminates. "Identasleeve" high temperature wire markers. "Durasleeve" flexible asbestos conduits. *"Gentape" printed, perforated indicating and drive tapes. "Teflon" impregnated glass fabric tapes, laminates.

General Precision, Inc., Subsidiary of General Precision Equipment Corp., Booths 1501-1511
Tarrytown, N.Y.
Systems for navigation, guidance and control. Computers. Detection, tracking, acquisition, and fire control. Simulation and logistic support. Industrial process control.
See also Kearfott Division, Librascope Division, Link Division.

(Continued on page 262A)

The letter "M" preceding a booth number indicates that the exhibitor will be found on the mezzanine at the back of the first floor.

Be sure to see all four floors for a complete view of 800 new ideas!

Your firm not listed?
If you would like to become an exhibitor in the IRE show, write for information to IRE Exhibits Dept., 72 W. 45th St., New York 36.

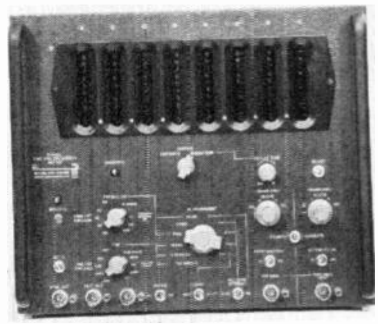
Whom and What to See at the IRE Show

(Continued from page 260A)

General Radio Co., Booths 3201-3208

22 Baker Ave.
West Concord, Mass.

▲ A. E. Thiessen, ▲ P. J. Macalka, ▲ W. R. Thurston, ▲ R. A. Boole, ▲ R. B. Richmond, ▲ C. E. Worthen, ▲ M. T. Smith, ▲ R. K. Peterson, ▲ S. W. DeBlois, ▲ W. R. Saylor, ▲ C. J. Lahanas, ▲ M. A. Gilman, ▲ L. J. Chamberlain, ▲ K. Adams, ▲ F. J. Finnegan, ▲ I. G. Easton, ▲ E. Karplus, ▲ P. Bishop, ▲ J. E. Snook, ▲ H. H. Dawes, ▲ D. B. Sinclair, ▲ M. J. Holtje, ▲ E. F. Sutherland, ▲ C. W. Harrison, ▲ R. E. Wilson, ▲ R. W. Frank, ▲ G. G. Ross, ▲ D. W. Brown, ▲ J. C. Held, ▲ R. H. Reinstra, ▲ A. P. G. Peterson, ▲ R. A. Soderman



Digital Time and Frequency Meter

Comprehensive display of coaxial instruments and components: Locking type coaxial connector; *high-accuracy analog type of frequency meter and linear discriminator; *high-reliability digital time and frequency meter with counter storage feature; *1000 mc frequency standard; *30-ampere Variac® Autotransformer; Strobotac® electronic stroboscope.

† See PROCEEDINGS OF THE IRE—Jan. through Dec. (1960), Jan., Feb., March (1961) for further information on our products.
See 1961 IRE DIRECTORY, fourth cover, for complete information on our products.

General Resistance, Inc., Booth 3026

430 Southern Blvd.
New York 55, N.Y.

▲ Charles Jasik, ▲ Lawrence Merson, ▲ Rubin Blumkin, Mike Lombardozzi, Frank Bertolotti, Len Nachemov

Resistor networks, *Twin-T filter networks, precision wire wound resistors, *dividers, *decade boxes, Wheatstone bridge, voltage dividers, summing networks, special temperature coefficient resistors, *"Resist-O-Stat," *"Dial-A-Vider."

General Scientific Corp., Booth 2523

See: San Fernando Electric Mfg. Co.

General Telephone and Electronics Corp., Booths 1908-10, 2322-2332, 2415-2425

See: Automatic Electric Corp. & Sylvania Electric Products Inc.

General Thermodynamics Corp., Booth 3037

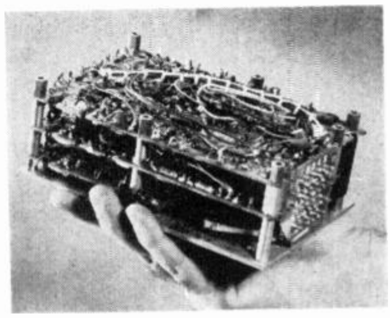
See: Falcon Division

Why carry a load of literature? Exhibitors will send their literature direct to you by mail if you circle their number on your "Lead-Master" card.

General Time Corporation, Central Research Laboratory, Booth 1726

Progress Drive
Stamford, Conn.

▲ R. W. Behringer, ▲ Ed. Roseff, D. Gudelis, ▲ Mel Lace, ▲ Dr. W. C. Anderson, ▲W. B. Weaver



"Incremag"—Tiros Timing Programming System

"Incremag"—Tiros I & II timing programming system. Magnetic counting dividing units are shown in one application. Useful in frequency division, timing, programming, control, memory and logic. Meets military missile and satellite specifications. Systems incorporating logic circuitry manufactured to your specifications or in 1-inch-square standard package. GT Chicago Laboratory: Mechanical timers.

General Transistor Corporation, Booths 1101-1106

See: General Instrument Corp., Semiconductor Division.

Gentape Corp., Booth 4132

Printed and perforated indicating and drive tapes for vertical instrumentation. See: General Plastics Corp.

Georator Corp., Booths 1230-1232

Tudor Lane
Manassas, Virginia

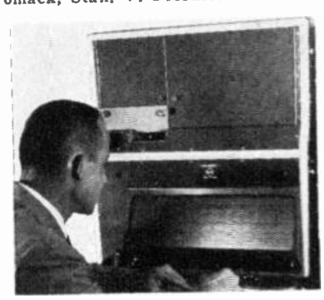
S. Krasnow, R. Prange, T. Greenburg, S. Benerofe

400 cycle permanent magnet "no-brush" generators, *"no-brush" dc supplies and battery charging systems; permanent magnet alternators; variable frequency supplies.

Geotech, Booth 3239

3401 Shiloh Road
Garland, Texas

Frank E. Gaillard, ▲ Jack H. Hamilton, James R. Womack, Stan. V. Preskitt



Auto-Processing CR-Tube

Analog CR-Tube or 16-trace 16mm recorder; 72-hour capacity; auto-processing; data displayed X10. Portable time system; 25#; 24Vdc; generates time marks, 60 cps power; 5/10⁷/wk stability; strobe time comparer-adjuster. Wide-screen film data viewer; motorized drive.

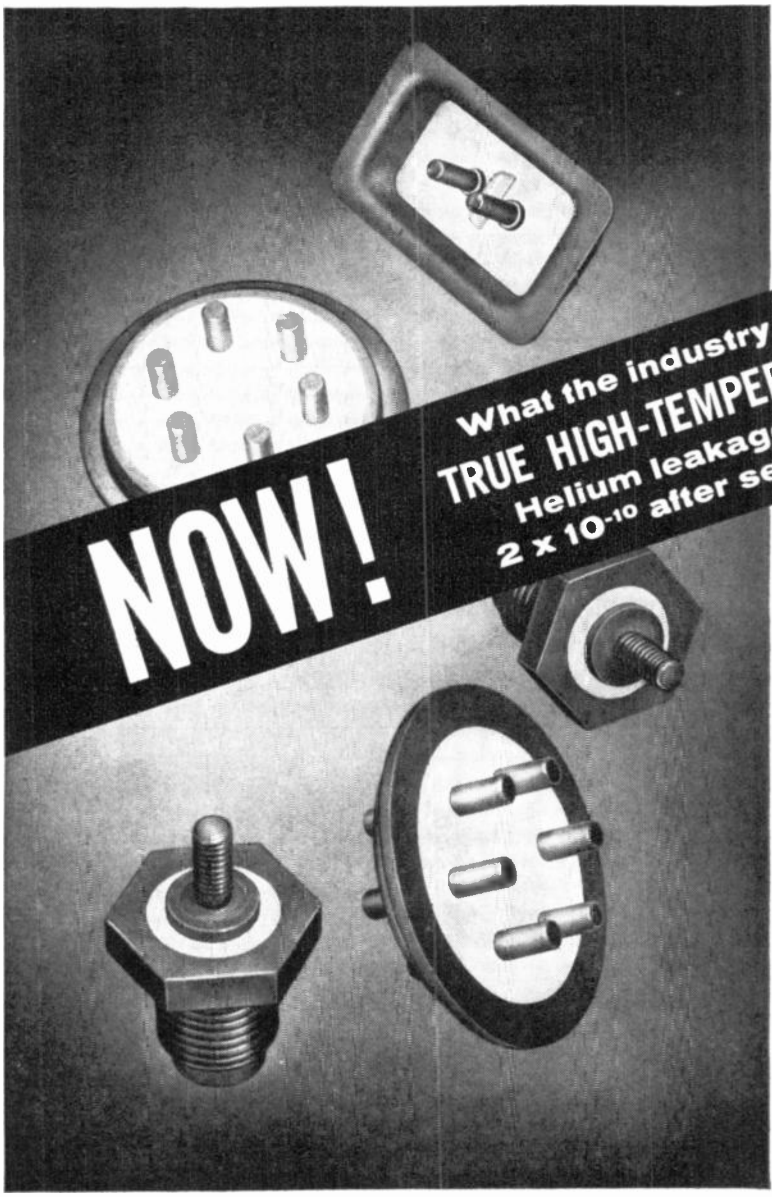
Geotechnical Corp., Booth 3239

See: Geotech

(Continued on page 264A)

BIG NEWS in high-temperature precision-molded insulation

SUPRAMICA® 620 "BB" ceramoplastic



Need a precision-molded insulation material with total dimensional stability under the most adverse thermal cycling, operating to 1200°F. . . . or a material with previously unattainable combination of properties? Check these facts about new SUPRAMICA 620 "BB" ceramoplastic:

- **Maximum temperature endurance of material 1200°F. (unstressed). Heat distortion temperature of material 1100°F. (ASTM D648-264 PSI)**
- **SUPRAMICA 620 "BB" ceramoplastic can be precision molded to most intricate geometries with gauge-like tolerances.**
- **SUPRAMICA 620 "BB" ceramoplastic will not carbonize.**
- **Absolute hermetic seals achieved directly during the molding cycle. Components meet a helium leakage rate of less than 2×10^{-10} cc/sec., after the following environmental tests:**
  1. Samples heat shocked a total of 20 cycles from boiling water for 30 minutes directly to ice water for 10 minutes.
  2. Samples heat shocked a total of 5 cycles, from 350°C. for 1 hour directly to room temperature for 10 minutes, to -70°C. for 1 hour, to room temperature for 10 minutes.
  3. Samples heated to 500°C. for 4 hours and directly to room temperature.
- **Thermal expansion factor matches many metals and alloys.**
- **New SUPRAMICA 620 "BB" ceramoplastic features a dielectric strength of 270 volts/mil, ⅛" thickness per ASTM D-149.**

See this newest advance in the Science of High-Temperature Insulation

Visit **BOOTH 2517-2519** at the NEW YORK I R E SHOW

General Offices and Plant: 126 Clifton Boulevard, Clifton, N. J.
Executive Offices: 30 Rockefeller Plaza, New York 20, N. Y.

World's largest manufacturer of ceramoplastics, glass-bonded mica and synthetic mica products

THE FIRST SYNTHAMICA® SYNTHETIC MICA · SINCE 1919 MYCALEX® THE INSULATOR · THE FIRST SUPRAMICA® CERAMOPLASTIC

MYCALEX CORPORATION OF AMERICA

Whom and What to See at the IRE Show

(Continued from page 262A)

Gertsch Products, Inc., Booths 3715-3717
3211 So. La Cienega Blvd.
Los Angeles 16, Calif.

▲ E. P. Gertsch, ▲ E. W. Watts, R. M. Bloniarz, H. F. Richardson, H. P. Faris, J. L. Landis

AC and DC ratio standards; coaxial switch, DB, percent deviation, programmable, and shaft driven ratio transformers; transistorized and automatic complex ratio bridges; variable phase standard; synchro and resolver simulators; transistorized null indicator; VHF frequency and deviation meters; RF amplifier-attenuator.

Giannini Control Corp., Booth 3935
See: Datex Corp.

Glass-Tite Industries, Inc., Booth 1905
725 Branch Ave.
Providence 4, R.I.

John A. Dodenhoff, Ralph R. Papitto, Frank W. Brakenwagen, Jr., Philip Schumacher, Christian D. Berger, D. L. Wilbur, Henry Laevsky, Leroy W. Beier, Gramer Yarbrough, Milton Paisner, Philip J. Scanlon

Complete line of glass-to-metal hermetic seals for relay industry, semiconductor manufacturers, etc. Escon: Complete line of plastic and high temperature hermetically sealed connectors. Advac: Complete line of ceramic-to-metal seals including high alumina types. See also: Advanced Vacuum Products, Inc., Booth 1928

▲ Indicates IRE member.
Indicates new product.

Glasseal Products Co., Inc., Booth 1519
725 Commerce Road
Linden, N.J.

Alexander Anderson, Ernest J. Camlet, Gus Eichelhardt, Jack Goss, Frank Emmet, Russ Diethert, Robert Sidnell, Fred Peterson, David Humes, Tom Ellis

Complete line of standard vacuum-tight high compression and Kovar glass-to-metal seals. Transistor terminations, diodes, connectors, headers, end-seals, feed-thrus, stand-offs, and rectifier housing. Plus brazing facilities, custom-designing, and "sealing service" for customer supplied components.

Globe Industries, Inc., Booth 2827
1784 Stanley Ave.
Dayton 4, Ohio

Max Isaacson, R. A. Stein, Howard Isaacson, Bob Tanis, Aaron Sivitz, Earl Matré, Yale Holt, Jerry Brinkman

Manufacturers of precision miniature motors, blowers, timers, actuators, and electromechanical devices.

Goldsmith Bros. Div., Booth 4518
Brazing alloys, fluxes, precious metals. See: National Lead Co.

Show Hours
10 a.m. to 9 p.m. daily
Monday through Thursday
March 20-23, 1961

John Gombos Co., Inc., Booths 2818-2820
Webro Road
Clifton, N.J.

John Gombos, Harold J. Schatz, ▲ Alfred A. Crivello, ▲ Gino DePaola, Robert Sepulveda, Herbert Berkowitz, ▲ Frank Rich, George Marshall, Ralph Taylor

Manufacturers of microwave components and subsystems. Complete line of triode oscillator and amplifier cavities; microwave tunable band-pass filters and microwave filters to customer requirements; manufacturers of electromechanical and mechanical assemblies; aluminum dip-brazing; research and development.

Good-All Electric Mfg. Co., Subsidiary of Thompson Ramo Wooldridge, Inc., Booth 1320
112 West First St.
Ogallala, Neb.

Q. T. Wiles, L. C. Kolste, E. M. Sheridan, K. A. Hagge, D. D. Rasdal, T. L. Pestel, L. R. Harry

*Subminiature 50-volt tubular capacitors for transistorized circuits of both military and civilian designs. *Epoxy molded, mylar dielectric tubulars. Our display will be rounded out with disc capacitors and numerous tubular types employing mylar, metallized mylar, and polystyrene films.

Gordos Corporation, Booth 1123
250 Glenwood Ave.
Bloomfield, N.J.

George B. Marchev, Robert Murray, Walter Murray, John Churchill

Magnetic reed switches, mercury switches, *wetted magnetic mercury switches.

W. L. Gore & Associates, Inc., Booth 4121
555 Paper Mill Road
Newark, Delaware

▲ W. L. Gore, R. D. Urquhart, P. B. Cooper, H. W. Arnold

Teflon insulated wire and cable. Complete harnesses of ribbon cable illustrating space and weight savings advantage of ribbon cable. High voltage wire with teflon insulation. Fiber filled abrasion resistant teflon insulation. Corona resistant teflon insulation. Tetra-Etch for making teflon bondable.

Gorham Electronics, Div. Gorham Mfg. Company, Booth 2632
333 Adelaide Ave.
Providence 7, R.I.

▲ R. S. Gordon, H. L. Mann, W. H. Duvall, ▲ C. D. Berger, ▲ R. Lannamann, C. VanSickler, M. Grosso, B. Scorza, ▲ C. Knothe, A. M. Dunkel, J. Basler

Fabricated and cast microwave components and assemblies, electromechanical assemblies.

Gorham Mfg. Co., Booths 2632 and 3063
See: Gorham Electronics Div. & Pickard & Burns, Inc.

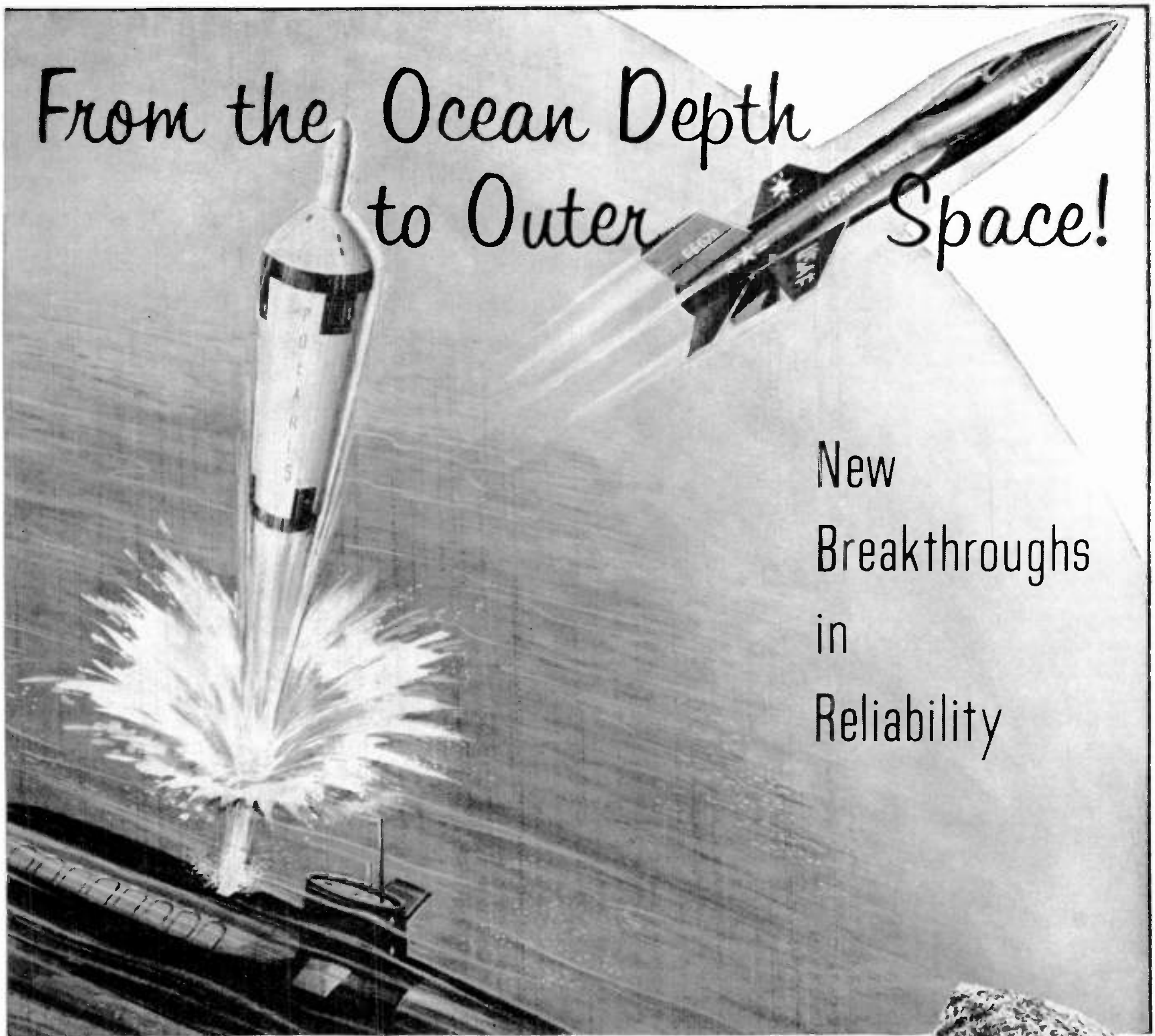
Gorman Machine Corporation, Booth 1018
480 S. Main St.
Randolph, Mass.

Kenneth Gorman, Harvey Snider, Mona Collum

Toroidal winding machines featuring the Model 600 winding from .055" I.D. to two inches O.D. with automatic sector winding and progressive bank winding. Predetermining counters. Also on display, the *new Model 1200 for winding toroids up to five inches O.D.

Gould-National Batteries, Inc., Booth 1120
See: Nicad Division

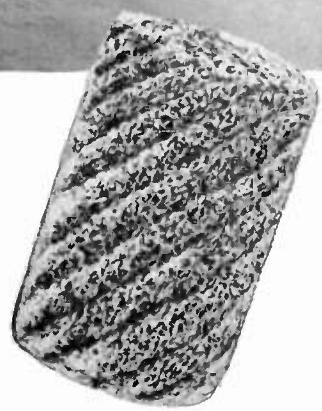
(Continued on page 266A)



Vibration and Shock Control for any Environment

Aboard the latest nuclear powered Polaris Submarines, Robinson MET-L-FLEX mounting systems safeguard performance and long-term reliability of inertial guidance and single sideband communications equipment —plus critical components in the Polaris missiles themselves. Robinson ***low-frequency*** shipboard mounting systems combine ***both*** vibration and shock protection—a new design breakthrough now available for the underwater and surface fleets of the U. S. Navy.

Nearly every aircraft and missile delivered to the Air Force since 1950 carries MET-L-FLEX mounting systems designed and produced by Robinson. In the X-15 aero-space research vehicle, for example, MET-L-FLEX mounts protect 24 vital electronic and electro-mechanical equipment units. Robinson has also pioneered in the development of high performance, high temperature resistant all-metal mounting systems for jet and rocket engine installations.



MET-L-FLEX cushions, fabricated from stainless steel wire, will not deteriorate!

ROBINSON VIBRASHOCK DIVISION
Vibration and Shock Control

GREATER RELIABILITY IN THE SPACE AGE THROUGH ENVIRONMENTAL CONTROL BY ROBINSON

ROBINSON *Technical Products Inc* **TETERBORO, NEW JERSEY**
WEST COAST ENGINEERING OFFICE: SANTA MONICA, CALIFORNIA

DESIGNERS AND MANUFACTURERS OF VIBRATION CONTROL SYSTEMS

Whom and What to See at the IRE Show

(Continued from page 264A)

Grant Pulley & Hardware Corp., Booth 4404
43 High St.
West Nyack, N.Y.

H. Schaeffer, Jack Vissman, Charles Agnoff, Walter Hess, Al Nelson, Joseph Norton, Robert Saunders, Alvin L. Ring, N. A. Gussack, Milt Gussack, William M. Linden, Jerry Bross, Lou Wichers, Robert Lawson

Grant will display the most complete line of industrial slides available. Booth will be manned by sales and engineering staff. Will contain lounge, all materials necessary to offer on-the-spot engineering services for packaging engineers.

Graphik Circuits Div., Booth 2535

See: Cinch Mfg. Co.

Grayhill, Inc., Booth 2801
561 Hillgrove Ave.
La Grange, Ill.

Ralph M. Hill, Charles P. Quinn, Gene R. Hill, Clifford J. Reesman, ▲ John M. Kikta, Alan Kramer, ▲ William Fitzsimmons

Miniature switches (push button, snap action *rotary tap), concentric shaft rotary switch, *push pull switch, power tap switch (10 amp), lighted push button switch, coil forms, stand-off insulators, test jacks, binding posts, test clips, push posts, pencil tube sockets, transistor sockets.

Great Eastern Metal Products Co., Div. of GEMP Manufacturing Corp., Booth 1115
22 Woodworth Ave.
Yonkers 2, N.Y.

Lester Weinberg

MIL-T-27A standard fabricated cases and covers. Blind inserts. Single and double end weld studs. Brackets. Custom built fabricated cases and covers. Non-standard YY cases and covers. Modification of drawn cases and covers.

Green Instrument Co., Inc., Booth 4332
295 Vassar St.
Cambridge 39, Mass.

Edwin T. Green, W. Franklin Fullerton, Lynd F. Tillyer, Edward G. Magnuson, Howard N. Heasley, Anthony R. Satullo

"Printed Circuit Air Drilling" Green pantograph engraving machines, rotary tables, compound slides, cutter grinder, production jigs and fixtures. Featuring the heavy-duty Model D-2 Green engraver.

Greibach Instruments Corporation, Booth 3828
315 North Ave.
New Rochelle, N.Y.

▲ Dr. E. H. Greibach, Fred P. Greenwood, William Joseph, Jerry Wasserman, S. Sussman, Bob Cunha, Jack Sarty, Alen Rosenthal-Canada, Fred Cowperthwait, Woody Brodhead

Meters: Direct measuring ac-dc, pivotless, highest in accuracy, sensitivity, ruggedness, reliability. Lowest millivolt drop, energy consumption. To .02 microamperes, full 6 inch scale. To 23 ranges. Selective expansion with effective 60-inch scale. From microamps to high amperes. From millivolts to kilovolts up to 5 megohms per volt.

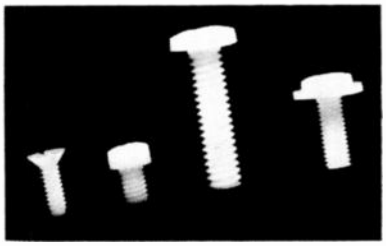
Gremar Manufacturing Co., Inc., Booth 2811
7 North Ave.
Wakefield, Mass.

▲ Carlton G. Marie, ▲ Sherman J. Somerset, Donald J. Reynolds, Ronald Young, F. A. Macdonald

Coaxial cable connectors and radio frequency fittings. Red line miniature series. *New subminiature series.

Gries Reproducer Corp., Booth 1030
125 Beechwood Ave.
New Rochelle, N.Y.

Carl Chase, Ken Keenan, John McDermott, Richard Goodman, Bruno DeStefani, Edward Brancato, Norman Riley, William Aleshire, Roy Lesher, Fred Teves, John Stetler

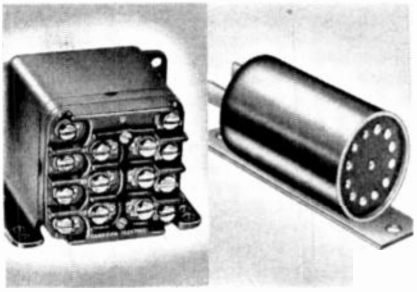


*Molded Delrin Screws

Tiny die cast zinc alloy and molded nylon, Delrin and other engineering thermoplastic precision components: Coil bobbins, gears and pinions, wire ties, cable clamps, *Delrin molded fasteners, nylon fasteners, screw insulators, bushings, washers receptacles, counter wheels. "Intercast" (cast assembled) movable components.

Guardian Electric Mfg. Co., Booth 2502-2504
1550 West Carroll Ave.
Chicago 7, Ill.

J. J. Rowell, G. G. Rowell, R. F. Heyne, F. J. Obici, L. Russo, J. Winkler, T. Cohen, T. J. Obszarny, R. Nelms, O. Kress, D. O. Boucher



Stepper Relay

Guardian Rotomite stepper: 12 position, 6 v.d.c. samples available. Other voltages obtainable with 6 to 7 weeks delivery. Prices: $4.00 to $4.50 in lots of 1,000. New series 3005 4 P.D.T. relay carries complete military standard approval. Hermetically sealed. Has high vibration resistance; operating range −65°C to 120°C. Standard coils 24 to 28 v.d.c. Special ac units operate up to 400 cps.

(Continued on page 268A)

IRE MEMBERSHIP

The IRE membership booths at the Waldorf-Astoria Hotel and the Coliseum main lobby can provide you with information and application blanks for IRE membership and professional group membership. Also available here are membership cards and pins, IRE publications, and order blanks for the "Convention Record" which gives the complete text of all papers presented at the convention.

Whom and What to See at the IRE Show

(Continued from page 267A)

Gudebrod Bros. Silk Co., Inc., Booth 4025
225 W. 34th St.
New York 1, N.Y.

F. W. Krupp, Paul Glesinger, ▲ A. Jarnes, C. C. Schrader, Fred Hooven, Bert Kaplan, Ira R. Saylor

Lacing tapes of nylon, dacron, teflon and glass with variety of finishes (wax, rubber, silicon, vinyl) to withstand temperatures up to 1650°F, also dial cords and special tie cords.

†

See PROCEEDINGS OF THE IRE—Feb., March, May, Aug., Oct., Dec. (1960), Feb., March (1961) for further information on our products.

See 1961 IRE DIRECTORY, page 642, for complete information on our products.

Gudeman Co., Booth 2826
340 West Huron St.
Chicago 10, Ill.

J. D. Hartley, P. J. Lovecchio, ▲ F. A. Lakowski

Capacitors, filters, pulse transformers, and delay lines.

▲ Indicates IRE member.
• Indicates new product.
† Exhibitor is servicing IRE Engineers through the IRE Package Plan.

Guidance Controls Corp., Booth 3017
110 Duffy Ave.
Hicksville, L.I., N.Y.

Dave Telson, Bob Everett, Joe Brewster, V. Verelli, Henry Marks, Walter Niles, ▲ H. Fener, B. Saiya, A. J. Mellen, Bill Rapp, John Carbone

Magnetic Clutches featuring the size 6 and 8, potentiometers, miniature motorgear-head assemblies, the world's smallest magnetic microphones and receivers.

HEEMCO, Booth 1820
See: Hill Electronics, Inc.

H P L Manufacturing Co., Booth 4512
15210 Miles Ave.
Cleveland 28, Ohio

G. R. Barber, M. E. Lorentz, B. Willig

Short-run stampings, all materials, 25 to 25,000 pieces. All parts produced to customer's specifications or as required.

HRB-Singer, Inc., Booths 1913-17
See: Diehl Mfg. Co. and Singer/Bridgeport Div.

Hallam, Sleight & Cheston Ltd., Booths 3406-08
Widney-Dorlec cabinet components. See British Industries Corp.

Halliburton Enterprises, Inc., Manufacturing Div., Booths 4508-4510
4724 So. Boyle Ave
Los Angeles 58, Calif.

B. N. Sammer, J. W. Murphy, J. A. Merriam, D. W. Goelz

Aluminum cases for military and industrial applications. Custom and standard. Seamless drawn, heat treated, airtight and shockproof, heavy duty, reusable cases for carrying and storage of aerial cameras, electronic controls and devices, aerological equipment, navigation instruments and other military equipment.

Hanovia Liquid Gold Div., Booths 4406-14
See: Engelhard Industries, Inc.

Hardwick, Hindle, Inc., Booth 2812
40 Hermon St.
Newark 5, New Jersey

Thomas B. Ure, ▲ Ferrall N. Sumrell, Howard O. Strand, Philip Fuchs, James T. Campbell, William Wankmuller, Charles Buebendorf

5-Watt Power Rheostat & Potentiometer

Complete range wire wound fixed and adjustable vitreous enamel resistors—tab and axial lead type MIL-R-26C specification. Rheostat and potentiometers power type—5, 12½, through 1,000 watts. MIL-R-22 specification. 5-watt (illustrated).

"Lead-Master" saves you time and trouble. To get exhibitors' literature sent direct to you by mail, circle the exhibitor's "Lead-Master" number, and leave your pocket card at the Coliseum Lobby.

Harrel, Inc., Booth 3948
1788 First Avenue
New York 28, N.Y.

▲ Holton E. Harris, Trygve O. Alger, Kenneth Levine, Jack Feinstein

High precision proportional temperature controllers. *New sub-miniature proportional temperature controller. Relay type temperature controllers. Film heaters. Complete thermal systems. Gyro accessories: 3-phase sine-wave wheel supplies, wheel transformers, torque drive amplifiers. Relay amplifiers. Low level magnetic amplifiers.

Harris-Intertype Corp., Booths 3602-3610

See: Gates Radio Co. & PRD Electronics, Inc.

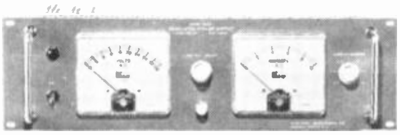
Harris Transducer Corp., Subsidiary General Instrument Corp., Booths 1101-1106
Woodbury, Conn.

John Berger, R. E. Mandelkorn, Matthew Morris

Standard and custom line of industrial ultrasonic cleaning equipment.

Harrison Laboratories, Inc., Booths 1429-1431
15 Industrial Road
Berkeley Heights, N.J.

▲ C. W. Harrison, ▲ R. E. Graham, ▲ A. M. Darbie, R. P. Buchner, ▲ D. J. Tighe, ▲ B. D Bunker



H-Lab Model 809A 0-36 volts @ 0-10 amps.

Regulated dc power supplies—A complete line of standard models with outputs to 320 volts and 25 amperes. Features include constant voltage and constant current operation, full overload and short-circuit protection, remote programming, remote error sensing, Auto Series and Auto Parallel operation, optional chopper stabilization.

† See PROCEEDINGS OF THE IRE—Jan. through June (1960), March (1961) for further information on our products.

See 1961 IRE DIRECTORY, pages 58 and 59, for complete information on our products.

Hart Manufacturing Co., Booth 1637
190 Bartholomew Ave.
Hartford 1, Conn.

Frank E. Barranco, Henry R. Dahmer, Victor C. Jones, Robert E. McIntosh, James T. Vincent, Robert P. Zupa

Electrical controls for electronic equipment: Relays—sensitive, high shock and vibration (+100 G's), high speed (1,000 cps), high temperature (+200°C), plug-in circuit, polarized, hermetically sealed, missile-aircraft types. Switches—rotary, snap action, toggle. Thermostats—hydraulic, remote bulb, integral selector switch. Outlets and pilot lights.

Harvard Industries, Inc., Booth 3844

See: Frequency Standards

(Continued on page 270A)

Show Hours
10 a.m. to 9 p.m. daily
Monday through Thursday
March 20-23, 1961

Whom and What to See at the IRE Show

(Continued from page 269A)

Harvey-Wells Electronics, Inc., Booth 3240
14 Huron Drive, East Natick Industrial Park
Natick, Mass.

Richard H. Leeman, ▲ George E. Engman, James W. Wood, William Robblee, James LaMent, Charles Bradley

Digital systems and modules including H-W 44K computer. Shaft encoder translators. 5 mc Data-Bloc and Data-Pac modules. New economy line (dc to 1 mc). "100 Series" Data-Bloc and Data-Pac modules. 10 mc and 1 mc decade scalers.

Hastings-Raydist, Inc., Booth 3309
Newcomb Ave.
Hampton, Va.

▲ Charles E. Hastings, James M. Benson, Raymond T. Doyle

Vacuum, velocity, flow, and pressure measuring instruments and controllers; also, Raydist electronic precision distance-measuring and position determining systems.

Hathaway Denver, Div. of Hathaway Instruments, Inc., Booth 2007
5800 East Jewell Ave.
Denver 22, Colo.

William A. Christian, B. E. Barnett, John T. Houston, Jr., Donald M. Cobbs, James E. Carson, William L. Davis, Kenneth G. Paddock, Dale O. Ballinger, Thurman Slater

Laboratory test instruments including *vacuum tube voltmeters, *comparison bridges, *signal generators, vibration meters; tuning fork frequency standards; miniaturized converters, inverters, rf filters and power supplies; rotary switches.

Hayden Publishing Co., Booths 4403-4405
830 Third Ave.
New York 22, N.Y.

Bryce Gray, Jr., ▲ Eugenie Lenz, Nancy Elston, T. Richard Gascoigne, James S. Mulholland, Jr., Robert E. Ahrensdorf, ▲ Edward E. Grazda, ▲ James A. Lippke, ▲ George Rostky, ▲ Howard Bierman, Robert Cushman, Alfred Rosenblatt, Arthur Solda, Charles Farley, Thomas Mount

"Electronic Daily" show news magazine published every day during IRE Show. Free distribution. Working editorial force operating at Coliseum. Also editors and circulation representative at booth to answer editorial and subscription questions for "Electronic Design" and "Electronic Designers' Catalog."

A. W. Haydon Co., Booths 1512-1514
232 North Elm St.
Waterbury 20, Conn.

▲ R. W. Perkins, ▲ G. O. Hoffman, ▲ W. Beswick, L. F. Smith, P. Famiglietti, G. Burns, R. Brodeur, R. Nicholson, J. Taylor, R. E. Varis, G. L. Wellnitz, B. Barraclough

AC and DC timing motors, automation test equipment, de-icing computers, elapsed time indicators, electronic timers, encoders, intervalometers, interval timers, portable test equipment, programmers, repeat cycle timers, sensors, steppers, stop clocks, system analyzers, time delay relays. Aircraft, military and commercial products.

Haydon Switch, Inc., Booth 1524
536 So. Leonard St.
Waterbury 20, Conn.

A. N. Milliken, D. J. Graff, T. Y. Korsgren, G. M. Kinney, L. Syarto, D. Meisenheimer, J. Moriarty

Complete switching controls, miniature snap-action, toggle actuated and pushbutton switches. Hermetically sealed and high temperature switches and assemblies. Custom motor driven multipole assemblies. Inertia switches. Gage, absolute, differential barometric pressure switches featuring subminiature and high temperature models.

C. I. Hayes, Inc., Booth 4533
800 Wellington Ave.
Cranston 10, R.I.

William E. Sauter, William C. Diman, Howard F. Brennan, Robert Brennan, Stanley Winters, Edward F. Mooney, Gordon Wheeler, Herbert W. Westeren, Frank Sahms, W. Robert Lewis

Console Vacuum Furnace

Vacuum furnace (Vacu-Master®); vacuum furnace heating element demonstration; silicon control rectifier power amplifier devices (pHayes-master®); consulting engineering metallurgical guidance; pictorial display of equipment depicting "Why electronics turned to Hayes," covering alloying, diffusion, sintering and brazing furnaces; crystal growing and recirculating gas dryers (Molecu-Dryer®).

Heath Company, Division of Daystrom, Inc., Booths 1702, 1801-1803
Benton Harbor, Mich.

C. M. Edwards, A. W. Greene, G. E. Davidson, L. F. Lechner, W. B. Latshaw, C. A. Robertson, R. E. Scowcroft, G. M. Krepp, S. W. Sizer

Do-it-yourself Heathkit products. *3" dc scope, *5" lab. scope, deluxe VTVM, *transistor checker, isolation transformer, Gm tube tester, CB transceivers, 2, 6 & 10 meter transceivers, *ignition analyzer, depth sounder, direction finders, transistor portable receivers, *educational kits, stereo amplifiers, AM/FM tuners, *KW linear amplifier, power converter. Hi-fi, test, amateur, and marine kits.

Heiland Division, Booths 2202-2214
See: Minneapolis-Honeywell Regulator Co.

Heinemann Electric Co.
Brunswick Pike (Rt. 1), Booths 2841-2843
P.O. Box 299
Trenton 2, N.J.

B. A. Berlin, E. Bromberg, B. A. Plesser, A. R. Costantino, N. J. Schwartz, N. E. Taylor, H. Bakes

Subminiature series VP circuit breaker. Weights 1.5 oz. Hydraulic magnetic operation. No temperature de-rating. Choice of tripping response. Shock and vibration resistant for mobile, portable, airborne equipment applications. Choice of internal circuits for auxiliary control functions. Priced for commercial use.

Heli-Coil Corp., Booth 4509
Shelter Rock Lane
Danbury, Conn.

E. Baruch, L. J. Brancato, H. W. Hall, H. O. Haas, Don Lee, C. W. Simmons

Stainless steel wire screw thread inserts, screw-lock inserts and related taps, gages and hand and power tools. Also Dodge expansion inserts for plastic applications in electronic and electrical design.

Helipot Division, Beckman Instruments, Inc., Booths 1201-1203
2500 Fullerton Rd.
Fullerton, Calif.

Dave C. McNeely, Karl Heller, Hank Crout, Ray Forbes, Arne Henriksen, Bruce Johnson, Vic Stevens, Herb Weisser, Paul Keefer, ▲ Stan Schneider, Marty Brummer

Multi-turn and single-turn potentiometers, trimming potentiometers, pin and lug type trimming potentiometers, turns-counting dials, delay lines including 1" diameter all-metal model cermet potentiometers, ac potentiometers, size 8, 11, 15 and 18 servomotors. New size servomotors, expanded scale meters, round panel meters, new commercial panel meters.

Hercon Electronics Corp., Booth 3240
See: Harvey-Wells Electronics, Inc.

Hermes Electronics Co., Div. of Itek Corp., Booths 3038-3039
75 Cambridge Parkway
Cambridge 42, Mass.

▲ A. J. Pote, E. D. Phillips, J. Burkhardt, ▲ H. Stevens, R. Wasserman, D. Brennan, Dick Joy, ▲ Dave Kosowsky

Time code generators—ultra stable oscillators—magnetic tape search units—decimal display assemblies—frequency error multiplier—magnetostrictive delay lines.

† See PROCEEDINGS OF THE IRE—Jan. through May, and Sept. through Dec. (1960) for further information on our products.
See 1961 IRE DIRECTORY, pages 266 and 442, for complete information on our products.

Hermetic-Pacific Corp., Booth 1621
See: Hermetic Seal Corp.

Hermetic Seal Corp., Booth 1621
43 River Road
North Arlington, N.J.

▲ Mannes N. Glickman, John D. Wood, Al Neumann, Frank A. Restaino, Herbert Perkins, Harry Paine, Joseph Spadafora, Harold Martin, Folke A. Erickson, D. D. Rosa

Glass-to-metal seals, miniature and micro-miniature, high conductivity pins, ceramic-to-metal seals, headers, terminals, transistor and diode housings, connectors: Rack and panel, AN, MS, Minikay, quick disconnect, *non-magnetic seals, stems, glass metal windows, vacuum fuses, thermal switches. See also: Connector Seals Corp.

(Continued on page 272A)

Whom and What to See at the IRE Show

(Continued from page 271A)

Hetherington Switch Div., Booths 1727-31

See: Control Switch Div.

Hewlett-Packard Co., Booths 3205-3215
275 Page Mill Rd.
Palo Alto, Calif.

▲ David Packard, ▲ William Hewlett, ▲ W. Noel Eldred, ▲ Barney Oliver, ▲ Dick Reynolds, ▲ John Cage, ▲ Al Bagley, ▲ Paul Stoft, ▲ Norm Schrock, ▲ Bruce Wholey, ▲ Peter Sherrill

Model 5512A Transistor Counter.

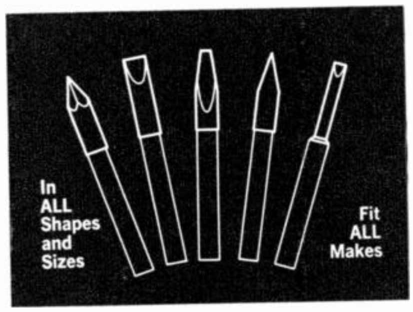
*Solid state 300 kc counter. *Solid state 1 mc counter. *Solid state 100 mc time interval counter. *Oscilloscope, dc to 1000 mc. *Frequency meter, 1 to 4 GC. Temperature compensated thermistor mounts. *SWR meter. TWT amplifier, 1 watt, 1 to 2 GC. *1 mc pulse generator. Ac/dc converter.

Hewlett-Packard Co., Booths 3019-3020, 3101-3102, & 3310-3312

See: Dymec Division, Boonton Radio Corp., & F. L. Moseley Co.

Hexacon Electric Co., Booth 4002
161 W. Clay Ave.
Roselle Park, N.J.

▲ R. O. Johnson, J. L. Grindrod, R. M. Leary, H. V. Neff, C. Ellingwood, L. E. Bruns, J. E. Zaiser, J. E. Smith, L. T. Bryan, R. M. Dunn, R. C. Bryan, Al Kulfan, R. Luneau, E. H. Powell, J. Enders, R. H. Fish, E. Charlton, G. Clouse, G. Hamilton, V. Gummert, W. Ihlefeld



"Durotherm" (pat. pending) non-freezing tips. Iron coated and immunized. For Hi-Temperature irons, anti-corrosion design absolutely prevents tips from sticking. The most wear-resistant yet developed. No need to remove tips daily to prevent sticking. Minimum heat loss.

Hi-G, Inc., Booth 2812
Bradley Field
Windsor Locks, Conn.

▲ Robert H. Wood, ▲ John A. Pfingsten, ▲ Douglas N. Wilson, ▲ Robert Farkas, ▲ Joseph A. Garratt, ▲ Michael M. Lanes, Walter Jannene, William W. Blelock, Alvin Lukash

Missile-type rotary-balanced armature relays, microminiature, subminiature, miniature, ac and dc versions. Time delay relays. Electronic specialty switching mechanisms. IF and RF coil assemblies.

Hickok Electrical Instrument Co., Booths 3616-3618
10514 Dupont Ave.
Cleveland 8, Ohio

R. D. Hickok, Dave Hughes, Frank Sawonik, Bob Kerzman, Harry Turkington, Hal Moore, Bob Arbogast, Ed Shortess, Bill Spears, Walter Cerveny, Harry Zimmerman, Jack Siringer

Panel meters, laboratory portable meters, card programming switch, tube testers, transistor testers, VTVM, V-OM, oscilloscopes, signal generators, stroboscope, in-circuit transistor tester, square wave generator, sine-square wave generator. Meter & Controls Div.: Panel meters, portable meters. Industrial & Government Div.: Testing equipment.

Hill Electronics, Inc., Booth 1820
300 N. Chestnut St.
Mechanicsburg, Pa.

Clarke D. Bittner, ▲ B. C. Hill, Jr., J. A. Nickerson

Crystal filters, oscillators, crystals low frequency range 400 CPS to 10 mc. Crystal ovens. Related products.

Hitemp Wires Co., Div. of Simplex Wires & Cables, Booth 4215
1200 Shames Drive
Westbury, L.I., N.Y.

Tommy Holmes, Bill Frogner, John Sheevan, Ted Sheron, Bob Martin, Jack Mulligan, Adam Garden, Tom Mills, Frank Buschman, Chris Wyer, Walter Merck, George Rolfe

*Ceramabond.

Hoffman Electronics Corp., Semiconductor Division & Military Products Division, Booths 1628-1632
3761 S. Hill St.
Los Angeles, Calif.

D. L. Baldwin, ▲ J. Black, ▲ E. Bradley, ▲ A. R. Cilia, ▲ Warren Davis, Warren Eberlen, ▲ H. V. Freudman, ▲ R. A. Hoffman, ▲ A. L. Nelson, ▲ R. S. Nickel, Kenneth Ray, R. S. Saichek, H. P. Briggs, J. W. Jones, ▲ C. Galaviano, ▲ K. C. McClellan, ▲ J. O'Brien, J. Senko, ▲ H. G. Wood

Silicon transistors and diodes, *zener devices, solar cells, tunnel and uni-tunnel diodes, *controlled rectifiers, light simulation, *solar power panels, "Tacan," submarine antenna, message coder, "Tall Tom," DCCS, 480L.

Hoover Company, Electronics Division, Booth 3845
110 W. Timonium Rd.
Timonium, Md.

▲ A. J. W. Novak, J. B. Miller, ▲ T. E. Harrowby, W. D. Gulick, L. J. Woodward, ▲ Henri Hoge, ▲ C. Hultberg, N. B. Beasley

Electronic instrumentation for military and industry. *Power converters, solid state, mobile and airborne, dc to dc, and dc to ac. *Static pulsers, communications components including repeater amplifiers. Telemetering transistorized voltage controlled oscillators, mixer amplifiers, signal conditioning amplifiers, and "Vernitel."

Hoyt Electrical Instrument Works, Inc., Booth M-13
42 Carleton St.
Cambridge 42, Mass.

V. S. Church, William Burton, ▲ George E. Morton, Douglas A. Hoyt, Nelson M. Warner, Jr.

Electrical indicating panel meters: 2% D'Arsonval dc milliammeters, microammeters, millivoltmeters, voltmeters, ammeters, high current shunts; matching 2% repulsion ac types. Donut transformers. Case styles: 1½"-6" plastic; 2½"-4½" bakelite; 2½"-8½" metal cases. 5% moving magnet indicators; dc milliammeters, ammeters, voltmeters.

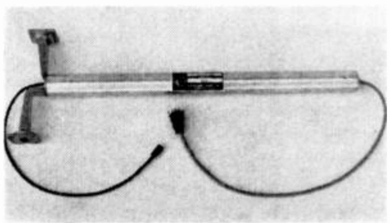
Hudson Tool & Die Co., Inc., Booths 4409-4411
18 Malvern St.
Newark 5, N.J.

Ernest Isler, Ed Kuzma, Larry Fitzpatrick, Ken Naylor, Pete Church, W. Herbert, Ray Sulat

Most complete line of deep drawn closures. 2000 various standard sizes from subminiature to transformer sizes. Available in MuMetal, stainless steel, aluminum, brass, copper, steel, Ni-Silver, Monel and others on request. Complete line of MIL-T-27A specification cases and covers.

Huggins Laboratories, Inc., Booths 2925-2926
999 E. Arques Ave.
Sunnyvale, Calif.

▲ Richard A. Huggins, ▲ Vernon D. Varenhorst, W. Bruce Pruitt



HA-82; 10-20 Kmc TWT Amplifier

TWT's and BWO's. HA-82 -10-20 kmc, 25 db gain; HA-70—S-band 7db noise figure; HA-54 —S-band PPM 15.5 db noise figure; *HA-53—L-band PPM 2 watt; *HA-63—L-band electrostatic 1 watt; HA-52—UHF electrostatic 5 mw; HA-86—UHF 7 db noise figure; *HA-61—7-14 kmc 15 db noise figure; HA-46 Ku-band 12 db noise figure.

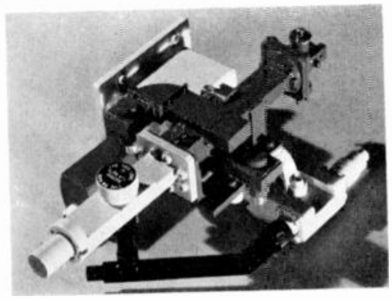
(Continued on page 274A)

Whom and What to See at the IRE Show

(Continued from page 273A)

Hughes Aircraft Co., Booths 1811-1817
Florence & Teale Sts.
Culver City, Calif.

T. H. Anderson, ▲ N. A. Begovich, W. D. Bird, Jr., F. Burns, J. E. Davenport, H. Dodson, A. E. Fisher, B. A. Gerpheide, J. C. Groth, Jr., D. W. Harr, W. L. Herron, J. Johnson, J. J. Kowall, E. E. Newberry, R. T. Plummer, J. C. Proctor, G. Sharp, L. Straw, W. D. Summers, ▲ J. J. Sutherland, J. F. Weatherman, G. F. Woods



S-Band Parametric Amplifier

Storage tubes, vacuum gage tubes and controls, welders, microwave components, parametric amplifiers and ferrite devices, nuclear products (radiation effects, facilities, detectors, linacs), traveling wave tubes, backward wave oscillators, Memo-Scope® oscilloscope, *Multitracer, scope cart, continuous contour cable, magnetic components, crystal filters, Ball tracking devices, console displays, waveguides.

† See PROCEEDINGS OF THE IRE—Jan., March, May, Sept., Oct., Nov. (1960), for further information on products of Semiconductor Division.

See 1961 IRE DIRECTORY, pages 188 and 538, for complete information on products of the Semiconductor Division.

Hull Corporation, Booth 4114
Hatboro, Pa.

▲ Frank Cramton, Lewis Hull, John Hull, John Leary, Joseph Piotrowski, Lawrence Plummer, Robert Zecher

(1) Latest model Hi-Pro high production packaged encapsulation press for encapsulating semiconductors, capacitors, resistors, coils and other components by Hull process. (2) Portable positive displacement metering, mixing and dispensing unit for potting small items with multiple component resins.

Hysol Corporation, Booth 4232
Olean, N.Y.

Gerald T. Quigley, Edward A. Buckley, Reginald C. Whitson, ▲ William C. Jenner, Virgil G. Lorenzini, William M. Punnett, Patrick J. Scutella

High performance liquid epoxy casting systems to meet the requirements of MIL-I-16923C, types B, C, *D; *conductive adhesives and coatings; general purpose potting, impregnating and casting compounds for electrical/electronic insulation; printing circuit coating compounds for application by dipping, spraying or brushing.

IERC Div., Booth 1522

See: International Electronic Research Corp.

ITT Components Div., ITT Industrial Products Div., ITT Laboratories, Booths 2510-20 & 2615-25

See: International Telephone and Telegraph Corp.

Illinois Condenser Co., Booth 2310
1616 N. Throop St.
Chicago 22, Ill.

L. W. Coleman, ▲ J. J. Kurland

Electrolytic capacitors, film capacitors, computer capacitors, special quality capacitors, ceramic encased paper capacitors, subminiature capacitors, energy storage capacitors.

Illinois Tool Works, Booth 1506

See: Licon Division

Illinois Water Treatment Co., Booth 4238
840 Cedar St.
Rockford, Ill.

Joseph Thompson, Frank Macioce, Richard Steinsvaag, Walter Storm, A. W. Michalson, Walter Coombs, C. Hugo Bergman, Vincent Miller, Stewart Miller

*Ion exchange water conditioning equipment including completely packaged automatically operated mixed bed deionizers designed to produce water of specific resistance ten megohms-centimeter and higher for production rinse operations.

Inca Mfg. Div., Booths 4028-29

See: Phelps Dodge Copper Products Corp.

Indiana General Corporation, Booths 1310-1316
105 Elm Street
Valparaiso, Ind.

J. R. Ireland, K. S. Talbot, J. W. Schallerer, W. R. Baughman, R. W. Warren, J. Cuff, S. C. Beyerl, H. Landsberger, R. W. Moore, I. A. Dickey, H. L. Johnson

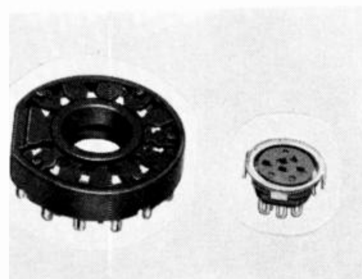
Complete line permanent magnets, new Indox speaker magnets, complete line of ferrites, telecommunication core assemblies, *threaded cores, threaded cup cores and bobbins, C-2 material for converter applications, memory cores, standard and temperature-controlled Microstacks, memory planes, memory systems, microwave ferrites, technical ceramics, ceramic-to-metal seals.

Indiana Steel Products Div., Booths 1310-1316

Permanent magnets. See Indiana General Corp.

Industrial Electronic Hardware Corp., Booth 2313
109 Prince St.
New York 12, N.Y.

Marvin Gottlieb, Nat Geldman, Joel Jacobs, John Donato, Steve Goodman



*Nuvistor and Compactron Sockets

*Nuvistor and Compactron sockets. *Edgeboard, *rack and panel connectors; molded and laminated tube sockets for printed circuitry and conventional wiring; slide switches; battery connectors; transistor sockets; relay sockets; antenna connectors; anode connectors; crystal and tube adapter sockets; wired assemblies; terminal strips; custom molding.

Industrial Electronics Magazine, Booth 4415

See: Electronic Equipment Engineering

Industrial Instruments, Inc., Booths 3225-3227
89 Commerce Road
Cedar Grove, N.J.

L. C. Cunniff, ▲ G. Dzula, ▲ R. Green, R. J. Kidder, R. I. MacAuley, K. O. Spang

Automatic high-speed precision testers including *one system for testing components on tape. Bridges for measuring resistance and impedance in laboratory and portable service. Decade resistance and capacitance units. Direct-reading low-resistance ohmmeters and wide-range megohmmeters.

Industrial Products—Danbury Knudsen Div., Booths 2402-2507

See: RF Products, Div. Amphenol-Borg Electronics Corp.

Industrial Test Equipment Co., Booth 3613
55 East 11th St.
New York 3, N.Y.

Melvin Schreibman, ▲ Raymond Rothschild, Carl Laskin, Gene Cahn

AC power supplies, phase meters, null detectors, frequency standards, impedance comparators, automatic Hi-Pot testers, specialized electronic test equipment.

Industrial Timer Corporation, Booths 1319-1323
1407 McCarter Highway
Newark 4, N.J.

Ken Kraemer, Todd Martin, Greg Galion, Bud Corbutt, Carmine Pellechio, Randolph McHale, Don Brown, Al Whiter, Walter Roginski

Full range of timing controls, punched tape and punched card programming equipment; full line of general purpose relays, footswitches, and buzzers. *Several new products including an electronic solid state transistorized timer and an electric stop clock will be exhibited for the first time.

Industro Transistor Corp., Booth 1627
35-10 36th Ave.
Long Island City 6, N.Y.

▲ Charles A. Tepper, Ira R. Becker, ▲ Archie McDougall, Sy Ostfield, ▲ Al Meadows, Adam Farkas, ▲ Steve Aivazian, Herbert Israel

Germanium PNP and silicon NPN transistors, diodes, and other semiconductor devices.

Inet Div., Booth 2003

See: Leach Corp.

Ingersoll Products Div., Booths 4225-4229

See: Emcor Ingersoll Products Div.

Inso Electronic Products, Inc., Booths 4054
1200 Commerce Ave.
Union, N.J.

Charles E. Nixon, H. H. Heyden, Vi Howell, J. J. Lightner, Fred W. Link, Allen S. Nace, Homer Pacent, Walter M. Padiak, Clyde Rush, Frank Welling

Thin-wall teflon insulated high temperature wire and cable for type "E" and "EE" MIL-W-16878C applications. Available in gages #2 to #32 AWG. Teflon multiconductor cables, miniature teflon coaxial cables per MIL-C-17C, thin-wall teflon tubing, special purpose cables designed and manufactured.

(Continued on page 278A)

from LIONEL, Hillside, New Jersey

Electromechanical Systems and Components: Our central plant has for years been a major producer of miniaturized electromechanical systems for both commercial and military use. Now for the first time, we are offering many of these components to industry at large. Some of the components now available include: *sequence relays, latching relays, time delay* and *power switches, bi-directional sequence relays, military low-energy transfer switches,* and a series of *miniaturized D.C.* and *universal motors.* In addition to our primarily commercial line, we also produce *miniature servo motors, servomechanisms, electrical* and *mechanical fuses, precision instruments, ordnance* and *communications equipment,* and other electronic products to customer specifications.

Our subsidiary, the LIONEL/INTERCONTINENTAL MANUFACTURING COMPANY, at Garland, Texas, is an important, experienced producer of *rocket motor casings, thrust nozzles, missile air frames,* and other parts and components for many weapons, including NIKE HERCULES, HONEST JOHN and LITTLE JOHN. We have demonstrated our competence on numerous prime and subcontracts to the government and industry, and have established an enviable reputation for fine product design and delivery on schedule.

For more information on any of the Lionel Corporation's products, systems, or services, check your area of interest on the coupon below, or contact us by phone or letter.

See us at the IRE Show:
LIONEL/TELERAD, Booth 1427; LIONEL/ANTON, Booth 2002.

THE LIONEL CORPORATION

Hoffman Place, Hillside, New Jersey

I am interested in receiving information on the following:

- ☐ Frequency meters
- ☐ Coaxial lines
- ☐ Mixers
- ☐ Duplexers
- ☐ Feeds and horns
- ☐ Power supplies
- ☐ Signal generators
- ☐ Missile beacon
- ☐ The complete line of Anton connectors
- ☐ Flexible waveguide
- ☐ Directional couplers
- ☐ Rotary joints
- ☐ Antennas
- ☐ Filters
- ☐ Straight waveguide sections
- ☐ Voltage regulator tubes
- ☐ Precision potentiometers
- ☐ Relays
- ☐ Switches
- ☐ Motors
- ☐ Nuclear radiation sensing tubes and chambers
- ☐ Nuclear systems
- ☐ R-F transmission systems
- ☐ Lionel facilities and capabilities

NAME____________________ TITLE____________________

DEPT.________________ COMPANY____________________

ADDRESS____

Whom and What to See at the IRE Show

(Continued from page 275A)

Institute of Radio Engineers, Booths in Main Lobby
1 East 79th Street
New York 21, N.Y.

Subscription, membership and professional group information available. Orders for convention record may be filled out at these booths. PROCEEDINGS OF THE IRE. 1962 IRE DIRECTORY Questionnaire available.

Instron Engineering Corporation, Booth 3043
2500 Washington St.
Canton, Mass.

Robert Flynn, John McAteer, E. J. Tolle, ▲ Donald Erb, ▲ William Esthimer, ▲ George Burr, Larry Cedrone

Electronic instruments for studies of stress-strain properties of materials and force-deflection characteristics of switches, relays and other electromechanical components. Dynamic digital readout system for printing out stress-strain or force-deflection data directly from measuring instrument in digital form or on punch tape.

Instrument & Apparatus News, Booth 4307

See: Instruments Publishing Co., Inc.

▲ Indicates IRE member.
Indicates new product.
† Exhibitor is servicing IRE Engineers through the IRE Package Plan.

Instrument Specialties Co., Inc., Booth 4313
244 Bergen Blvd.
Little Falls, N.J.

J. D. Roberson, J. H. Baker, J. H. Roberson, W. G. Carson, F. S. Stickney, A. W. Ullmann, R. J. VanVlandren, F. L. Landry, J. E. McLean

Standard stock beryllium copper finger contact strips and rings. Custom made beryllium copper flat and helical springs and screw machine products.

Instruments & Control Systems, Booth 4307

See: Instruments Publishing Co., Inc.

Instruments For Industry, Inc., Booth 1424
101 New South Road
Hicksville, L.I., N.Y.

Allan Merken, Robert Mandel, Hal Borgen, Henry H. Hentrich, ▲ Ronald Hirsch, ▲ Robert Lockwood, ▲ Eugene Novikoff, ▲ Lawrence Algase, Dennis Dugan

Countermeasures and communications systems, receivers, transmitters, telemetry gear, RF amplifiers and amplifier systems, mixers, multipliers, modulators, video amplifiers, VHF/UHF sockets, connectors, *precision potentiometers, bandpass filters.

Instruments Publishing Co., Inc., Booth 4307
845 Ridge Ave.
Pittsburgh 12, Pa.

Richard Rimbach, Richard J. Rimbach, Jr., Robert C. Brandegee, ▲ Milton H. Aronson, Harold H. Short, Robert Donnelly, Melvin J. Nervie, Eugene McKenna, Claude Morrison

Technical magazines—"Instruments & Control Systems" (published monthly), and "Instrument & Apparatus News," and "Military Systems Design," published bimonthly. Also books pertaining to industrial instrumentation, electronics, and control.

Intelex Systems, Booth 2510

See: International Telephone & Telegraph Corp.

International Business Machines Corp., Booths 3808-3812
590 Madison Ave.
New York 22, N.Y.

Peter W. Klinger

IBM will discuss the latest systems and components developments from the IBM engineering laboratories. Two improved tunnel diodes and a new fabrication method.

(Continued on page 280A)

First and Second floors—Components

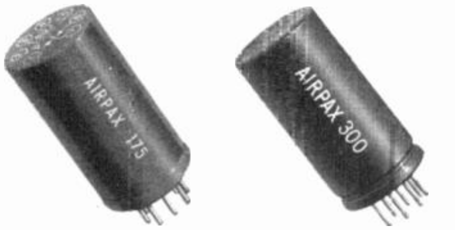
Third floor—Instruments and Complete Equipment

Fourth floor—Materials, Services, Machinery

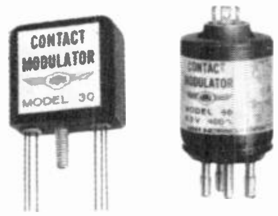
AIRPAX

CHOPPERS
CIRCUIT BREAKERS
TELEMETRY SYSTEMS
MAGNETIC COMPONENTS

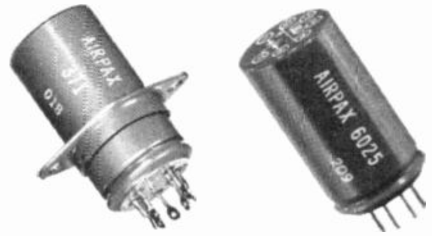
IRE
BOOTHS
2306
2308



Miniature hermetically sealed electro-mechanical CHOPPERS for stabilized DC amplifiers used in computers, servos, bridges and control systems. TYPE 175 has 60 CPS drive; TYPE 300 uses 400 CPS drive.

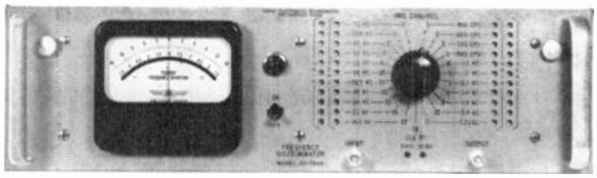


These tiny CHOPPERS have the same long-life reliability characteristics as their larger counterparts. MODEL 30 is for 60 CPS operation; MODEL 46 uses a 400 CPS drive.

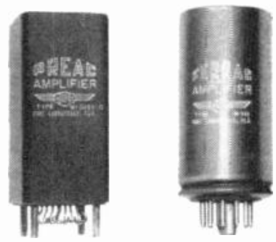


TYPE 371 uses center pivoted armature construction to permit operation under conditions of severe shock and vibration. TYPE 6025 is a transistor chopper with self contained drive transformer. Drive, 50 to 5000 CPS.

The MAGMETER® frequency detector delivers an output current directly proportional to input frequency with an accuracy of 0.1%.



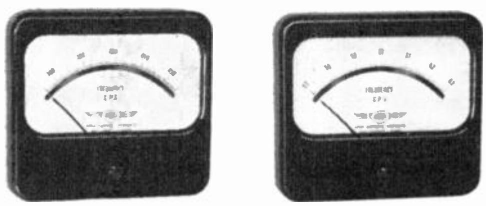
The CALIBRATOR series of frequency discriminators utilizes solid state components for long trouble-free life. Available in single and multi-channel units.



PREAC magnetic amplifiers are high sensitivity DC units with an extremely stable null. FERRAC instrument push-pull magnetic amplifiers have exceptional stability and linearity.

Miniature CIRCUIT BREAKERS of the magnetic type are available in ratings from 50 ma. to 10 amps.

Custom TRANSFORMERS are produced to exacting requirements. Rigid QC procedures assure highest reliability.



Expanded scale FREQUENCY METERS with an accuracy of 0.1% are completely self contained.

Illustrations are representative of the devices which Airpax produces. A complete line of choppers, both electromechanical and transistor types, cover every conceivable condition of use.

Telemetry equipment, employing solid state components, uses a single front panel switch in the multi-channel type to select each of the 23 IRIG information channels. The Airpax MAGMETER® frequency detector is the "heart" of these devices.

The circuit breaker line features both military and commercial types with or without isolated indicating circuits. Breakers are available in series, shunt and relay types and in ganged assemblies for 2 and 3 phase circuit protection.

AIRPAX ELECTRONICS INCORPORATED

AC61

AIRPAX ELECTRONICS
INCORPORATED
CAMBRIDGE DIVISION • CAMBRIDGE, MARYLAND
SEMINOLE DIVISION • FORT LAUDERDALE, FLA.

SEND FOR THIS NEW ROHR BROCHURE

It describes unique capabilities in the design and manufacture of large antenna structures which have become available through creation of Rohr Aircraft Corporation's Antenna Systems Division.



This new division offers a team of top engineering talent — men who have participated in the design and construction of most of the large antennas in existence in the Free World. This talent has been turned to development of structures sufficiently precise to meet the increasingly rigid requirements of advanced systems — to attaining a standard of precision previously considered impossible.

This sort of precision is not new at Rohr. For years we have been developing techniques to produce large, precise aircraft structures. As a result, Rohr has achieved recognition throughout the aerospace industry for quality flight components, and the company's specifications on honeycomb and other structural components have become the criterion in the industry.

Rohr's low overhead and burden rates offer economies impossible in electronic systems firms, where unrealistic fabricator-engineer ratios push costs upward. Rohr applies precision and economy of production, proven through years of aircraft experience, to the manufacture of large antenna structures. Consider this unusual combination of talent and facilities in your future antenna projects.

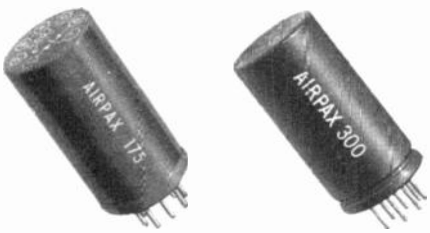
ROHR REPRESENTATIVES WILL BE AT THE IRE SHOW IN NEW YORK MARCH 20-23.

ROHR
AIRCRAFT CORPORATION

MAIN PLANT AND HEADQUARTERS: CHULA VISTA, CALIF.; PLANT: RIVERSIDE, CALIF.; ASSEMBLY PLANTS: WINDER, GA.; AUBURN, WASH.

AIRPAX

CHOPPER
CIRCUIT BREAK S
TELEMETRY SYSTEM
MAGNETIC COMPON



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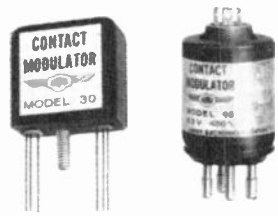

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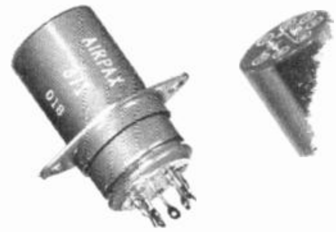
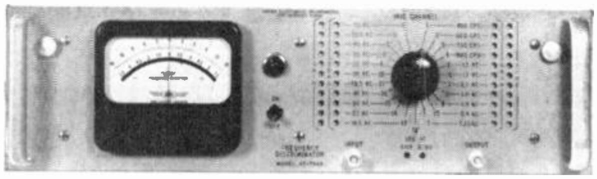


TYPE 37! uses ce ture construction t under conditions e vibration. TYPE 6 chopper with sel transformer. Drive.

The MAGMETER® frequency detector delivers an output current directly proportional to input frequency with an accuracy of 0.1%.



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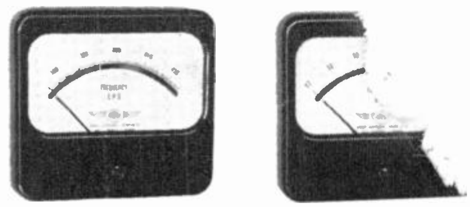

Expanded scale FREQUENCY METERS with an accuracy of 0.1% are completely self contained.

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INCORPORATED
CAMBRIDGE DIVISION • CAMBRIDGE, MARYLAND
SEMINOLE DIVISION • FORT LAUDERDALE, FLA.

Whom and What to See at the IRE Show

(Continued from page 278A)

| Eastern Co.,

Ave.
l, N.Y.

rice Berez, Lawrence
bert, Charles Kraver

veyor type machine for
al pieces such as capaci-
en is 3600 pieces per
2F, hand operated ma-
ecial lever action num-
nting serial numbers
Six digits on top of
meter), etc.

International Electric Corp., Booths 2510-20 & 2615-25
See: International Telephone & Telegraph Corp.

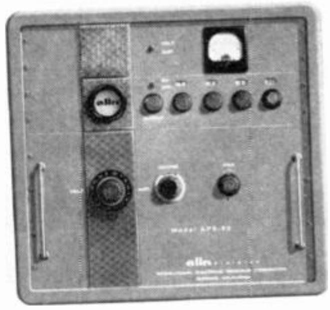
International Electronic Industries, Inc., Booth M-2
Fessey Lane, Box 9036
Nashville 12, Tenn.

T. L. Yount, A. G. Janis, J. L. Draper, J. C. Center, J. V. Kennedy, J. P. Adams, Ed Fox, ▲ A. M. Holladay, Howard King, Maurice Frye

Miniature electrolytic capacitors, including tantalum foil, solid tantalum, wet slug tantalum and aluminum foil. Microminiature electrolytic capacitors, primarily applied in transistorized circuitry. Military and commercial versions include tantalum foil, tantalum slug solid electrolyte; tanta-Micro Min tantalum slug solid electrolyte; tantalum slug wet sintered and aluminum foil axial and plug in lead types. See also: Standard Pressed Steel Co.

International Electronic Research Corp., ELIN Div., Booth 3018
135 West Magnolia Blvd.
Burbank, Calif.

John R. Foster, ▲ John E. Markley, Jr., Ted Rafalovich, Otto Leichliter, Russell E. Randall, Harvey Riggs, Don Rich, Fred Miller



Precision AC Voltage Source

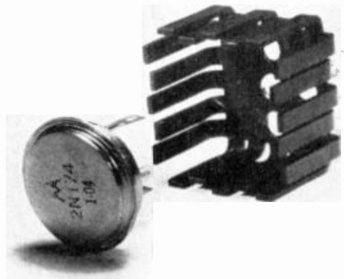
The *new APS-50 ac voltage source for meter calibration featuring variable voltage and frequency at 50 VA and a complete line of ac voltage calibration units and precision ac power sources with both single and three phase outputs.

First Aid Room

A nurse is in charge at all times. First aid room is located on the first floor mezzanine, northwest corner of the first floor. Take elevator 20.

International Electronic Research Corp., IERC Division, Booth 1522
135 West Magnolia Blvd.
Burbank, Calif.

Harvey Riggs, Don Rich, Fred Miller, ▲ John E. Markley, Jr., ▲ John C. McAdam, Ted Rafalovich



"UP-" Series Power Transistor Dissipator

A complete line of heat dissipating tube shields and tube shield and socket assemblies and an expanded line of transistor heat dissipators and retainers featuring the *new "TXB" series for T05 and T09 size transistors and the "UP-" series for natural air and forced air cooling of power transistors.

† See PROCEEDINGS OF THE IRE—Jan., March, May, July, Sept., Nov. (1960), Jan. and March (1961) for further information on our products.
See 1961 IRE DIRECTORY, page 702, for complete information on our products.

International Instruments, Inc., Booth 2813
P.O. Box 2954
New Haven 15, Conn.

R. C. Livingston, Jack Connolly, Geo. O'Hara, Harry Quick, Jr.

*Electronic control meters, side indicator panel meters, miniature panel meters.

International Pump & Machine Works, Inc., Booth 4219
81 Dorsa Ave.
Livingston, N.J.

Thomas J. Scala, Otto Blank, Frank D'Alessio, Arthur E. Hallander

High vacuum equipment and components. Packaged high vacuum pumping systems. Altitude test chambers. Mechanical and oil diffusion pumps. *Vacuum valves, baffles, cold traps, and vacuum gages. See also: F. J. Stokes Co.

(Continued on page 283A)

▲ Indicates IRE member.
* Indicates new product.
† Exhibitor is servicing IRE Engineers through the IRE Package Plan.

Lecture Halls in the Coliseum are located on the Fourth Floor. See complete program of speakers and papers in the editorial section of this issue.

Rohr's record of achievement in precision metal fabrication clearly reflects a capabili, to meet the demanding requirements of antenna production.

Here is a capability which adapts perfectly in phases of antenna production: big, structural framework; bonded components for reflec surfaces; brawny mechanical parts, machiner matically to watch-like precision.

.E
OTHS
306
308

.S
ENTS

REFLECTING ROHR'S ANTEN

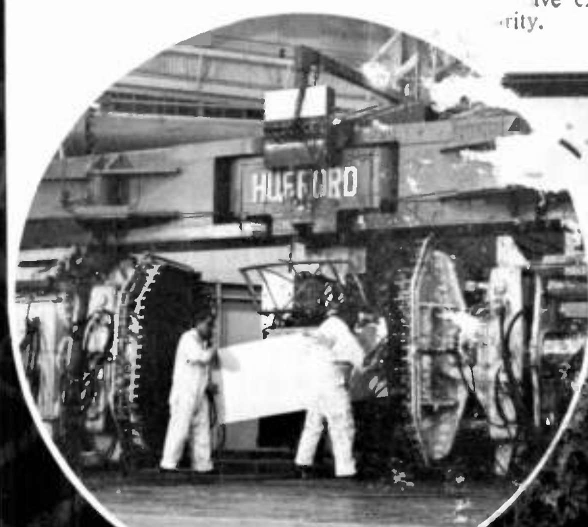
For more than 20 years, Rohr has new materials and methods economically to industrial req resulted in new knowledge con of materials, forming techniques brazing, and in the developme and machining methods.

ter pivoted arma- permit operation severe shock and 5 is a transistor contained drive 50 to 5000 CPS.

More recently, Rohr has added ognized as leaders in the field of anten fabrication. This specialized experience with enlightened engineering, progressi continuing research and modern faciliti sult: a capability ideally suited to the p production of antennas and their support equi

FOR MORE DETAILS CONCERNING THIS ROHR CAPABILITY NEXT PAGE, OR WRITE MR. K. H. LIPPITT, MANAGER, SYSTEMS DIVISION, DEPT. 27, ROHR AIRCRAFT CORP. CHULA VISTA, CALIFORNIA.

ers are high in extremely ment push- ave excep- rity.



ROHR
AIRCRAFT CORPORATION

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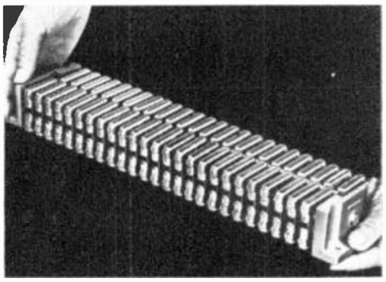
Whom and What to See at the IRE Show

(Continued from page 280A)

International Rectifier Corporation, Booths 2901-2903
233 Kansas Street
El Segundo, Calif.

W. H. Atkinson, ▲ W. E. Wilson, A. Scott, F. W. Parrish, F. Gift, E. Diebold, H. Harnish, J. Staluppi, H. Pappas, R. Knox, D. Conrad, S. Kramer, I. Gomora, G. Cafero, M. Gutman, W. Catterson, E. March



*Silicon Superpower Rectifier Columns

*Superpower high voltage rectifier columns. *1.8 amp rated diffused junction silicon rectifiers, *1N429 zener reference element; 1, 10, 16 amp rated silicon controlled rectifiers, complete line silicon zener voltage regulators, 6 to 250 amp rated silicon power rectifiers, silicon cartridges, silicon solar cells, readout photocells, selenium photocells, sun batteries.

International Resistance Co., Booths 2428-2432
401 N. Broad St.
Philadelphia 8, Pa.

G. Butler, J. B. Henry, R. Bailey, W. Canfield, R. Waldron, R. Dinsmore, E. Wells, K. Schaefer, J. Searing, P. Troilo, D. Jarvis, F. Delnevo

Complete line of fixed and variable resistors—composition, deposited carbon, metal film, power and precision wire wound. Also insulated chokes, selenium diodes, rectifiers, precision potentiometers, etched cable and multiconductor flat wire cable, pressure transmitters and displacement transducers, microminiature Mu-circuits.

International Telephone & Telegraph Corp., Federal Laboratories Div., Booths 2510-2520, 2615-2625
500 Washington Ave.
Nutley, N.J.

J. D. Phelan, E. A. Zappile, Murray Block, A. Isaacs, M. Weiner, T. Warren, L. Pollack, S. R. Hoh, R. E. Lott, G. E. Howarth, John Burke, E. J. Felesina, J. P. Fitzpatrick

Two important developments in space communication . . . 24 hour satellites, ferroelectric energy converter. O/H ratio equipment: parametric amplifier (communications, radar, telescopy, navigation), dual diversity combiner; electronic spectroanalyzer; infrared devices; transistorized airborne ILS and Tacan; Loran C; Digital Communication System (DIGICOM). Complete facilities for the design, development and manufacture of complex airborne and ground electronic systems in the fields of navigation, communication, identification, counter-measures, guided missi es, infra-red and special devices.

Your firm not listed?

If you would like to become an exhibitor in the IRE show, write for information to IRE Exhibits Dept., 72 W. 45th St., New York 36.

International Telephone & Telegraph Corp., ITT Components Div., Electron Tube Dept., Booths 2510-2520, 2615-2625
100 Kingsland Rd.
Clifton, N.J.

W. P. Maginnis, W. C. Schmitt, R. W. Deutsch, K. Anspach, C. L. Baxter, J. Wood, C. Malinow, J. Kircher, K. Liddane, K. Pritzlaff

Iatron storage tubes. Traveling wave tubes, Power tubes and Kuthe hydrogen thyratrons and hydrogen diodes.

Isotronics, Inc., Booths 1217-1219
Route 46
Lodi, N.J.

L. R. Johnson, D. Grant, J. C. Doyle, D. E. Hempel, R. Presby, S. Strindberg, H. Notarius, T. Kennedy, R. Kennedy, R. W. Lade

Glass to metal hermetically sealed relay headers, crystal bases, end seals, transistor bases, Kovar and compression seals. Special plating to all specs. Vacuum plating processing equipment, terminals, connectors to A/N specs. Formerly L. L. Constantin & Co.

Itek Corp., Booths 3038-3039
See: Hermes Electronics Co.

Itek Electro-Products Co., Booths 3038-3039
Crystal filters. See: Hermes Electronics Co.

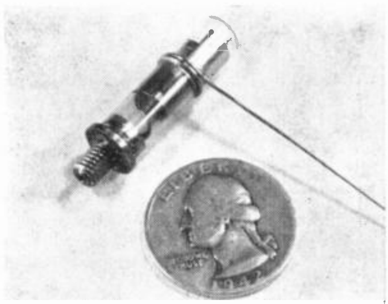
J-B-T Instruments, Inc., Booth 2734
133 Hamilton Street
New Haven 8, Conn.

Roland M. Bixler, Eric Ericson, William Cogger, Charles Meyers, Louis Umile, William Fitzgerald, Carl Iaccarino, William Oliver, Virginia Devitt

Vibrating reed frequency meters; vibrating reed frequency-sensitive relays; elapsed time meters, including sealed and 400-cycle types; toggle switches; rotary selector switches, molded or laminated; subminiature switches, 12 position rotary; lever action switches; temperature indicating instruments and testers.

JFD Electronics Corporation, Booth 1622
6101 Sixteenth Ave.
Brooklyn 4, N.Y.

▲ Jack Goodman, ▲ Fred L. Strauss, ▲ George Kase, ▲ John Neenan, ▲ David Taub



*Variable Temperature Coefficient Capacitor

Precision piston trimmer capacitors: Glass, quartz, ceramic dielectrics: Miniature series—Sealcaps—Differentials—Split-stators — Max-C's —Panel mount or printed circuit types—*Tiny Trims—LC tuners—Fixed and variable inductors—Fixed and variable lumped constant and distributed constant delay lines—*Temperature compensating devices. Antennas: Military, indoor and outdoor TV, accessories.

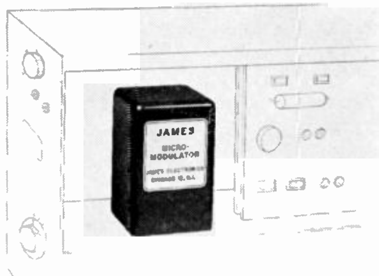
(Continued on page 284A)

Whom and What to See at the IRE Show

(Continued from page 283A)

R. Jahre & Co., Theater 3000
Teraohmmeters, capacitors. See: Rohde & Schwarz

James Electronics, Inc., Booth 2100
1050 North Rockwell St.
Chicago 18, Ill.
▲ John A. Kennedy, R. C. Canning, ▲ G. W. Plice, M. E. Crowe



Micro-Modulator—A Solid State Chopper

Instrument modulator/choppers, mechanical, solid state and photo cell; Micro-Scan relays, high speed low level instrument/computer switching; instrument transformers, chopper, transducer, geophysical; miniature transformers, military, industrial.

Japan Electric Industry, Booth 1923
Div. of Dempa Shinbun, Inc.
2 Kanda Matsuzumi-cho
Chiyoda-ku, Tokyo, Japan
Harold Hirayama, H. Kawamura, H. Maeda
Products of Toko Radio Coil Laboratories, Ltd.: Ceramic variable capacitors, *mechanical filters, transistorized IF modules, miniature superwideband RF transformers, *subminiature resistors, IF transformer oscillating coils. (Distributed by General Instrument Corp., N.J.)

Ray Jefferson, Inc., Booth 1922
See: Delta Coils, Inc.

Jennings Radio Manufacturing Corp., Booths 1802-1804
970 McLaughlin Ave.
San Jose, Calif.
Paul M. Barton, Roderick Neibaur, William W. Hicks, ▲ Lewis B. Steward, ▲ Wesley N. Lindsay, Howard Walters, ▲ Calvin Townsend, ▲ Jo Emmett Jennings
High power vacuum fixed and variable capacitors, vacuum power switches for power or industrial use, vacuum transfer relays for transmit-receive and antenna switching, vacuum coaxial relays, and high voltage measuring equipment.

Jerrold Electronics Corp., Booths 3904-3906
15th & Lehigh
Philadelphia 32, Pa.
▲ Caywood C. Cooley, Jr., ▲ Alex Kirkaldy
Sweep freq. RF measurements by comparison 500 kc to 1200 mc: *Model 900-B sweep signal generator; model 900-A wideband sweep; model 707 precision sweep; voltage comparators; marker generators; RF bridge—50 DB return loss (VSWR-1.006); RF log amp 2 mc to 200 mc—70 DB dynamic range.

Jetronic Industries, Inc., Booth 1922
See: Delta Coils, Inc.

Jettron Products, Inc., Booth M-10
56 Route 10
Hanover, N.J.
Kenneth Johnsen, William Hemmel, Harry Curran
*Socket for Clevite Spacesaver transistor, *grounded grid socket GE 7296 tube, *transistor test socket, micromodule test socket, magnetron connector, UHF socket GE 7077, anode connector-cable assembly, VHF socket RCA tetrode, socket varactor diode, test sockets for tantalum capacitors and Micro Pico, Transi-T.

Jonathan Mfg. Co., Booth 4502
720 E. Walnut Ave.
Fullerton, Calif.
M. Fritz Hagen, Richard Becker, John Meyer
Thinline ball bearing slide mounts standard chassis in standard RETMA cabinets. *Full ball bearing slides featuring quick disconnect and 180 degree pivot, over-all width ½ inch. *Jonathan new "Even-Pull" handles. *Cable carrier.

Howard B. Jones Div., Cinch Mfg. Co., Booth 2535
1026 South Homan Ave.
Chicago 24, Ill.
E. J. Pool, ▲ G. J. Hunt, C. W. Nelson, J. M. Litman
Multi-contact plugs and sockets, barrier terminal strips, fanning strips, terminal panels, fuse mounts.

M. C. Jones Electronics Co., Inc., Subsidiary of The Bendix Corporation, Booth 2331
185 North Main St.
Bristol, Conn.
S. T. Urbank, ▲ D. H. Coe, G. H. Edwards, ▲ F. K. Clark, F. Roskosky, W. Matthews, E. Testa, H. Krause

Calorimetric Type Wattmeter

MicroMatch RF power and VSWR measuring instruments, 0.5 to 8000 mcs., 10mws. to 10 megawatts including RF and dc output directional couplers, RF load resistors and coaxial line tuners. Waveguide and coaxial RF components to customers' specifications.

Jordan Electronics, Booths 2301-2303
See: Victoreen Instrument Co.

Julie Research Laboratories, Inc., Booth 3238
603 West 130th St.
New York 27, N.Y.
▲L. Julie, L. McCulley, W. Thomson, B. Jacks, B. Steinburg, O. Bonet, H. Bueno, F. Trautman
Primary dc lab facility; precision voltage supply; standard cell oven; *primary resistance oven; dc and ac primary voltage dividers; *ac calibration standard; *oil-filled precision resistors; primary standard resistors; *double-decade resistance standard; *multiple resistance standard. Primary standard resistance oven: Accuracy and stability to 0.0008%.

(Continued on page 285A)

Whom and What to See at the IRE Show

(Continued from page 284A)

Kanthal Corp., Booth 4222
Amelia Place
Stamford, Conn.

Erik Hagglund, ▲G. W. Eisenbeis, R. C. Bossa, E. J. Chappa

Precision resistance alloys insulated with Ceron ST and F through agreement with Sprague Electric Co. Operating temperatures to 500 C. Favorable space factor for precision resistors. Thermocouple alloys with exceptional stability at elevated temperatures. Complete line of electrical resistance alloys.

Kay Electric Co., Booths 3512-3518
14 Maple Ave.
Pine Brook, N.J.

Harry R. Foster, Elmo E. Crump, Irving Silberg, Thomas Dougherty, Jim Connors, Karl Sturz, George Murphy, Roy Huebner

Audio Frequency Sweeping Oscillator

Sona-Sweep Model M—Audio frequency sweeping oscillator and frequency marker covering range from 20 cps to 200 kc. Sweeping oscillators, frequency markers, random noise generators, precision attenuators, audio spectrum analyzers, pulse carrier generators.

† See PROCEEDINGS OF THE IRE—Jan. through Dec. (1960) and Jan. through Dec. (1961) for further information on our products.

See 1961 IRE DIRECTORY, page 330, for complete information on our products.

Kearfott Division, General Precision, Inc., Booths 1501-1505
Little Falls, N.J.

Edward Berlly, H. E. Bloom, D. J. Fisher, R. J. Ganther, J. E. McDonough, J. R. Stangl, R. Wray, J. W. Kearney, P. Pytal, R. I. Wollenberg, C. M. Donnelly, D. A. Chiafulio, N. J. Jordan

Servo system components—size [illegible] 8 and 11; gyros, accelerometers and gyro platforms; test and ground support equipment; microwave devices and systems; electronic components; ferrite components; special motors; analog computers and components; power equipment; transistors and microelectric components; inertial systems.

† See PROCEEDINGS OF THE IRE—Jan., Feb., March, April, May, Aug., Sept., Oct., Dec. (1960), Jan., March (1961) for further information on our products.

See 1961 IRE DIRECTORY, pages 120 and 121, for complete information on our products.

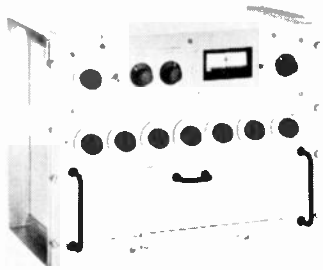
(Continued on page 286A)

Whom and What to See at the IRE Show

(Continued from page 285A)

Keithley Instruments, Inc., Booth 3920
12415 Euclid Ave.
Cleveland 6, Ohio

▲ J. F. Keithley, ▲ J. L. Gibson, ▲ J. Praglin, ▲ A. D. Oliverio, ▲ H. Sohn, ▲ R. Wood, M. T. Davies, T. G. Brick



Model 515 Megohm Bridge

Megohm bridge, *milli-microvoltmeter, *electrometers, *regulated high-voltage supplies, *micro-microammeter, electronic trip, *electronic relay, microvoltmeters, milliohmmeters, megohmmeters, multi-purpose electrometers, differential input electrometer, linear and logarithmic micromicroammeters, log and period amplifier, dc and ac amplifiers, static meter.

Kellogg Switchboard & Supply Co., Booths 2510-20 & 2615-25
See: International Telephone & Telegraph Corp.

Kelsey-Hayes Co., Booth 4006
See: Utica Drop Forge & Tool

Kemet Company, Division of Union Carbide Corp., Booth 2405
Madison Ave. & West 117th St.
P.O. Box 6087
Cleveland 1, Ohio

K. S. Collart, ▲ G. H. Didinger, ▲ M. B. Farrar, W. H. Fritz, R. L. Gollwitzer, P. R. Hostacky, H. S. Pattin

Solid tantalum capacitors for transistor amplifiers, R-C timing circuits and other applications. Semiconductor silicon for production of power rectifiers and signal diodes. Getters for all types of electron tubes. Silicon monoxide for thin film evaporation. Grid lateral wires for winding grid.

Kemtron Electron Products, Inc., Booth 2828
14 Prince Place
Newburyport, Mass.

A. N. Dugar, E. T. Casellini, R. Berry, J. Scholl

Semiconductors—silicon and germanium point contact diodes. Germanium gold bonded diodes. Silicon junction medium power diodes.

Ken-Tron Corp., Booth M-22
395 Lynway
Lynn, Mass.

Nelson W. Hearn

Connectors: Coaxial, microphone, RF type, subminiature. Jacks and jack fields, plugs, test jacks.

A complete listing of all registrants at the IRE Show and Convention, showing company affiliation and local hotel, is posted on the back wall of the mezzanine on the west side of the first floor.

D. S. Kennedy & Co., Booth 2129
155 King St.
Cohasset, Mass.

▲ Robert J. Grenzeback, John H. Lamothe, ▲ Howard H. Hubbard, Lawrence D. Copeland, ▲ Philip L. Rockwood, ▲ Robert Callaway, Peter Covel, ▲ John Dawson, Don McKeen

Radar antennas—radio telescopes—trackers—microwave towers—complete antenna systems—spincast antennas—waveguide horns.

Kent Mfg. Corp., Booth 1921
Strip terminals. See: Thomas & Betts Co., Inc.

Kepco, Inc., Booths 2636-2638
131-38 Sanford Ave.
Flushing 55, L.I., N.Y.

▲ Kenneth Kupferberg, Max Kupferberg, Jack Kupferberg, George Hill

Voltage and current regulated dc power supplies; transistorized, vacuum tube, magnetic, and hybrid designs.

†

See PROCEEDINGS OF THE IRE—Jan. through Dec. (1960), Jan., Feb. (1961) for further information on our products.
See 1961 IRE DIRECTORY, page 484, for complete information on our products.

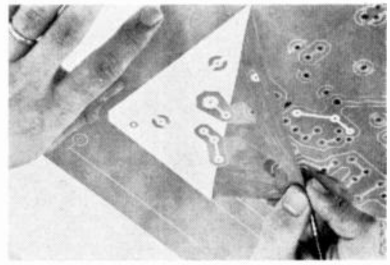
Kester Solder Co., Booth 4221
4201 Wrightwood Ave.
Chicago 39, Ill.

F. C. Engelhart, F. Kaiser, J. H. Humble, J. M. Johnson, H. E. Reed, J. Blakeley, E. Garfield, T. L. Sellaro, L. W. Feldman, T. V. Churbuck, G. R. Clouse, C. P. Howe, F. A. Ross, G. L. Fisher, Jr., C. L. Barber

*Kester's Universal Soldering Machine SD-4 model 1 of turn-table construction with adapters of specific type to accommodate many different units or assemblies. Wide-range adjustable operating speed. Long-life heating element with temperature control. Solders and soldering fluxes. Kester "Solderforms."

Keuffel & Esser Co., Booth 4506
300 Adams St.
Hoboken, N.J.

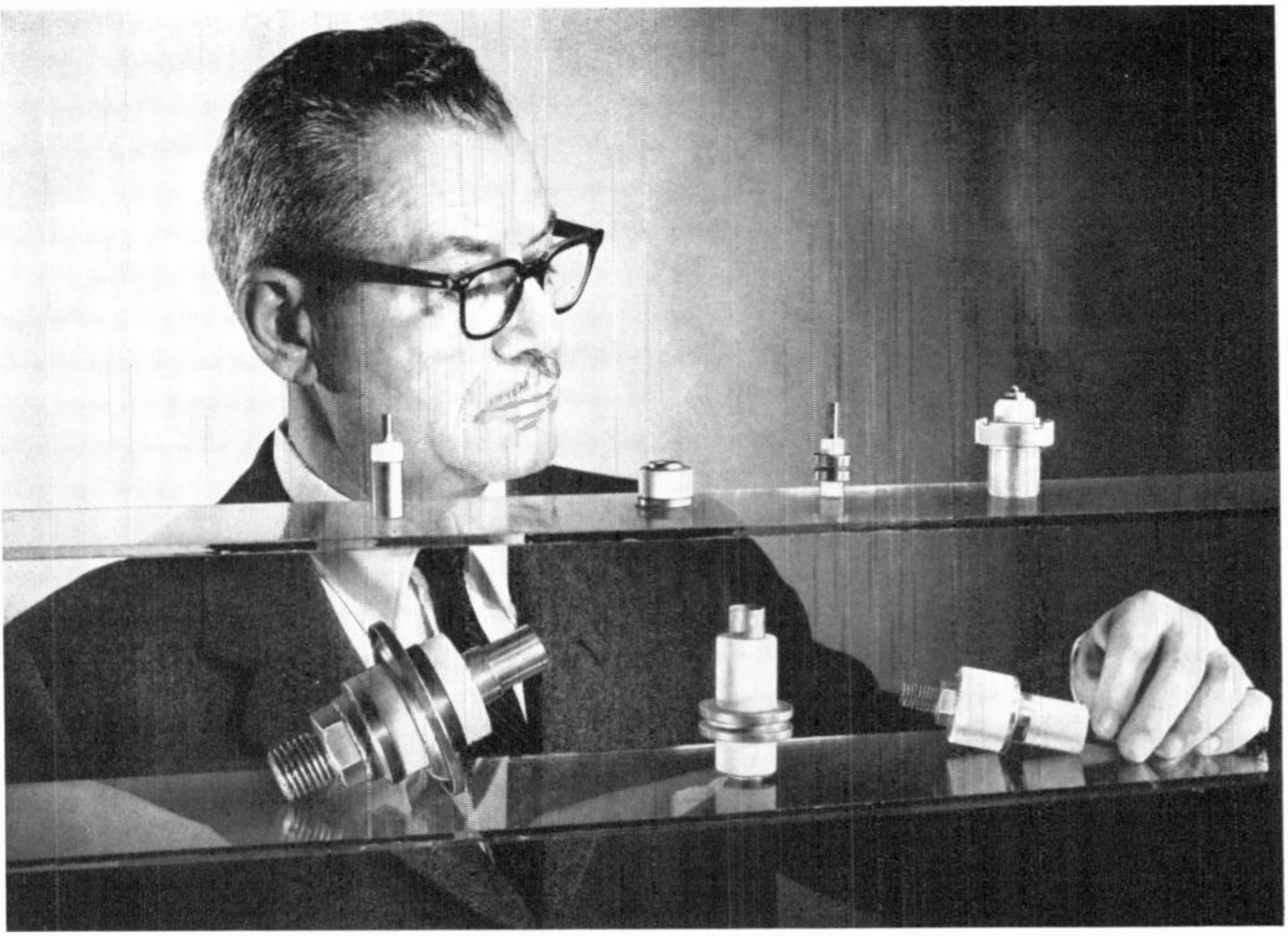
Charles Stein, Ralph Richards, Dale Hawkins, Ronald Henwood, Gerry Raso



*New Printed Circuit Technique

*New methods for preparing printed circuit layouts. Basic materials used: K & E "Stabilene"® scribe coat, peel coat and cut 'N' strip films. Special cutting tools and scribing tools also on exhibit. *New evaluation kit to be demonstrated.

(Continued on page 288A)



Engineering hints from Carborundum

Use KOVAR® Alloy to solve problems in sealing to ceramics

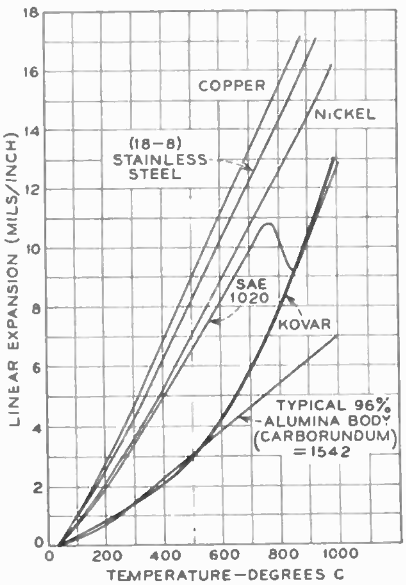
KOVAR, the original 29% nickel, 17% cobalt, 54% iron alloy, was developed for sealing to low expansion glass, but is now being used extensively for making pressure and vacuum tight seals with metallized ceramics of the low expansion type.

The curves at right show the expansion of KOVAR compared with a representative high alumina ceramic body. The expansivity match up to 500 C is very close, and the difference in expansion at higher temperatures is closer than with most common metals and alloys.

The fact that KOVAR is slightly higher in expansion at elevated temperatures is an actual advantage when the ceramic is on the inside of the unit since the resulting joint is placed in compression. The degree of compression is slight compared with that resulting from the use of a metal of higher expansion.

While a considerable difference in expansivity can sometimes be tolerated with the metal on the outside of thick sections of ceramic, this is not the case when the ceramic section is thin. Closer compatibility of expansivity, such as is obtained with KOVAR, is also required when the metal is on the inside of the ceramic or for sandwich or end type seals where both tensional and shear stresses must be kept to a minimum.

KOVAR alloy is stocked in a variety of sizes of rod, wire, tubing, sheet, cups and eyelets. Your inquiries are invited for prices, technical information and recommendations on specific problems. Write Dept. P-31, Latrobe Plant, Refractories Division, The Carborundum Company, Latrobe, Pa.



For permanent vacuum and pressure-tight sealing... count on

CARBORUNDUM®

Hope you'll stop by our booth at the IRE Show.

Kidde Electronic Laboratories, Walter Kidde & Company, Inc., Booth 1926
9 Brighton Road
Clifton, N.J.

▲ N. Diepeveen, T. Jacobsohn, W. Masnik, E. Olsta, R. Langfelder, E. Demers, R. Gilbert, H. Randel, E. Rollins, M. Schwartz, H. Matarazzo, F. Leone

Static power supplies, inverters, converters, frequency changers, static relays, static contactors, static light flashers, thermistors, ground support equipment.

Kin Tel, Division of Cohu Electronics, Inc., Booths 3607-3611
5725 Kearny Villa Road
San Diego 12, Calif.

Henry J. Pannell, Joseph Szewzuk, Daniel Knox, Donald Hoiland, ▲ Frank R. Martin, John JaQuay, Richard L. Harmon, James R. Langham, Raymond Suttles, ▲ William S. Ivans, Edward T. Clare, Charles G. Bowen

Self-contained and automatic closed-circuit TV using standard and MIL-spec environmental cameras; digital voltmeters with multi-input scanner, comparator, and ac and dc preamplifiers; dc and ac voltage standards; non-digital measuring instruments; chopper-stabilized dc amplifiers having wideband response and isolated input circuits.
See also Massa Labs. & Millivac Instruments Div.

†

See PROCEEDINGS OF THE IRE—March through Dec. (1960), Jan. through Dec. (1961) for further information on our products.
See 1961 IRE DIRECTORY, pages 110-111, for complete information on our products.

Whom and What to See at the IRE Show

(Continued from page 286A)

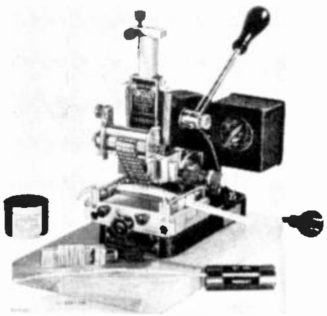
Kings Electronics Co., Inc., Booths 2221-2223
10 Marbledale Rd.
Tuckahoe 7, N.Y.

▲ S. Jackson, ▲ G. Nuremberg, ▲ M. Weissman, W. Lavers, H. Watson, F. Lorge

A line of Foamflex and TNC connectors with excellent VSWR readings individually calibrated for specific or broadband use. K-Grip connectors will be assembled by factory production employees.

Kingsley Machine Co., Aircraft-Missile Division, Booth 4236
850 Cahuenga Blvd.
Hollywood 38, Calif.

George E. Kingsley, A. C. Sheffield, Norman Friedman



Wire and Tube Marking Machines

Hand operated and motor driven machines for marking wiring circuit code references on aircraft, missile and electrical wiring. Equipment for marking tubing and sleeving for wire identification markers. Electric ovens for sintering markings on teflon insulated wires.

Kinney Vacuum Division, The New York Air Brake Co., Booths 1309-1311
3529 Washington St.
Boston 30, Mass.

W. B. Mills, W. H. Crowley, G. W. Brewer, J. A. Brower, W. T. Chester, P. E. Dunning, V. J. Leonetti, A. W. Livesey, R. R. Cyr, P. D. Reifenrath, C. H. Foundas, G. A. Davis, A. J. Shivers

Kinney's high vacuum evaporator with electron beam source—*New line of components including high speed diffusion pumps. McLeod type high vacuum gage with exceptional range of pressure readings, new line of Vane pumps. Ion pump evaporators.

†

See PROCEEDINGS OF THE IRE—Jan. March, May, Aug., Oct., Dec. (1960), Jan., March (1961) for further information on our products.
See 1961 IRE DIRECTORY, page 35, for complete information on our products.

▲ Indicates IRE member.
* Indicates new product.
† Exhibitor is servicing IRE Engineers through the IRE Package Plan.

Kistler Instrument Corporation, Booth M-8
15 Webster St.
North Tonawanda, N.Y.

R. W. Lally, W. P. Kistler, Max Bennett, V. Siegel, W. Schutrum, W. Waytena, J. F. Lally

Servo (force balance) and natural quartz pressure, force and acceleration measuring instruments. *Miniature precision servo accelerometer. *high frequency natural quartz crystal accelerometer that is statically calibrated. These instruments serve as laboratory standards for shock and vibration testing and for accelerometer calibration.

Mathias Klein & Sons, Inc., Booth 4429
7200 McCormick Rd.
Skokie (Chicago 45), Ill.

H. B. Wilson, C. F. Castino, R. Colsant, S. P. Gavin

Pliers of all types designed for the electronics field. Over 100 types and styles will be on display and demonstrated.

Knapic Electro-Physics, Inc., Booth 4531
936-40 Industrial Ave.
Palo Alto, Calif.

Dean K. Knapic, Robert D. Yeaman, Richard K. Wilcox, Harvey S. Court, ▲ Phillip H. Wexler, Paul E. Brodrick, Theodore M. Jenkins, Joe McCaslin, Gordon Babcock, Jack Sullivan, Michael G. Kaufman, Michael Goldeen, Wayne Kway

Silicon and germanium monocrystals in all sizes and resistivities for semiconductor use. Large diameter grown ingots up to eight inches for infrared dome and lens application. Gallium arsenide.

Knight Electronics Corporation, Booths 3831-3833
210 S. Des Plaines
Chicago 6, Ill.

L. S. Preskill, A. Henry, ▲ L. M. Dezettel, ▲ G. Randolph, W. Purcell, ▲ C. Ratcliff

Knight-Kits. Professional electronic equipment in kit form. Laboratory dc triggered sweep scope, automatic AC-VTVM, stereo high-fidelity amplifiers and tuners, amateur gear, intercom, portable radios, training kits. *stereo tape preamplifier, *70 watt stereo amplifier.

James Knights Co., Booth 2706
101 East Church St.
Sandwich, Ill.

▲ John F. Silver, Glenn Munro, Louis A. Dick, W. R. Doede, ▲ Robert B. Beetham

Precision quartz crystals in conventional and "Glasline" holders. Precision ovens and crystal using assemblies, including crystal filters and complete miniature transistorized crystal controlled oscillators.

†

See PROCEEDINGS OF THE IRE, Jan.-Dec. (1960), Feb., April, June (1961) for further information on our products.
See 1961 IRE DIRECTORY, page 430, for complete information on our products.

Koito Electronics Co., Ltd., Booth 2929
See: Rye Sound Corp.

Korfund Company, Inc., Booth 1324
Cantiague Road
Westbury, L.I., N.Y.

S. Lee Perlow, ▲ Nicholas F. Kfoury, Alan White, Leo Balandis, Arthur Degenholtz, Robert Orff, Joseph Feigen, Francis Kirschner, Robert Upton, J. I. Hammond, Dr. B. K. Erdoss, D. H. Vance

Vibration and shock isolation systems for gyros, inertial platforms, computers, and other electronic equipments; broad temperature elastomer mount; all-attitude spring mounts; rotationally constrained mountings for gyros; "Vibrodamper" structural coating for resonant structure problems; shock and vibration proof shipping containers. Transducers and instruments for measurement of vibration, strain, and noise (Acoustics & Instruments Div.).

Krengel Manufacturing Co., Inc., Booth 4231
227 Fulton St.
New York 7, N.Y.

A. L. Gershon, George A. Feldman, John A. Collins, Jr., Howard D. Gershon, Gilbert M. Bloch, Lloyd B. Thompson, Harold Murray, Dominick Ponzo

Marking devices: "Deep-Kut" engraved rubber stamps and dies, offset presses, markers, numberers, nameplates, automatic coders, ticket punches, engraved stencils, alphabet stamps, brass stamps, checks and tags, inspection stamps, self-inking stamps, hand printing presses, special inks, safety steel dies and stamps, seals.

Krohn-Hite Corp., Booths 3708-3710
580 Massachusetts Ave.
Cambridge 39, Mass.

▲ W. L. Bixby, J. McLaughlin, G. Hite

Ultra high regulation 0.0005% load, 0.0002% line—fully transistorized power supplies; stable-amplitude low distortion ac power sources; low-distortion oscillators; ultra-low frequency variable electronic filters; ultra-low distortion power amplifier and direct coupled 50 watt power amplifiers.

Kulka Electric Corp., Booth 2900
633-643 South Fulton Ave.
Mount Vernon, N.Y.

▲ Eugene R. Kulka, William Kulka, Elliott Edelman, Adolph Friedman, Ralph Horowitz, ▲ Robert Smith, Jay Friedman, David Friedman

A complete line of military terminal boards; commercial line of terminal blocks and strips; military type aircraft toggle switches, single and double pole; heavy duty pressure contact terminal blocks; printed circuit type terminal blocks; power receptacles and outlets; complete line electrical wiring devices; hardware for terminal blocks; harnesses.

† See PROCEEDINGS OF THE IRE—March (1960), Feb., March, May, Aug., Oct., Dec. (1961) for further information on our products.

See 1961 IRE DIRECTORY, pages 551 and 558, for complete information on our products.

(Continued on page 290A)

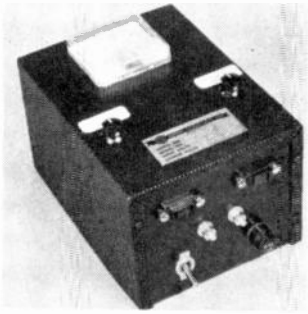
IRE
Telephone and
Hospitality Center
South American Room
First Mezzanine
Entrance from
20 West 60th St.
or Mezzanine Floor

Whom and What to See at the IRE Show

(Continued from page 289A)

Kupfrian Mfg. Corp., Booth 4318
1 Henry St.
Binghamton, N.Y.

W. J. Kupfrian, C. J. Chase, E. Kirkhuff, F. E. Kent, W. Shaw, E. Braddock, T. Kennedy, K. M. Grout, A. Brown

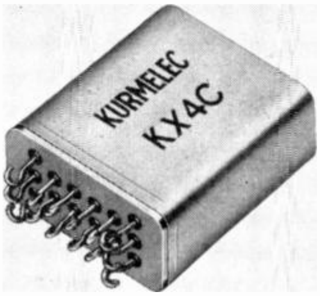


Frequency-Regulated Transistorized Inverter.

Standard and custom-built transistorized power supplies; electrical cable and harness assemblies; flexible shafts for remote controls; specialized hardware including miniature Oldham couplings and universal joints.

Kurman Electric Co., Subsidiary of Crescent Petroleum Corp., Booth 2135
191 Newel St.
Brooklyn 22, N.Y.

▲ Julian Goodstein, Raphael Spiegelman, John Scotti, Eric Krieger, Wallace Green, Herman Tawil



Kurman Astrorelay (Microminiature)

Complete line of "off-the-shelf" relays, hermetically sealed, open and plug-in types, sensitive, telephone, subminiature, polar, power, antenna change-over, motor starting, keying, and the Astrorelay—a 4 PDT microminiature, 50 G's, 5,000 cps—dim.: 0.875 × 0.800 × 0.400.

LEL, Inc., Booths 2106-2108
75 Akron St.
Copiague, N.Y.

▲ David L. McPherson, ▲ Bernard Erde, ▲ Charles Baker, ▲ Walter Hollis, ▲ Charles Bissegger, ▲ Robert Murphy, ▲ Jack Vigiano, ▲ William Maggio, ▲ Stanley Rosenberg, ▲ George Flanagan

Parametric Preamplifier

Telemetry parametric preamplifier—weatherproofed sealed unit for antenna mount use, suited for distant range tracking, troposcatter links, or radio astronomy applications. Orthomode mixer preamplifiers, X-band receiver using varactor multiplier, S-band solid state microwave receiver. *new microwave telemetry front ends.

L.F.E., Booths 3819-3821
See: Laboratory for Electronics, Inc.

LIECO, Inc., Booth 2433
See Lieco, Inc.

Laboratory for Electronics, Inc., Booths 3819-3821
Instrument Div., 711 Beacon St., Boston Mass.
Computer Products Div., 1079 Commonwealth Ave., Boston, Mass.

John Cullen, ▲ Perry Pollins, ▲ Irving Versoy, ▲ James Christian, ▲ Peter Jorrens, Morton Simon, Frank Neri, Allen Sparr, Jack Klayman, ▲ Harry Lockhart, Walter Loyte, Jim Buzzell, Fred Carroll

L.F.E. Instrument Div.— Model 5024 microwave stability tester; Model 5012 MTI test set; Series 814 ultra-stable microwave oscillators; Model 5009 microwave stability tester; Epsi-Line balanced crystal mixers. L.F.E. Computer Products Div.—Magnetic devices; transformers and heads; ultra-sonic delay lines; Bernolli disk storage device.

(Continued on page 292A)

DON'T MISS THE FOURTH FLOOR!

Production engineering is rapidly becoming one of the most important facets of the radio-electronic industry. Fourth floor exhibits are devoted to this subject. On the fourth floor, you can find new machinery and tooling techniques, and discover ways to make your own product better, cheaper and faster. Don't pass up this opportunity to acquire new methods and knowledge on that all-important aspect of electronics—

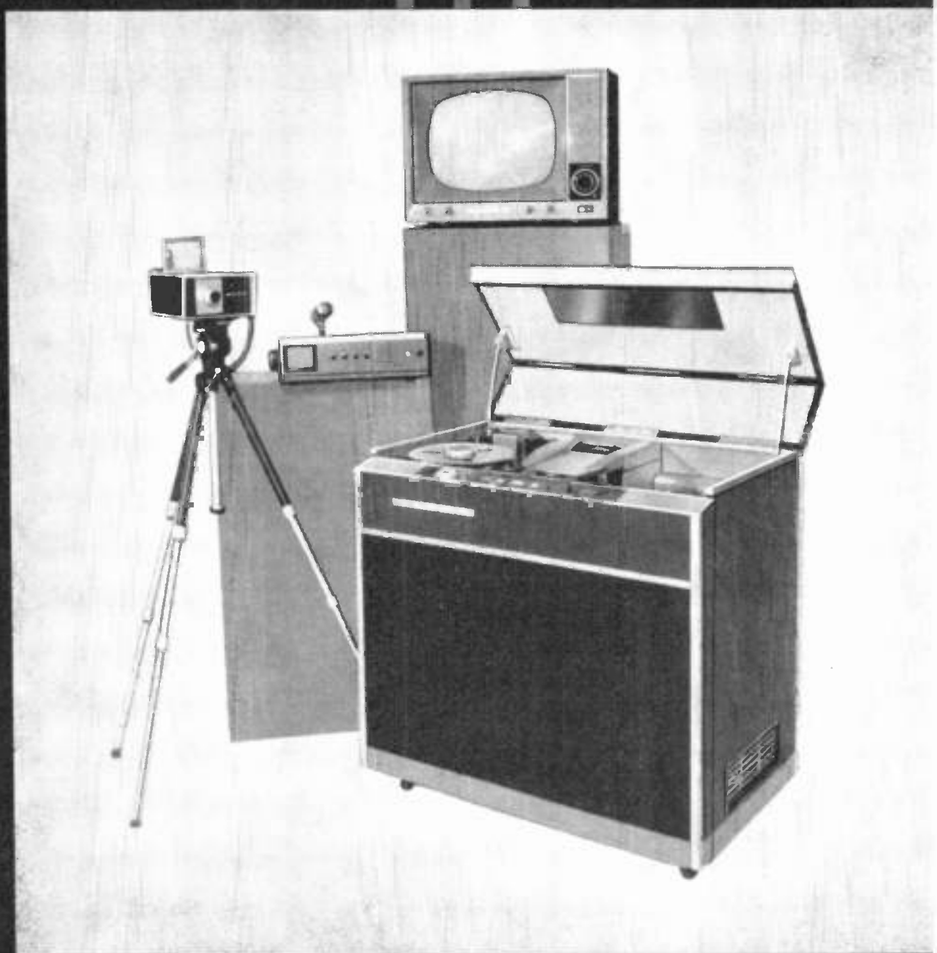
PRODUCTION—FOURTH FLOOR

SONY®

RESEARCH MAKES THE DIFFERENCE

introducing the

SONY TRANSISTORIZED
VIDEOCORDER



For the first time a **COMPACT,** transistorized video tape recorder. This unit enables one hour of continuous recording.

CAPACITY: 2400 feet of tape.

DIMENSIONS:
- Recorder —
  3′ width x 3′ length x 2′ height
- Receiver Set —
  2′ width x 1′2″ length x 1′4″ height
- Camera Control Unit —
  1′4″ width x 1′4′ length x 5″ height

IRE SHOW BOOTH #1732

SONY CORP. / TOKYO, JAPAN

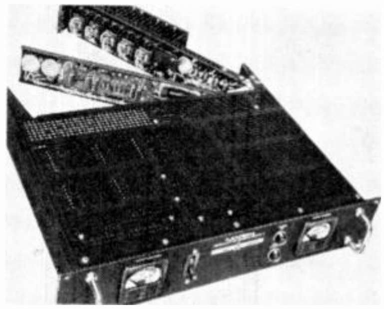
For further information: SONY CORP. OF AMERICA 514 Broadway, New York 12, N. Y. • Tel.: WO 6-0800

Whom and What to See at the IRE Show

(Continued from page 290A)

Lambda Electronics Corp., Booths 2917-2918
515 Broad Hollow Road
Huntington, L.I., N.Y.

▲ Lester Dubin, ▲Simeon Weston, Merrill Simon, ▲ Sol Greenberg, ▲ Benjamin Shmurak, William Kellerman



Transistorized Regulated Power Supply

Regulated dc power supplies. Announcing at the Show *a new series of transistorized power supplies. LA Series: 0—34 VDC (5, 10 and 20 amp); 20—105 VDC (2. 4 and 8 amp); 75—330 VDC (0.8, 1.5 and 3 amp). Com-Pak® series and LT series also on display.

† See PROCEEDINGS OF THE IRE—Jan. through Dec. (1960), Jan., Feb., March (1961) for further information on our products.

See 1961 IRE DIRECTORY, pages 19-26, for complete information on our products.

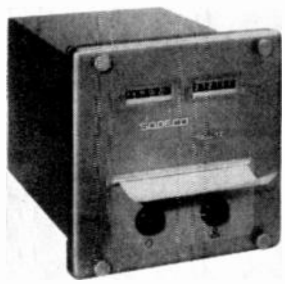
Land-Air, Inc., Stepper Motors Div., Booth 1600
16226 S. Broadway
Gardena, Calif.

Clarence Adams, Armand Vasquez, Thomas Wallace

Stepper motors, relays, blanking amplifiers, flare ejection system, code selector relays, dc power supplies, solid state pulsers, synchro-positioners, servo-motor packages.

Landis & Gyr, Inc. Booth 3015
45 West 45th St.
New York 36, N.Y.

H. A. Jenny, W. H. Goudy, W. Steinmann, ▲ M. Wiesendanger, R. Rosa



Sodeco Printing Counter

Sodeco (Geneva, Switzerland): Electro-magnetic impulse counters; electronic high-speed counters; predetermining counters; monodecade counters; add-subtract counters; printing counter and printing counter with date and time printer. Landis & Gyr S. A. (Zug, Switzerland): Pulse generators, instrument transformers.

Langevin Div., Booths 1208-10
See: Maxson Electronics Corp.

Lansdale Div., Booths 1302-1308
See: Philco Corp.

LaPointe Industries Inc., Booth 2113
155 West Main St.
Rockville, Conn.

J. H. Stillbach, D. Malone, J. W. Anderson, Fred Wisk, A. Esten

Printed circuitry and assemblies; flexible printed circuits; variable air dielectric capacitors. Test sets and components.

Larson Instrument Co., Booth 3121
Greenbush Road
Orangeburg, N.Y.

Louis H. Larson, G. Adam, R. MacFeety, R. Foley, R. Adam, E. Talbot, H. Kulik

30 styli inkless recorder, high speed, accuracy 2 milliseconds, response time 1 millisecond, quick change selector 3600 : 1, 60 : 1. Also, contact meter controller with plug-in transistorized amplifier, high speed, accuracy, repeatability 1% of full scale, compact.

Lavoie Laboratories, Inc., Booths 3815-3817
Matawan-Freehold Road
Morganville, N.J.

A. P. Buckley, Lawrence Lippert, ▲ Thomas Laugesen, Frank Slovenz, Louis Tischler

Precision instruments designed and produced to provide highest standards of performance and reliability in oscilloscopes, spectrum analyzers, frequency standards and meters, counters, specialized oscilloscope development and production for commercial and military sales, Robotester automatic test equipment. *Automatic cable checker.

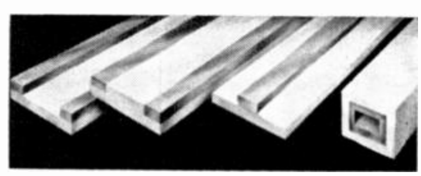
Leach Corp., Booth 2003
18435 Susana Road
Compton, Calif.

▲ Robert L. Jannen, Joseph Baker, Thomas Tracy, John Galraith, Del Smith, Beverly Johnson

Electronic and electromechanical switching devices: relays, solid state "Static" switches, timers, packaged modules; tape recorders and accessory electronics; telemetry equipment; static dc power supplies.

Leach & Garner Company, Industrial Division, Booth 4051
Leach & Garner Bldg.
Attleboro, Mass.

Gerald F. Tucci, Sam Greenbaum, Arthur O. Marcello, Fred Dole, J. Doeschner



Laminated and solid precious metal contact material. Alloys of gold, silver, platinum and palladium. Sheet, wire, and tubing. Overlay, inlay, toplay, thrulay, and edgelay. Silver and gold solders. Nonferrous and precious metal foil strip material. Waveguide tubing. Roll-formed shapes. See also: General Findings & Supply Co.

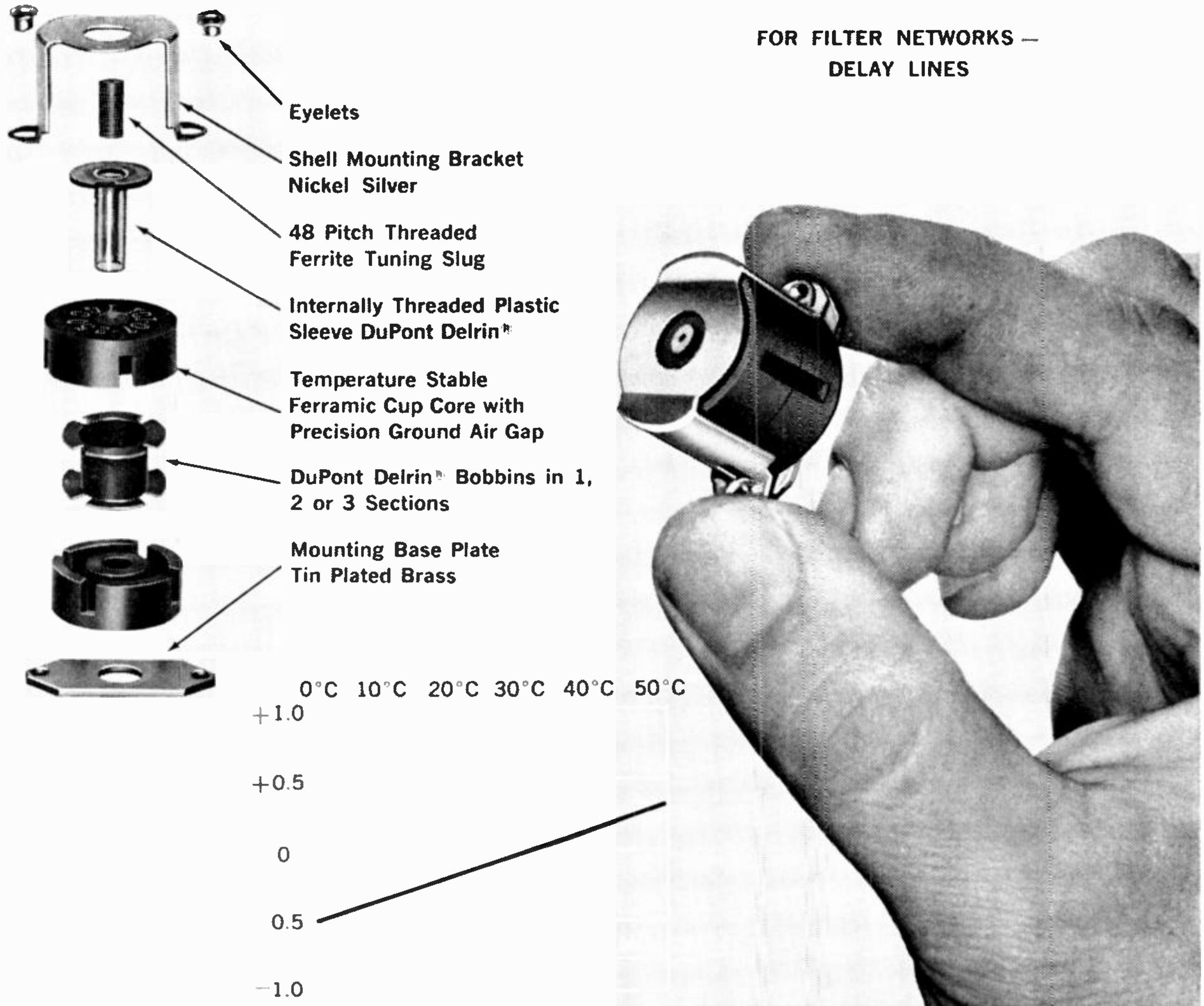
Leecraft Mfg. Co., Inc., Booths 2829-31
Bracket mounted sockets, lampholders. See Dialight Corp.

(Continued on page 294A)

▲ Indicates IRE member.
* Indicates new product.
† Exhibitor is servicing IRE Engineers through the IRE Package Plan.

From General Ceramics Division of
INDIANA GENERAL CORPORATION

FOR FILTER NETWORKS —
DELAY LINES



Typical Curve for a TC-1-03-250 Cup Core

FERRAMIC® Cup Core Assemblies with Unmatched Stability 0° C to 50°C

(International Series)

FEATURES THAT PAY OFF IN PERFORMANCE AND COST

- Seven sizes from stock .599" to 1.425" O.D.
- Frequencies — 1KC to 1MC
- "Q" values to 750
- Standard Gapped Inductance Values 40 to 1000 MH/1000 turns
- Extreme temperature stability
- Trimmer for minimum of 12% adjustment
- Complete assembly available

Now, a complete line of in-stock cup core assemblies designed for electronic coil applications requiring inductance and permeability having exacting temperature stability and linearity.

The high "Q" factor exhibited by these temperature compensated cup cores is engineered to meet the most rigid coil design requirements.

TC permeability stable units combine optimum operating performance in the smallest possible space providing complete design flexibility at low cost.

For exact recommendations and fast off-the-shelf deliveries, write, wire or phone today — ask for Bulletin 28.

VISIT US AT
THE I.R.E. SHOW
BOOTHS 1310-16

INDIANA GENERAL CORPORATION

GENERAL CERAMICS

Phone VAlley 6-5100 • Direct Distance Dialing Code 201

KEASBEY, NEW JERSEY, U. S. A.

TECHNICAL CERAMICS, FERRITES AND MEMORY PRODUCTS

Whom and What to See at the IRE Show

(Continued from page 292A)

Leesona Corporation, Booths 4323-4325
P.O. Box 1605
Providence 1, R.I.

W. T. Crocker, C. J. Zaikowski, W. L. Rainford, W. J. Quinn, A. W. Wachta, I. J. Marsh

Coil winding machinery: Models 107—108—featuring one operator handling two fully automatic #107 machines. Model #108 machine for manually feeding paper insulation between wire layers; quick set-up features for short runs and varied coil specs.

Lel, Inc., Booth 2106-08
See: LEL, Inc.

Lelanite Corporation, Booth 4055
P.O. Box 152
Webster, Mass.

Arthur G. Perry, Ernest E. Perry, Frank E. Dane, Leonard H. Russell, James Ford, Herbert Newton

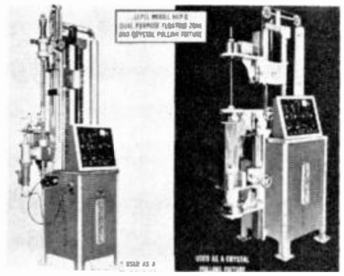
Molded products. Molded rubberized cushioning. Molded expanded styrene. Polyurathane foam. Rubberized hair and fiber.

▲ Indicates IRE member.
* Indicates new product.

Show Hours
10 a.m. to 9 p.m. daily
Monday through Thursday
March 20-23, 1961

Lepel High Frequency Labs., Inc., Booth 4213
54-18 37th Ave.
Woodside 77, L.I., N.Y.

H. H. Watjen, C. L. Jennings, E. N. Curcio, W. J. Palocsik, A. L. Bellini, A. Vescuso, W. Manning Grimm. F. G. Holzhausen, John Dietz, R. Brachold



Lepel Model HCP-D

High frequency induction heating equipment 450 kilocycle nominal frequency. Also megacycle frequency equipment. *Floating zone and crystal pulling combination, Model HCP-D, dual purpose fixture (illustrated). Induction heating generator, bench model for bonding pretinned wires, water recirculator.

Lerco Electronics, Inc., Booths 2101-2103
Terminals and knobs. See: Microdot Inc. (now Lerco Division)

Levinthal Electronic Products, Inc., Booth 3002
See: Radiation at Stanford (Radiation, Inc.)

Librascope Division, General Precision, Inc., Booths 1507-1509
808 Western Ave.
Glendale, Calif.

D. A. Johnson, R. Meade, M. Hirsh, P. Shipp, C. Smith, J. Bunnel, F. Matthews, J. Frye, G. Roberts, P. McGiven, D. Sanson, F. Bristow

1). Converters; 2). Shaft-to-digital encoders; 3). Mechanical components; 4). Navigation and missile control computer; 5). General purpose digital process control computer.

Licon Division, Illinois Tool Works, Booth 1506
6606 W. Dakin St.
Chicago 34, Ill.

J. B. O'Connor, J. O. Roeser, H. F. Benjamin, P. A. Roth, R. E. Sparks, P. A. McCullough, R. Henry

Precision snap-action switches, accessory actuators; basic sensitive, miniature, subminiature, heavy duty, industrial, diecast, and hermetically sealed units. Panel mounted lighted pushbutton switches. *Environment-free subminiature limit switches. Rotary de torque solenoids, stepping motors, and selector switches. Packaged modular components, e.g. resistors, capacitors, etc.

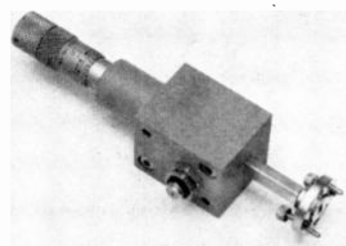
First and Second floors—Components

Third floor—Instruments and Complete Equipment

Fourth floor—Materials, Services, Machinery

Lieco, Inc., Booth 2433
Syosset Industrial Park
130 Eileen Way
Syosset, L.I., N.Y.

▲ A. Zeitz, ▲ M. Zanichkowsky, M. Egan, W. McHugh, S. Goldstein, W. R. Griffin, Robert Greene, Walter Brouilette, Max Symon, George Bohman, M. Goldstein



Balometer UG-98/U UG-99/U

Balometer (millimeter) attenuators, antenna accessories, adapters, bend and twists, couplers, detectors, dividers, dummy loads, *filters, flanges, gaskets, mixers, mounts, probes, shorts, switches, scanners, tees, terminations, transitions, tuners. Companion bias supply (to Balometer pictured above) is battery operated with wire wound resistors to insure low noise level.

Lindberg Engineering Company, Semiconductor Division, Booth 4013
2450 West Hubbard St.
Chicago 12, Ill.

S. J. Mack, P. E. Bjork, ▲ T. O. Mumper, ▲ R. T. Trebing

10 kw high frequency generator, *horizontal zone leveling furnace, portable vacuum furnace.

Line Electric Co., Inc., Booths 1319-23

Relays, buzzers, and footswitches. See: Industrial Timer Corp.

Ling-Altec Electronics, Inc. & Ling Electronics, Inc., Booths 3802-06

See: Ling-Temco Electronics, Inc.

Ling-Temco Electronics, Inc., Ling Electronics Div., Booths 3802-3806
1515 S. Manchester Ave.
Anaheim, Calif.

R. C. Erickson, L. E. Gillingham, ▲ Mort Zimmerman, Mike Ling, Sol Cornberg, Irving Presser, Cameron G. Pierce, Charles Theodore, Stan Walters, Robert Lewis, Stanley Grayson, Clifford Raber, Charles Harmon, Wally Graves, Jack Struble, Douglas McCroskey

Airborne timer devices and correlator units; static converter, dc-dc converter. Vibration and high intensity sound test equipment consisting of programming consoles, control panels, high power amplifiers, shakers, and high intensity transducers. Television broadcast and closed circuit equipment. Automatic controls, radiation systems, solid-state devices, spiral antennas.

Link Belt Corp., Booth 2525

See: Syntron Company.

Link Division, General Precision, Inc., Booth 1511
Binghamton, N.Y.

D. Fox, R. Seals, T. Harding, M. Seldon, L. Arnett

Character generation and display systems, digital plug-in modules, analog building blocks, A/D—D/A conversion modules, servo systems and components, universal analog function generator, hi-speed digital function generator.

Lionel Corporation, Booths 2002 & 1427

See: Anton Electronic Labs., Inc., & Telerad Division

Liquid Carbonic Div., Booth 3011

See: General Dynamics Corp.

Littelfuse, Inc., Booth 2923
1865 Miner Street
Des Plaines, Ill.

J. D. Hughes, H. A. Cornelius, W. A. Clements, W. J. Henke

"New line of 3AG miniature fuse holders incorporating latest improvements in design. Offering for first time a versatile selection of two different knob designs and two types of solder terminal connections. Available for standard commercial or military applications.

Little Falls Alloys, Inc., Booth 4015
189 Caldwell Avenue
Paterson 1, N.J.

Harold M. Malm, Harold G. Williams, James V. Sacco, Al Veltri

Sharp cornered square and rectangular wire for connectors. Round edge flat wire for plug type connectors. Beryllium copper, bronzes for springs and forms. Nickel clad titanium for ceramic to metal brazing or seals. Zirconium copper wire.

Your registration admits you to the show for all four days, and to all technical sessions at the Coliseum and the Waldorf-Astoria. Be sure to keep your badge or pocket card with you at all times on the floor. Registrations are not transferable.

Litton Industries, Inc., Booths 1610-1618, 1709-1717
336 North Foothill Road
Beverly Hills, Calif.

W. P. Corderman, Harry J. Gray, L. W. Howard, Crosby M. Kelly, Russell W. McFall, Dr. Norman H. Moore, George T. Scharffenberger, G. P. Tanquary, George Tallaksen, William F. Boyd, Tanney Oberg, George Marshall, James Weidenman, Justin Oppenheim, Norman Pell, Edmund Shimbel, Alfred Shapero, Raymond Geiger, Austin Cooley, L. Harriss Robinson, Henry Bechtold, Ernest Clover, Jack Gentry, Paul Robichaud, John Lovett, Robert F. Nelson, Arnold Kaufman, Vin Carver, Paul Crapuchettes, John McCullough, Berk Baker, David Mutchler, Norman Fyler, John Gerling, Tom Bristol, Leonard Bernier, Frank Oakes, Thomas P. Cheatham, Norm Mehl, George Tinker, Ted Jacobsen, Karl Clough

Fibre optics demonstration, inertial guidance demonstrations, computer components, bio-medical equipment, antennas, klystrons, magnetrons, cathode ray tubes, potentiometers, microwave components, transformers, printed circuits, electronic hardware, communication equipment, synchronous motors, chronometers, frequency standards, missile tape recorder, tape recorder, magnetic heads, ferrite devices, teaching machines, mechanical switches.

Lockheed Missiles and Space Div., Lockheed Aircraft Corp., Booth 3807
P.O. Box 504
Sunnyvale, Calif.

Stan Pforr, ▲ Dale Fuller, ▲ Frank Mansur, ▲ K. T. Larkin, ▲ W. F. Main, ▲ R. L. Vader

Microsystems electronics—chemically fabricated electronic circuits for application in airborne and spatial vehicular systems.

Lord Manufacturing Co., Booths 2838-2840
1635 West 12th St.
Erie 6, Pa.

M. D. Wood, J. M. Weaver, V. Ellis, J. P. Cooney, R. P. Thorn, T. J. Loftus, L. J. Schwemmer, J. T. Gwinn, G. H. Billman

Products for engineered vibration, shock, and noise control, including customized complete mounting systems, unit isolators, and bonded rubber items. Dyna-Damp structural sections and panels.

Lumatron Electronics, Inc., Booths 3059
116 County Courthouse Road
New Hyde Park, L.I., N.Y.

▲ Gerard G. Leeds, John P. Phillips, ▲ Richard S. Rothschild, ▲ Paul Schwartz, ▲ Charles Askanas

Automatic Switching Time Test Set

Millimicrosecond test instruments for measuring high frequency and ultra fast risetime waveforms. Model 400 Series automatic switching time test sets for measuring switching times of transistors, diodes, tunnel diodes and circuits. Model 112 sampling oscilloscope. Nanosecond pulse generators and semiconductor test sets.

(Continued on page 296A)

Whom and What to See at the IRE Show

(Continued from page 295A)

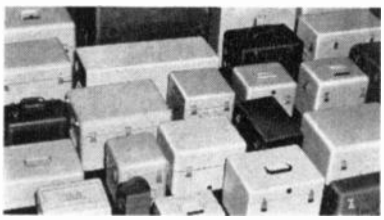
MB Electronics, Booths 3107-3109
781 Whalley Ave., P.O. Box 1825
New Haven 8, Conn.

Joseph A. Dudrick, Jack Newton, James F. Kavanagh, Bruce F. Petersen, James C. Stephens

Three new ceramic magnet vibration exciters, 15, 25 and 40 pounds force with frequency range up to 15 kc. Sine and random vibration test control console with automatic equalization of the random spectrum. Vibration meters and pickups.

MM Enclosures, Inc., Booth 4011
111 Bloomingdale Road
Hicksville, L.I., N.Y.

Michael C. Presnick, Louis J. Wepy, Irving Colen, William Hees, George Boziwick, Phillip Luce, Carl Berntsen, Robert Ebert, Kenneth L. Reidy, Norman Stachalek, Ernie Williams, Chester A. Milewski, Richard Sager



Military Cases

Electronic instrument, transit and combination cases constructed to conform to military specifications MIL-T-945, MIL-T-21200, MIL-C-4150, MIL-T-4734 and MIL-STD-108. Metal electronic enclosures and housings. Custom fabricated precision assemblies and weldments.

M-O Valve Co. Ltd., Div. General Electric Co. Ltd. of England, Booths 3406-08

Gold Lion tubes, Genalex special purpose tubes. See: British Industries Corp.

MRC Manufacturing Corp., Subsidiary of Materials Research Corp., Booth 4240
47 Buena Vista Ave.
Yonkers, N.Y.

Dr. Sheldon Weinig, Dr. Josef Intrater, Jack Freeman, Al Riccardo, Steven Hurwitt, Irma Weinig

Zone melting apparatus, arc-melting unit, radiant energy equipment, electron beam zone melting, diffusion furnace.

Lecture Halls in the Coliseum are located on the Fourth Floor. See complete program of speakers and papers in the editorial section of this issue.

Machlett Laboratories, Inc., Subsidiary of Raytheon Company, Booths 2611-2612
1063 Hope St.
Springdale, Conn.

W. Brunhart, H. D. Doolittle, D. S. Frankel, R. A. Hoffman, R. E. Nelson, M. Rome, R. N. Rose, R. S. Schoedler, C. V. Weden, A. F. Wegener, S. Yanagisawa, C. W. B. Edson, R. C. Parlette, D. W. Slater, R. R. Slocum

DP-11 125kv—300 Amps—Pulse Triode

Electron tubes: UHF planar triodes; shielded grid triodes; tetrode; high vacuum rectifiers; TV camera tubes; scan conversion tubes; high power vapor cooled tubes.

MacLeod & Hanopol, Inc., Booth 3713
10 Roland St.
Charlestown 29, Mass.

▲ L. Hanopol, J. M. MacLeod, G. Deming

Capacitance bridge, capacitance meter, capacitance standards, *capacitance decade, megohmmeter.

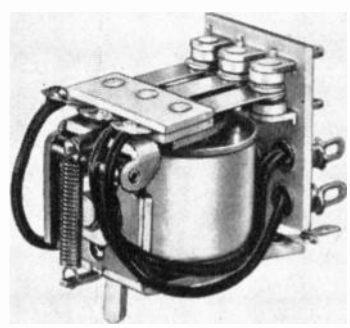
Magne-Head Division, General Instrument Corp., Booths 1101-1106
3216 W. El Segundo
Hawthorne, Calif.

▲ Martin Braude, Cliff Fowler

Magnetic drums and heads.

Magnecraft Electric Co., Booth 2513
3352 West Grand Ave.
Chicago 51, Ill.

▲ H. D. Steinback, John E. Deimel, M. S. Steinbeck, William Gorman, William Conlon, William Brennan



Relays: Telephone type, latching, general purpose, ac-dc, sensitive, hermetically sealed, crystal case, low cost general purpose, printed circuit, time delay, rotary, antenna switching, dust cover, high speed, military miniature and subminiature. *Standard and subminiature magnetic reed relays and assemblies.

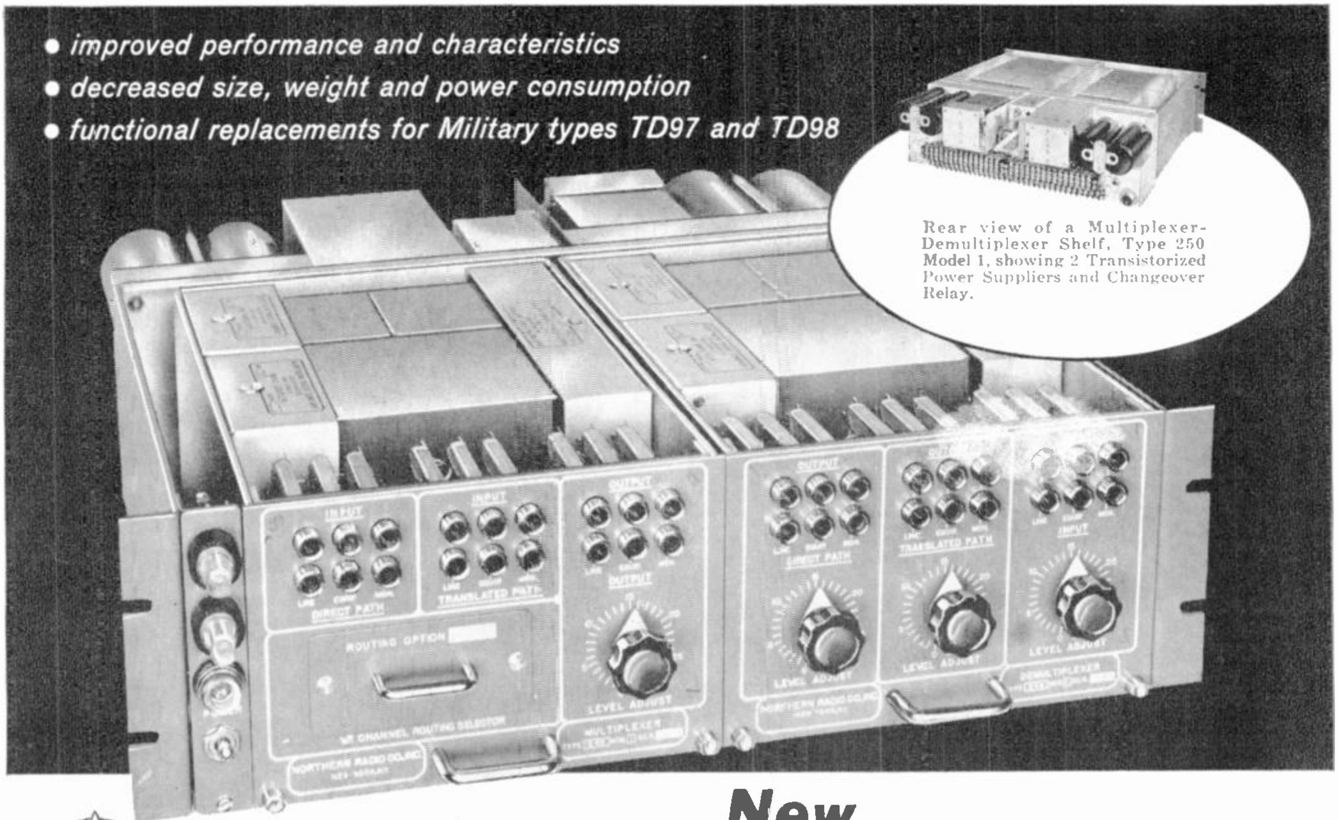
Magnetic Controls Company, Booth 1623

Magnetic amplifiers See: ADC Incorporated

(Continued on page 298A)

▲ Indicates IRE member.
Indicates new product.
† Exhibitor is servicing IRE Engineers through the IRE Package Plan.

- *improved performance and characteristics*
- *decreased size, weight and power consumption*
- *functional replacements for Military types TD97 and TD98*



Rear view of a Multiplexer-Demultiplexer Shelf, Type 250 Model 1, showing 2 Transistorized Power Suppliers and Changeover Relay.

NORTHERN RADIO New ALL-TRANSISTOR MULTIPLEXER and DEMULTIPLEXER

Type 248 Model 1 Type 249 Model 1

The new Multiplexer, Type 248 Model 1 (functional replacement for Multiplexer TD97-FTG-2), and Demultiplexer, Type 249 Model 1 (functional replacement for Demultiplexer TD98-FGR-3) are intended for use with twin-channel, single-sideband radio circuits operating in the high-frequency range. Their purpose is to derive two voice-frequency circuits from each of the radio channels. By means of frequency division multiplexing, the radio bandwidth from 200 to 6000 cps is divided into two transmission circuits, each with a bandwidth from 375 to 3025 cps. Four such vf circuits are derived from the twin-channel radio, and these are used to transmit carrier telegraph signals or to provide telephone or facsimile service.

The Multiplexer and Demultiplexer are designed to slide into the Northern Radio Type 250 Model 1 Shelf, which accommodates two each Multiplexers or Demultiplexers, or one each Multiplexer and Demultiplexer.

Two Multiplexers, Type 248 Model 1, are required for full utilization of the capacity of a radio transmitter. One is used to transmit telegraph, telephone, or facsimile signals from two vf circuits to the radio channel designated as sideband A. The second Multiplexer performs the same function for sideband B. In this way four vf circuits are applied to the twin-channel radio transmitter.

Two Demultiplexers, Type 249 Model 1, are required for full utilization of the capacity of a radio receiver. One is used to receive telegraph, telephone, or facsimile signals for two vf circuits from the radio channel designated as sideband A. The second Demultiplexer performs the same function for sideband B. In this way four vf circuits are derived from the twin-channel radio receiver.

The Multiplexer and Demultiplexer are transistorized equipments, including necessary bandpass filters, line amplifiers, carrier frequency sources, modulators and attenuators. The Multiplexer requires a nominal 14 volts DC at 125 milliamperes; the Demultiplexer, approximately 200 milliamperes at the same voltage. The power supply is normally provided from the Northern Radio Power Supply, Type 223 Model 1, which is plugged into the rear of the Type 250 Model 1 Shelf.

WRITE ON YOUR LETTERHEAD FOR LITERATURE TO DEPT. IRE-3

NORTHERN RADIO COMPANY, inc.

147 West 22nd Street, New York 11, N. Y.

Pace-Setters in Quality Communications Equipment

In Canada: Northern Radio Mfg. Co., Ltd., 1950 Bank St., Billings Bridge, Ottawa, Ontario.

SEE OUR EXHIBIT AT BOOTH 3510, IRE SHOW

Whom and What to See at the IRE Show

(Continued from page 296A)

Magnetic Core Corp., Booth 2937
See: Faradyne Electronics Corp.

Magnetic Metals Co., Booth 1625
Hayes Ave. at 21st St.
Camden 1, N.J.

▲ H. F. Porter, ▲ D. O. Schwennesen, W. J. Miller, W. G. Pettit, H. V. Paynter, G. L. Morrow, D. O. Stanton, ▲ W. T. Mitchell, H. H. Hackett, W. Y. Hallman

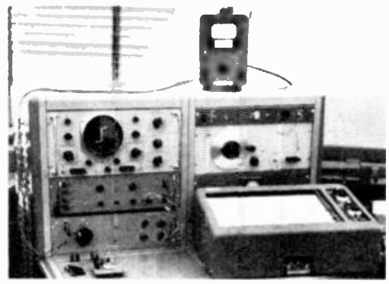
Electromagnetic cores and shields: Centricores made from Super Square mu "79" will be featured. These tape wound cores are identically duplicate in all essential magnetic dimensions from unit to unit in any lot and from lot to lot without deviation.

Magnetic Shield Div., Booth 4110
See: Perfection Mica Co.

A complete listing of all registrants at the IRE Show and Convention, showing company affiliation and local hotel, is posted on the back wall of the mezzanine on the west side of the first floor.

Magnetics, Inc., Booth 2533
Butler, Pa.

Arthur O. Black, ▲ Robert W. Olmsted, James E. Frauenheim, William S. Spring, William J. Irvine, Robert C. Woodward, ▲ James W. Graham, Harry A. Savisky, Richard M. Pisarcik, John T. Lee, Joseph M. Whitley



* Laboratory Core Tester

Products include tape wound cores, permalloy powder cores, bobbin cores, laminations, and shields. *Core tester which describes hysteresis characteristics of various core materials; will aid in better understanding of core functions, and magnetic amplifier design problems.

† See PROCEEDINGS OF THE IRE—Jan., April, May, July, Sept., Nov. (1960), March, April, June, Aug., Oct., Dec. (1961) for further information on our products. See 1961 IRE DIRECTORY, page 424, for complete information on our products.

Magnetics, Inc., Industrial Control Equipment Div., Booth 2437
Butler, Pa.

Arthur O. Black, ▲ Robert O. Olmsted, James E. Frauenheim, William S. Spring, William J. Irvine, Robert C. Woodward, ▲ James W. Graham, Harry A. Savisky, Richard M. Pisarcik, John T. Lee, Joseph M. Whitley

Components for static industrial control systems such as magnetic amplifiers and power control units which feature new voltage surge suppressors.

Magtrol, Inc., Booths 1230-1232
240 Seneca St.
Buffalo 4, N.Y.

J. E. Duncan, J. F. Duncan, J. Traise, W. P. Robinson, T. Greenburg, S. Benerofe

Subminiature friction clutches, brakes in military and *commercial types; stationary coil hysteresis clutches; *clutch-pot combinations; dynamometers; servo packages; *pancake clutches and brakes.

D. E. Makepeace Division, Booths 4406-14
See: Engelhard Industries, Inc.

P. R. Mallory & Co., Inc., Booths 1410-1412
3029 E. Washington St.
Indianapolis 6, Ind.

James E. Lincoln

Batteries, capacitors, carbon controls, wire-wound controls, resistors, rheostats, switches, jacks and plugs, silicon rectifiers, vibrators, relays, contacts, high density metals, resistance welding materials, electrode materials for electrical discharge machining, custom molded plastic parts, timer switches, power supplies, tuning devices, communications equipment.
See also: Radio Materials Company

Mansol Ceramics Co., Booth 2937
See: Faradyne Electronics Corp.

Manson Laboratories, Inc., Booth 3241
375 Fairfield Ave.
Stamford, Conn.

▲ J. M. Shapiro, H. Feldman, S. Jacobson, B. Krieger, ▲ W. A. Wood

Crystal frequency synthesizers; highly stable oscillators and *reference frequency generators, kilocycles to kilomegacycles; ultraprecise crystal ovens; high power pulse modulators; *high voltage power supplies; *SSB systems; *high level UHF transmitters and receivers; custom pulse transformers and charging chokes.

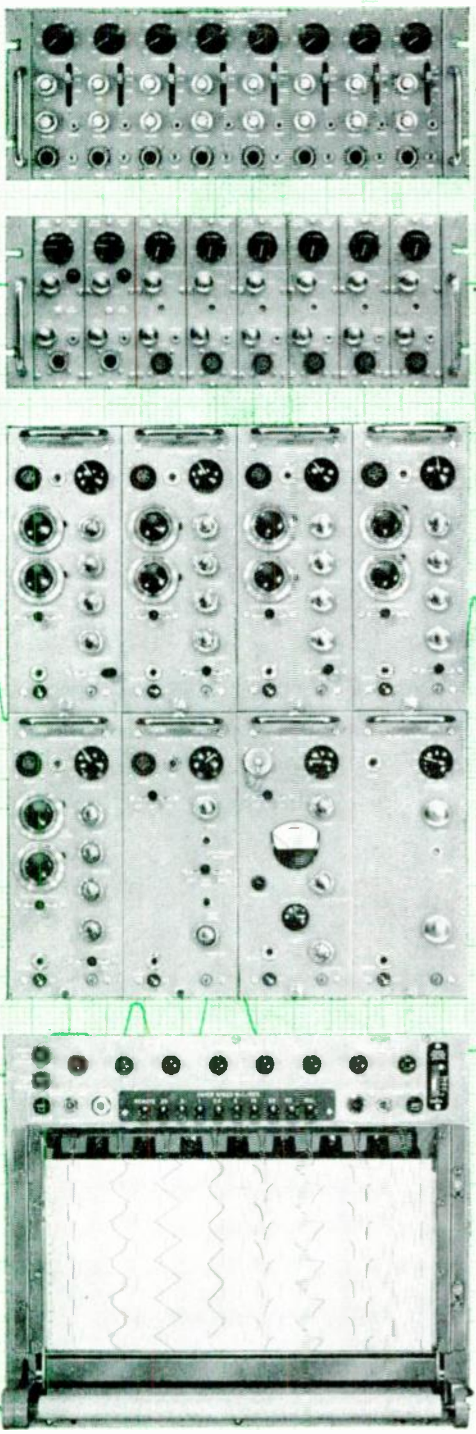
(Continued on page 300A)

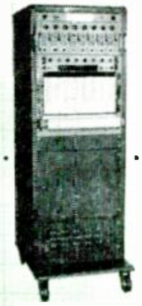
▲ Indicates IRE member.
* Indicates new product.
† Exhibitor is servicing IRE Engineers through the IRE Package Plan.

CAFETERIA
Second mezzanine. Take elevator 16 from south side of any floor.

Sanborn has probably already designed your "custom" oscillographic recording system

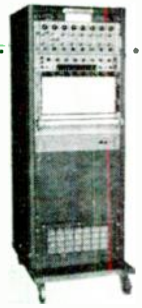
"Building block" recorder and amplifier design permits maximum flexibility to meet specific application needs





950 **Series — truly low cost — identical channels**

6 or 8 identical DC recording channels — either high gain, 10 uv/div; medium gain, 0.5 mv/div; or low gain, 10 mv/div. Medium and high gain types are completely transistorized, have floating and guarded input circuits. Frequency response DC to 150 cps within 3 db, 10 div peak-to-peak with low and medium gain systems, to 100 cps with high gain system. Amplifier panel space only 7" x 19", recorder 17½" x 19".



850 **Series — economical, flexible — miniature plug-in preamps**

Interchangeable plug-in preamps, eight to a 7" high module, available in Phase Sensitive Demodulator, DC Coupling, Carrier and Low Level types. System response to 150 cps within 3 db, 10 div peak-to-peak, depending on preamps used. Input circuits single-ended, push-pull, or floating and guarded, depending on choice of preamp.

350 **Series — versatile, high performance — interchangeable preamps**

Provides greatest possible application flexibility, with interchangeable preamps in Carrier, DC Coupling, Phase Sensitive Demodulator, Differential DC, Low Level, Logarithmic and Frequency Deviation types. System response DC to 150 cps within 3 db at 10 div peak-to-peak — input single-ended, floating and guarded, or push-pull — depending on preamplifier used. Eight preamps in two 4-unit modules occupy 21" x 19" of panel space; usable separately with individual power supplies to drive meters, 'scopes, etc.

"350" style Recorder Assembly — used in all the above systems. Provides transistorized, plug-in, current-feedback power amplifiers . . . low impedance, velocity feedback damped galvanometers . . . 8" of visible record . . . 9 electrically controlled chart speeds . . . inkless traces on rectangular coordinate charts . . . flush front recorder, vertical chart plane. Recorders with horizontal chart plane also available for 350, 850 and 950 systems.

Sanborn oscillographic recording systems also include the tube-type 1- to 8-channel "150" Series with 12 plug-in preamplifiers; and the "650" 1- to 24-channel optical oscillograph with response to 5 KC and 8-channel amplifier available separately for driving any galvanometer. For complete data contact one of the Sanborn Sales-Engineering representatives located in principal cities throughout the United States, Canada and foreign countries.

SANBORN COMPANY
INDUSTRIAL DIVISION
175 Wyman Street, Waltham 54, Massachusetts

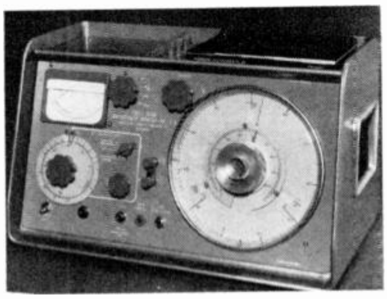
SEE THIS EQUIPMENT AND OTHER SANBORN OSCILLOGRAPHIC RECORDING SYSTEMS, AMPLIFIERS AND TRANSDUCERS ON DISPLAY AT BOOTHS 3701-03-05, I.R.E. SHOW, NEW YORK COLISEUM, MARCH 20-23.

Whom and What to See at the IRE Show

(Continued from page 298A)

Marconi Instruments, Booths 3702-3706
111 Cedar Lane
Englewood, N.J.

R. J. Bailey, S. E. Ellam, K. Elkins, ▲ J. L. Garthwaite, ▲ W. Oliver, V. O'Herlihy, ▲ W. A. Buck, B. E. Morris



*¼% Universal Bridge

*¼% precision universal RCL bridge, *standard AM signal generator 10kc-72mc, *400-550mc FM generator for command receiver tests, *FM deviation meters for telemetering and FM broadcast, wide range Q meter, multi-channel telephone systems test equipment, double pulse generator, communications receivers.

† See PROCEEDINGS OF THE IRE—Feb., March, April, May, June, Aug., Oct., Dec. (1960), Jan., Feb., March, April, May, June, Aug., Sept., Oct., Nov., Dec. (1961) for further information on our products.

See 1961 IRE DIRECTORY, page 332, for complete information on our products.

Marion Electrical Instrument Div., Booths 2202-14

See Minneapolis-Honeywell

Markem Machine Co., Booths 4210-4212
150 Congress St.
Keene, N.H.

John G. Powers, Bernard E. Toomey, A. J. Marshala, Joseph H. Lyon, John E. Kelen, Harold B. Lampman, Gilmore G. Fretz, Roland Benson, George E. Fraser, Jr., William B. Morgan

Miniature JAN diode printer—small motorized offset printer—U-1026 semi-automatic transistor side wall printer—122A automatic printer for top and side wall with latest features; 69AC color bander up to 6 colors simultaneously on diodes, resistors and capacitors.

Marlane Development Co., Inc., Booth 4431
153 E. 26th St.
New York 10, N.Y.

Jesse Lane, Marv Rubinstein, Sid Ackerman, Bill Sosnow, Herman Reade, Richard Ober, Ernest Gilbert, Janet Garber

Selectron process of high speed selective plating for engineering applications. Demonstration and discussion of selective plating techniques on printed circuits, waveguide components, simplified soldering, and other electronic applications. Equipment on display for field maintenance operations, light manufacturing, and research and development.

Show Hours
10 a.m. to 9 p.m. daily
Monday through Thursday
March 20-23, 1961

Martin Co., Booths 3922-3924
Baltimore 3, Md.

Peter Roche, John DeVisser

Electronic Systems for Air Defense, ASW, Reconnaissance, Guidance, Control, Communications, Support Equipment.

Massa Division, Cohu Electronics, Inc., Booths 3603-3605
280 Lincoln St.
Hingham, Mass.

John F. Hubbard, ▲ Ernest A. Massa, David S. Evans, ▲ Frank Massa, Jr., ▲ Kevin M. Corbett

Portable 4-channel recorders, portable 6-channel recorders, portable rectilinear direct writing recorders, multi-channel rectilinear direct writing recorders, dc amplifiers, chopper stabilized amplifiers, strain gage amplifiers, servo amplifiers, oscillographs, accelerometers, sound pressure microphones, hydrophones, ultrasonic transducers.

Master Specialties Co., Booth M-17
956 E. 108th St.
Los Angeles 59, Calif.

Al Franklin, Herman Jones, Chuck Sloane, Gene Burroughs, Howard Siegel

Roto-Tellite, word indicator lights, Roto-Tellite switch lights, time delay relays, phase sequence relays and flashers.

Materials Research Corp., Booth 4240

High purity metal crystals. See: MRC Manufacturing Corp.

Maurey Instrument Corp., Booth 1619
7924 So. Exchange Ave.
Chicago 17, Ill.

▲ E. J. Maurey, Jr., ▲ James Kolbe

Potentiometers, precision, wirewound, ½" to 8", linear and non-linear, high temperature, hermetically sealed. Custom designed to special function, or choose from established standard line. Precision rotary switches and various electromechanical devices designed to order.

W. L. Maxson Corp., Booths 1208-1210

See: Maxson Electronics Corp.

Maxson Electronics Corporation, Booths 1208-1210
175 Tenth Ave.
New York 18, N.Y.

Al Beichek, ▲ Judd Blass, ▲ Eugene Cronin, ▲ Herb Kahn, Donald Levine, ▲ William Maginnis, Anthony Pignoni, ▲ Charles Schmidt, ▲ Murray Simpson, ▲ Joseph Stehn

Development and manufacture of air height surveillance radar equipment; microwave antenna components; microwave phase shifters; receivers and IF amplifiers; electronic scanning radar systems; fuzes; safety and arming devices; analogue computer components and systems; mapping, navigational radar, and communication equipment. See also: Unimax Switch Div.

Don't go away mad
because you tired yourself out carrying a heavy stack of literature. Use the "Lead-Master" card, and the exhibitor will send his literature to you by mail.

McCoy Electronics Co., Booth 2215
Mt. Holly Springs, Pa.

Luther W. McCoy, David B. Jacoby, George K. Bistline, Jr., Edward P. Boise, Robert B. Ker

Crystal filters, single sideband or band-pass types 1.0 mc to 75.0 mc. Quartz crystal units, metal types HC-18/U and HC-6/U. Also vacuum all glass types HC-18/U and HC-6/U. New vacuum all glass micromodule crystals measuring .28" × .28" × .075".

McDowell Electronics Inc., Booth 4130
105 Forrest St.
Metuchen, N.J.

R. B. McDowell, S. J. McDowell, D. Day, J. Thompson, D. Tobin, J. Wagner

Dependable radio frequency induction heating equipment, 750 watts through 50 kilowatts output—Varimatic turntable, variable in speed, for use in conjunction with induction heaters for soldering and brazing applications.

McGraw-Edison Co., Booths 2740-44 & 3502-04
See: Bussmann Mfg. Div., Thomas A. Edison Industries, Measurements Div.

McGraw-Hill Book Co., Inc., Booth 4120
330 W. 42nd St.
New York 36, N.Y.

John Stockwell

Scientific and technical book publishers in the fields of electronics, nucleonics, and control engineering.

McGraw-Hill Publishing Co., Inc., Booths 4314-4316
330 W. 42nd St.
New York 36, N.Y.

Frederic M. Stewart, ▲ Donald H. Miller, ▲ Henry M. Shaw, ▲ William S. Hodgkinson, ▲ Donald R. Furth, ▲ Warren H. Gardner, ▲ William J. Boyle, ▲ David M. Watson, ▲ George F. Werner, Hugh J. Quinn

"Electronics" Magazine—the technical weekly for the entire field of electronics, more particularly those commercial and government enterprises whose editorial interests are in engineering, research, design, production, management and use of electronic materials, components, equipments and systems. "Electronics Buyers' Guide" and Reference Issue—published July 20th as 53rd issue of "Electronics."

McLean Engineering Labs., Booth 1621
70 Washington Road
P.O. Box 228
Princeton, N.J.

Wallace W. McLean, ▲ W. B. Eckenhoff, A. Donald Hay, ▲ James G. Robinson, Ralph Kricker, David Donaldson, Frederic R. Doll

Specialized cooling equipment for ground, airborne, and shipboard electronics. More than 250 models of blowers and fans. Many available from stock. Precision military drag cup tachometers, permanent magnet tachometers, hysteresis, servo and induction motors, sine wave and permanent magnet generators.

McLean Syntorque Corp., Booth 1624
Precision military specification motors, tachometers, sine wave and permanent magnet generators. See. McLean Engineering Labs.

McMillan Industrial Corporation, Booth 3223
Brownville Ave.
Ipswich, Mass.

▲ Edward B. McMillan, William H. Davis III, Charles Snow, Donald R. Skeffington, Arthur H. Webber

*Microwave absorbers for all frequencies, broad- and narrow-banded, including Type NEO-T. *Power line filters of 100 db plus attenuation from 14 kc to 45,000 mc. Aircraft radomes.

McMillan Laboratory, Inc., Booth 3223
See: McMillan Industrial Corp.

Measurements, A McGraw-Edison Division, Booths 3502-3504
P.O. Box 180
Boonton, N.J.

▲ Harry W. Houck, ▲ Norman W. Gaw, Jr., Walter B. Manson, C. Edwin Williams, Albert B. Eldridge, Jerry Ingalls, ▲ John H. Redington, J. F. Lawrence

Model 700 Frequency Meter, 25-1000 MC

Portable field frequency meter. Standard signal generators, transistor testers, frequency meters, pulse generators, square wave generators, television signal generators, UHF radio noise and field strength meters, megohm meters, peak voltmeters, RF attenuators, crystal calibrators, intermodulation meters, megacycle meters, inductance bridges, capacitance bridges, vacuum tube voltmeters, special test instruments.

† See PROCEEDINGS OF THE IRE—Jan. through Dec. (1960), Jan. through Dec. (1961) for further information on our products.

See 1961 IRE DIRECTORY, page 335, for complete information on our products.

Mechatrol Division, Servomechanisms, Inc., Booth 2715
1200 Prospect Avenue
Westbury, L.I., N.Y.

Victor See, E. J. Chevins, J. Conway, J. Hopkins, G. Dinger, D. Ladner, E. Scudero, R. Sebris, H. Sabath, E. Meder

Servo motors, hysteresis synchronous motors, integral gearhead motors, viscous and inertially damped servo motors, damping and temperature compensated integrating tachometers, stepper motors, electronic and mechanical breadboard parts including amplifiers, power supplies, modulators (60 and 400 cycles), metal film potentiometers.

Adolf Meller Company, Booth 1040
387 Charles Street
P.O. Box 6001-Turnkey
Providence, R.I.

Max E. Meller, Henry Hamburger, Anthony Ricci

*New lengths and diameters synthetic ruby raw material for lasers and masers. Precision, close tolerance work to customer's specifications. Sapphire windows, domes, lenses, rods, tubes, spacers. Alumina powder 99.98% pure—for polishing, lapping and honing of ceramics, metals, glass.

(Continued on page 302A)

Whom and What to See at the IRE Show

(Continued from page 301A)

Melpar, Incorporated, Special Products Division, Booth 3943

3000 Arlington Blvd.
Falls Church, Va.

▲ E. H. Bradley, ▲ Holmes S. Moore, ▲ Benjamin H. Dennison, H. I. Rudman, David L. Bier, John C. Frasca

Printed circuits (layout, fabrication, assembly, test) featuring Resistance Fused Eyelets; UHF bandpass filters; stripline directional couplers; miniaturized photoelectric readers, and associated control units; "Melfoam" ceramic (2500°F) dielectrics; "Mel-Ink" solvent resistant marking compounds; "Melpak" epoxy and polyester casting resins.

Melray Mfg. Co., Booth 4512

See: HPL Mfg. Co.

First and Second floors—Components

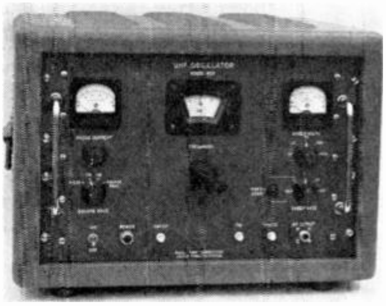
Third floor—Instruments and Complete Equipment

Fourth floor—Materials, Services, Machinery

Menlo Park Engineering, Booth 3813

711 Hamilton Ave.
Menlo Park, Calif.

▲ Harold W. Harrison, ▲ C. A. Walter, Frank Abel



UHF Electronically Swept Oscillator

UHF electronically swept oscillator and complete line of microwave sweep oscillators. Low and medium power broadband TWT amplifiers. All units available to cover range of 0.5 to 18 kmc in six frequency bands.

† See PROCEEDINGS OF THE IRE—Jan., March, May, July, Sept., Oct. (1960), March (1961) for further information on our products.

See 1961 IRE DIRECTORY, page 506, for complete information on our products.

Mepco, Inc., Booths 2802-2804
35-37 Abbett Ave.
Morristown, N.J.

▲ R. Gebhardt, J. Mervin, W. Ryerson, W. Hoefer, C. Miller, R. Halpin, G. Cooper

High reliability precision wirewound, carbon film, and *metal film resistors; *miniature wirewound and carbon film resistors for printed circuits; special TC resistors; *miniature power resistors; weldable lead resistors; resistor networks.

Merck and Co., Inc., Chemical Div., Booth 4513

Rahway, New Jersey

C. A. Graf, Dr. G. Krsek, M. Judge, C. Carroll, William Reed, Dave Hall, Dr. T. Benedict, F. Bourassa

All forms of Merck ultra-pure silicon including float zone refined doped single crystals in various diameters and lengths; vapor deposited single crystalline silicon layers of different types and resistivities; III—V compounds; and thermoelectric material.

Metachemical Associates, Inc., Booth 4431

See: Marlane Development Co., Inc.

Metal Processing Co., Booth 4020
41 Canfield Road
Cedar Grove, N.J.

S. Duffield Swan, E. Lamar Gostin, Albert M. Mims, Richard D. Lindner, Howard B. Carpenter

Chemically deposited nickel and gold coatings used on headers, connectors, transistors, terminals, chassis, and printed circuits. Materials and equipment for these plating operations.

Metal Textile Corp., Division General Cable Corp., Booth 4430
Roselle, N.J.

William Luke, David Kramer, T. Rassumssen, George Meyh, G. Harris, J. Bressler, S. deMille, C. L. Wiley, A. Johnson, A. Cohen, A. Nosty, D. Reiff

Metex *Combo-Strip—electronic weatherstrip. RF gaskets—combination gaskets. *Metact electrical contacts—tube shield inserts.

Metals & Controls Division, Booths 1409-1421

See: Texas Instruments Incorporated.

Metcom, Inc., Booth 3929
76 Lafayette St.
Salem, Mass.

▲ Richard J. Broderick, Harold F. McEnness, ▲ Harold Heins, Philip A. Bagnell, ▲ Louis W. Roberts, Milton R. Hamilton

Development and manufacture of microwave duplexing tubes and devices—gas switching, TR and ATR tubes, magnetrons, klystrons, waveguide components, spark gaps, pressurizing windows, complete duplexing assemblies.

Methode Manufacturing Corp., Booth 3947

7447 W. Wilson Ave.
Chicago 31, Ill.

W. J. McGinley, W. T. Jensen, C. R. Conner, W. E. Stubbings, E. E. Gehrt, V. Brown

Printed circuits, etched, plated, embossed. Funnelets, eyelets, plated through and flashed. Connectors, rack and panel, cylindrical high environmental and printed circuit card. Sockets, tube and transistor. Flexible printed circuit and film insulated wiring. Assemblies of printed circuits, connectors, and related electronic components.

(Continued on page 304A)

MICROWAVE OSCILLATOR STABILITY AND ITS MEASUREMENT

with emphasis on techniques to measure accurately residual frequency modulation, analyze disturbance frequencies, and determine drift

by R. M. WALLACE
Manager, Instrumentation Section
LABORATORY FOR ELECTRONICS, INC.

Since World War II, the stability required of microwave oscillators has become more and more stringent, and with the requirement, the need to measure stability characteristics. And for the purposes of this discussion, we shall concern ourselves only with measurements on continuous-wave oscillators whose frequency is constant within ±50 kilocycles per second during whatever period of time one may wish to measure stability. Specifically, this requirement implies oscillators with some form of external stabilization.

Microwave oscillators stable to within a few cycles per second are required today in many diverse fields. Perhaps the oldest and still very important usage is as a local oscillator in moving target indicating radar systems. Newer applications include radio astronomy, backscatter phase measurements, determining response characteristics of narrow-band microwave devices, electron paramagnetic spectroscopy, and secondary frequency standards.

In all of these, two kinds of instability are of primary concern: residual frequency modulation, as well as its cause, periodic or non-periodic, which we call short-term instability; and drift, which is long-term instability. The first dependable instrument to measure these instabilities was LFE's 5004, marketed in 1955, which still is the state of the art of competitive stability testers. In 1959, a factor of ten improvement was offered in the Model 5009. Since then, further substantial improvement has resulted in the 5024, to be announced in March of this year.

The 5024 is basically a double superheterodyne receiver of extraordinary stability and refinement. To help explain some of its performance characteristics, a very simplified block diagram is shown below. In operation, the crystal oscillator is varied until a harmonic is found which produces a 30 mc/s output from the mixer. The balanced mixer together with the last multiplier of the multiplier chain is a plug-in unit to facilitate band changes. Four heads are currently available covering the frequency ranges as follows with the sensitivities indicated: 1000 to 3200 mc/s (0 to −35 dbm), 5000 to 6100 mc/s (0 to −25 dbm), 7000 to 10,000 mc/s (0 to −20 dbm), and 9000 to 11,000 mc/s (0 to −12 dbm). Other frequency ranges up to Ku band are available on special order.

After amplification at 30 mc/s, the test signal is heterodyned down to 120 kc/s and further amplified. The inputs to both i-f amplifiers are available for direct injection of test signals. Thus 30 mc/s ±50 kc/s, as well as 120 kc/s ±50 kc/s signals can be analyzed.

In the 2nd i-f amplifier, each stage is a cathode-coupled amplifier which is resistance-capacitance coupled to the next. Because of extreme limiting, the sinusoidal input is converted to very steep-edged square waves. These output pulses are then differentiated, and the positive-going spikes are used to trigger a blocking oscillator which, by means of a delay line, generates square-edged pulses of extremely constant amplitude and duration. There is one constant-energy pulse for each cycle of sinusoidal input to the 2nd i-f amplifier.

It is important to note that, up to this point, the double conversion employed to reduce the input signal to quantized pulses at 120 kc/s does not affect the error information of frequency drift or frequency modulation, provided that the input signal is sufficiently stable to remain within the 70 to 180 kc pass band of the 2nd i-f amplifier. Thus frequency variations (error information) have not been changed. Beyond this point, however, frequency variations are converted to voltage variations.

Now, if the amplitude of these constant-energy pulses is E and the width is t, then the average output voltage E_o as read on a d-c voltmeter is $E_o = E\,t\,f$, where E and t are constant and f is a frequency in the 2nd i-f pass band. By simply providing a bucking voltage equal to the E_o at the center of the pass band (120 kc), a zero-center meter can be used to read drift, plus or minus, about the frequency at the start of a test. On the 5024, two drift ranges are supplied: ±50 kc/s and ±5 kc/s, the latter with a separate zero-adjust control. A BNC jack is also provided for recording long-term drift.

If frequency modulation of the input signal is present (short-term instability), there is an a-c component superposed on the average d-c level, E_o. F-M deviations exist here as jitter of both the leading and trailing edges of the quantized pulse train, pulse length remaining constant. The magnitude of the a-c component is $dE_o = E\,t\,df$.

To recover this component for display as peak f-m deviation, the quantized pulse train is put through a low-pass filter to remove the 120 kc/s carrier and all higher frequencies. Removal of the carrier and higher frequencies leaves only the disturbance frequencies. Five pass bands can be selected: 10 to 150 cps, 10 to 500 cps, 10 to 1500 cps, 10 to 10,000 cps, and 10 to 20,000 cps. All band widths are measured at the 3 db points.

After amplification and detection, the filter output is fed to a meter on the front panel which is calibrated to read peak deviation. Eight full-scale ranges are provided: 10, 30, 100, 300, 1000, 3000, 10,000, and 30,000 cps. A BNC jack is provided for observation by means of an oscilloscope to help determine the nature and hence the origin of the disturbance frequencies.

A separate tunable filter is also available for spectrum analysis of the disturbance frequencies. This filter, or wave analyzer, is tunable from 10 to 10,000 cps, in three ranges, tuning range measured between 1.5 db points. Its Q is 50 across all bands.

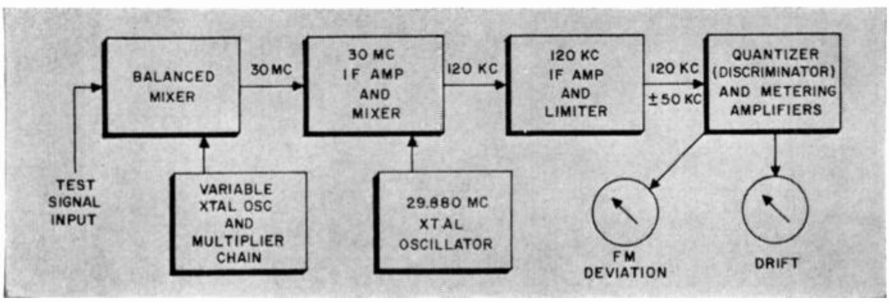
When the tunable filter is used and with reasonable care, the minimum measurable f-m deviation is as follows:

0.2 cps at 30 mc/s and 120 kc/s,
0.3 cps at L band,
0.5 cps at S band,
0.7 cps at C band,
1.5 cps at X band, and
2 cps at Ku band.

The principal advantages of the 5024 over the older 5009 are in the widening of the dynamic operating range of f-m deviation, plug-in heads reduced in cost to about one-third of previous heads, Epsiline (etched circuit) plumbing through C band, and updating of all circuits. And in addition, the 5024 is smaller and lighter.

An interested reader can obtain much more detailed information by requesting Bulletin 5024. For this bulletin, or the answers to particular questions, write Mr. Perry Pollins at the address below.

LABORATORY FOR ELECTRONICS, INC.
Instrument Division
714 Beacon Street, Boston, Massachusetts



Whom and What to See at the IRE Show

(Continued from page 302A)

Metronics, Inc., Booth 2937

See: Faradyne Electronics Corp.

Metronix, Inc., Booths 3916-18

Panel meters, portable transistor testers, comparison bridges. See Assembly Products, Inc.

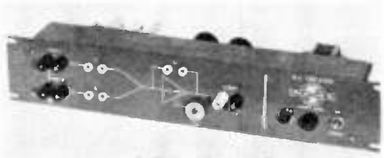
Micamold Electronics Mfg. Corp., Booths 1101-1106
65 Gouverneur St.
Newark 4, N.J.

M. Lissner, A. DiGiacomo, W. Rieman, W. Pelliccia, G. Margitich, B. Kohl, I. A. Clarke, A. S. Gartner

Tantalum; mica; "Missilmite"; high reliability per Mil C-14157A; subminiatnre per Mil C-2[illegible] capacitors.

Micro Gee Products, Inc., Booth 3842
6319 W. Slauson Ave.
Culver City, Calif.

▲ B. W. McFadden, R. W. Nowack, D. L. McFadden



DC Operational Amplifier

Model 505A low-cost dc operational amplifier, completely self-contained, response to 5000 cps with output sufficient to drive servovalves, recorders, galvanometers and other instrumentation. Model 61A oscillating rate table, response to 100 cps, 100 pound load capability, excellent waveform and threshold characteristics.

Micro Switch Div., Booths 2204-06

See: Minneapolis-Honeywell Regulator Co.

Micro-Test, Inc., Booths 2101-2103

Strain gages, dc amplifiers. See: Microdot Inc.

Microdot Inc., Booths 2101-2103
220 Pasadena Ave.
South Pasadena, Calif.

Guy M. Martin, Harold A. Lichnecker, Edward J. Crell, Forrest Besocke, William E. Brown, Jack B. Lindsey, Paul N. Bertness

Microminiature coaxial cable and connectors, *multipin connectors, transformers and magnetic devices, strain gages, transducers, *dc amplifiers, *telemetry devices, Lerco terminals and knobs. All products illustrate Microdot's emphasis on miniaturization.

Micromech Mfg. Corp., Div. of Sanford Mfg. Corp., Booth 4038
1020 Commerce Avenue
Union, N.J.

R. E. Tucker, E. F. Shine, John Santillo

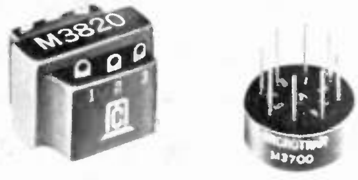
Advanced design Micro-Matic precision wafering machines with the Roton table drive, Micromech diamond wheels, semiconductor crystal holding and orientation fixtures, optical orientation systems, and the Micromech "Performeter" (diamond wheel performance indicator).

Micromega Corp., Booths 3410-3414

Parametric amplifiers, ferrite circulators and isolators. See: FXR Inc.

Microtran Company, Inc., Booth 2311
145 E. Mineola Ave.
Valley Stream, L.I., N.Y.

▲ Albert J. Eisenberg, ▲ Harold Edelstein, ▲ Richard Chaber, ▲ Walter Benscher, Charles Langabeer, Kitty Flanders



Transformers—Toroids

Miniaturized molded transformers. Transistor transformers designed for printed circuit board construction; custom designed transformers and toroids MIL-T-27A in molded or hermetic construction. Catalog line of miniature transistor transformers, dc-dc converter, 400-silicon rectifier power, 400-isolation, low level chopper available from distributors.

Microwave Associates, Inc., Booths 2302-2304
Northwest Industrial Park,
Burlington, Mass.

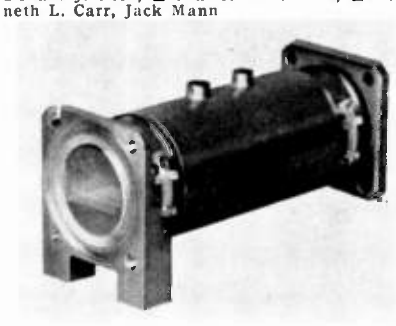
Robert J. Allen, George S. Kariotis, Richard Dibona, Erik Stromsted, Ron Kelstrup, Herbert Cox, Paul Bougas, Frank Tarr, Tony Decarolis

Solid State Switch

*Solid-state duplexers, limiters, *switches—new, compact. Ferrite devices, and gas duplexing devices (solid-state). Microwave mixer, video diodes. *New line varactor diodes in subminiature all-glass, "pill," and hermetic reversible cartridge types. Microwave waveguide devices including *new solid-state harmonic generators.

Microwave Development Labs., Inc., Booth 2407
92 Broad St.
Babson Park 57 (Wellesley), Mass.

▲ Nathaniel Tucker, ▲ Kenneth D. Jefferies, John Hall, Richard Tucker, Jack Hanley, William Davis, ▲ Edward Salzberg, ▲ Henry J. Riblet, ▲ Robert Brosnahan, Fred J. Orr, Donald J. Rich, ▲ Charles H. Carson, ▲ Kenneth L. Carr, Jack Mann



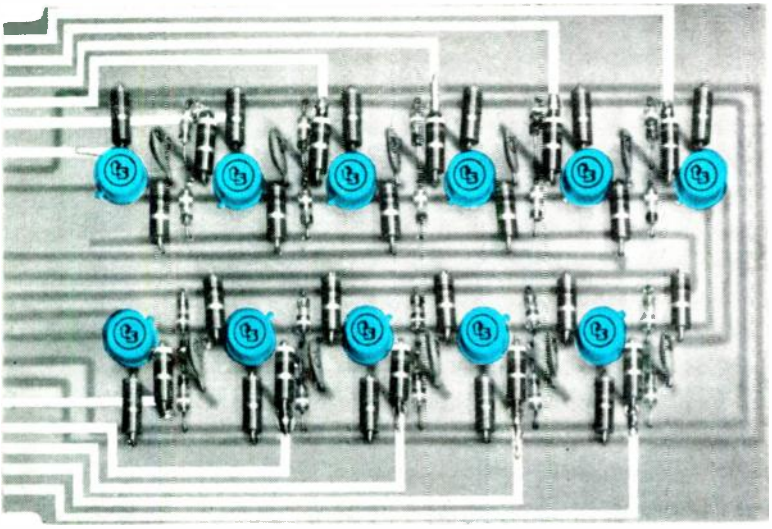
Hi-Q, Low Loss Band Pass Filter

Microwave coax to waveguide adaptors, waveguide to waveguide adaptors, bends, transducers, rotary joints, *switches, windows, attenuators, circulators, couplers, short slot hybrids, hybrid tees, duplexers, diplexers, detectors, hybrid mixers, *tee mixers, monopulse antenna couplers, filters, cavities, *phase shifters, SSB generators, loads. See also: Strand Labs.

(Continued on page 306A)

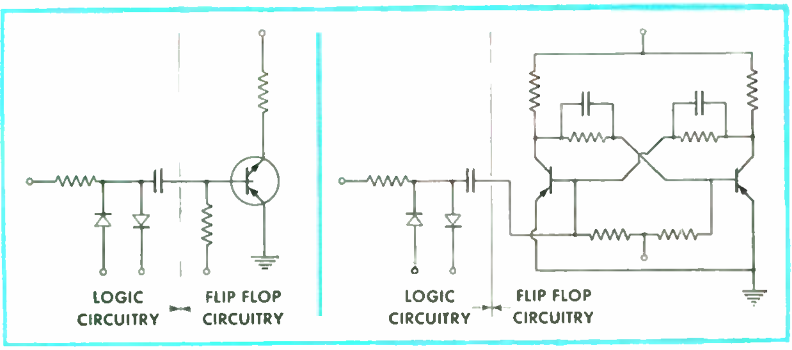
SLASH COMPONENT REQUIREMENTS with Dynaquad

new Tung-Sol 4-layer **PNPN** Bistable Transistor

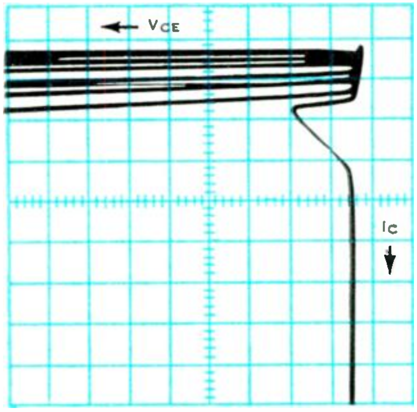


Here is a shift register panel which demonstrates the enormous component savings and the substantial reduction in backboard wiring and circuit complexity that can be achieved through the use of Tung-Sol Dynaquad transistors. This component advantage is typical of the assembly economy (especially with printed circuitry) that can be realized in many other applications, including: computer memory and readout; core drivers; relay activators; sweep generators; and high energy switching. For full technical details write: Tung-Sol Electric Inc., Newark 4, New Jersey.

1 printed circuit board assembly performs the job of 3. 10-bit shift register designed with Tung-Sol Dynaquad transistors. Just one assembly is required where 3 are necessary when designed with conventional components.



7 components replace 14. Comparison of a single stage of the 10-bit shift register designed with Dynaquad transistors (left) and conventional components (right) shows the circuit simplicity and component reduction obtained with Tung-Sol's new germanium multilayer alloyed junction transistor.



Dynaquad is a three-terminal device featuring regenerative switching characteristics. One terminal—the base—serves as the control gate for initiation of the regenerative action. It permits turn-on and turn-off by bursts of drive power. In this way, a small signal controls large amounts of energy in a ratio not approached by conventional 3-layer junction transistors. Trace shows Dynaquad collector characteristics with base current turn-on.

2N1966 2N1967 2N1968

Typical electrical characteristics and ratings.

P_C	collector dissipation at 25°C	120	MW
BV_{CES}	collector breakdown voltage	− 50	volts
I_{CS}	sustaining current	15	Ma
I_B (on)	base turn-on current	0.1	Ma

Technical assistance is available through: Atlanta, Ga.; Columbus, Ohio; Culver City, Calif.; Dallas, Tex.; Denver, Colo.; Detroit, Mich.; Irvington, N.J.; Melrose Park, Ill.; Newark, N.J.; Philadelphia, Pa.; Seattle, Wash. In CANADA: Abbey Electronics, Toronto, Ont.

TUNG-SOL®

see Tung-Sol Dynaquad Transistors at the IRE show booth Nos. 2334-2336, 2427-2429

Whom and What to See at the IRE Show

(Continued from page 304A)

Microwave Electronic Tube Co., Inc., Booth 3929
See: Metcom, Inc.

Mid-Century Instrumatic Corp., Booths 3835-37
See: Computer Systems, Inc.

Mid-Eastern Electronics, Inc., Booth 3009
32 Commerce St.
Springfield, N.J.

▲ William W. Hartz, ▲ Roy L. Anthony, Lawrence C. Oakley, Gunther A. Bielefeld

UHR bridge—basic standard to 10^{16} ohms. Certified resistance standards to 10^{14} ohms. *Megatrometer Model 71OH—to 10^{16} ohms. Transistorized power supplies: SC series—plug-in, high power, small size, low price. *MP 40-.2—portable, constant voltage and current. ST and HC—high current, to 50 amps.

Military Systems Design, Booth 4307
Booth 2208
See: Instruments Publishing Co., Inc.

James Millen Mfg. Co., Inc., Booth 2515
150 Exchange St.
Malden 48, Mass.

▲ James Millen, ▲ E. E. Williams, ▲ R. Wade Caywood, O. I. Haszard, Philip A. Eyrick

Magnetic metal shields, grid dip meters, antenna bridges, baluns, encapsulated inductors, electronic equipments and components; delay lines, delay line kits. Complete line subminiature components including mechanical devices and coils. Instrumentation oscilloscopes.

†

See PROCEEDINGS OF THE IRE—Jan. through Dec. (1960), Jan., Feb., March (1961) for further information on our products.

See 1961 IRE DIRECTORY, page 402, for complete information on our products.

Millivac Instruments, Div. of Cohu Electronics, Inc., Booth 3601
Lincoln St.
Hingham, Mass.

▲ Dr. W. K. Volkers, Mrs. D. J. Volkers, Imek Metzger, Donald P. Morey

World's first ultra-low-noise amplifier which combines high input impedance (10 meg) with "hushed transistor" operation less than 0.5 microvolts).—Low-drift choppers.—Linear scale ohmmeters and bridges.—Sensitive VTVM-s.

▲ Indicates IRE member.
* Indicates new product.
† Exhibitor is servicing IRE Engineers through the IRE Package Plan.

CAFETERIA
Second mezzanine. Take elevator 16 from south side of any floor.

Mincom Division, Minnesota Mining and Manufacturing Company, Booth 3243
2049 South Barrington Ave.
Los Angeles 25, Calif.

C. S. Tobias, Morgan White, Jack Richards, Gerald Hamilton

*G-100 recorder/reproducer—bandwidth to 300 kc at 60 ips; all-transistorized, wide dynamic range, completely phase-equalized six speeds. CM-100 video band recorder/reproducer—predetection recording capability; frequency range extended to 1.2 mc at 120 ips. Advanced design provides 7 tracks with 14-track conversion capability.

Minneapolis-Honeywell Regulator Co., Boston Div., Booth 2208
40 Life St.
Boston 35, Mass.

George Bailey, Richard S. Burwen, John W. Rhinesmith, Frank Melanson

T6GA galvanometer amplifier and DISA or AccuData series of differential amplifiers.

Minneapolis-Honeywell Regulator Co., Industrial Systems Div., Booth 2214
10721 Hanna St.
Beltsville, Md.

J. G. Booth, J. O. Paull, R. M. Hadley

Analog magnetic tape systems and magnetic heads.

Minneapolis-Honeywell Regulator Co., Micro Switch Div., Booths 2204-2206
Chicago and Spring Streets
Freeport, Ill.

W. J. Betz, R. C. Remley, S. F. Doctor, A. C. Bahnsen, A. H. Bahnsen, J. C. Ellis, R. D. Miller, J. Hyldgaard, F. Terrell, W. Polley, J. Phillips, A. D. Portsmore, S. Markosian, W. Landers, R. Eadie, D. Guide, E. Moran, J. Tapkas

Lighted and unlighted pushbutton switches, electronic switch-circuit assemblies, toggle switches, rocker actuated key switches, decimal-to-binary and other rotary selector switches, door interlock switches, basic switches, magnetic hold-in switches, proximity switches, adjustable "differential travel" switch, miniaturized lighted pushbutton switches, 25-ampere basic switch.

Minneapolis-Honeywell Regulator Co., Precision Meter Division, Booth 2202
Grenier Field
Manchester, N.H.

E. E. Doherty, Gordon Steady, Richard Rattigan, Henry Woolner, C. A. Anderson, Edward S. Maury, Harry A. Donahue, Jr., J. A. R. Bischoff, Joseph P. Curry, Walter Witzel, Kenneth J. Cumming

Medalist panel meters, ruggedized panel meters; conventional round, square and edgewise panel meters; aircraft instruments, miniature indicators, meter mechanisms, elapsed time indicators, ac Iron Vane meters MM-1 Medalist meter, null meter in MM-1 case, hermetically sealed edgewise meter.

Minneapolis-Honeywell Regulator Co., Rubicon Div., Booth 2210
Ridge Ave. at 35th St.
Philadelphia 32, Pa.

Alex Schoemann, Earl Benson, Lou Gill, Bernie Conti

Wheatstone bridge, Kelvin bridge, potentiometers, galvanometer, resistors (NBS and Reichsanstalt).

Minneapolis-Honeywell Regulator Co., Semiconductor Div., Booth 2212
1015 S. 6th St.
Minneapolis 4, Minn.

Tom Macgill, Fred Hammerle, Stan Furber, Roy Larsen, Dave Johnson, Bill Rittman

Silicon and germanium power transistors, triodes and tetrodes, circuit applications illustrated for series voltage regulator, 5 watt class A power amplifier, 125 watt class B linear power amplifier, "ripple clipper" filter for dc power supply, dc to ac square wave power inverter.

Minneapolis-Moline Company, Booth 3044

See: Molectronics Corp.

Minnesota Mining & Mfg. Co., Magnetic Products Div., Booth 1209
900 Bush Ave.
St. Paul 6, Minn.

W. F. Enright, J. H. Bimrose, J. G. Bondus, J. F. Maye, R. J. Patterson, R. A. Peterson, J. J. Rogers, P. B. Van Deventer, J. A. Watson, P. J. Cafferty, R. J. Waters, C. L. Alden

"Scotch"-brand instrumentation, video, and audible range tapes and accessories.

Minnesota Mining & Mfg. Co., American Lava Corp. & Mincom Div., Booths 4401 & 3243

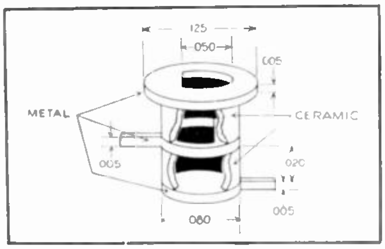
See: American Lava Corp. & Mincom Division

Missiles and Space Div., Lockheed Aircraft Corp., Booth 3807

See: Lockheed Missiles and Space Div.

Mitronics, Inc., Booth 1902
1290 Central Ave.
Hillside, N.J.

Harvey Pensack, Baynard Smith, Bob Eaves, Tony Monari, Allan Davis, Lloyd Lamb, George Resetter, Billy Shultz, Carl Carlen, Fred Silvester, John Scott, Frank Kenney



*New Transistor Housing

New transistor housing made of 96% alumina ceramic metallized with molybdenum manganese. Metal parts are of Kovar. Braze material is copper-silver eutectic. Specialists in producing metallized ceramic parts for the semiconductor and vacuum fields.

† See PROCEEDINGS OF THE IRE March, May, July, Sept., Nov., Dec. (1960), March, June, Sept. (1961) for further information on our products.

See 1961 IRE DIRECTORY, page 452, for complete information on our products.

(Continued on page 308A)

Be sure to see all four floors for a complete view of 800 new ideas!

Whom and What to See at the IRE Show

(Continued from page 307A)

Mnemotron Corporation, Booth M-4
1 North Main St.
Spring Valley, N.Y.

▲ Manfred Clynes, Richard Gallivo, Dr. Nathan Kline, Michael Kohn, ▲ Lawrence Saper

*Analog Data Tape Recording System

*New low cost multi-channel precision analog data tape recording system, recording any electronic variable dc to 5 kc. Solid-state circuits, 0.2% accuracy, large dynamic range, 16 : 1 speed ratios for time expansion and contraction. *Continuously adjustable transportation delay recorder for analog computers.

Model Engineering & Mfg., Inc., Booth 2305
See: Tru-Ohm Products.

Modular Molding Corp., Booth 1916
See: G-L Electronics Co., Inc.

Moldtronics, Inc., Booth 2801
Thermosetting plastic moldings. See: Grayhill, Inc.

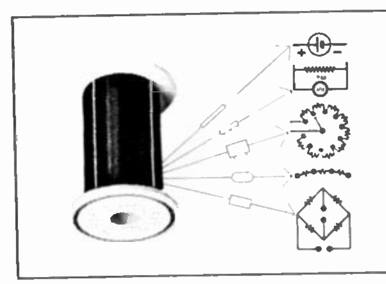
Molectronics Corporation, Subsid. Minneapolis Moline Co., Booth 3044
6344 Arizona Circle
Los Angeles 45, Calif.

Josh Gershuny, Harry Robertson, ▲ Joseph Steinfeld, Charles Stewart

Electronic test equipment and instrumentation: digital voltohmmeters, digital ratiometers, digital counter units, vacuum tube voltmeters, oscilloscopes, relay testers, and custom instruments; portable and rack mounting units.

Molecu-Wire Corporation, Booth 4212
Route 537
Scobeyville, New Jersey

▲ Edward E. Edmunds, ▲ Stephen Poch, Arthur S. Lichter, Albert Young, Sam Dixon



Fine and superfine resistance wire .0004" to .010" diameter. Bare, enamelled, oxidized and fabric covered finishes. Also precision grade grid lateral wires.

Molecular Electronics, Inc. Subsidiary of Precision Circuits, Inc., Booth M-9
85 Weyman Ave.
New Rochelle, N.Y.

Bernard Reich, Michael Benanti, William Orloff, Charles Sabel, Herbert Reiss, Jack Lehmann, Herbert Schwartz, Stephan Gulyas

Equipment for semiconductor device testing: *In-circuit, gain bandwidth, alpha cutoff, *general purpose test sets. Reliable printed wiring boards and assemblies. *Unicell—3D maintainable electronic package.

Monroe Calculating Machine Co., Booths 1610-18, 1709-17
See: Litton Industries, Inc.

Monsanto Chemical Company, Booths 4026-4027
800 N. Lindberg Blvd.
St. Louis 66, Mo.

▲ R. F. Meehan, ▲ John Weber, R. A. Staniforth, Paul Hamilton

Semiconductor materials including—ultra-pure zone-refined silicon single crystal rods; polycrystalline silicon rods; and III-V intermetallics.

Montrose Div., Booths 2222-2232 & 2329-2331

See: Bendix Corporation

F. L. Moseley Co., Booths 3310-3312
409 North Fair Oaks
Pasadena 3, Calif.

▲ Francis L. Moseley, ▲ James H. Burnett, ▲ Robert N. Flanders, Myron H. Hunt

Autograph X-Y recorders featuring the *Model 135, world's most compact 8½" × 11" recorder. Strip chart recorder, *transport delay simulator, *waveform translator, logarithmic converter, ac to dc converter, optical line follower, servo voltmeter, punched tape and card translator, digital magnetic tape plotting system.

Donald P. Mossman, Inc., Booth 2112
P.O. Box 265
Brewster, N.Y.

Donald P. Mossman Jr., Ben W. Rist, Edward Brunner, R. L. Maher, George Moler, John Billis, Ray Perron

Push button switches—Interlocking, multiple station, illuminated, non-locking, alternate action. Lever switches—Cam, single hole mount type. Turn switches—Multiple circuit, locking and non-locking.

Motor Generator Corp., Booth M-6
Troy, Ohio

R. B. Bravo

Motor generators, frequency changers.

Motorola Semiconductor Products, Inc., Booths 1117-1118
5005 East McDowell Road
Phoenix, Ariz.

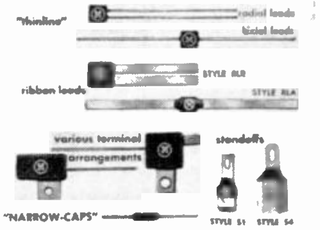
▲ R. H. Rudolph, ▲ F. J. Van Poppelen, John Gray, Bob Burns, ▲ Herb Ackerman, Chuck Scott, Bill Kraus, ▲ Larry Kelly, Gerry McGonagle, ▲ Dan Linhart, ▲ Ray Kimbell, Jack Pyle

Epitaxial silicon and germanium mesa transistors, economy types of mesa transistors, *silicon rectifiers, silicon zener diodes, *"slow silhouette" industrial power transistors, milliwatt audio transistors, "Meg-A-Life" certified-reliability semiconductor, and military-type transistors rectifiers and zener diodes.

† See PROCEEDINGS OF THE IRE—Jan. through July and Sept. through Dec. (1960), Jan., Feb., March (1961) for further information on our products.
See 1961 IRE DIRECTORY, page 192, for complete information on our products.

Mucon Corporation, Booths 2807
9 St. Francis St.
Newark 5, N.J.

M. A. Prince, P. D. Aaron, A. Perkins, B. Ansell, D. Baker, W. Kuehl, E. Grayden, M. Lynn, ▲ J. Geartner



Subminiature Ceramic Capacitors

Subminiature ceramic capacitors tailored to your available space. Wide choice of ceramic bodies for desired characteristics. Units to 150°C. Ribbon, wire and tab lead arrangements. Low-voltage, high-capacitance units for transistor circuitry. "Narrow-Caps" for 1/10 inch mounting, in 19 stock sizes.

† See PROCEEDINGS OF THE IRE—Feb., March, Aug., Oct., Dec. (1960), Jan., March, June (1961) for further information on our products.
See 1961 IRE DIRECTORY, page 392, for complete information on our products.

Muirhead & Co., Ltd., Booth 3230
Beckenham, Kent, England

See: Muirhead Instruments, Inc.

Muirhead Instruments Inc., Booth 3230
441 Lexington Ave.
New York 17, N.Y.

▲ P. L. Irvine, A. E. W. Hibbitt, R. W. Watler, I. H. H. Smith, ▲ A. Roy Smith, ▲ F. A. Miles, L. F. Purcer

Precision RMS Decade Voltmeter

Precision voltage measuring equipment including precision RMS decade voltmeter accuracy 0.05%, range 1mV to 300V, 5c/s to 100kc/s; and *precision vernier potentiometer accuracy 1 part in 100,000 range 1μV to 1.8 V. Also Weston standard and reference cells and servo components.

▲ Indicates IRE member.
* Indicates new product.
† Exhibitor is servicing IRE Engineers through the IRE Package Plan.

PLAN IN ADVANCE!

Use this issue of *Proceedings of the IRE* to make your plans well before you get to the convention and show. Decide which technical sessions and social events you want to attend, and what exhibits at the show you will find of most interest. Advance planning will save you a great deal of time and effort, and will insure that you do not miss seeing or hearing about that one new product or technique which may be of vital importance to you in your work during the next year.

Whom and What to See at the IRE Show

(Continued from page 309A)

Multicore Solders Ltd., Booths 3406-08

Ersin Multicore solder. See British Industries Corp.

Murata Mfg. Co., Ltd., International Division, Booth 3839

Kaiden, Nagaoka-Cho,
Otokuni-Gun, Kyoto, Japan

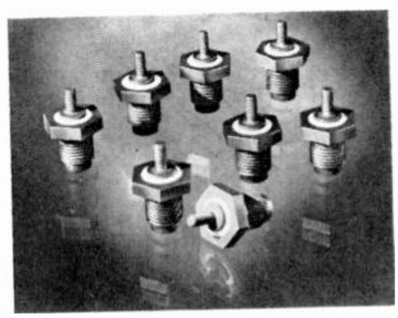
▲ Osamu Saburi, Tatsuya Akebi, Shojiro Senbongi, Robert M. Cunha, ▲ Vincent J. Archdeacon

Ceramic capacitors for transistor use, mechanical IFT for transistor use, thermistors, ultrasonic vibrators, steatite insulators, micromodule wafers, ceramic capacitors for transmitter use, tubular and disc ceramic capacitors, stand-off capacitors, feed-thru capacitors, glass trimming capacitors, filters, piezoelectric tuning forks.

Mycalex Corporation of America, Booths 2517-2519

125 Clifton Boulevard
Clifton, N.J.

▲ Jerome Taishoff, ▲ Alfred S. Backus, ▲ Henry M. Richardson, Albert J. Monack, Winfield Darrow, Stanley Rodney, William J. Ormston, George J. Lynch, Walter J. Zalewski, Edgar C. Worden, Jerome P. McCarthy, Myron Cohen, William Fondiller, Myron I. Gordon, Edward V. deVilleroy, Francis A. Barr



Hermetically Sealed Chip Detector Plugs

High temperature ceramoplastic insulation—New: "Supramica"® 620 "BB" high temperature (1200°F) precision-moldable ceramoplastic insulation. Produces true hermetic seals (leakage only 2×10^{-10} cc/sec. helium). Also other "Supramica" ceramoplastics, "Mycalex"® glass-bonded mica, "Synthamica"® synthetic mica, electromechanical commutation switches, plates, and precision tube sockets. Miniature and subminiature tube sockets.

NRC Equipment Corp., Booths 4425-4427

160 Charlemont St.
Newton Highlands 61, Mass.

J. H. Moore, R. H. Binkerd, H. M. Farrow, G. King Jr., S. G. Burnett, W. G. Small, J. C. Dolan, D. Preis, J. Flood, B. V. Thorley, T. E. Burleigh, C. Herrmann

*New model 3144 vacuum coater, *new model 4" portable pumping system, new model 2801C crystal puller. New diffusion pumps (HS6-1500 & HS4-750). UHV gages including battery-operated thermocouple gage and control and red-head (to 10^{-11}). Also, UHV cold traps, feed-thrus, valves and gettering pumps.

Nacimco Products, Booths 2101-2103

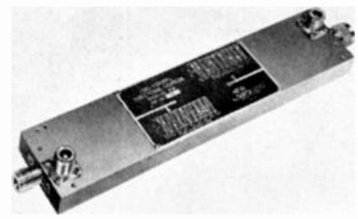
Transducers. See: Microdot, Inc.

▲ Indicates IRE member.
* Indicates new product.
† Exhibitor is servicing IRE Engineers through the IRE Package Plan.

Narda Microwave Corp., Booths 3809-3813

118 Herricks Road
Mineola, L.I., N.Y.

▲ William A. Bourke, ▲ Stuart D. Casper, ▲ James A. McFarland, ▲ Edward S. Hensperger, Jack Bull, ▲ Adolph Brenner, ▲ Donald S. Elkort, ▲ Phillip Levine, ▲ Peter Lubell, Frank Lefore, ▲ Howard Bertan



35DB Directivity Double Octave Coupler

*Coaxial variable coupler attenuator, ferrite isolators and components, digital frequency meters and attenuators magnetron modulators, klystron power supplies, transistorized VSWR and power meters, bolometers and thermistors, coaxial directional couplers, complete waveguide and coaxial setups from dc to 90 kilomegacycles.

National Carbon Co., Booths 2401-05

See: Union Carbide Consumer Products Co.

National Cash Register Co., Electronics Div., Booth 1228

1401 East El Segundo Blvd.
Hawthorne, Calif.

▲ L. J. Hines, W. Irwin, E. J. Haley

A line of computer memory components. Cylindrical thin film electro-deposited magnetic rod; magnetic rod array, high speed magnetic rod memory; Ferrite core array for memory applications meeting extreme environmental conditions; microencapsulation and photochromism.

National Company, Inc., Booths 1405-1407, 3506-3508

61 Sherman St.
Malden, Mass.

▲ R. S. Alter, M. Becker, R. Caulk, ▲ H. D. Guy, ▲ R. Hawkins, ▲ R. E. Kilham, I. LaGarde, ▲ W. A. Mainberger, P. C. McFaull, ▲ A. Orenberg, ▲ M. Oxman, ▲ T. B. Robinson, ▲ R. W. Sproul

Atomichron, *primary frequency standards, troposcatter communications equipment, *amateur radio and short wave listening receivers, Elasticable, *Coup-link hardware, drives, captive hardware, knobs, chokes and servo devices. See also: National Radio Co., Inc., and Servo Dynamics Corp.

National Electronics, Inc., Booths 2410-12

Thyratrons, ignitrons. See: Eitel-McCullough, Inc.

National Lead Company, Booth 1518

111 Broadway
New York 6, N.Y.

Carl Hack, Elbert Minarcik, Julian Koerner, John Nees, Ed Olson, Julius Sabo, Al Podesta, Bob Hale, C. E. Evans, D. S. Pasternack, Phil Ruppert, H. B. Hansbury

Electric soldering irons and *replaceable tips. Solders, brazing alloys and fluxes. Electronic titanates and zirconates for capacitor and transducer shapes. Precious metals and their alloys for electronic applications.

(Continued on page 312A)

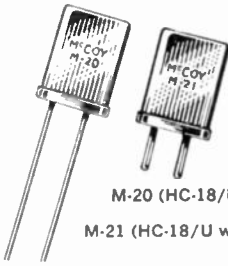
CRYSTALS & CRYSTAL FILTERS

Regardless of its size, type, or frequency any crystal bearing the name McCoy can be relied upon to deliver the ultimate in frequency control despite wide temperature variations and extreme conditions of shock and vibration.

M-1 (HC-6/U)

METAL ENCASED STANDARD SIZE AND MINIATURE CRYSTAL UNITS

shown actual size

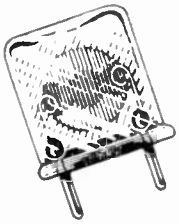


M-20 (HC-18/U)

M-21 (HC-18/U w/pins)

The crystals that made the name of McCoy a synonym for quality. Metal encased, HC-6/U size is available in frequencies from 500.0 kc to 200.00 mc.

Fills the need for miniature crystals in frequencies from 2.5 mc to 200.0 mc. Meets specs MIL-C-3098B and ARINC No. 401.



G-1 (Military HC-27/U)

ALL GLASS STANDARD SIZE AND MINIATURE CRYSTAL UNITS

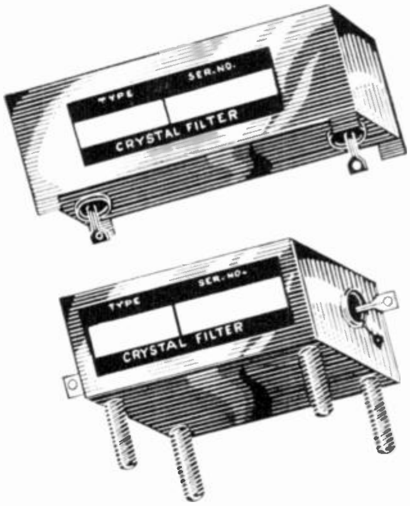
shown actual size

G-20 (Military HC-26/U)

G-21 (Military HC-29/U)

This vacuum sealed, hard glass crystal unit possesses all of the quality features for which the McCoy M-1 is so famous. It has long term frequency stability five times better than the conventional metal types. Available in frequencies from 500 kc to 200 mc.

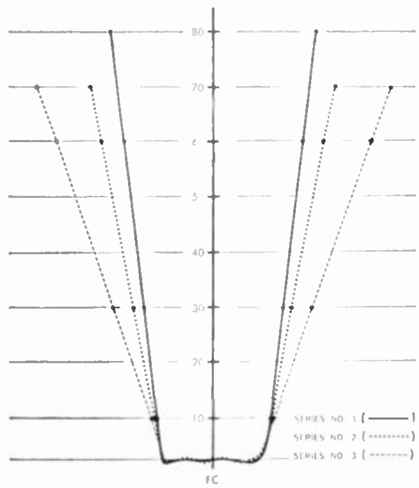
This vacuum sealed, hard glass crystal unit meets the new CR-73/U and CR-74/U specifications. It has long term frequency stability five times better than the conventional metal type. Available in frequencies from 5000 kc to 200 mc.



CRYSTAL FILTERS

Our many years experience in designing and producing top quality oscillator crystals have enabled us to develop and produce filters of equal desirability. Current production includes filters in the 1.0 mc to 30 mc range, with bandwidths of .01% to 4.0% of center frequency. A number are available without costly design and prototype charges.

Actual Size for Series 3 Types



See the **New!**

MICRO MODULE CRYSTALS (GLASS)

AT THE RADIO ENGINEERING SHOW
NEW YORK COLISEUM
MARCH 20 thru 23 BOOTH NO. 2215

.28" square x .075" thick
frequency range: 7000 kc to 200 mc
Now available in limited quantities

Write today for our free illustrated catalogs which include complete listing of military specifications. For specific needs, write, wire or phone us. Our research section is anxious to assist you.

McCoy ELECTRONICS CO.
Dept. P-3
MT. HOLLY SPRINGS, PA.
Phone: HUnter 6-3411

Whom and What to See at the IRE Show

(*Continued from page 310A*)

National Radio Company, Inc., Booths 1405-1407, 3506-3508
37 Washington St.
Melrose 76, Mass.

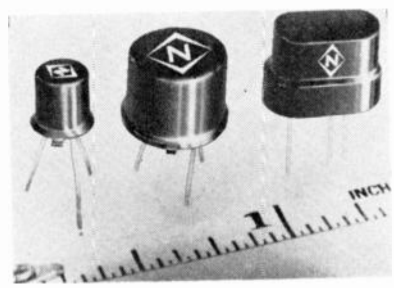
M. L. Ferber, ▲ W. F. Genett, E. R. McDonald, S. W. Natkin, ▲ F. B. Roberts, P. D. Sullivan

Receivers, components, hardware. See also: National Co., Inc., and Servo Dynamics Corp.

National Research Corp., Booths 4425-27
See: NRC Equipment Corp.

National Semiconductor Corp., Booth 1929
Sugar Hollow Road
Danbury, Conn.

▲ Dr. B. Rothlein, ▲ Dr. E. Clarke, J. Gruber, Dr. R. Rau, R. Hopkins, G. Schneider, J. Hegarty, B. Wonnacott, Dr. M. Schneider, ▲ A. Kumble



Mesa Transistors

Silicon transistors—PNP-alloy 2N1440 and 2N327A series—inverted switch in both TO-5 and TO-18 package offering low saturation drop and low leakage current, *new NS192 series—TO-18 amplifier types. NPN-Mesa-2N702, 3, 706, 560 switching, 2N756, 2N696, 7, 9 and 2N497 medium power series.

Navigation Computer Corp., Booth 3232
Valley Forge Industrial Park
Norristown, Pa.

John Paul Jones, ▲ David M. Biberman, ▲ Henry N. Longley, Victor Schwab, Henry Apfelbaum, Harvey Druker

"Navcor" *new products include *an analog to digital converter, *universal module tester, *digital experimenter with *demo logic cards, *an Industrial Series of logic modules, along with time-tested 100 and 300 series of transistorized digital systems modules and indicators.

E. V. Naybor Labs., Booths 1230-1232
26 Manorhaven Blvd.
Port Washington, L.I., N.Y.

▲ E. V. Naybor, B. Lazich

6 PDT miniature high performance relay; time delay relays (25 MS to 10 seconds); symbol indicators.

Nems-Clarke Company, Booths 3917-3919
See: Vitro Electronics.

New Departure Div., General Motors Corp., Booth 2128
269 North Main St.
Bristol, Conn.

C. S. Fleet, A. J. Muir, L. W. Rodden, A. C. Lormore

Representation of miniature and instrument ball bearings for servomechanisms, miniature gear trains and gyros.

New Hermes Engraving Machine Corp., Booth 1124
154 West 14th St.
New York 11, N.Y.

N. Schimmel, W. Dannheisser, H. Susskind, G. Berlant, M. Kaufman, R. H. Laird, Jr., R. H. Laird III, T. Wegge, B. Werfel

Pantograph engraving machines for panels, dials, nameplates, profiling and milling of all plastics.

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See PROCEEDINGS OF THE IRE—Feb., March, May, Aug., Sept., Nov. (1960), March (1961) for further information on our products.

See 1961 IRE DIRECTORY, page 677, for complete information on our products.

New York Air Brake Company, Booths 4309-4311
See: Kinney Vacuum Division

Nicad Division, Gould-National Batteries, Inc., Booth 1120
172 Pleasant St.
Easthampton, Mass.

W. R. Albrecht, F. C. Anderson, A. W. Brunsell, E. S. Graham, A. H. Lindsay, L. R. Mannheim, R. T. Perron, L. R. Ringer, T. Ulrich, J. D. Whittemore, Jr., E. S. Penfield

"Nicad" nickel cadmium batteries are reliable, compact, light in weight, have low resistance and provide sustained voltages at high discharge rates over a wide temperature range. They recharge rapidly, withstand shock, vibration and indefinite storage. No corrosive fumes—low maintenance. Sealed Cell Div.: Nickel cadmium sealed cells.

Nikon, Inc., Booth M-1
111 Fifth Ave.
New York 3, N.Y.

O. G. Heinemann, J. Feldman, P. Kyle, M. Golob, T. Sappington, R. Seifert, H. Schwartz, L. Silverman, J. Gilbert, E. Prager, A. Heinemann

Optical comparator for fast accurate inspection and quality control. Stereo and binocular microscopes, measuring microscopes, auto collimators, illuminated table magnifiers, charts and measuring scales—all for fast accurate inspection and quality control.

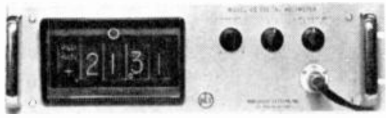
Nippon Electric Co., Ltd., Booth 3919
2 Shiba Mita Shikoku-Machi, Minato-Ku
Tokyo, Japan

Masahisa Miyaji, Seishi Arisaka, Toshio Takabayashi, Kyoji Miyato

Transmitting tube, disc-sealed tube, travelling wave tube, wide band repeater tube, mesa transistor, parametric diode, microwave diode, controlled rectifier, solar cell, other semiconductor devices; wire spring, miniature polarized and reed relays; wire spring crossbar switch; other relays and switches.

Non-Linear Systems, Inc., Booths 3011-3012
Del Mar Airport, Box 728
Del Mar, Calif.

R. C. Wynne, James F. Helfrich, Rex Orton, William Kievit, Michael Guliano, W. E. Bradbury, Thomas Kurtzer, William Olbrich, H. Scharfe, A. Brandmaier, Robert Thomas, Paul Kemp, Stuart Zuck



Digital Voltmeter Reads to ±99.99 MV

AC-DC digital voltmeters, ohmmeters and ratiometers. Automatic data loggers. Visitor can operate all instruments. *New products are world's fastest 5 digit voltmeter, digital millivoltmeter, low-cost digital voltmeter with plug-in stepping switches, low cost universal data logger.

Norbute Corp., Booth 2135

See: Kurman Electric Co.

Nord Photocopy & Electronics Co., Booth 3123

Photocopy machine. See: Television Utilities Corp.

Norrich Plastics Corp., Booth 4046
206 Babylon Turnpike
Roosevelt, L.I., N.Y.

Richard E. Thaw, Norman L. Thaw, Frank Guzman

Epoxy bobbins, epoxy "Encap" shells, epoxy "high heat' precision components, nylon bushings, teflon electronic parts, Kel-F components, aircraft and missile components, precision metal screw machine parts, collars, hubs, rollers, pins, bolts, radio parts, assemblies, subassemblies, bobbin coil winding kit. Custom manufacture.

North American Electronics, Inc., Affiliate International Resistance Co., Booth 1520
71 Linden St.
West Lynn, Mass.

Arthur H. Bruno, R. W. Smith, Frank J. Mitchell, N. Edward Chapman, J. P. McCusker, Charles H. Trout, William C. Cacciatore

NORTH AMERICAN nae ELECTRONICS, INC.

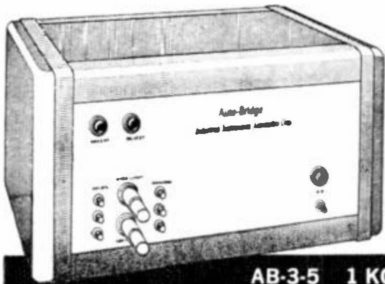
Semiconductors—diffused silicon PNPN controlled rectifiers for power control and switching applications requiring up to 16 amps, voltage ranges up to 400 volts. Power silicon rectifiers complete line JAN types, voltage regulators, USAF approved 1N429 reference diode. High voltage cartridges and special assemblies.

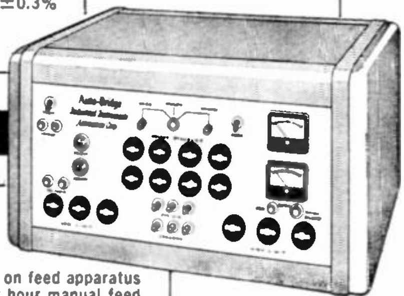
North American Philips Co., Inc., Booths 1512-14, 1524, 2409, 2522-2530, & 2802-04

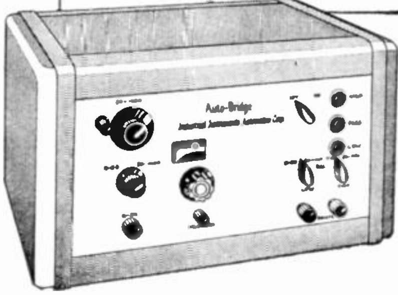
See: Amperex Electronic Corp., Electrical Industries, Ferroxcube Corp. of America, A. W. Haydon Co., Haydon Switch, Inc., Mepco, Inc., Price Electric Corp.

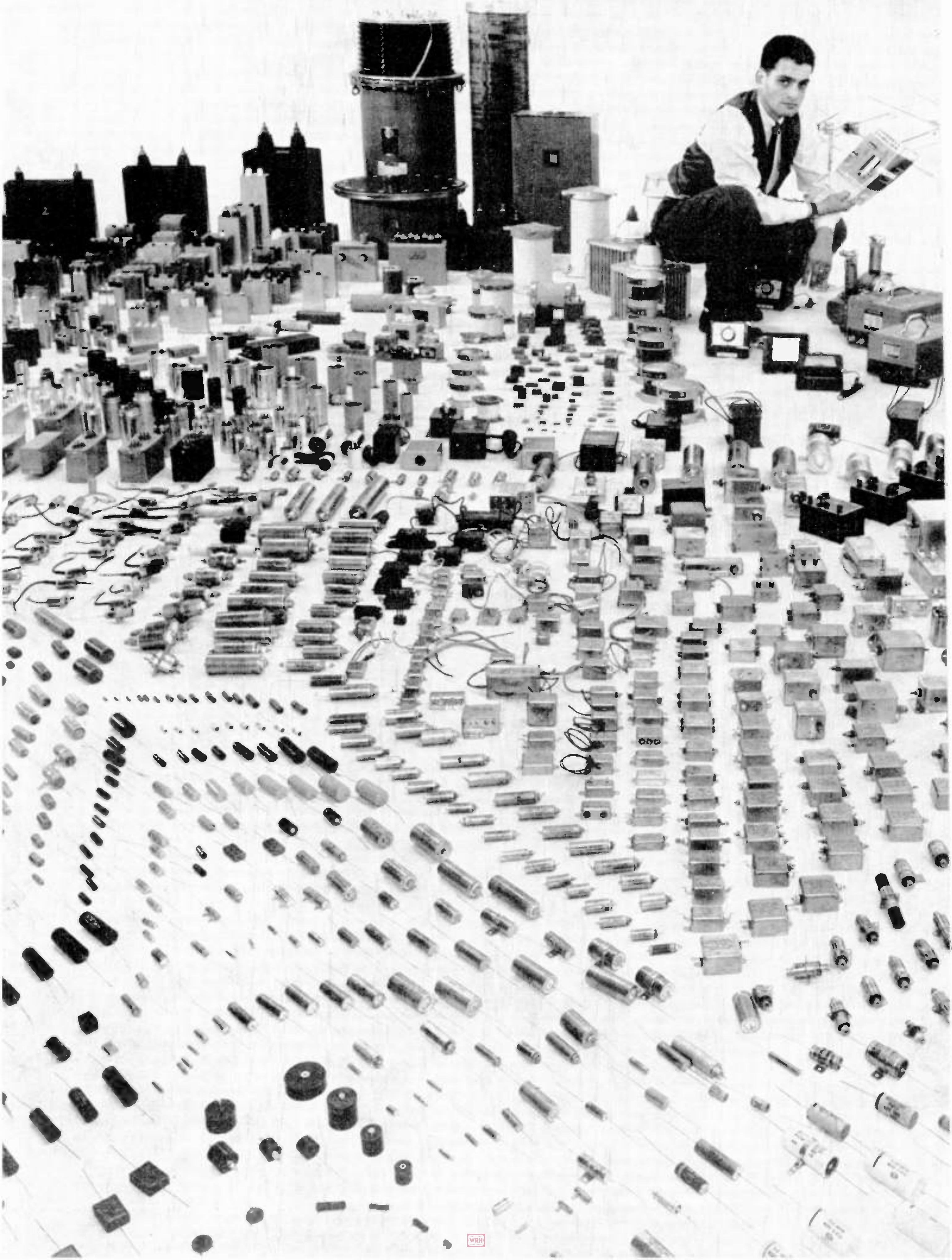
(Continued on page 316A)

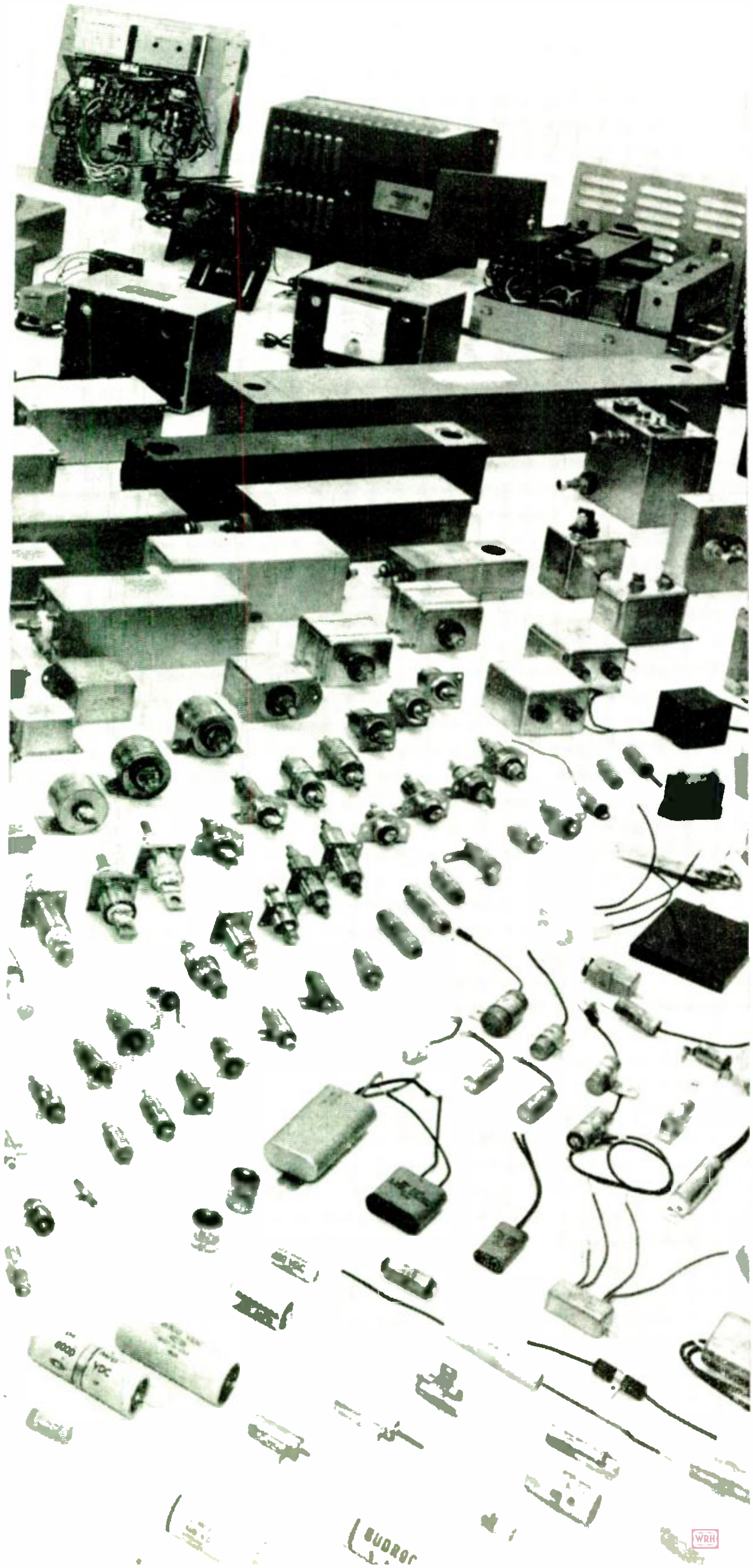
▲ Indicates IRE member.
* Indicates new product.
† Exhibitor is servicing IRE Engineers through the IRE Package Plan.











Whom and What to See at the IRE Show

(Continued from page 313A)

North Atlantic Industries, Inc., Booth 3939
Terminal Drive
Plainview, L.I., N.Y.

M. D. Widenor, W. Lipkin, S. Herman, J. A. Gregorio, P. Greenstein

Single, multiple and broadband phase angle voltmeters including militarized modular type, ac ratio boxes and ratio standards, and new militarized model; militarized phase sensitive ac-dc converters, complex-voltage ratiometers, phase angle oscilloscopes, militarized and modularized instrument servos, indicators, repeaters.

North Electric Co., Booth 2125
553 South Market St.
Galion, Ohio

W. Tucker, ▲ W. W. Crissinger, R. Parker, W. F. Keally, P. Van Valkenburgh, J. Guercio, E. J. Seppala, Charles Rich, Morgan Richards, H. R. Rivitz, J. Lindemann, W. F. Tidd, ▲ T. W. Parsons, ▲ W. E. Reagan, J. L. Green, H. H. Brewer

Communication and control system concepts utilizing North products including Paricode supervisory control, electronic switching, automatic controls, military type amplifiers, relays, crossbar and rotary stepping switches, multi-terminal connectors, key strips, key switches, and custom type power supplies.

North Hills Electronics, Inc., Booth 3022
Alexander Place
Glen Cove, L.I., N.Y.

▲ Sydney Cramer, ▲ Leo Staschover

AC-DC Ultra Precision Current Source

Equipment Department: Constant current supplies for testing gyros, diodes, transistors, relays, magnetic cores, batteries, fuses, bolometers, accelerometers. Components Department: Coils, toroids, filters, wideband transformers.

Northeast Scientific Corp., Booth 2844
30 Wetherbee St.,
Acton, Mass.

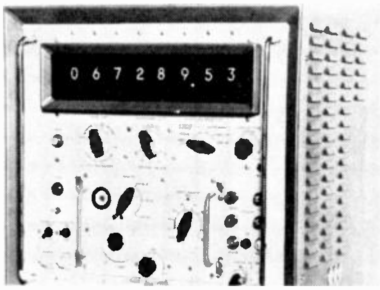
John Hogan, ▲ Clement Moritz, John Parkhill

Regulated high voltage supplies with maximum voltages to 10 kv and output currents to 1 ampere, constant current supplies, and millimeter wave generators.

Lecture Halls in the Coliseum are located on the Fourth Floor. See complete program of speakers and papers in the editorial section of this issue.

Northeastern Engineering, Inc., Booth 3229
25 S. Bedford St.
Manchester, N.H.

▲ C. N. Chagaris, ▲ C. J. Kannair, Jr., ▲ B. E. Lamere, ▲ J. L. McCluskey, ▲ N. L. Westlake



Development and manufacture of frequency, period, and time interval measurement instruments and systems. Frequency counters and converters, frequency standards, digital printers, code converters, preset decades and decade scalers. Inertial gyro test equipment.

Northern Radio Co., Inc., Booth 3510
143-9 West 22nd St.
New York 11, N.Y.

▲ S. A. Barone, A. J. Odgers, ▲ J. S. Harris, I. C. Lambert

Transistorized frequency shift terminal equipment.

Northrop Corp., Booth 3711
See: Page Communications Engineers, Inc.

Nortronics Division, Booth 3711
See: Page Communicaitons Engineers, Inc.

Offner Electronics Inc., 3051
3900 N. River Road
Schiller Park, Ill.

George W. Little, ▲ Dr. Franklin F. Offner, Richard Cozak, James Janisch

*New dual channel and Type R series Dynograph multichannel direct-writing oscillographs with microvolt sensitivity for dc or ac signals; electroencephalographs; dc differential data amplifiers; all transistorized. Special equipment for industrial and medical applications.

Ohmite Manufacturing Co., Booths 2333-2335
3601 Howard St.
Skokie, Ill.

Roy S. Laird, Kenneth M. Arenberg, Edward A. Rehe, Manny Forester

Etched foil tantalum capacitors; two new larger sizes plain foil tantalum capacitors; ceramic wafer metal film, micromodule resistor; tiny 1 watt wirewound resistor; 7 watt molded power precision resistor; 20 ampere variable transformer; line of 30 volt high amperage variable transformers. Rheostats, switches, chokes, diodes.

Omaton Div., Booths 1735-37
See: Burndy Corp.

Optical Coating Laboratory, Inc., Booth 4037
2789 Giffen Ave.
Santa Rosa, Calif.

Rolf F. Illsley, Danforth Joslyn

Vacuum deposited thin films for electrical and optical uses (such as satellite power supply solar cell coatings), heat light separation filters, optical maser coatings, infrared filters in the 8 to 13 micron region, ultraviolet coatings, research in "molectronic" circuitry.

Optimized Devices, Inc., Booth 3060
864 Franklin Ave.
Thornwood, N.Y.

A. Zuch, ▲ A. Arcand, J. Murtha, R. Olsen

Automatic semiconductor test station for inspection and reliability testing, displaying go no-go measurements, digital data indication and readout on IBM Output Writer, precision ac/dc voltage comparators. Automatic multiconductor cable test equipment.

Ortho Filter Corp., Booth 1626
7-11 Paterson St.
Paterson 1, N.J.

▲ Jerome Potash, George Pagonis, William McGravey, Thomas Fogg, Frank Olandesi

Resistors, power supplies, delay lines.

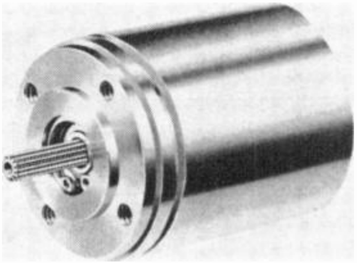
Oryx Company, Booth 4109
13804 Ventura Blvd.
Sherman Oaks, Calif.

Jack Fields, Jack Simon, Marvin A. Schwartz, ▲ Jack Blasman, Bernard L. Cahn, L. K. Ingber, John Nolan

Only complete line precision miniature soldering irons. From 6V to 24V, ac, dc. For production, services, or laboratory applications. 10 watts—355°C 110VAC—uses 3/32" tip. 15 watts—380°C—110VAC -7/32" tip. 6V microminiature tweezers—1 ounce—length 5"—tip diameter 1/32"—tip temperature at 6V 300°C.

John Oster Mfg. Co., Avionic Division, Booths 1330-1332
1 Main Street
Racine, Wis.

▲ Andrew Barbaccia, Melvin Kohner, Morton Last, George Lathrop, Paul Lindblom, Marvin Nelson, Robert Ramm, Donald Uhen, David Yonis



Hi-Temp Size 11 Servo

Missile quality components. Newest designs in high and low temperature servos, damped servos, synchros (transmitters, receivers, differentials, control transformers), resolvers, generators, motor tachometers, ac drive motors, dc motors, motor gear trains, servo torque units, electromechanical assemblies and indicators.

† See PROCEEDINGS OF THE IRE—Jan., March, April, July, Sept., Nov. (1960), Jan., March (1961) for further information on our products.

See 1961 IRE DIRECTORY, page 466, for complete information on our products.

Oxley Developments Co., Booth 1822
Air dielectric trimmers. See British Radio Electronics, Ltd.

(Continued on page 318A)

Whom and What to See at the IRE Show

(Continued from page 317A)

Ozalid Division of General Aniline & Film Corp., Booth 4106
Ozalid Road
Johnson City, N.Y.

P. Beronio, W. Blaha, L. Edmonson, G. Lacher, V. Lysell, G. McNinney, A. Prensky, R. Ross, W. Spencer, J. Toye, E. Weibrecht, A. Weinberger, L. Yockey

Ozalid will exhibit *new direct-copy Diazo equipment and sensitized materials (both Ozalid dry-process and Ozafax semi-dry process); sensitized papers, cloth and plactics for printed circuits; drafting equipment and supplies. *Several new machines will be shown.

PCA Electronics, Inc., Booth 1335
16799 Schoenborn St.
Sepulveda, Calif.

Hal Proppe, Richard L. Phillips, ▲ Max Shaw

Miniature and subminiature pulse transformers, distributed constant delay lines, lumped constant delay lines, variable delay lines, filters.

PRD Electronics, Inc., Booths 3602-3606
202 Tillary St.
Brooklyn 1, N.Y.

▲ H. C. Nelson, D. Cooper, ▲ L. H. Fisher, ▲ P. Mariotti, ▲ W. A. Weissman

PRD 809-A Klystron Power Supply

Complete line of microwave and electronic test equipment. Klystron and BWO/TWT power supplies, slotted sections, variable and fixed attenuators, sliding shorts, standard mismatches, sliding terminations, rotary standing wave indicators, bolometers and thermistor mounts, frequency meters, *standing wave amplifiers, power bridges, *calorimeters, etc.

Pace Electrical Instruments Co., Inc., Booth 1515
See: Precision Apparatus Co., Inc.

Pacific Division, Daystrom, Incorporated Booth 1704
9320 Lincoln Blvd.
Los Angeles 45, Calif.

Jack H. Zillman, Bob Wolin, Allan Richards, Joe O'Callaghan, Frank McClure

Gyros, transducers.

Don't wear yourself out

carrying heavy loads of literature. Use the "Lead-Master" system, and exhibitors will send literature direct to your home or office, as given on your registration card. Simply circle the appropriate number on the "Lead-Master" card and leave it with us in the Coliseum Lobby as you go.

Pacific Semiconductors, Inc., Booths 2312-2314
12955 Chadron Ave.
Hawthorne, California

S. L. Spiegel, Frank E. O'Brien, Robert Reid, Phil Astra, Irv Samuels, Don Ganson, Gene Gould, William Eckess

*Laminar diodes, VHF silicon transistors, silicon power transistors, silicon computer transistors, micro-transistors and micro-diodes, silicon diodes and rectifiers.

Packard-Bell Electronics Corp., Booths 3911-3913
12333 West Olympic Blvd.
Los Angeles 64, Calif.

Hal Davis, Ted Smith, Dick Terry, Jack Behr

Computer-controlled checkout systems evaluation; *analog-to-digital converters; digital circuit modules; dc amplifiers; closed circuit television; *solid state multiplexers. Packard-Bell Service Division: Closed circuit television.

Paco Electronics Co., Inc., Booth 1515
See: Precision Apparatus Co., Inc.

Pacotronics, Inc., Booth 1515
See: Precision Apparatus Co., Inc.

Page Communications Engineers, Inc., Subsidiary of Northrop Corp., Booth 3711
2001 Wisconsin Ave., N.W.
Washington 7, D.C.

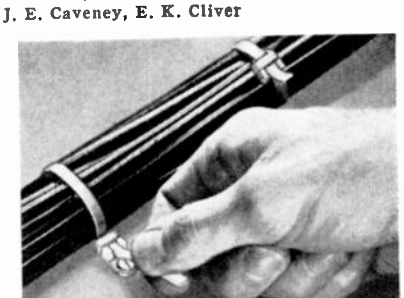
▲ Walter R. Brehm, ▲ Don Palmer, S. Tanner, J. P. Gaines, ▲ Arnold Rosenberg, ▲ P. D. Rockwell, ▲ T. Moriarty, ▲ J. Sutton

Communications engineering services—design, planning, installation, testing, maintenance and operations of complete communication systems on a worldwide basis, including the "scatter" modes of communications.

Paktron Division, Booth 1506
Packaged modular electronic components. See: Licon Division, Illinois Tool Works.

Panduit Corp., Booth M-14
17301 Ridgeland Ave.
Tinley Park, Ill.

J. E. Caveney, E. K. Cliver



Super Flexible Lok-Straps

Lok-Strap adjustable cable clamps and ties are now available in a new material providing complete flexibility from $-65°F$ to $+225°F$. They are unaffected by moisture and are extremely durable even in applications subject to extreme flexure and vibration.

Panoramic Radio Products, Inc., Booths 3402-3404
520 South Fulton Ave.
Mt. Vernon, N.Y.

▲ Bernard Schlessel, ▲ William I. L. Wu, ▲ Edward F. Feldman, ▲ Julian Hirsch

Spectrum analyzers from ½ cps through 44,000 mc—Subsonic to microwave. Frequency response plotters, ½ cps-15 mc. Communications systems analyzers. FM/FM telemetry test instruments. Display featuring improved new model SPA-4a spectrum analyzer, 10 mc –44 kmc with one head and unsurpassed sensitivity. SSB-3a comprehensive single spectrum analyzer system 100 cps-40 mc with two tone rf and af generator for Xmitter and receiver tests with 60 db linear range. LP-1a Panoramic sonic analyzer with C-2 auxiliary unit now covers 5 cps-22.5 kc range with 2 cps resolution capability. *New 11 point telemetry calibrator, TMC-411E, all electronic 7" high, 0.002% accuracy.

†

See PROCEEDINGS OF THE IRE—Jan. through Dec. (1960), Jan. through Dec. (1961) for further information on our products.
See 1961 IRE DIRECTORY, page 334, for complete information on our products.

Par-Metal Products Corp., Booths 4302-4304
36-62 49th St.
Long Island City 3, N.Y.

A. A. Parmet, John Novak, James Berry

Four basic types of slide assemblies of our universal cabinet racks. All welded universal cabinet racks for 19", 24", 30" wide panels, with solid side walls or intermediate side panels, utility desk assemblies.

Parker-Hannifin Corp., Booth 4243
See: Parker Seal Co.

Parker Seal Co., Booth 4243
10567 Jefferson Blvd.
Culver City, Calif.

Al Wickson, Don Lee, John Watson, George Moss, Nelson Harway

Electr-O-Seals for waveguide flanges. Vacuum seals. Hermetic seals. Molded in place (Metal-rubber) seals. Parker O-Rings.

Pascol Div., Booth 1506
See: Licon Div., Illinois Tool Works.

Peerless Electrical Products Div., Booths 3802-3806
See: Ling-Temco Electronics, Inc.

Penn Engineering & Mfg. Corp., Booth 1519
Box 311
Doylestown, Pa.

K. A. Swanstrom, J. E. Connard, B. C. Sandemar, F. Ofner, M. Brenner

PEM captive fasteners and hardware. New floating self-locking captive fasteners. *Miniature captive fasteners, *new nylon spacers for printed circuits, new lightweight self-locking and self-clinching fasteners.

Penta Laboratories, Inc., Booth 2736
312 North Nopal St.
Santa Barbara, Calif.

▲ J. J. Woerner, R. L. Norton, R. F. Van Wickle

Electron tubes, transmitting and special purpose types; beam pentodes, tetrodes and triodes, low-jitter hydrogen thyratrons, vacuum switches.

Perfection Mica Co., Magnetic Shield Div., Booth 1110
1322 N. Elston Ave.
Chicago 22, Ill.

▲ Glenn Vance, Glenn L. Powers, ▲ C. M. Jorgensen, ▲ Dave Jones, ▲ John Dreier, ▲ George Harris

Inverted nesting Netic Co-Netic cans having slots in side walls permit simple assembly and lead-outs. Slots are positioned so that a minimum opening results on completion, assuring virtually complete magnetic shielding. Configuration minimizes number of layers required.

Perkin Electronics Corporation, Booths 1116-1118
345 Kansas Street
El Segundo, Calif.

▲ Philip Diamond, ▲ George W. Mousel, Johan H. Maters, Tom W. LeNay

Magnetic amplifier regulator dc power supplies and ac line voltage regulators; transistorized ac line voltage regulators; transistorized modular type dc power supplies; transistorized low voltage, high current dc power supplies; magnetic amplifier transistorized missile ground support power supplies.

Perkin-Elmer Corp., Booth 2810
See: Vernistat Division

Perkin Engineering Corp., Booths 1416-1418
See: Perkin Electronics Corp.

Pesco Products Division, Borg-Warner Corporation, Booth M-20
21700 North Miles Road
Bedford, Ohio

R. H. Montgomery, M. W. Nesbitt, C. R. Browning, R. L. Schroeder, W. A. Blackman, R. A. Brewer

Infrared detector cell coolers, thermoelectric power generators, electronic cooling packages, axial flow fans, electric motors, static inverters, permanent magnet alternators, engine-driven ac generators.

Phaostron Instrument & Electronic Co., Booths 1428-1430
151 Pasadena Ave.
South Pasadena, Calif.

I. W. Eisenberg, H. J. Veitch, Norman Logan

Panel meters, laboratory standards, sensitive relays, test equipment, airborne components.

Phelps Dodge Copper Products Corp., Booths 1028-1029
Inca Manufacturing Division
Fort Wayne, Ind.

A. F. Van Ranst, R. Hall, H. Saunders, G. D. Hilker

Magnet wires that pace the industry come from Phelps Dodge! Poly-Thermaleze, the special multi-purpose wire, and a complete line of solderable and bondable wires spearhead widely diversified P.D. line. Also, latest progress in ceramic wires.

(Continued on page 320A)

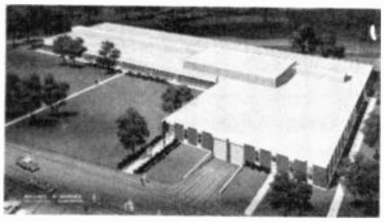
▲ Indicates IRE member.
* Indicates new product.
† Exhibitor is servicing IRE Engineers through the IRE Package Plan.

Whom and What to See at the IRE Show

(Continued from page 319A)

Philco Corp. Lansdale Division, Booths 1302-1308
Church Road
Lansdale, Pa.

C. H. Warshaw, ▲ C. D. Simmons, W. F. Maher, J. J. McCartin, E. W. Bobigan, E. Mayock, ▲ J. Ekiss, ▲ C. R. Gray, W. Brydia, C. F. McCarthy, Jr., J. W. Mintzer, G. L. Mechelin



New Transistor Production Facility

Panorama of Philco research and development in semiconductors, starting with surface barrier transistor in 1952—first transistor produced by precision etch electro-chemical process—progress through to 1961 with announcement of new spat-silicon precision alloy transistor and look to the future with new breakthroughs.

† See PROCEEDINGS OF THE IRE—Jan. through Dec. (1960), Jan. through Dec. (1961) for further information on our products.
See 1961 IRE DIRECTORY, pages 31 through 34, for complete information on our products.

Philco Corp., Lansdale Division, Equipment Manufacturing Operations, 4th Floor Demonstration Room
Lansdale, Pa.

S. L. Parsons, E. J. Greenholt, R. W. Weingrad, W. Moll, R. Fluck, S. Boscia, R. T. Vaughan, W. Scott, M. Hesselgesser, R. Goulet, R. Schwitzer, D. Kelly

Automatic transistor testing equipment featuring error-safe interlock; "project virtue" room—and elevated-temperature life test racks. Programmed reliability tester with card readout has unique protection against variables. Manufacturing equipment; transistor blank scriber, modular dry boxes, vacuum ovens.

Philco Corp., Sierra Electronic Corp. Div., Booths 3031-3032
See: Sierra Electronic Corp.

Philips Electronics, Booths 1512-14, 1524, 2409, 2522-2530, 2802-2804
See: Amperex Electronic Corp., Electrical Industries, Ferroxcube Corp. of America, A. W. Haydon Co., Haydon Switch, Mepco, Price Electric Corp.

▲ Indicates IRE member.
* Indicates new product.
† Exhibitor is servicing IRE Engineers through the IRE Package Plan.

Phillips Control Corp., Booth 2340
59 West Washington St.
Joliet, Ill.

M. A. Hayward, ▲ J. H. Rowell, R. E. Nieland, W. Johnston, William Facinelli, M. H. Buys, J. P. Breaton, D. L. Schofield

Relays and solenoids: Commercial and military standards of telephone, power, general purpose, and the *new 2, 4, and 6 pole microminiature series.

Photocircuits Corporation, Booths 2201-2203
31 Sea Cliff Ave.
Glen Cove, L.I., N.Y.

▲ A. P. Kingsbury, G. Geddy, J. Calpena, ▲ R. P. Burr, J. Bedell, G. Messner, ▲ A. Kelly, ▲ J. Saffery

Printed circuit wiring, including miniaturized landless Tuf-Plate plated thru holes. Printed circuit wiring assemblies. Encapsulayer, multiple layer circuitry. Printed armature motors. Photoelectric tape readers, including *new 300 characters per second—Model 300R.

Physical Sciences Corp., Booths 3911-13
See: Packard-Bell Electronics Corp.

Pic Design Corp. Subsidiary of Benrus Watch Co., Inc., Booth 1517
477 Atlantic Ave.
East Rockaway, L.I., N.Y.

Herman Hering, Peter J. Wellenberger, Charles Keenan, John Swane, William Swane, Truman Tappan

Precision instrument parts and components, breadboard kits, magnetic clutches, engraved dials, tool components, precision 2 and 3 gears, anti-backlash gears, no mar set screws, multi-ratio gear box, differentials, speed reducers, zero adjustable couplings, limit stop assemblies.

Pickard & Burns, Inc., Subsidiary of Gorham Manufacturing Co., Booth 3063
240 Highland Ave.
Needham 94, Mass.

▲ I. J. Metcalfe, ▲ F. C. Leiner, ▲ M. N. Arlin, ▲ M. F. Spears, ▲ J. J. Glynn, ▲ H. S. Burns, ▲ P. C. Smith, ▲ R. B. Enemark, ▲ R. Gordon

Research, development, manufacturing; long distance communication and navigation systems; VLF timing and frequency control systems; antenna systems; propagation studies; system evaluation; VLF receivers; radar and ECM equipments, cosmic radiation instruments. New "Raloc" frequency calibrator; *antenna coupler; *temperature monitor; *loop antenna.

Pitometer Log Corp., Booth 3023
237 Lafayette St.
New York 12, N.Y.

Bernard Kahn, Rudy Volhard, ▲ R. C. Rosaler, ▲ Norman Strum, D. J. Kreines, ▲ Gordon Silversmith, ▲ Ed Wrobel, Ed Bleistein, Michael Smolin

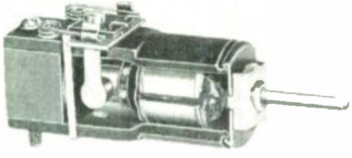
Stalo stability testers covering UHF, L, S, C and X-Bands. Tunable microwave stable local oscillators (stalos). *Solid state harmonic generators using varactor frequency multipliers. *Moving target indicator radar signal simulators. High ambient temperature transistorized electronic controls.

CAFETERIA
Second mezzanine. Take elevator 16 from south side of any floor.

Pittman Electrical Developments Co., Booth 2101

Sellersville, Pa.

Charles A. Pittman III, William G. Blacklock



Model DC 60 Motor

Wide range of quality commercial grade miniature permanent magnet field motors, 3 to 28 volts dc, 0.0018 to 0.031 hp. Adaptable for a variety of power or control functions. Integral gearing to customer specifications available in production quantities.

Plastic Capacitors, Inc., Booth 2738

2620 N. Clybourn Ave.
Chicago 14, Ill.

S. Meskan, H. Francis, D. Sonkin, H. Lavin, D. Dolin, M. Leff

†New commercial high voltage capacitors, high reliability paper mylar, close tolerances polystyrene, metallized mylar capacitors from 50V to 120KV. Mylar, polyethylene, teflon, paper dielectrics exceeding mil requirements. High voltage PFN's, low current transistorized, tube oscillator, line voltage type power packs to 100KV.

Plastoid Corporation, Booth 4128

42-61 24th St.
Long Island City 1, N.Y.

W. Grant, D. J. Nichols, A. W. Anderson, J. L. Weiss, M. Weinschel, W. Moffett, ▲ J. Tomey, ▲ L. Brodsky, C. Myslinski, T. DelGuidice, D. Haggerty, W. Kihm

Specifications of wire and cable constructions for hook-up, power communication and control, aircraft, coaxial cable, seismograph cable, gun control, atomic energy, score board, switchboard, underwater sound, airport control, electronic instruments, power cabler per IPCEA spec., kite cable, shipboard cable.

Polarad Electronics Corp., Booths 3301-3307

13-20 34th St.
Long Island City 1, N.Y.

▲ A. Allen, A Goldberg, R. Savold, ▲ J. P. Schindler, R. Sheloff

Transistorized Field Intensity Receiver

Transistorized calibrated field intensity receiver Model CFI provides accurate field measurements from 1,000 mc to 10,000 mc; Model RT transistorized microwave receiver (AM, FM and pulse) for 950 mc to 11,260 mc; Model SA 84T transistorized spectrum analyzer measuring all microwave parameters from 10 to 40,880 mc; complete line microwave signal generators from 500 to 50,000 mc, spectrum analyzers from 10 to 100,000 mc, and microwave receivers from 400 to 84,200 mc, microwave lab. equipment, ceramic reflex klystron tubes, servo analyzers. Info available on Mobile Field Labs and Demonstrator.

† See PROCEEDINGS OF THE IRE Feb., April, June, Sept., Nov. (1960), Jan., March (1961) for further information on our products.

See 1961 IRE DIRECTORY, pages 107 and 108, for complete information on our products.

(Continued on page 322A)

Whom and What to See at the IRE Show

(Continued from page 321A)

Polyphase Instrument Co., Booth 2839
East Fourth St.
Bridgeport, Pa.

E. C. Capuzzi, R. H. Simmons, G. H. Weiland, R. Hitchens, Arno Meyer, E. Bard, H. Wu, Fred Young, Jr., S. Glassman, C. Korman, R. Adams, W. Stemler

Pulse transformers, filters, magnetic amplifiers, delay lines, toroids, Pico-ultra-min filters, *Picotran transformers, specialty transformers, instruments, transducers.

Polytechnic Research & Development Co., Inc., Booths 3602-06

See: PRD Electronics, Inc.

Pomona Electronics Co., Inc., Booth M-25
1500 East Ninth Street
Pomona, Calif.

Joseph J. Musarra, Carl Wm. Musarra, Jack Weber, David S. Linz

Test accessories, patch cords, molded cable assemblies, 3/4" molded double accessories, test socket tube adapters, tube socket savers, circuit designer breadboard, surface mounted breadboard sockets, Model HB, Model 1391 isolation patch cord, Model 1390, isolation plug.

Popper & Sons, Inc., Booth 4125
300 Park Ave., South
New York 10, N.Y.

R. G. Illner, L. J. Heller, Walter L. Popper, Robert A. Popper

Marking machines to print on components and almost any other product.

Potter & Brumfield, Inc., Div. of American Machine & Foundry Co., Booths 2702-2704
Princeton, Ind.

T. B. White, James Rudy, Nelson Havill, M. J. Kelly, ▲ Z. R. Smith, H. L. Huntsinger, J. V. Foster

Complete line of micro-miniature power, sensitive, general purpose, special purpose and telephone type relays.

Potter Instrument Co., Inc., Booths 3405-3407
Sunnyside Blvd.
Plainview, L.I., N.Y.

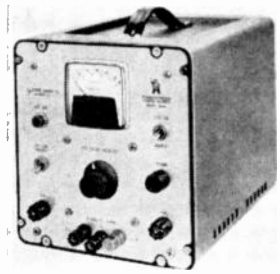
▲ E. Gray, ▲ W. Jennings, ▲ R. Schram, ▲ J. Richardson

Operating high speed transistorized tape transport with oscillogram display of start-stop profiles. Operating high speed transistorized "Line at a time" printer receiving information from perforated tape loop reader.

Your registration admits you to the show for all four days, and to all technical sessions at the Coliseum and the Waldorf-Astoria. Be sure to keep your badge or pocket card with you at all times on the floor. Registrations are not transferable.

Power Designs, Inc., Booth 1516
1700 Shames Dr.
Westbury, L.I., N.Y.

H. Roth, A. Silver, S. Gordon, R. Sterman, S. Hochman, J. Lightstone, J. Boscov



Model 3240 Transistorized Power Supply

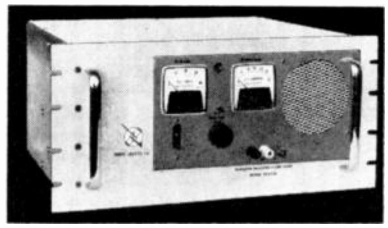
Semiconductorized power supplies utilize the unique properties of semiconductor devices to create new circuit concepts achieving performance, efficiency and reliability hitherto unattainable. Constant voltage/constant current power supplies with programmable crossover to either mode of operation; high efficiency pulse integrating circuitry and other new techniques.

Power Equipment Co., Booth 2125

Custom power supplies. See: North Electric Co.

Power Sources, Inc., Subsidiary of Technical Operations, Inc., Booth 1719
Burlington, Mass.

▲ Jon B. Jolly, Raymond Sprague, ▲ Robert R. Smyth, ▲ R. H. Packard



Transistor Regulated Power Supply

Compact transistor regulated power supplies for tube and transistor voltages, exclusive Sineverter®, modular ac-dc units, static inverters, converters, emergency power for microwave links, field hospitals, all portable requirements. *Two new lines, one high, one low voltage. Warranted five years. Regulator circuit protects transistors without dc fuses or circuit breakers. Transient-free output long-life, compact cooling systems.

Powertron Ultrasonics Corp., Booth 2008
Patterson Place, Roosevelt Field
Garden City, L.I., N.Y.

William G. McGowan, Charles Leonhardt, ▲ Sid Tomes, ▲ William C. Blucke, Paul Steen, Richard Braun, Paul Hand

Ultrasonic Level Control

*Sonoswitch liquid level sensor, meets cryogenic specifications. In-line ultrasonic intensifier for high level ultrasonic processing of liquids in mixing, homogenizing, dispersion, etc. Autosonic line of automatically tuned ultrasonic cleaners.

Precise Electronics & Development Corp., Booth 3106
76 East Second St.
Mineola, L.I., N.Y.

▲ M. Byron, Sol Schwartz, J. Kirschbaum, J. Rubenfeld, G. Vignola, W. Filippi, H. Young, S. Isgro, R. Byron

Oscilloscopes, tube testers, VTVM, AF-RF signal generators, TV marker bar generator, power lab, voltage regulator power supply, decade boxes, probes, transistor kits, AM-FM tuners, low cost high efficiency stereo amplifiers. Transformers & coil components.

Precision Apparatus Company, Inc., Subsidiary of Pacotronics, Inc., Booth 1515
70-31 84th Street
Glendale 27, L.I., N.Y.

S. M. Weingast, S. Sparer, G. N. Goldberger, A. Kosakowsky, S. Solomon, V. I. Robinson, A. D. Mentzer, J. Weingast, A. S. Weingast, J. Futterman, J. MacLennan, A. Greenfield

"Precision" test and measuring instruments for industry: AC millivoltmeter, in-circuit transistor tester, C-R-L bridge, industrial oscilloscope. "Pace" panel meters for industry: Core magnet movements, 1½" size meter, plus complete line of D'Arsonval types to 7" sizes. "Paco" electronic instrument kits and hi-fi audio equipment kits: *Depth finder, regulated power supply, grid-dip meter, sweep generator.

Precision Circuits, Inc., Booth M-9
See: Molecular Electronics, Inc.

Precision Instrument Company, Booth 3035
1011 Commercial St.
San Carlos, Calif.

John M. Magida, ▲ James A. Koch

Transistorized miniature instrumentation tape recorders. Compact laboratory type solid-state unique 50 channel tape recorder/reproducer using continuous tape loops, with up to 75 feet of tape loop for simulation and time delay applications.

Precision Scientific Co., Booth 3824
3737 W. Cortland St.
Chicago 47, Ill.

J. J. Kinsella, J. Black, W. G. Kells, W. H. Dickson, H. P. Biemolt, J. M. Gafner

Constant temperature cabinets. Freas vacuum oven with 1½ cubic foot capacity. Vacuum pump line and vacuum manostat plus general laboratory utilities.

Premier Metal Products Co., Booths 1204-1206
337 Manida St.
New York 59, N.Y.

Edwin L. Kossoy, Harold L. Miller, Mayer Faynberg

Consoles, racks, chassis, cabinets, panels, utility boxes, cases, speaker boxes, etc., for the electronics industry. Manufacturers of the Prem-O-Rak modular console system.

Prentice-Hall, Inc., Booth 1532
Englewood Cliffs, N.J.

Karl Karlstrom, ▲ John H. Davis, ▲ Frank Bitner, Jo Austin

Publishers of books in the field of electronics, engineering and science. Reference material featured will include "Handbook of La Place Transformations" by Nixon; "Theory and Application of Ferrites" by Soohoo; "Creative Engineering Analysis" by Ryder, and "Successful Preparation for FCC Radio Operator's License Examinations" by Geiger.

Price Electric Corp., Booth 2109
East Church & 2nd Sts.
Frederick 1, Md.

J. V. Roughan, R. J. Harrant, B. L. Reeder, T. McLaughlin.

Latest techniques in printed circuit relays, plus our complete line including miniature, subminiature and microminiature relays for military and commercial applications.

Printed Electronics Corp., Booth 2130
See: Electralab Printed Electronics Corp.

Probescope Company, Inc., Booth 3234
8 Sagamore Hill Drive
Port Washington, L.I., N.Y.

Lawrence Zarrow, Harold Hershkowitz, Michael Fragnito, Richard Ramski, ▲ Julian Silverman, Harold Sheeder, ▲ Harry Rutstein, Phil Goldstein

Spectrum analyzers, sub-sonic, sonic, super-sonic, and ultrasonic. Dual channel audio spectrum analyzer. Extended range spectrum analyzer. Multiple channel oscilloscopes and telemetering spectrum analyzer, and telemetering markers and calibrators. Range extenders. Signal alternators and synchronous sweep generators.

Pyle-National Company, Booth 1927
1334 N. Kostner Ave.
Chicago 51, Ill.

J. F. Shearer, R. P. Hanson, L. Milewicz, F. Nestler

Pyle-Star-Line electrical connectors MIL-C-5015-D and MIL-C-26500.

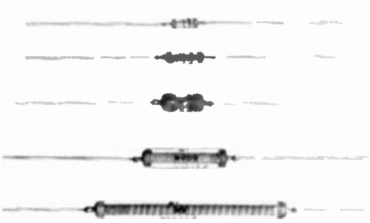
Pyramid Electric Company, Booth 1212
Orange Street
Darlington, S.C.

M. A. De Matteo, J. Starr, ▲ R. Lane, ▲ J. Bonner, M. Meeker

Complete line industrial and commercial capacitors for TV-radio, military and aerospace electronic equipment, industrial controls and computers, etc. High grade electrolytics, true subminiature electrolytic capacitors, electrolytics to MIL-C-62B specifications, tantalum, mylar, and all film types to all military specifications.

Pyrofilm Resistor Company, Inc., Booth 2102
U.S. Highway 46
Parsippany, N.J.

John M. Hinkle, Patrick B. Daniels, William Dodge, R. David Robin



Precision carbon film resistors, MIL styled resistors, PyroSeal precision resistors, PyroSeal resistor networks, carbon film microwave resistors, ultra temperature series resistors, miniature resistors, hi-voltage resistors, hi-meg resistors, bulb-type resistors.

Pyrofuze Corp., Booths 4322-24
Pyroforic products. See: Sigmund Cohn Corp.

(Continued on page 324A)

▲ Indicates IRE member.
Indicates new product.
§ Exhibitor is servicing IRE Engineers through the IRE Package Plan.

Whom and What to See at the IRE Show

(Continued from page 323A)

Quan-Tech Laboratories, Booth 3031
60 Parsippany Blvd.
Boonton, N.J.

▲ John VanBeuren, Alan Stansbury, ▲ Ron C. Pittenger, Neil Uptegrove, Richard Struble, Fred R. Stamfli, Richard Snyder, Richard Conrad

Quan-Tech Model 170 Power Supplies; from left to right, Version T with Terminal Strip, Version B for Bench Us:, and Version C with Octal Plug

Instruments for precise quantitative measurement and analysis of resistor and transistor noise; wave and noise spectrum analyzer; *amplitude distribution analyzer; transistorized amplifiers for general instrumentation; constant-current supply; ac microammeter; regulated power supplies; transistorized modular power supplies.

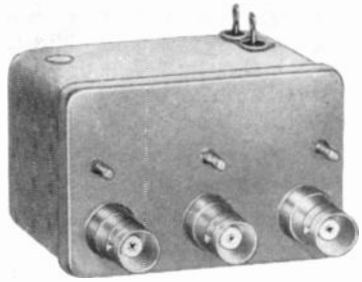
REF Dynamics Corporation, Booth 4327
393 Jericho Turnpike
Mineola, L.I., N.Y.

J. Donald Bowers, Harold Maron, Jack Simon, Anthony J. Fiori, Frank Quitoni, William B. Maxwell

Sheet metal fabrication; reinforced fiberglas fabrication; test and ground support equipment.

R F Products Div. of Amphenol-Borg Electronics Corp., Booths 2102-2108, 2501-2507
33 E. Franklin St.
Danbury, Conn.

Neil Blair, K. A. Waldron, ▲ Charles Camillo, G. William Vockerath, Norman Cresci, ▲ Carl Concelman, Myron Rose, Robert Felber, Kent Buell, Bernard Washisko, Joseph LaGambina, ▲ Ronald Geiken, John Huneke, Ivan Pedersen



DK Hermetically-Sealed Coaxial Switch

Coaxial switches in hermetically sealed, miniature, remote, manual and rotary designs for high-power, transfer, attenuation, circuit insertion, etc. RF connectors in subminiature, crimp-type push-on and aluminum UG and non-UG designs. Coaxial cables, wire: High-temp flexible, subminiature, large multiconductor.

RLC Electronics, Inc. Booth M-7
805 Mamaroneck Ave.
Mamaroneck, N.Y.

▲ Alan Borck, ▲ Philip Wright, Charles Furrer, M. Miller, Charles Malinow, George Moler, Fred Finder, Robert Borg, V. Herson

Complete line of coaxial microwave components, test equipment and sub-systems; including fixed and variable attenuators, directional couplers, low pass, high pass, and band pass filters; hybrids, mixers, power dividers, rf front ends, slotted lines, terminations.

RS Electronics Corp., Booth 2338
435 Portage Ave.
Palo Alto, Calif.

▲ Robert K-F Scal, Wallace F. Burton, ▲ Clinton O. Lindseth, ▲ John Isabeau

Command and telemetry receivers (transistorized), transistorized IF amplifiers, distributed amplifiers, transponders, UHF receivers, pulse modulators, *FM signal generators, noise measuring equipment, transistorized broad band amplifiers, inverters, custom designed power supplies, missile check-out systems, sub-carrier oscillators, custom development and engineering.

Radar Measurements Corp., Booth 3005
190 Duffy Ave.
Hicksville, L.I., N.Y.

Meredith McBride

Electronic instruments, systems, and components. Instrumentation.

Radiation at Stanford, Subsidiary of Radiation Incorporated, Booth 3002
Stanford Industrial Park
Palo Alto, Calif.

Albert J. Morris, Harry G. Heard, Eli Goldfarb, Robert Giebeler

Radar and communications transmitters, modulators, power supplies, data acquisition and processing equipment.

Radiation, Inc., Booth 3001
Melbourne, Fla.

F. Fernety, L. P. Clark, Jr., W. W. Dodgson, Jr., Grady Hartzog, C. J. Underwood, Jr., John Boswell, Dom Casale, Jack Petersen, H. Trenner, ▲ C. H. Hoeppner

Low-level multiplexing in an active demonstration, NOR module system standardization through NOR logic in an active demonstration, 16 mm sound and color film featuring a high-speed digital data system.

(Continued on page 326A)

MICROWAVE DEVICE NEWS from SYLVANIA

50% Smaller!
80% Lighter!

LOW-PRICED PPM-FOCUSED TWT's

for test equipment applications

TYPES	FREQUENCY RANGE (kMc)	POWER OUTPUT	GAIN-db (Min.)
TW-4267	1-2	10 mW	35**
TW-4268	1-2	1 W	30*
TW-4261	2-4	10 mW	35**
TW-4260	2-4	1 W	30*
TW-4281	4-8	10 mW	35**
TW-4278	4-8	1 W	30*
TW-4282	8-12	5 mW	35**
TW-4273	8-12	1 W	30*

**Small signal gain *At saturation

Sample quantities of L- and S-band TWT's immediately available.

Sylvania introduces important advantages to microwave amplifier applications where economy, compact size, light weight are vital design considerations.

Less than 4 lbs. in weight and 2¼″ in maximum diameter, Sylvania TWT's for test equipment present unusual opportunities for design of compact equipment when compared with bulky 15-35 lb. package of the solenoid types. However, electrical performance advantages over solenoid types are still maintained. Investigate the wide range of TWT's by Sylvania. Contact your nearest Sylvania Sales Engineering Office, or write Electronic Tubes Division, Sylvania Electric Products Inc., Dept. MDO-C, 1100 Main Street, Buffalo 9, N. Y.

See the Sylvania I.R.E. Exhibit!
Booth #2322-2332, 2415-2425

SYLVANIA

SUBSIDIARY OF
GENERAL TELEPHONE & ELECTRONICS

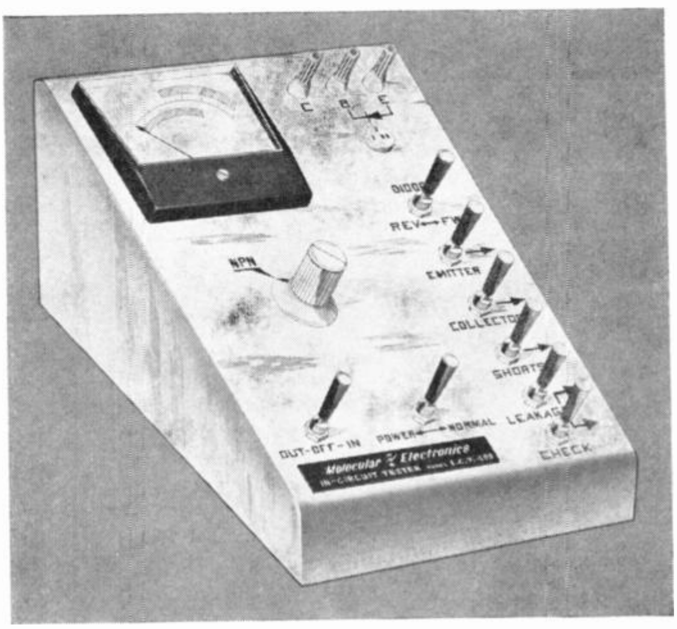
GENERAL SYSTEM

to fill a need...

for reliable, simple in-circuit and out-of-circuit testing of semiconductor devices

New model I.C.T.-100

- Checks transistors, diodes, rectifiers *in* and *out* of circuit
- Detects opened, shorted, leaky devices *in* circuit
- Measures replacement in circuit without soldering
- For all types of common circuits *irrespective of circuit loading*
- Simple-to-use: no previous device history needed—no charts or specs to consult



Developed by MOLECULAR ELECTRONICS, a subsidiary of Precision Circuits, Inc., the versatile Model I.C.T.-100 reflects the unusual benefits of this combination.

Molecular Electronics includes a group of specialists offering wide experience in the characterization, measurement and evaluation of semiconductor devices, through test instruments and consultation.

The daily experience gained by Molecular Electronics is available to others, to help meet requirements in quality control, research and production.

Discover the benefits of Molecular Electronics' other semiconductor instrumentation: Model G320 general purpose tester, Model F220 alpha-cutoff test set, Models F-20 and F-30 gain-band width testers . . . and broad semiconductor testing and evaluation capabilities. Write for prices and details.

at the I.R.E. booth M-9

"where performance is equal to promise"

Molecular Electronics INC.

a subsidiary of PCI

85 Weyman Avenue, New Rochelle, New York • BEverly 5-4300

Whom and What to See at the IRE Show

(Continued from page 324A)

Radio Corporation of America, Defense Electronic Products Div., Booths 1602-1608, 1701-1707
Camden, New Jersey

F. M. Farwell, W. G. Bain, H. R. Wege, I. K. Kessler, S. W. Cochran, S. N. Lev, J. G. Mullen, J. R. Dunn

Micromodules, micromodule concept, BMEWS, Dyna Soar, ground support equipment, atomic clock, map printer, submarine recorder, video file, advanced communications systems techniques.

Radio Corp. of America, Electron Tube Division, Booths 1602-1608, 1701-1707
415 South Fifth Street
Harrison, N.J.

D. Y. Smith, L. S. Thees, J. B. Farese, M. J. Carroll, G. J. Janoff, L. D. Kimmel, J. A. Haimes, D. R. Ozvath, W. H. Myers, H. M. Dean, J. H. Mosher, H. B. Wilson, W. R. Earley, H. F. Bersche, J. E. Kelley, H. S. Stamm, K. B. Shaffer, W. H. Allen, C. B. Kilian, J. M. Lunney, J. R. Meagher, G. E. Ryan, E. J. Carney, A. F. Slattery, L. O. Shanafelt, C. E. Burnett, G. W. Duckworth, V. C. Houk, J. F. Cooper, G. R. Rivers, J. T. Wilson, M. E. Markell, H. F. Hafker, M. D. Boylan, R. A. Bassell, D. G. Koch, L. W. Aurick

Receiving, storage oscillograph, camera, microwave, power, and phototubes. Color and 100° picture tubes. Photocells, test equipment, and electroluminiscent panels. Nuvistors.

† See PROCEEDINGS OF THE IRE—Feb., April, June, Aug., Oct., Dec. (1960), Feb. (1961) for further information on our products.
See 1961 IRE DIRECTORY, pages 54 and 55, for complete information on our products.

Radio Corp. of America, Semiconductor and Materials Division, Booths 1602-1608, 1701-1707
Somerville, N.J.

A. M. Glover, W. H. Painter, R. K. Joslin, T. R. Hays, R. D. Wick, E. B. May, J. M. Cleary, H. J. Cornys, D. R. Deakins, C. H. Lane, K. M. McLaughlin, N. R. Green, R. Koehler

Special ferrites, microminiature modules, transistors for entertainment, industrial, military, and computer applications. Silicon rectifiers, thermoelectric materials, tunnel diodes.

† See PROCEEDINGS OF THE IRE—Jan., March, May, July, Sept., Nov. (1960), Jan., March (1961) for further information on our products.
See 1961 IRE DIRECTORY, pages 56 and 57, for complete information on our products.

Radio-Electronic Master, Booth 4424
See: United Catalog Publishers, Inc.

Radio Engineering Laboratories, Inc., Booths 1301-1303
29-01 Borden Ave.
Long Island City 1, N.Y.

▲ Frank A. Gunther, C. R. Runyon III, Harry Sadenwater, ▲ George Papamarcos, Seymour Sinuk, T. Phil Rizzuti, ▲ H. H. Robinson, Harold Goldstein, Donald Quinn, Sam Bayer, Donald F. Koijane

FM tropospheric scatter radio communications equipment. Exciters, low noise diversity receivers, combiners, fault indicators, dummy loads, and noise loading intermodulation test equipment. FM line of sight radio terminals.

Radio Frequency Laboratories, Inc., Booths 3115-3119
Powerville Road
Boonton, N.J.

Robert Crocetti, Robert Denton, Henry Emker, Jack Janicke, Richard Treible

AC/DC instrument calibration standards of all types; magnet charging, treating and measuring equipment; laboratory type variable frequency power supplies; crystal impedance meters; FSK and AM data transmission, telegraph, control and telemeter terminals and accessories.

Radio Materials Co. Div. of P. R. Mallory & Co., Inc., Booth 1414
4242 West Bryn Mawr
Chicago 46, Ill.

R. D. Bourgerie, R. M. Merritt, H. Byrne, ▲ H. Lavin, ▲ F. Spellman, C. Johnson, J. Kornberger, J. M. Baxter

Ceramic Discap capacitors.

Radio Receptor Co., Inc. (Selenium Division), Subsidiary of General Instrument Corp., Booths 1101-1106
240 Wythe Ave.
Brooklyn 11, N.Y.

A. Nash, E. P. Moore, J. Loebenstein, H. Miller, V. Griski

Very high voltage selenium rectifiers; flat, compact embedded bridge stacks, vibration and moisture proof; direct plug-in replacement for 6X4 tube; contact protector for computer relays; diode matrix for computers; subminiature diode 15 micro amps 26 volts dc; high voltage cartridge rectifiers; Siemens flat type rectifiers.

Ramo-Wooldridge Div., Booths 1435-1635
See: Thompson Ramo Wooldridge, Inc.

George Rattray Co., Inc., Booth 1424
Potentiometers. See: Instruments For Industry, Inc.

(Continued on page 328A)

Keep this book for future reference, so you will be able to remember "Who made it?" and discover "Where can I reach them now?"

Whom and What to See at the IRE Show

(Continued from page 327A)

Rawson Electrical Instrument Co., Booth 3311
110 Potter St.
Cambridge 42, Mass.

▲ **Morley J. Lush, W. D. Hague, Jud Williams**

*New 1/10 of 1% rotating coil gaussmeter. *new 100 megacycle laboratory standard RF voltmeters, electrostatic voltmeters, peak voltage rectifiers, wattmeters, thermal meters, multimeters, fluxmeters, dynamometer type meters, microammeters, millivoltmeters, milliammeters, panel mounting meters.

Raychem Corporation, Booth 4504
Oakside at Northside
Redwood City, Calif.

▲ **Peter W. Wallace, William W. Dunn, Robert S. Deal, Rod E. Titus, Robert M. Halperin**

Irradiated modified polyolefin wire and multiconductor cable. Irradiated modified polyolefin, miniature coaxial cable. Heat-shrinkable tubing.

Rayclad Tubes Inc., Booth 4504

See: Raychem Corp.

Raytheon Company, Commercial Apparatus & Systems Div., Booth 2609
Power Supply & Voltage Regulator Operations
1415 Boston Providence Highway
Norwood, Mass.

R. Curtis, W. Nicholson, W. Anderson, G. Zipf, R. Foote, E. Carujo, W. Bryan

New Series 2020 voltage regulating transformers—a broad line of more than 2000 ratings for line voltage regulation, filament voltage regulation and power supply application. Four case styles available. with output ratings from 10 VA to 10,000 VA.

(Continued on page 330A)

Whom and What to See at the IRE Show

(Continued from page 328A)

Raytheon Company, Commercial Apparatus and Systems Div., Booth 4045
Production Equipment Operations
1415 Boston Providence Highway
Norwood, Mass.

John McCarthy, John Kelly, Donald Hawes, B. B. Stuart, Edward Keating, Vaughn Judd, John Callahan, Larry Mastromattei, Austin Morrill, W. Anderson, George Zipf, Robert Foote, H. N. Ewertz

Precision welding equipment, Model M welding head with 30 kva ac power supply; 300 watt Model 333 ultrasonic impact grinding machine; improved miniature, bench-mounted welding heads for module application.

Raytheon Company, Industrial Components Division, Booths 2609-10-11
55 Chapel St.
Newton 58, Mass.

R. Knowles, F. Schillinberg, G. Greenstein, E. Fisher, L. Caudill, E. Frank, T. J. White, R. Gates, W. Cronburg, E. H. Clark, E. Neville, M. Koning, T. Jedrzejewicz, A. Luftman, G. Johnston, L. Eaton

Subminiature and miniature industrial receiving tubes, low power transmitting tubes, gas and vapor tubes, *Weld-Pak circuit modules, *light indicator modules, industrial cathode ray tubes, storage tubes, printer tubes, control knobs, panel hardware, noise modules, *accelerometers, Raysistor relays, magnetostriction filters, Rayspan spectrum analyzer, entertainment receiving tubes, *frame grid subminiatures.

Raytheon Company, Machlett Laboratories, Inc., Booths 2611-12
See: Machlett Laboratories, Inc.

Raytheon Company Microwave & Power Tube Division, Booths 2602-2606
Foundry Avenue
Waltham 54, Mass.

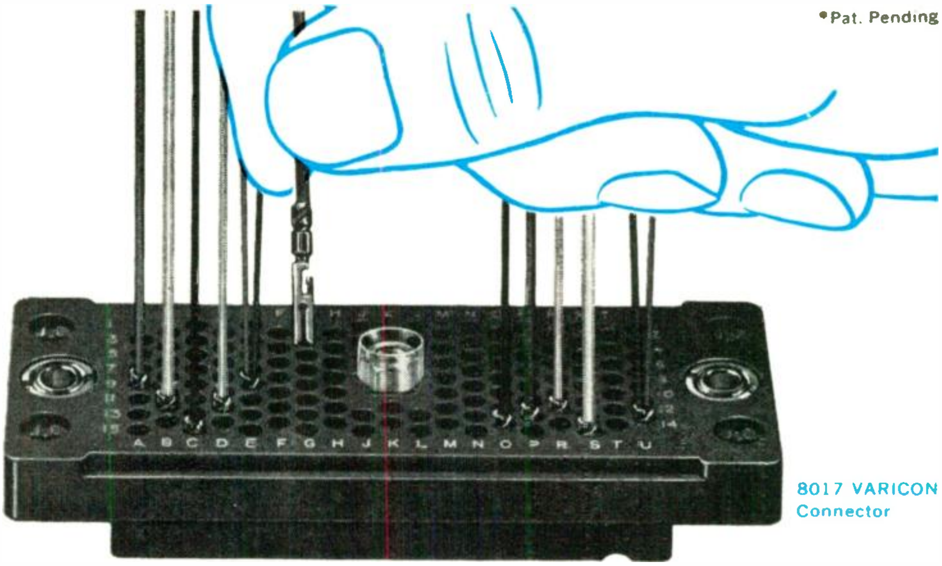
A. F. Vacaro, B. Silberman, F. Giacolone, G. J. Callahan, R. Devlin, R. Robichaud, W. H. Packer, J. Graham, T. Mahoney

QKW 750A Traveling Wave Tube

Complete high power S-band MOPA chain, Amplitrons, high-power traveling wave tubes, communications klystrons, mm klystrons, communications type traveling wave tubes, magnetrons, "O" type backward wave oscillators, IR detectors, ceramic components.

(Continued on page 332A)

First and Second floors—Components
Third floor—Instruments and Complete Equipment
Fourth floor—Materials, Services, Machinery



why

is ELCO'S NEW VARILOK* the most ingenious crimp-type self-locking contact of all?

because

it is the only crimp-type contact which, in one size only, accommodates all sizes of wire from 18 gauge to 30 gauge! Because it is the only crimp-type contact which offers positive locking into connectors each time, every time. And because it .s the only crimp-type contact giving you the unmatched reliability and versatility of the VARICON; mating with itself or with numerous other VARICONS!

so discover for yourself ELCO VARILOK's unparalleled features! Available loose for use with hand-tools; or in reel form with power operated bench-machine.* Also available: a contact withdrawal tool; and crimp gauge!

See these tools in operation at our Booths 1420-1422 IRE Show

IF IT'S NEW...
IF IT'S NEWS...
IT'S FROM... ELCO

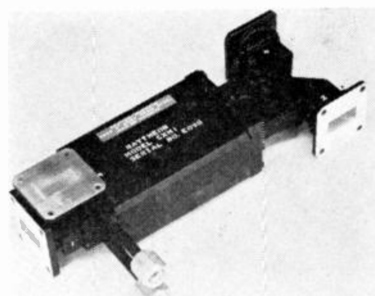
ELCO CORPORATION: M Street below Erie, Philadelphia 24, Pa., CU 9-5500

ELCO Pacific: 2200 Centinela, West Los Angeles 64, Cal., GRanite 8-0671
International ELCO A. S., Lindealle 42, Copenhagen, Vanlose, Denmark
ELCO Australasia, Bradberry House, 55 York Street, Sydney, Australia

Whom and What to See at the IRE Show

(Continued from page 330A)

Raytheon Company Microwave & Power Tube Division, Booths 2601-2606
Special Microwave Devices Operations
130 Second Ave.
Waltham 54, Mass.
▲ Dr. Howard S. Scharfman, Ralph M. Moschella, ▲ John Stabile, Robert Rigel, James Caugcr, A. F. White, ▲ Dr. Colin Bowness, ▲ John Q. Owen, ▲ Basil Vafiades



Model CXHI High Power X-Band Circulator

Complete line of coaxial isolators and three port circulators. High power X-band circulators. Isolators. UHF band through K-band, switches. Modulators in a wide range of power handling capacity and frequency coverage. Ferrite materials. Lasers.

Raytheon Company, Semiconductor Division, Booths 2613-2614
215 First Ave.
Needham Heights 94, Mass.
▲ H. J. Finison, ▲ G. Williams, ▲ F. M. Dukat, ▲ W. S. Peters, ▲ H. F. Schunk, K. J. Bell, ▲ D. Rubinfien, J. E. Harrison, ▲ L. Leary, ▲ D. F. Brockett
PNP and NPN silicon transistors, PNP and NPN germanium transistors, subminiature germanium and silicon transistors, silicon rectifiers, silicon diffused junction diodes, gold bonded and point contact germanium diodes, Circuit-Paks.

Raytheon Company, Sorensen & Co., Inc., Booth 2604
See: Sorensen & Co., Inc.

Reeves-Hoffman Div., Dynamics Corp. of America, Booth 1309
Cherry & North Sts.
Carlisle, Pa.
C. M. Rahn, ▲ R. Van Gavree, ▲ G. Spease, F. Gross, M. O'Hanlan, A. Muller
Quartz crystal units, crystal filters, crystal ovens, crystal oscillators, frequency standards.

Reeves Instrument Corp., Booths 1305-1307
East Gate Blvd.
Roosevelt Field
Garden City, L.I., N.Y.
T. Curtin, S. Feuerman, J. Gavin, W. Gold, I. B. Goldberg, J. Gotthelf, J. Z. Kunze, C. Lax, J. Michael, P. I. Rafield, G. H. Steinberg

Inertial Floated Integrating Gyros

Antenna pedestals; modular transistorized amplifiers; *gyros; *induction resolvers; servo-mechanical components; solid state diode electronic multipliers; analog computers; stable platforms.

Reeves Instrument Corporation, Farmingdale New Jersey Division, Booth 1202
Lakewood Road
Farmingdale, N.J.
Roger M. Daugherty, A. Robert Taylor, Michael B. Kraus, Joseph M. Noll, P. Collalto, J. Nevins, J. Ewansky, M. Sajor, G. Holt
"Reliant" single side band equipment. "Standard Electronics" FM, video broadcast equipment. "Amertran" transformers and voltage regulators.

Reeves Soundcraft Corp., Booth 1331
Great Pasture Road
Danbury, Conn.
T. J. Dempsey, R. E. Schlicht, C. Beck, W. A. Morrison, G. P. Bassett, E. Reynolds, B. Oyen, J. Dobbs, C. Mass, R. Fuller
Magnetic recording tapes and accessories for audio, video and instrumentation recording.

Relcoil Products Corp., Booth 2812
See: Hi-G, Inc.

Renbrandt, Inc., Booth 1906
6 Parmelee St.
Boston 18, Mass.
M. Rogers, Sy Orken, Raymond Renner, Edison Brandt
Backlash free flexible servo-couplings for electromechanical instruments. "Tinymite" flexible couplings for low cost applications.

(Continued on page 334A)

PLAN WITH PESCO

for the new world of THERMO-ELECTRIC power generation and cooling*

From the research laboratories of the Borg-Warner Corporation and Pesco Products Division, full-scale development programs have created three basic applications of thermo-electricity now available to systems engineers.

Thermo-electric cooling units provide pin-point temperature control for transistors, resistors, and other electronic components demanding restricted heat limits.

Infrared detector cell thermo-electric coolers maintain temperatures to –90° C., while eliminating the storage and plumbing problems involved with cryogenic liquid cooling systems.

Thermo-electric generators may be integrated in remotely located detection, telemetering, and other electronic circuitry to give enduring, maintenance-free power sources.

Existing hardware for all three applications has been designed for specific systems. Borg-Warner and Pesco research engineering can produce similar units to meet your specialized requirements for temperature, heat removal, or power.

8989-PC

Pesco Products Division
Borg-Warner Corporation • Dept. I-3
24700 North Miles Road • Bedford, Ohio

I am interested in the following thermo-electric applications:

☐ Electronic Cooling ☐ Power Generation
☐ Infrared Detector Cell Cooling

Specification data: ______________________

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NAME ______________________

COMPANY ______________________

ADDRESS ______________________

CITY ______________ ZONE ____ STATE ________

Pesco engineering production

PESCO BW PRODUCTS BORG-WARNER

* another development of Pesco Borg-Warner research

PESCO PRODUCTS DIVISION
BORG-WARNER CORPORATION
24700 North Miles Road • Bedford, Ohio

Export Sales: Borg-Warner International Corp., 36 South Wabash Ave., Chicago 3, Illinois

Whom and What to See at the IRE Show

(Continued from page 332A)

Reon Resistor Corp., Booth 1115
155 Saw Mill River Road
Yonkers, N.Y.

▲ Leon Resnicow, J. J. McCann, Gilbert Sokolow, Stanley J. Shute, Jr., John B. H. Fry, Ann P. Adelman, Jean Schuldenfrel

Molded composition variable potentiometers per MIL-R-94B, RV4, RV5, RV6. Meet all applicable specifications. Fixed precision wirewound resistors per MIL-R-93B. Precision resistor networks. Miniature power resistors. Silicone sealed power resistors.

Republic Aviation Corporation, Special Products & Services Division & Missile Systems Division, Booth 3010
Farmingdale, Mineola, & Springdale, N.Y.

▲ A. B. Speed, G. R. Davis, ▲ B. Sokol, W. Ryder, W. Budny, ▲ R. Sherry, ▲ W. Derganc

Standard and custom production battery testers, capacity analyzers and chargers for alkaline and acid type batteries. Complete power systems. "D" cell chargers. Design, development and fabrication of radar, radomes and reflectors. Airborne electronic systems, data links and airborne computers.

Rex Corp., Booth 4308
See: William Brand-Rex Division

Rheem Semiconductor Corp., Booths 2436-2438
350 Ellis St.
Mountain View, Calif.

Joe Hurley, Rudy Maravich, ▲ Gordon Schontzler, Frank Breene, Jerry Proudfoot, Dan Dwyre, Ben Roesch, Bob DiMassimo, Tom Neuviller

Silicon mesa transistors, silicon diodes and special assemblies. Featuring "Microbloc" transistors and CSP (controlled surface potential) ultra reliability diodes.

Rhotometers, Inc., Booth 1109
User adjusted ultra-precision resistors. See: Consolidated Resistance Co. of America, Inc.

Richland Glass Co., Booth, 2937
See: Faradyne Electronics Corp.

John F. Rider Publisher, Inc., Booth 4516
116 W. 14th St.
New York 11, N.Y.

▲ John F. Rider, Jerome Kass, Donald H. Gieb, William J. Marcus, Nat Bodian, H. Bernard Mark, Sherry Berger, Shiela Kessler, Beryl Peters, Cynthia Stephens

Publishers of texts and manuals on electricity, electronics, physics, mathematics, computers, nucleonics, space technology, industrial management, high fidelity and servicing. Rider "pictured text" courses.

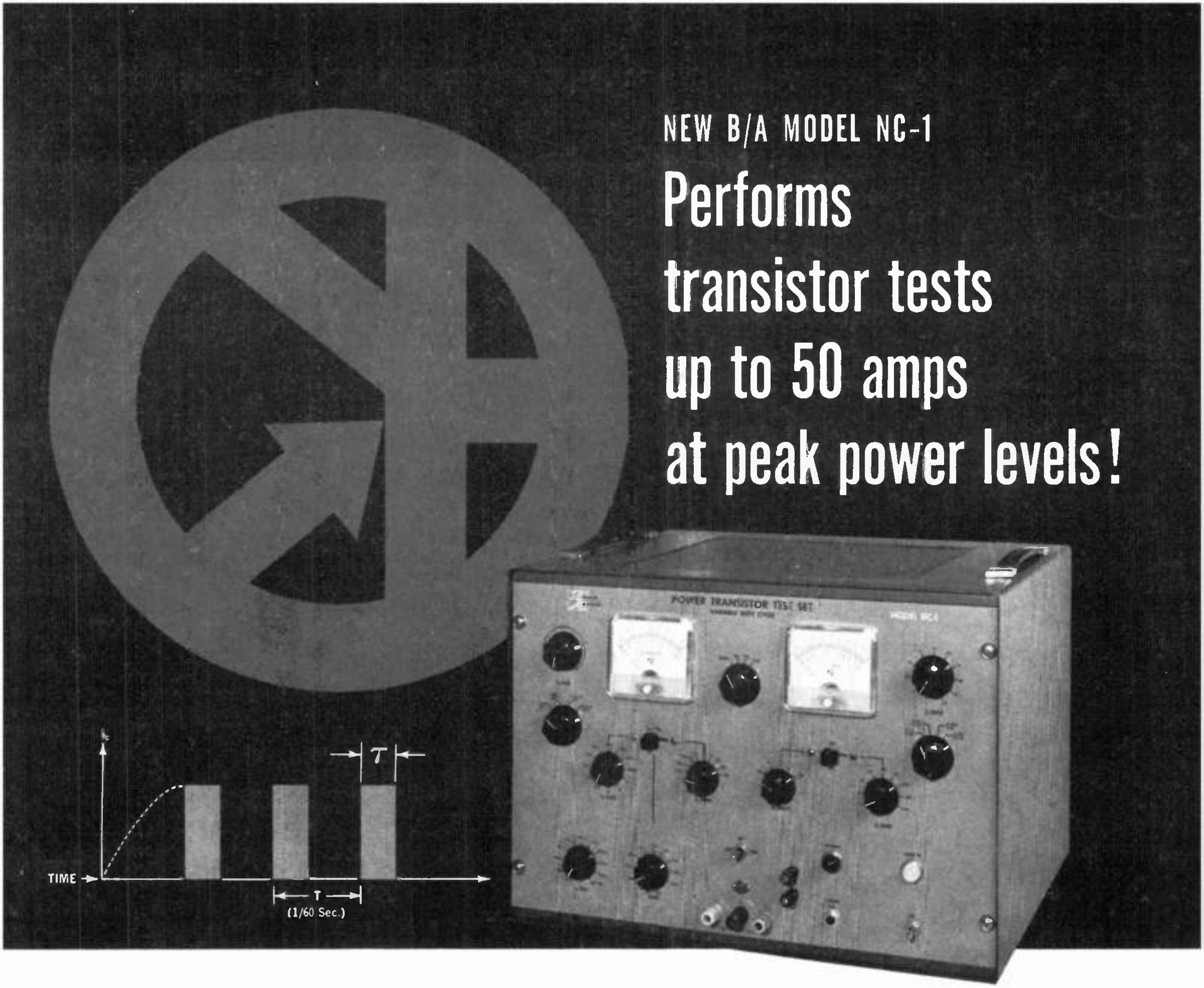
Riggs Nucleonics, Booth 3018
See. International Electronic Research Corp., ELIN Div.

(Continued on page 336A)

One registration entitles you to permanent entry to the show for all four days. Be sure to keep your identification badge or pocket card and bring it with you when you return. Registration is not transferable.

NEW B/A MODEL NC-1

Performs transistor tests up to 50 amps at peak power levels!



Only the Baird-Atomic NC-1 offers you the advantages of a direct reading, variable duty cycle test set for non-destructive measurement of medium and high-power transistors.

Check these important features:

- Minimizes heat sink requirements
- Under optimum conditions, requires only 6/10ths of 1% of the input power used in conventional DC current tests
- Permits 750 watts max. power with max. current of 50A or max. voltage of 250V
- Provides DC meter readings of V_{BE}, I_B, V_{CE} and I_C — common emitter configuration under pulse conditions
- Measures leakage currents, I_{CO} and I_{EO}, by standard techniques
- Allows breakdown measurements to be performed under variable bias conditions
- Evaluates switching capabilities of device under dynamic conditions

The Baird-Atomic Model NC-1 applies suitable pulse drive signals to the transistor under test and then peak detects the resulting current pulses at the same measuring value as steady state DC. Because the average pulse signal power is considerably lower than that of steady state DC, less stress is put on the transistor. This permits power tests to be made at a level many times that of rated device dissipation.

Write today for additional information and name of your nearby Baird-Atomic representative.

See us at Booths 3216-3218
IRE Show, New York

B A

BAIRD-ATOMIC, INC.
33 university road · cambridge 38, mass.

BAIRD-ATOMIC HAS THE MOST COMPLETE LINE OF TRANSISTOR TEST EQUIPMENT

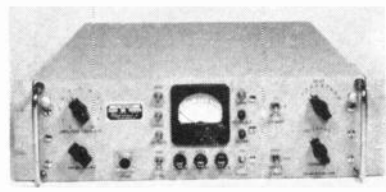
Whom and What to See at the IRE Show

(Continued from page 334A)

Rixon Electronics, Inc., Booths 3064-3065

2414 Reedie Drive
Silver Spring, Md.

▲ James L. Hollis, ▲ C. J. Harrison, ▲ J. C. Myrick, W. F. Rhodes, ▲ R. E. Davis, M. Frank, ▲ D. W. Perry, ▲ H. A. Ray, W. A. Linton, ▲ R. A. Wainwright, A. Gatfield, G. Holland



Sebit-25

Digital data transmission equipment, synchronous (*Sebit-24) and non-synchronous (KY-612) for voice wire facilities. Amplitude and delay equalizers EN-766-2, EN-766-8 & EN-766-4. *Solid state power supplies and relays. Simulated transmission lines. Design-development, production of communication oriented equipment.

† See PROCEEDINGS OF THE IRE—Jan. through Dec. (1960), Feb., March (1961), for further information on our products.

See 1961 IRE DIRECTORY, page 324, for complete information on our products.

Robinson Vibrashock Div., Robinson Technical Products, Inc., Booths 2506-2508

Teterboro Air Terminal
Teterboro, N.J.

Frank E. Dal Lago, Robert E. Fojt, Robert J. Fowski, James J. Greed, Fred R. Ling, Henry T. Lowell, Raymond T. Magner, Fred J. Maltais, Richard G. Mango, Warren A. Reider, ▲ Robert A. Sprung, Harold Waring

Vibration isolation and shock control systems, units and devices for the protection of electronic, electrical and electro-mechanical equipment as used on aircraft, industrial, missile and mobile installations.

Rogan Brothers Incorporated, Booth 4133

8031 N. Monticello Ave.
Skokie, Ill.

J. J. Rogan, Fran Kosowicz

See This *New Knob

A variety of control knobs, suitable for all electrical and electronic applications. Knobs being molded plain, may be branded to customers' requirements. *A new series of decorative knobs, especially designed for electronics manufacturers.

Rohde & Schwarz Sales Co. (U.S.A.), Inc., Theater 3000

111 Lexington Ave.
Passaic, N.J.

▲ Rudolf Feldt, Jay L. Fisher, Ernest Bick, H. Lucins, Allen Vreeland

Tuned amplifiers and selective voltmeters from 45 cps to 4500 mc including Selectomat, an automatically tuned electronic voltmeter. New and improved frequency and time standards including VLF receiver and phase comparator for remote control. New frequency synthesizer-exciter. New hi-voltage Schering bridge, *other new precision bridges. New FM broadcasting relay receiver. Improved Polyskop.

† See PROCEEDINGS OF THE IRE—Jan. through May, July (1960), March (1961), for further information on our products.

See 1961 IRE DIRECTORY, page 246, for complete information on our products.

Roller-Mike, Inc., Booth 4511

110 Wall St.
New York 5, N.Y.

Walter Cronan, Dorothy A. Murray, Martin Brakas, Stan Urry

Roller-Mike Model "DA" automatic motor driven production size and thickness measuring machine. Range—0 to 1¼". Tolerance 10 millionths. *Model "E" ditto, range 0 to .125", tolerance 10 millionths. Measures and separates thousands an hour of semiconductor dice, sub-assemblies, etc.

Roller-Smith, Booths 2721-25

See: Cornell-Dubilier Electric Corp.

Rosan, Inc., Booth 4016

2901 West Coast Highway
Newport Beach, Calif.

H. Baynton, Al Redlitz, Paul Spangler, Al Eckert, G. Mathews

Fasteners of the space, electronic, and automative age. Slimsert, world's finest thin-wall insert. Press-Lock principle fasteners. Rosan Press-Lock principle is the latest development in fasteners for thick and thin materials.

Rotating Components, Inc., Booth 1234

267 Green St.
Brooklyn 22, N.Y.

N. F. Giarra, J. H. Mills, A. G. Miller, G. R. Sprinsky, B. Hurewitz, Max Saposowitz, Martin Gross

Standard "Buord" servo motor line in sizes 8, 10, 11, 15, 18—available with gearheads. Complete line ac hysteresis and reluctance synchronous, induction, gear motors. Full range ac blowers, fans. Subfractional HP, 60 cycle, 400 cycle, variable frequency, MIL spec, stock or custom.

Rotron Mfg. Co., Booths 2822-2824

Hasbrouck Lane
Woodstock, N.Y.

▲ J. C. van Rijn, Paul M. Beard, David Carlson, James J. McGowan, Percy S. Lyon, E. N. Goddard, Bertram R. Roome, John Cerasaro, Arthur Gran

Complete line of cooling devices for ground, shipboard, aircraft and missile applications. Specialties include (1) Family of miniature, high-speed 400 cps fans; (2) Designs for high pressure or vacuum up to 70" W.G.; (3) Commercial fan 5" square which will deliver 100 CFM free delivery.

(Continued on page 338A)

American-Marietta's new EMC Epoxy Molding Compounds mold precision resistors

10 TIMES FASTER

Here's why Campbell Industries relies on EMC for high volume resistor molding

- **INCREASED PART PRODUCTION** Switching to EMC transfer molding from a liquid potting system enabled Campbell Industries of Dover, N. H. to boost operator resistor output more than 1000%! Campbell finds that dry, granular one-component EMC is readily mixed in larger batches to help them insure lot uniformity and top part performance in their Fixtohm deposited carbon resistors.
- **LOWER REJECT RATE** Because EMC is 100% reactive with minimal post-shrinkage, uniform, and non-outgassing, Campbell has been able to reduce reject rates to less than 1% for surface blemishes and variance from design dimensions.
- **GREATER HANDLING EASE** The soft flow of versatile EMC means negligible strain in molding and assures that resistor elements remain properly positioned in the mold for dense, equal encapsulation on all sides of the part.

SEE THAT
NEW IDEA
AT

BOOTH
NO. 4517

MARCH 20-23, 1961
IRE SHOW
NEW YORK COLISEUM

A=M ®

AMERICAN-MARIETTA COMPANY

Adhesive, Resin & Chemical Division

SEATTLE, WASHINGTON	NEWARK, OHIO
3400 13th Avenue S. W.	42 South Third Street

Whom and What to See at the IRE Show

(Continued from page 336A)

Rowan Controller Co., Booth 2131
2315 Homewood Ave.
Baltimore 18, Md.

J. C. Ellis, A. L. Haskell, R. L. Dalton, D. G. Munger, A. Wehrung, ▲ S. M. Becker, G. C. Ellis, C. Morgan

Complete line of standard commercial panel meters (8 models, accuracies to ±0.5%), expanded scale voltmeters and frequency meters (4 models, accuracies to ±0.1%), ruggedized instruments (4 models, accuracies to ±0.75%), multimeters (4 models), megohmmeters, transistor-meters, and multimeter accessories.

Rubicon Division, Booth 2210
See: Minneapolis-Honeywell Regulator Co.

Rutherford Electronics Co., Booth 3317
8944 Lindblade St.
Culver City, Calif.

▲ C. E. Rutherford, D. F. White, ▲ R. Sakamoto, H. W. Mette

High repetition rate, fast rise time pulse generators, precision time delay generators, *transistorized pulse generators, *programmable pulse generators, multiple pulse generators, special pulse and time delay systems, *modular pulse systems, pulse accessory equipment, single pulse generators, pulse mixer assemblies, attenuators, terminations, citizens' band radio.

Rye Sound Corporation, Booth 2929
145 Elm St.
Mamaroneck, N.Y.

Richard M. Livingston, Charles David, Fred Rosenwasser, Richard Hirschmann, Pietre Geervliet, J. Merican, E. Flynn, D. Jaffee, Fred Hough

Self Retaining Flexible Test Prod

Rye Sound: Earphones, earloops, eartips, earmolds, stethosounds, stethoplugs, stereosounds, foot switches, telephone pick-ups, dictating machine accessories. Rye-Hirschmann: Plugs, sockets, terminals, miniature plugs, connectors and couplings, multiple connectors, alligator clips, banana plugs, test products, Rye-Ampliyox Transformers & Transducers: Microphone insets, earphones, test products, headsets.

S-F-D Laboratories, Inc., Booths 2708-2720
See: Varian Associates.

(Continued on page 340A)

▲ Indicates IRE member.
* Indicates new product.
† Exhibitor is servicing IRE Engineers through the IRE Package Plan.

Whom and What to See at the IRE Show

(Continued from page 338A)

Sage Electronics Corporation, Booth 2235
Country Club Road
East Rochester, N.Y.

▲ F. Dwight Sage, Davidge H. Rowland, ▲ J. C. Van Arsdell, Allen P. Mills

Miniature precision wirewound resistors; power ratings from 1 to 50 watts; tolerance from 5% to .05%; Sage "Clipper" clip-mount heat sink resistors. Non-inductive counterparts for all styles. Introducing *weldable leads and newly designed higher wattage chassis mount resistors.

Sage Laboratories, Inc., Booth 1225
3 Huron Drive
East Natick Industrial Park
Natick, Mass.

▲ Ted Saad, William Kennedy, George Ayoub, Ernest Lattanzi, John Camuso

*Phase shifter, microwave attenuators, microwave filters, stripline components, microwave crystal holders, cobrids, *microwave mixers, microwave packaging TEM lines.

Howard W. Sams & Co., Inc., Booth 4048
1720 E. 38th St.
Indianapolis, Ind.

W. D. Renner, Mal Parks, Jr., John W. Merritt, T. A. Shonfield, Robert M. Hall

Specialized services, operation and service manuals, product catalogs, engineering analysis, product testing, training materials, direct mail service, technical writing, technical compilation, art and photographic service, printing. "Photofact" folders, PF Reporter, "Tube Facts."

▲ Indicates IRE member.
* Indicates new product.
† Exhibitor is servicing IRE Engineers through the IRE Package Plan.

San Diego Scientific Corp., Booth 3021
3434 Midway Dr.
San Diego 10, Calif.

▲ Dr. D. C. Kalbfell, ▲ John W. Bodnar, John J. Chaparro

*"Magne-Alarm"®—a low cost solid state limit monitor for use with thermocouples, resistance thermometers, thermistors and strain gage inputs that uses magamp as only active element. "Magne-Plexer"®—solid state multiple input commutator (multiplexer) providing 5 volt outputs from millivolt level sources, operating at rates to 20 kc.

San Fernando Electric Manufacturing Company, Booth 2523
1509 First St.
San Fernando, Calif.

Donald E. Rubendall, Kermit Hawkins, A. F. Dreyer, Michael A. Rosenberg, Lyle R. Smith, John Hines, Robert Roberg, Al Livera, Ed Polk, Art Mazzerella, Sil Venturi, Joe Poitras, Helen Jensen, Eileene Johnson

West-Cap "Red Head" ceramic cap to Mil-C-11015/18 &/19. Paper & foil to Mil-C-25C. Paper plastic to Mil-C-14157B & Mil-C-26086/6. Mylar, polystyrene, teflon to Mil-C-26086/1/2/3/4 (USAF) & Mil-C-19978(Ships) metallized paper & metallized mylar to Mil-C-18312 (Navy). Microminiature metallized paper feed-thru caps to Mil-C-11693B. Rap-N-Fil mylar.

(Continued on page 342A)

CAFETERIA

Second mezzanine. Take elevator 16 from south side of any floor.

Climaxing ITT's long history of pioneering in the traveling wave tube field are these new PPM types covering C and X bands and distinguished by the highest power output over the greatest bandwidths thus far available. The X-band TWT Type X-354 is rated at 5 watts CW from 8 to 12 kilomegacycles; the C-band TWT Type X-370 is rated at 10 watts CW from 4 to 8 kilomegacycles. Type X-368 serves as a driver for the X-354. As in other ITT traveling wave tubes, construction is exclusively metal and ceramic.

Power output and frequency coverage of this caliber result in a new standard of performance. For ECM requirements, frequency diversity radar or any other broadband microwave application, ITT has a complete line of S-band, C-band and X-band TWTs rated from .050 to 10 watts CW and to 1 kilowatt pulse output. ITT traveling wave tubes are available for immediate delivery and are backed by the world-wide resources and facilities of the ITT System.

Write for information on the complete line of ITT traveling wave tubes. Application assistance is available for your specific requirements.

ELECTRON TUBE DEPARTMENT ■ COMPONENTS DIVISION

INTERNATIONAL TELEPHONE AND TELEGRAPH CORPORATION, CLIFTON, NEW JERSEY

ITT COMPONENTS DIVISION PRODUCTS: POWER TUBES · IATRON STORAGE TUBES · HYDROGEN THYRATRONS · TRAVELING WAVE TUBES · SELENIUM RECTIFIERS · SILICON DIODES AND RECTIFIERS · TANTALUM CAPACITORS

Whom and What to See at the IRE Show

(Continued from page 340A)

Sanborn Company, Booths 3701-3705
Waltham 54, Mass.

Steven Bilowich, Ralph Hanson, Edgar Pulsifer, ▲ R. Paul Foster, A. E. Lonnberg, ▲ Arthur Miller, ▲ J. William Sauber

Models 311 portable transducer amplifier indicator, 321 portable 2-channel carrier amplifier recorder, *322 portable 2-channel medium gain dc amplifier recorder, 358-16 16-channel direct-writing oscillograph, 650 direct writing optical oscillograph and associated amplifiers, 769 8-channel monitor oscilloscope.

† See PROCEEDINGS OF THE IRE—Jan., Feb., March, April, May, June, Aug., Sept., Oct., Nov., Dec. (1960), Feb., March (1961) for further information on our products.

See 1961 IRE DIRECTORY, pages 64 and 65, for complete information on our products.

Engineers find facts faster in the IRE Directory. Copies may be purchased at IRE booths in the Coliseum lobby or the Waldorf-Astoria.

Sanders Associates, Inc., Booth 1723
95 Canal St.
Nashua, N.H.

Robert W. Polley, Robert W. Danielson, Donald Ayer, Charles Bucci, Morris Silverman, James Russell, Harvey Hollister, Louis A. Garten, William Clark

"Tri-Plate" strip transmission line components and engineered circuits; semiconductor mounts; high-speed pulse circuitry for computers. "Flexprint" harnesses and cables as equipment components. "Minicube" blower, one-inch cube. Special instruments and controls; weapons systems engineering.

Sanford Mfg. Corp., Booth 4038
See: Micromech Mfg. Corp.

Sangamo Electric Co., Booths 2205-2207
11th and Converse Sts.
Springfield, Ill.

▲ R. R. Wylie, H. L. Kunz, ▲ G. M. DeKraker, ▲ Roger Miller, Cal DeMars, ▲ Ken McGee, ▲ C. H. Hudson, ▲ Richard Pline, Ralph Moon, Alex Finley, ▲ Glen Schulze, Roy Thomas

Mica, paper and plastic film capacitors, miniature transformers, filters, coils. Record/reproduce magnetic tape systems.

Sargent & Greenleaf, Inc., Booth 1508
See: Security Devices Laboratory.

▲ Indicates IRE member.
* Indicates new product.
† Exhibitor is servicing IRE Engineers through the IRE Package Plan.

Sarkes Tarzian, Inc., Booth 1730
415 N. College Ave.
Bloomington, Ind.

S. Tarzian, S. Niciejewski, W. Petrosky, F. Lucas, H. Anderson, E. Riggs, E. Chadwick

Complete line of silicon rectifiers and other semiconductor devices, current ratings from 150 ma to 1000 amperes and voltage ratings from 50 to 10,400 (in assembly) volts. Also showing selenium rectifiers, magnetic tape and television tuners.

Schutter Microwave Corp., Booth 1728
80 East Montauk Highway
Lindenhurst, N.Y.

▲ Norman Kjeldsen, ▲ Milton D. Hirsch, ▲ Edward Buckley, ▲ Dan McDonald, ▲ Frank Lippman

Microwave components, mixers, duplexers, bends, attenuators, adapters, transitions, suppressors and rotary joints & dummy loads.

Scientific-Atlanta, Inc., Booths 3936-3938
2162 Piedmont Rd., N.E.
Atlanta 9, Ga.

▲ Glenn P. Robinson, Jr., ▲ William H. Bradley, ▲ J. Searcy Hollis, ▲ Roland E. Moseley, R. Bradford Ellis

1.) 2/axis servo driven telemetry antenna positioner; 2.) Solid state servo amplifier; 3.) Synchro buffer amplifier for driving up to six synchro indicators; 4.) High speed rotary joint, operating range dc to 16 kmc; 5.) Coaxial bolometer detector mount; 6.) Coaxial shunt mixer; 7.) Coaxial resistive network.

Scintilla Div., Booths 2222-2232 & 2329-2331
See: Bendix Corporation.

H. H. Scott, Inc., Booth 3950
111 Powder Mill Road
Maynard, Mass.

William Glaser, ▲ E. Dyett, Bruce Langmuir, ▲ Thomas Pickett, ▲ Rob Crane, W. Hague, Rob Julian, Rob Bergman, Jean Jolkovski, John Carlson

Sound Meter

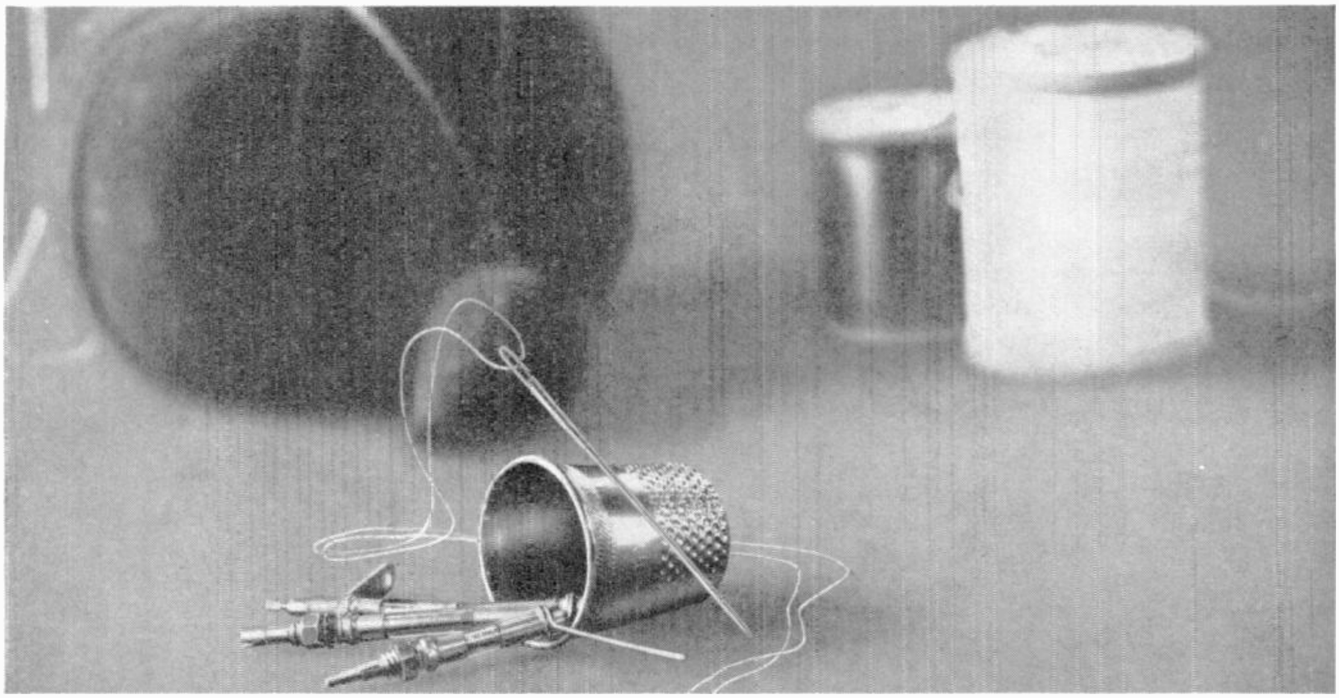
Sound meter, sound level meter, sound analyzer, random noise generator, decade amplifier, AF power amplifier, logarithmic indicating amplifier, FM broadcast monitor, high fidelity component kits.

Seal-A-Metic Div., Booth 2808
Glass-to-metal seals. See: Filtors, Inc.

(Continued on page 344A)

A complete listing of all registrants at the IRE Show and Convention, showing company affiliation and local hotel, is posted on the back wall of the mezzanine on the west side of the first floor.

YOU ARE LOOKING AT THE WORLD'S SMALLEST PISTON CAPACITOR THE tiny-trim*



A major advancement in variable piston capacitors developed and offered exclusively by JFD

New from JFD—the *Tiny-Trim*—so small, so slim, that you can carry a dozen of them in a thimble!

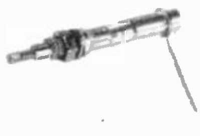
One-fourth the weight and less than *one-half* the diameter of JFD miniature trimmer capacitors, the *Tiny-Trim* is JFD's answer to the exacting demands of sub-miniature design. It delivers *more* capacitance per cubic inch than any other conventional variable piston capacitor — plus the advantages of premium reliability, unique adaptability, and unprecedented sensitivity.

JFD *Tiny-Trim* capacitors are available in panel mount and printed circuit board types that meet or exceed applicable performance requirements of MIL-C-14409A. Write today for complete data of this dramatic new development and how it can help you solve your space, weight and reliability problems.

- Overall diameter: 1/8 inch. Overall length above panel: 35/64 inch to 1-1/64 inch.
- Double the sensitivity of JFD standard trimmers. Special adjust mechanism provides 102 turns per inch for extra fine adjustment.
- Increased maximum to minimum capacitance ratio per unit (minimum: 0.5 pf.).
- Operating temperature $-55°$ to $+125°$C.
- Low temperature coefficient of capacitance.
- Anti-backlash design for precise tuning resolution.
- Low inductance for high frequency use.
- Ultra linear tuning assures accurate alignment—absolute repeatability.
- Rugged shock and vibration resistance.
- 500 V. DC working voltage.
- 10^6 megohms insolation resistance.
- Q factor of 500 (measured as per JFD #5178).
- 0.5 inch ounce tuning torque.

Model*	Capacitance Range MMF Measured Per JFD #5177 Min.	Max.	D.C. Working Volts	Dielectric Strength Measured For 5 Seconds at 50% R.H. at Max. Rated Cap.	Insulation Resistance Measured After One Minute at 500V. D.C. and 50% R.H.	Q Factor Measured Per JFD #5178	Unit Weight Grams	Dimen.** Max. ±1/32 K
TT901	0.5	2.0	500	1000	10^6 Megohms	500	0.62	25/64
TT902	0.5	3.0	500	1000	10^6 Megohms	500	0.64	33/64
TT903	0.5	5.0	500	1000	10^6 Megohms	500	0.79	49/64
TT904	0.5	7.0	500	1000	10^6 Megohms	500	0.94	1-1/64

*These units are also available in the same capacitance values for printed circuit boards in models TT911, TT912, TT913 and TT914. **Length front of panel.



(shows actual size) Model TT902

*Trademark

Order from your local JFD Component Distributor who can supply your requirements up to 299 pieces or order direct for production quantities.

JFD

JFD ELECTRONICS CORPORATION

Components Division • 6101 16th Avenue • Phone DEwey 1-1000 • TWX-NY25040

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P.O. Box 3416	6414 W. Higgins Ave.	Ruth Drive	51 McCormack Street
7311 Van Nuys Blvd.	Chicago, Illinois	Marlboro, Mass.	Toronto, Ontario, Canada
Van Nuys, Calif.	Phone: SPring 4-4175	Phone: HUntley 5-7311	Phone: ROger 9-1129
Phone STate 1-3530			

VARIABLE TRIMMER PISTON CAPACITORS • FIXED METALIZED INDUCTORS • LC TUNERS • DIPLEXERS
FIXED AND VARIABLE, DISTRIBUTED AND LUMPED CONSTANT DELAY LINES • PULSE FORMING NETWORKS

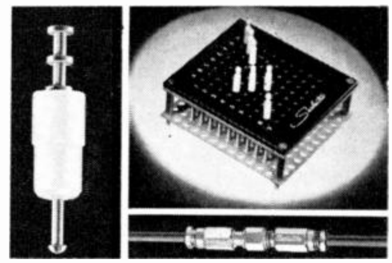
BE SURE TO VISIT JFD BOOTH 1622 AT THE NEW YORK IRE SHOW

Whom and What to See at the IRE Show

(Continued from page 312A)

Sealectro Corp., Booth 2919
610 Fayette Ave.
Mamaroneck, N.Y.

William Silberstein, George Mohr, Augustus S. True, Larry Willis, Albert Powell, Milan Robich, Robert Walcovy, James Iantorno, George Bechtold, William McNulty, Paul Carmel, Remi Wrona, Jack Itzkoff, Joseph Zukovich



New products shown by Sealectro include greatly extended line of "Press-Fit" teflon terminals for virtually every requirement. *new concept in fast-assembly "Con-Hex" subminiature RF connectors, complete cordless program system utilizing the "Sealectoboard" for switching and component interpositioning by simple push of a pin at desired point in circuit.

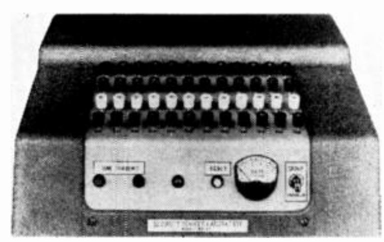
Secon Metals Corp., Booth 1052
7 Intervale St.
White Plains, N.Y.

▲ Eugene Cohn, Richard Gordon

Wire for the heart of your component: Engineered for precision potentiometers, semiconductors, resistance thermometers, and strain gages. 600°C insulated wire, potting cements, galvanometer suspension strip, electroplated wire, high tensile strength magnet wire, fuse wire, fine ribbon and titanium wire.

Security Devices Laboratory, Electronics Div. of Sargent & Greenleaf, Inc., Booth 1508
21 Seneca Ave.
Rochester 21, N.Y.

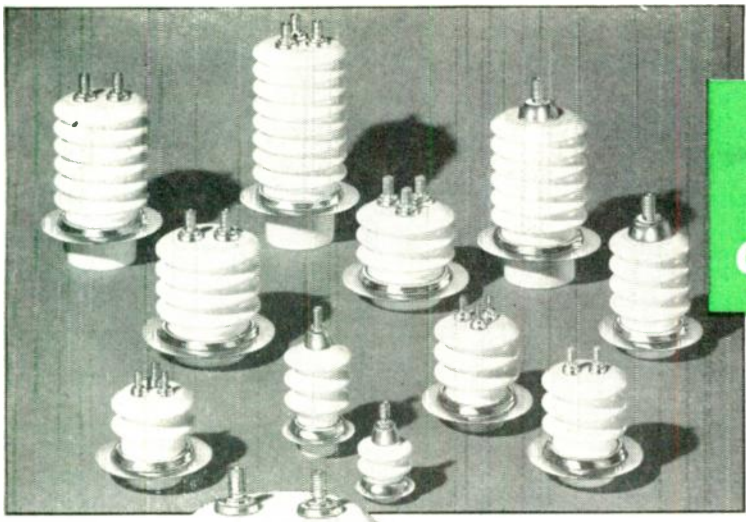
Joseph Williams, Robert Gillette, Harvay Dorren



ET 12-4 Encoder

Resonant Reed Relay: Oscillator Control. Resonator J610 oscillator and J500 relay controls are extremely stable electromechanical component devices used to generate and decode specific alternating current signals. Also encoder and decoder equipment and BF series battery holders to accommodate all cell sizes.

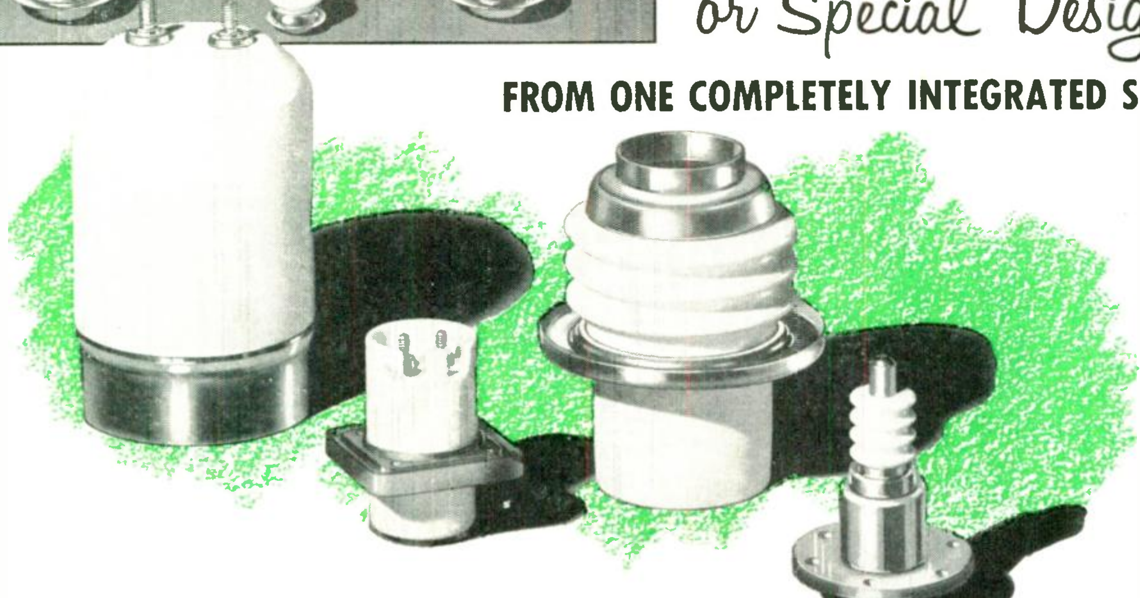
(Continued on page 316A)



ALITE®
CERAMIC-TO-METAL SEALS

Standard Bushings or Special Designs

FROM ONE COMPLETELY INTEGRATED SOURCE



ALITE — with its completely equipped facilities for producing high quality, vacuum-tight, ceramic-to-metal seals — is geared to meet all your requirements for high alumina ceramic-metal components. From design to finished assembly, every manufacturing step — including formulating, firing, metalizing and testing—is carefully supervised in our own plant. Result: effective quality control and utmost reliability.

Hermetic seals and bushings made of high alumina Alite are recommended for electromechanical applications where service conditions are extremely severe or critical. Alite has high mechanical strength and thermal shock resistance. It maintains low-loss characteristics through a wide frequency and temperature range. It resists corrosion, abrasion and nuclear radiation. Its extra-smooth, hard, high-fired glaze assures high surface resistivity.

To simplify design problems and speed delivery, Alite high voltage terminals, feed-throughs and cable end seals are available in over 100 standard sizes. However, when specifications call for special units for unusual applications, you can rely on expert assistance from Alite engineers to help you take full advantage of Alite's superior properties.

Write us about your specific requirements today.

WRITE FOR HELPFUL FREE BULLETINS

Bulletin A-7R gives useful comparative data. Bulletin A-40 describes Alite facilities and complete line of Alite Standard Bushings.

ALITE DIVISION

U. S. STONEWARE

BOX 119 ORRVILLE, OHIO

New York Office — 60 East 42nd St.

102-G

Whom and What to See at the IRE Show

(Continued from page 344A)

Selectrons Ltd., Booth 4431
See: Marlane Development Co., Inc.

Semicon Associates, Inc., Booths 2708-2720
See: Varian Associates

Semiconductor Products, Booth 4126
See: Cowan Publishing Corp.

Seminole Div., Booths 2306-08
See: Airpax Electronics, Inc.

Sensitive Research Instrument Corporation, Booths 3409-3411
310 Main St.
New Rochelle, N.Y.

Marvin I. Steinberg, Leonard J. Patterson, ▲ H. Russell Brownell, Michael Kane, Robert Most, F. Patrick Johnston, Ronald Wangerin, Earl Elliott

AC-DC calibration consoles; .01% transfer standard; precision vernier potentiometer; expanded scale, self-checking polyranger; pocket size dc instrument calibrator; variable standard mutual inductor; electrical indicating instruments, standard cells, galvanometers, shunts and accessories for voltage, current, power and magnetic measurements.

†

See PROCEEDINGS OF THE IRE—Jan. through Dec. (1960), Jan. through Dec. (1961) for further information on our products.

See 1961 IRE DIRECTORY, page 202, for complete information on our products.

Servel, Inc., Booth 2709
See: Burgess Battery Co.

Servo Consultants, Ltd., Booths 3406-08
Nyquist diagram plotter. See British Industries Corp.

Servo Corporation of America, Booths 3707-3709
11 New South Rd.
Hicksville, L.I., N.Y.

▲ B. G. Evans, ▲ R. J. Johnson, ▲ J. E. Niebuhr

General and special purpose pulse instrumentation, analog and digital; time delay generators; magnetic core testers; voltage and current calibrators; electronic counters. See also: Electro-Pulse, Inc.

Servo Dynamics Corp., Booths 1405-1407, 3506-3508
Box 310
Dover, N.H.

A. R. Abbott, J. Bowler, B. Osthues, C. S. Smith

Servo devices. See also: National Co., Inc., and National Radio Co., Inc.

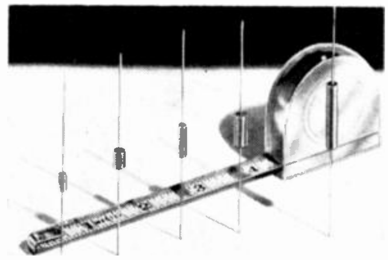
Servomechanisms, Inc., Booth 2715
See: Mechatrol Division

Your firm not listed?

If you would like to become an exhibitor in the IRE show, write for information to IRE Exhibits Dept., 72 W. 45th St., New York 36.

Shallcross Manufacturing Company, Booth 2634
Selma, N.C.

D. M. O'Halloran, R. B. Crisp, J. C. Barbour, Dewees H. Shallcross, John S. Shallcross, C. W. Sharek



Subminiature Precision Wirewound Resistors

*AC decades, *subminiature resistors, *miniature delay lines, resistors, resistance networks, RC networks, bridges, rotary switches, attenuators.

Shell Cast Corp., Booth 4111
Larger chassis. See: Arwood Corp.

Shepherd Industries, Inc., Booth 1930
103 Park Ave.
Nutley 10, N.J.

John French, Dan Giffin, ▲ Dr. William Duerig, ▲ William Murphy, Art Leuthesser, ▲ Don Killen, L. L. Driggs, Dan Coll, Dave Carpenter

Digital tape transports, bin type and airborne; digital magnetic memory drums; magnetic heads for tape transports and drums; logic circuitry, solid state amplifiers; analog tape transports.

Shielding, Inc., Booths 3061-3062
514 North Read Ave.
Riverton, N.J.

▲ John W. McDonald, Jr., ▲ I. P. Reath, James J. McDevitt, A. M. Diccianni, Paul L. Amore, J. V. Walsh, J. A. Maguire

Shielded enclosures and accessories.

Shockley Transistor, Unit of Clevite Transistor, Booth 2118
Stanford Industrial Park
Palo Alto, Calif.

▲ Frank Newman, ▲ David R. Steenhausen

Type D, AD, J and G 4-layer silicon (switching) diodes and the *new Type E 4-layer, subminiature, glass packaged, silicon (switching) diode.

Shurite Meters, Booth 2734
2″ electrical indicating instruments in ac and dc. See: J-B-T Instruments, Inc.

Sibley Company, Booth 1108
Bridge St.
Haddam, Conn.

Merrill J. Whiston, Hal R. Roffman, Jr., Daniel Dewey, Jr., Robert Murray, John Churchill, Philip Goldthwaite, Walter Murray, R. S. Pettigrew, H. Carvey, James Gallagher

Printed circuits, disc and drum commutators, flushed or raised plated-thru hole circuits, and electronic assemblies. Engineering research and development, department for circuitry conversion, miniaturization and high-temperature applications. Precious metal plating of electronic parts.

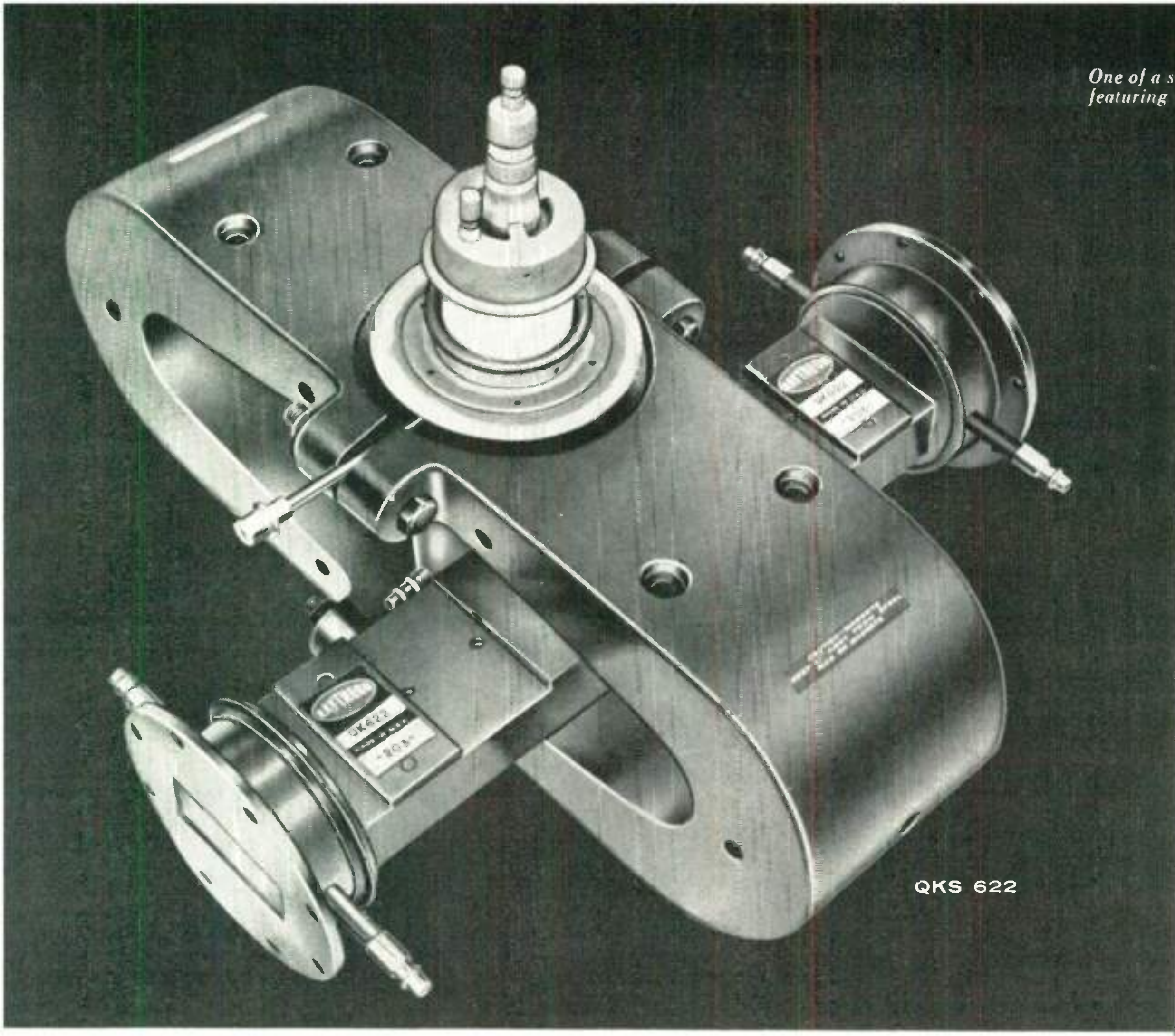
F. W. Sickles Division, General Instrument Corp., Booths 1101-1106
165 Front St., P.O. Box 330
Chicopee, Mass.

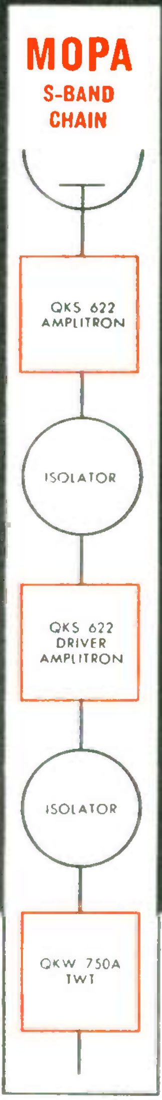
M. Cohen, H. Chapman, H. Lamothe, E. Gostyn, H. Wernick, F. Kitty, E. Messing

Delay lines and filters.

Siegert, Ltd., Booth 1822
Miniature deposited carbon resistors. See: British Radio Electronics, Ltd.

(Continued on page 348A)





Raytheon pulsed-type Amplitron* produces 3-megawatt S-band output at efficiencies of 75 to 80%

QKS 622 tubes are used as driver and final amplifier stages of broadband MOPA chain.

Raytheon Amplitrons are ideally suited for high power MOPA applications where extremely high efficiency is required. For example, a single QKS 622 Amplitron can produce up to 15 kw average and 3 megawatts peak power with 70 to 80% efficiency. Easily achieved parallel operation doubles these power outputs. Adequate drive power is supplied by the QKS 622 operating at lower levels.

This unusually compact 2,900 to 3,100 mc Amplitron has been operated at 30-microsecond pulse widths, and can be expected to perform satisfactorily at far greater widths. A companion tube, the QKS 783, covers 2,700 to 2,900 mc. Both tubes are specified for 1,000 hours.

QKS 622 GENERAL CHARACTERISTICS (Typical Operation)

	DRIVER	FINAL AMPLIFIER
Pulse Duration	11 μsec	10 μsec
Duty Cycle	.0055	.0050
Peak Anode Voltage	48-52 kv	50-54 kv
Peak Anode Current	20 a	66 a
Peak Power Output	600 kw	3.0 Mw
RF Driver Peak Power	48 kw min	550 kw min
Cold Insertion Loss	0.5db	0.5 db
Heater Power	None Required	

Write for detailed information and application service to Microwave and Power Tube Division, Raytheon Company, Waltham 54, Massachusetts. In Canada: Waterloo, Ontario.

*Raytheon Trademark

RAYTHEON COMPANY

RAYTHEON

MICROWAVE AND POWER TUBE DIVISION

BOSTON, MASS., BRowning 2-9600 • ENGLEWOOD CLIFFS, N. J., LOwell 7-4911 • BALTIMORE, MD., SOuthfield 1-0450 • CHICAGO, ILL., NAtional 5-4000 • DAYTON, OHIO, BAldwin 3-8128 • LOS ANGELES, CALIF., PLymouth 7-3151 • CANADA: Waterloo, Ont., SHerwood 5-6831

Whom and What to See at the IRE Show

(Continued from page 346A)

Sierra Electronic Corporation, Div. of Philco Corp., Booths 3031-3032
3885 Bohannon Dr.
Menlo Park, Calif.

Sanford K. Ashby, Harold D. Farnsworth, Martin J. Gothberg, Charles M. Volkland

*RF calibration test set, including 125 watt power sources and accurate power monitor for six frequencies from 30 through 1300 mc, calorimeters. *transistor testers, frequency selective voltmeters, monitoring oscilloscopes, bi-directional and termination wattmeter, waveguide and coaxial terminations.

Sierra Research Corporation, Booth 3024
P.O. Box 22
Buffalo 25, N.Y.

John P. Chisholm, Harold K. Fletcher, ▲ Herbert Mennen, ▲ Vernon H. Siegel, Robert J. Theisen, ▲ Sherwood H. Calhoun

PAM coders and decoders, computer accessories, analog multipliers, radar equipment, broadside array antennas, transistorized indicators, target simulators, and ship motion recording instrumentation, high-level torque meters.

Sigma Instruments, Inc., Booths 2628-2630
170 Pearl St.
S. Braintree 85, Mass.

P. Garnick, R. B. Wolf, C. E. Heller, H. W. Fleming, W. H. Holcombe, F. C. Burridge, R. H. Pierce, L. D. LaFlamme, L. B. Stein, Jr.

Stepping motor—operates up to 400 steps/sec.; with printed circuit becomes 10 and/or 20-position stepping switch, speeds up to 240 steps/sec. Microwatt-sensitive magnetic amplifier—for precise detection and control of temperature. Relays—sensitive, for general purpose and special applications.

Signal Magazine, Booth 4226
1624 Eye Street, N.W.
Washington 6, D.C.

W. J. Baird, Campbell Steward, Judith H. Shreve, Rita A. Gallagher

SIGNAL

SIGNAL Magazine—Official monthly publication of the Armed Forces Communications & Electronics Association, serving all branches of Government and Industry as it endeavors to maintain and improve cooperation between the Defense and Industry Team in design, maintenance and operation of communications, electronic and photographic equipment. Copies of March issue—featuring Air Force Communications-Electronics story, available for one dollar each.

Silicon Transistor Corp., Booth 1326
150 Glen Cove Rd.
Carle Place, L.I., N.Y.

Robert L. Ashley, Randolph Bronson, Donald DesJardin, Laurence LeBow, Howard E. Kaepplein, Jerrold Krasny

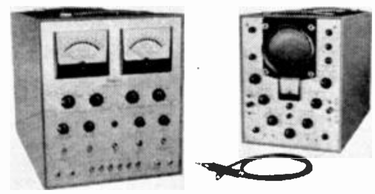
Silicon high conductance, fast switching, high temperature circuit diodes in subminiature glass package. Reliable silicon power transistors from 15 to 85 watts, 5 amps, very low saturation resistance.

Simberkoff Sales Co., Booth 1206
See: Collins Electronics, Inc.

Simplex Wires and Cables, Booth 4215
See: Hitemp Wires Co.

Simpson Electric Company, Booths 2321-2325
5200 W. Kinzie St.
Chicago 44, Ill.

J. R. Whiteside, M. O. Buehring, W. R. Johansen, P. DePaolo, I. Rebeschini, A. Stephens, A. Arbeiter, R. Tice, A. Weill, J. Mandel



Laboratory Test Equipment

Laboratory test equipment featuring wide band oscilloscope, pulse generator, and self powered laboratory standard calibrator. Complete line of meters in various styles and sizes designed for stock and custom. Round, rectangular, and wide view. Portable test equipment for industrial, radio/television, military and communications applications.

Sinclair Radio Laboratories Inc., Booth 1337
412 Chamber of Commerce Bldg.
Buffalo, N.Y.

▲ Dr. George Sinclair, ▲ Peter Yachimec, ▲ Dr. W. V. Tilston, ▲ Dr. J. R. Richardson, ▲ Floyd G. Buckles, Russell G. Sears

*New close channel separation duplexer in 150 to 175 mc band. *New high selectivity band pass filters, also in 150 to 175 mc band. *New tunable military vehicle antenna in 30 to 50 mc band. Various special low pass filters. Various communications antennas.

Singer-Bridgeport, Div. of The Singer Mfg. Company, Booth 1917
915 Pembroke St.
Bridgeport 8, Conn.

T. William Benedict, R. E. Karcher, N. R. Williams, Jr., Richard Norwood, H. C. Avrigan, Walter Benning

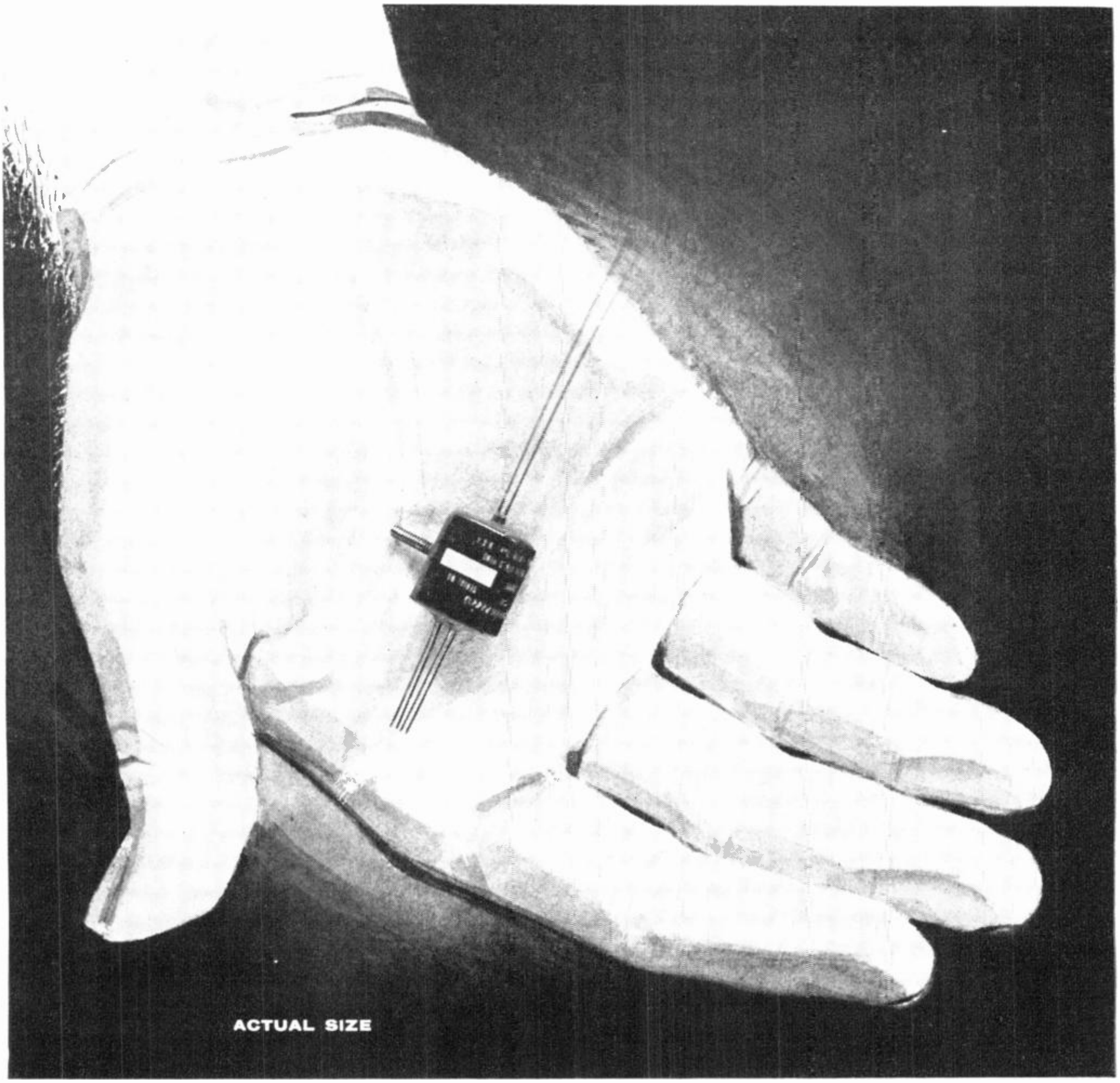
Hi-shock switches, timing mechanisms, Replicote mirrors, fiber optics, electronic components, security systems and components, optical electronics components. See also: Diehl Mfg. Co.

Skottie Electronics, Inc., Booth 2602
Disc and tubular type ceramic capacitors. See: Astron Corp.

(Continued on page 350A)

FIRST AID ROOM
First mezzanine. Take elevator 20 from north side of any floor.

▲ Indicates IRE member.
* Indicates new product.
† Exhibitor is servicing IRE Engineers through the IRE Package Plan.



GIANT IN PERFORMANCE — MIDGET IN SIZE

PERFORMANCE PROVED UNDER PEAK OPERATING CONDITIONS

Designed for both military and industrial applications requiring maximum performance and minimum size to meet modern high performance standards of the most sophisticated electronic systems. The Spacetronics Chopper* is hermetically sealed and perfectly balanced. Wiping action makes the unit an excellent dry circuit component. The Chopper provides dependable performance under conditions of shock, vibration and other environmental conditions. Design has virtually eliminated thermal EMF's generally experienced between contact materials and leads to encasements. An inquiry directed to Spacetronics, Inc., P. O. Box 12325, Fort Worth, Texas, will provide you with additional details on this highly versatile component.

Spacetronics
INCORPORATED

*Manufactured and sold under license from Rawco Instruments, Inc.

6000 CAMP BOWIE BOULEVARD — FORT WORTH, TEXAS

Skydyne, Inc., Booths 1514-1515
River Road
Port Jervis, N.Y.

▲ Robert L. Weill, ▲ William F. Maccallum, Larry McFadden, Ted Porter, G. B. Parsons, Steven E. Mautner

Standard line of molded fiberglas cases; sandwich construction test bench and sandwich construction transit or carrying cases. *New design and construction concept for greater protection of sensitive equipment—one piece construction, completely bonded. Also combined transportation operational cases.

Sliding Mechanisms, Inc., Booth 4522
2701 W. Ohio St.
Chicago 12, Ill.

James W. Houck, Rodney Turner, James W. Houck, Jr., Louis S. Adezio, Jerry Bouton, Ellis Scovel, Louis J. Ackerman, Gill Bassin, Herman C. Bloom, Henry J. Kobitter, Phyllis Kobitter

*New Positive Slide Lok, eliminates problem of locks releasing under shock and vibration testing. Guaranteed not to unlock or open unless manually released by means of rod release button. Combinations of locking and pivoting mechanisms in either closed or extended or both closed and extended positions.

▲ Indicates IRE member.
* Indicates new product.
† Exhibitor is servicing IRE Engineers through the IRE Package Plan.

Whom and What to See at the IRE Show

(Continued from page 348A)

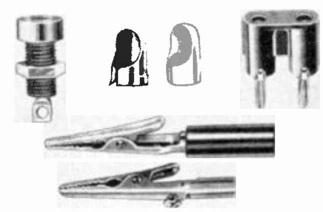
Slip Ring Company of America, Booth 2603
3612 W. Jefferson Blvd.
Los Angeles 16, Calif.

Robert A. Felburg, Robert E. Wolfe, Charles Gehrke, Don A. Hausrath

Stable platform slip rings & stable platform simulator for testing. Noble metal slip ring and switching devices.

Herman H. Smith, Inc., Booth 2225
2326 Nostrand Ave.
Brooklyn 10, N.Y.

Ira L. Landis, Sheldon Sackman, Charles Gold, Harry Weston, Nat Kopf

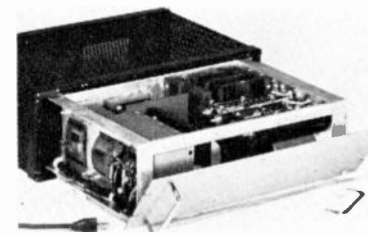


Complete line of phone tip plugs, jacks, banana plugs and jacks; binding posts; nylon plugs and jacks; alligator clips; test prods and test leads; cabinet handles, shaft accessories and mounting accessories; patch cords, standard, dual and subminiature; telephone type plugs and jacks.

Sodeco, Geneva, Switzerland, Booth 3045
See: Landis & Gyr, Inc.

Sola Electric Co., Div. of Basic Products Corp., Booths 2815-2819
1717 Busse Road
Elk Grove Village, Ill.

John Topel, ▲ H. U. Hjermstad, ▲ R. H. Schlote, ▲ J. P. Kennedy, ▲ J. T. Keefe, ▲ R. DuChatellier, J. E. Warhola, L. C. Marschall, N. P. Marshall, H. H. Haass, Don Frandson, R. J. Hesse, James Bowen



*Transistorized regulated dc power supplies (type CVQ). Static-magnetic ac voltage regulators—types available to serve voltage requirements of various applications: Line voltage (types CVS and CVN), filament (type CVF), plate-filament (type CVE). Static-magnetic regulated dc power supplies (type CVDC).

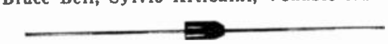
Solid State Products, Inc., Booth 1920
1 Pingree St.
Salem, Mass.

▲ R. W. Diamond, ▲ W. A. Schromm, ▲ J. B. Hangstefer, ▲ L. H. Dixon

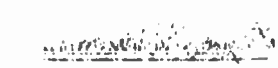
Advanced silicon semiconductor components: *PNPN controlled switches (TO-18). *PNPN Trigistors (TO-18), pulse on-off control, single base input. *Diffused silicon transistors. *PNPN photo-devices. Complete range of PNPN control and logic devices—controlled rectifiers, controlled switches and Trigistors.

Solitron Devices, Inc., Booth 2005
500 Livingston Street
Norwood, N.J.

Benjamin Friedman, ▲ William Kearns, Frank Wisnewski, Paul Breen, Jr., Ray DeFelice, Bruce Bell, Sylvio Artibalni, Venable Hudson



SOLITRON SOUNVISTER WHITE NOISE DIODE



WHITE NOISE SPECTRUM

(Random Noise 2 to 20,000 cycles)

Manufacturers of hermetically sealed, double diffused silicon rectifiers, axial type up to 6 amps, 1200 volts, PIV, also stud base units, full-wave bridges, high voltage solidpaks, dual diodes, "Sounvister," white noise diodes, noise sources and generators.

Sonobond Corporation, Subsidiary of Aeroprojects, Inc., Booth 4235
310 E. Rosedale Ave.
West Chester, Pa.

R. S. Ames, D. D. Kirkpatrick, W. N. Rosenberg, E. B. Webb, D. Maryott, R. S. Hurley, E. D. Fox, J. M. Peterson

Ultrasonic metal joining equipment. Featuring a 100 watt "Sonoweld" ultrasonic welder, automatically welding wire to wire and wire to tabs.

Sonotone Corp., Booth 1901
Elmsford, N.Y.

J. August, P. Caddoo, O. Hammelmann, R. McCarthy, E. Murphy, L. Sajor

Vented and sealed sintered plate, nickel cadmium cells. Space environment batteries. Electronic power supplies missile ground support power supplies.

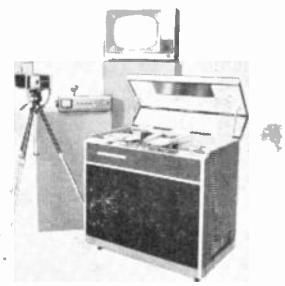
(Continued on page 352A)

Whom and What to See at the IRE Show

(Continued from page 350A)

Sony Corporation, Booth 1732
351 Kitashinagawa-6
Shinagawa-ku, Tokyo, Japan &
514 Broadway
New York 12, N.Y.

Hiroshi Tada, Nobutoshi Kihara, Tsuneo Morita, Thomas Y. Arai



Products of Sony Corporation

Memory heads for magnetic drums. Video recording heads. Video cameras. Sony Hi-D tape.

Sorensen & Co., Inc., Subsidiary of Raytheon Company, Booth 2604
Richards Ave.
South Norwalk, Conn.

J. M. Polis, R. E. Slater, ▲ B. Campbell, K. A. Rich, C. Woodhull, R. A. Lewis, G. Patton

*New power supplies including: Regulated variable-voltage "B" supplies; miniature transistorized supplies; high and low voltage supplies; also *new frequency changers, inverters and converters. Series "M" magnetic voltage regulating transformers for line regulation, filament regulation and power supply application.

Southco Division, South Chester Corp., Booth 4407
3rd & N. Gov. Printz Blvd.
Lester, Pa.

T. A. Guiler, A. E. Anstett, T. R. Dunlevy, H. J. Jordan, R. E. Seixas, W. S. Clement, J. O. Snyder, R. E. Kirmss

Standard and specialty fastening devices for electronic equipment. *Quick inject-eject fasteners for printed circuit boards. Standoff thumb screws, dawl fasteners, latches and locks for removable panels, slides, etc. Blind rivets.

Southern Electronics Corporation, Booth 2217
150 W. Cypress Ave.
Burbank, Calif.

▲ Norman Schwartz, George E. Gansell, Will Gold, Charles Hampson, Jack Klein, John McNamara

Precision plastic capacitors meet Mil C 19978 and Mil C 25A. Subminiature polystyrene capacitor. Designed into 15 missile applications and major analog computer integrators.

Space Technology Labs., Inc., Booths 1435-1635

See. Thompson Ramo Wooldridge, Inc.

Sparta Mfg. Div., Booth 4105

See: Diamonite Products Mfg. Co.

Spaulding Fibre Co., Inc., Booths 4216-4217
310 Wheeler St.
Tonawanda, N.Y.

E. C. Leitz, J. E. Miner, G. W. Voss, F. H. Fellows, B. E. Grogg

Spauldite laminates for electronics, phenolics, melamines, epoxies, polyesters, glass filament wound tube GFW-10, copper clad laminates, vulcanized fibre, fibreboards, fire resistant and high temperature laminates.

Specific Products, Booth 3908
21051 Costanso St.
Box 425
Woodland Hills, Calif.

▲ J. C. Van Groos, ▲ John Cowley, James Sherman, ▲ Norman Riemenschneider, Vern Hopfler, Robert Myers, ▲ Robert Walp

WWV receivers. Model WWVC, Model SR7. Transistorized WWV receivers, battery operated Model *WVTR. *New VLF receiver Model VLA. Model AK8 antenna kit.

Spectra Electronics Corp., Booths 2241-43

Ultra-violet density meter. See: Douglas Microwave Co., Inc.

Spectrol Electronics Corp., Booths 1907-1909
1704 South Del Mar Ave.
San Gabriel, Calif.

Bob Chase, Don Vaughan, Harry Jackson, Gene Young, Les Williams, Dick Lewis, Frank Bianchi, Dick Smetana, Paul Trautmann, Bert Swirsky, Tom Finlay

*Model 80 transistor-size potentiometer in printed circuit or panel mount style. *Models 50 and 60, 3/8" and 1/2" square trimmer potentiometers in aluminum case. Thirty-eight standard models single-turn and multiturn precision potentiometers. *Model 30 satin-chrome finish ten-turn indicating dial. Transistorized-miniaturized power supplies.

Spectrum Instruments, Inc., Affiliate of Probescope Co., Inc., Booth 3234

See: Probescope Co., Inc.

Sperry Rand Corporation, Sperry Electronic Tube Division, Booth 2735
Gainesville, Fla.

▲ J. R. Whitford, ▲ V. R. Learned, W. J. McClenahan, G. R. Lawrence, ▲ R. W. Cornes, D. E. Musgrave

Complete family of klystron and traveling wave tubes for aero-space and ground based microwave systems. Covering P through Q bands, milliwatt to multi-megawatt applications.

Sperry Rand Corporation, Sperry Gyroscope Company Division, Booth 2739
Great Neck, L.I., N.Y.

K. Brigham, C. Jay Moorhead, J. J. Rutherford

Semiconductor components, klystron tubes, traveling wave tubes, microwave components and antennas.

Sperry Rand Corporation, Sperry Microwave Electronics Co. Division, Booth 2737
Clearwater, Fla.

F. Lavelle, J. Leutwiler, C. Brown, J. Newitt, G. Eckert, P. Ely, D. Wells

Microline, complete line of microwave test instruments, miniaturized isolators and circulators, radar test equipment.

Sperry Rand Corporation, Sperry Semiconductor Division, Booth 2733
South Norwalk, Conn.

G. W. DeSousa, W. Montgomery, ▲ D. G. Paterson, ▲ L. L. Emmel, E. P. Berlin, L. C. Grannis, J. Cuzzupoli, S. Austin, C. Symeon, J. Sausais, R. Bossert, A. Berry, ▲ W. Blinoff

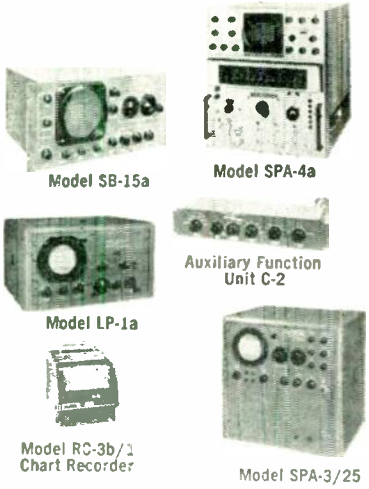
Silicon alloy PNP transistors; silicon NPN mesa transistors; general purpose silicon diodes; low current silicon computer diodes; high current silicon computer diodes; high voltage silicon computer diodes; *silicon Stabistor diodes; *"Semi-Nets"®—Semiconductor integrated networks; *silicon PNP chopper transistors.

Sperry Rand Corp., Wright Machinery Co. Division, Booth 3054

See: Wright Machinery Co.

(Continued on page 361A)

▲ Indicates IRE member.
Indicates new product.
† Exhibitor is servicing IRE Engineers through the IRE Package Plan.



Model SB-15a

Model SPA-4a

Auxiliary Function Unit C-2

Model LP-1a

Model RC-3b/1 Chart Recorder

Model SPA-3/25

in spectrum analysis 5 cps—44,000 mc.

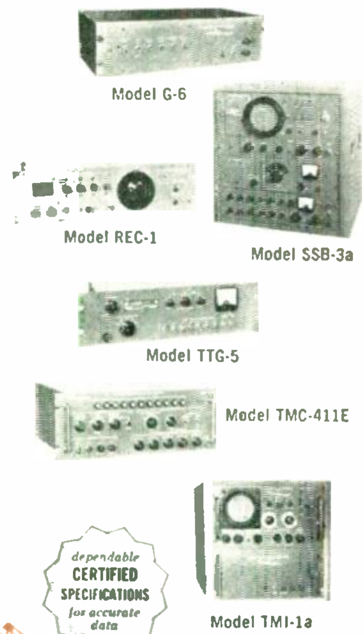
NEW Model SPA-4a Microwave Spectrum Analyzer: 10 mc-44,000 mc without changing heads. Unsurpassed **usable** sensitivity, exceptionally low distortion, high resolution capability, and accurate frequency and amplitude calibration are among the SPA-4a's exclusive features for more reliable microwave spectrum analysis. Other important advantages for fast, simple, accurate analysis include: ONE tuning head (1 HF triode and 2 klystrons); 2 independent, continuously adjustable, stable dispersion ranges (0-70 mc and 0-5 mc); adjustable IF bandwidth 1-80 kc; push-button range selector; and 3 calibrated amplitude scales.

Model SB-15a Ultrasonic Spectrum Analyzer: 0.1 kc-600 kc. Only 8¾" high. Features variable sweep width (1 kc-200 kc), resolution capability of 100 cps. (automatic and manually adjustable), 60 db dynamic range. Ideal for a wide variety of applications.

NEW LP-1a Spectrum Analyzer, Aux. Unit C-2, RC-3b/1 chart recorder combination: 5 cps-22.5 kc. LP-1a range extended down to 5 cps. Improved variable resolution, from 2 cps. up, provided by Unit C-2's highly selective narrow band filters. Model RC-3b/1 12" × 4½" chart readouts and adjustable scanning times (10 secs-16 hrs) supplement LP-1a's "quick look" CRT analyses. Adjustable sweep widths (40 cps-5 kc). 60 db dynamic range. Combination widens applications of this time proven spectrum analyzer for noise, vibration, harmonic and other AF spectrum analyses.

Model SPA-3/25 Spectrum Analyzer: 1 kc-25 mc (usable to 200 cps). Variable sweep width 0-3 mc, resolution capability 200 cps. Versatile "workhorse" instrument for analyses in audio, video and communication bands. Also for noise studies.

you pose the problem...these Panoramic instruments provide fast, accurate solutions



Model G-6

Model REC-1

Model SSB-3a

Model TTG-5

Model TMC-411E

Model TMI-1a

in frequency response plotters ½ cps—15 mc.

Companion Sweep Generators used with Panoramic Spectrum Analyzers to automatically plot amplitude response vs. frequency of filters, amplifiers, transducers, etc. for single line display on analyzer CRT and/or chart. High analyzer selectivity and synchronous tracking of sweep generator by analyzer assure unlimited dynamic range, *response to fundamental frequency only* (filters out noise, hum, harmonics). Examples: G-6 used with SPA-3/25 (above) over 0-15 mc range, G-1 used with SB-15a (above).

in communications systems analysis

New Model SSB-3a Spectrum Analyzer, combined with REC-1 Range Extender (below) **and TTG-5 2-tone RF Generator** (below). A complete self-checking package for testing AM, SSB and multiplexed transmitters *and* receivers (100 cps-40 mc) by single and 2-tone methods. Uniform sensitivity over entire range. All distortion and internal hum down at least 60 db.

Model REC-1 Range Extender (100 cps-2 mc), optional for use with SSB-3a (above), SB-8b Type T200 and SB-12a Panalyzors. Features 0-15 kc incremental vernier for convenient, easily resettable fine tuning.

Model TTG-5 2-tone RF Generator, available separately. Furnishes pairs of crystal controlled signals from 3 mc-30 mc. Adjustable separations 0-0.1%. All unwanted signals down 60 db. Used for distortion analysis of receivers, RF networks, as 2 tone transmitter exciter.

Model TTG-2 2-tone AF Generator (100 cps-10 kc), part of SSB-3a (above), also available separately. Digital frequency selection, accuracy ± 2% (± 1% optional). Adjustable metered output 4 V max. @ 600 Ω. All unwanted signals down 60 db. A general purpose single or 2 tone source for distortion testing.

in telemetry test instruments

NEW, IMPROVED Model TMC-411E, all electronic 11 point Telemetering Frequency Calibrator. Provides all IRIG FM/FM channels simultaneously. Only 7" high. ± 0.002% accuracy, high reliability.

Model TMI-1a: 350 cps-85 kc. Spectrum analyzer for rapid monitoring of all or any part of subcarrier spectrum, checks pre emphasis, analyzes subcarrier, cross-talk, VCO deviations, etc.

dependable CERTIFIED SPECIFICATIONS for accurate data

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at I.R.E. booths 3402-3404

See these versatile instruments in dynamic action, solving actual problems. They're part of Panoramic's growing range of economical, easy-to-use devices for Research, Development and Production. Talk to Panoramic specialists about your specific problems.

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PANORAMIC RADIO PRODUCTS, INC.
522 South Fulton Avenue, Mount Vernon, N.Y.

Phone: OWens 9-4600 • TWX: MT-V-NY-5229 • Cables: Panoramic, Mt. Vernon, N.Y. State

eem

Sec. 2900

Positions Wanted

By Armed Forces Veterans

In order to give a reasonably equal opportunity to all applicants and to avoid overcrowding of the corresponding column, the following rules have been adopted:

The IRE publishes free of charge notices of positions wanted by IRE members who are now in the Service or have received an honorable discharge. Such notices should not have more than five lines. They may be inserted only after a lapse of one month or more following a previous insertion and the maximum number of insertions is three per year. The IRE necessarily reserves the right to decline any announcement without assignment of reason.

Address replies to box number indicated, c/o IRE, 1 East 79th St., New York 21, N.Y.

MARKETING/PRODUCT PLANNING

Data Communication Systems. Regional sales and field engineering manager, military and commercial accounts. Standard and special systems using wire line, radio and microwave transmission. Also experience in computer and special purpose EDP systems sales, advertising and sales promotion. BSEE. Age 37. 13 years experience. Box 3007 W.

ELECTRONICS SALES EXECUTIVE

South or Central America desired, as representative for electronics component or system manufacturing. BSEE 10 years applied experience from semiconductors to systems. Demonstrated managerial ability. Fluent in Spanish and other languages. Married and family. Previous overseas engineering experience. Member of IRE, age 37. Box 3008 W.

ENGINEERING EXECUTIVE

15 years experience in directing engineering departments in field of entertainment electronics, with additional background in manufacturing, purchasing, finance, and general management. Expert in handling growing pains of small company in $2,000,000-$5,000,000 yearly gross sales category. Age 40. Will consider participation. Box 3010 W.

ENGINEERING TECHNICIAN

Graduate of American Television Institute of Technology, with B.S. in Television Engineering. Married, age 37. 10 years experience in Radio and TV Broadcast Engineering. Wants position with up and coming firm that is going places with opportunity for further study and advancement desirable. Box 3011 W.

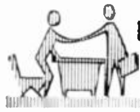
MANUFACTURERS' REPRESENTATIVE

California Experience. Now in New York area planning April 1961 return to West Coast. Interested in interviewing companies anxious for better representation and more sales. If not near New York suggest we meet during IRE Show, but please write now. Box 3015 W.

ENGINEERING TECHNICIAN

6 years experience in military communications systems and miniature audio systems. Will graduate from RCA Institutes (advanced electronics course) in February of 1961. Some college background. Age 28; married. Box 3016 W.

(Continued on page 356A)



Positions Wanted

(Continued from page 354A)

ELECTRICAL ENGINEER

Seeking management position. Nearly 10 years of successful experience in planning, organizing, and administering of various phases of projects in the development of electro-mechanical products from specifications through prototype and final test. Box 3017 W.

CONSULTING ENGINEER

BSEE. 1958, EIT certificate 1958. 2 years technical publications experience with technical and managerial training at the graduate level. 1 year Naval electronic school and 1 year as a Naval electronics technician. Other electrical utility and heavy steel mill control experience. Member IRE. Associate Member AIEE. Age 27. Desires association with an architectural and engineering firm. Box 3018 W.

TRANSFORMER DESIGNER

9 years experience in design, production, test and tooling for a wide variety of small transformers. Particular emphasis on design for epoxy encapsulation and on design of Hi Q reactors and low level multi shielded units. Box 3019 W.

ENGINEER

Age 33; married; 1 child. Navy Electronic Technician. BEE. Analytical, imaginative, artistic; not oratorical. 10 years experience with airborne electronic equipment. Seeks firm in Oklahoma, Minnesota, upper New York or Oregon which can express logical product-demand evaluation. Box 3028 W.

ENGINEER

Interested in production. BS. in E.E., MBA. in Production. Completed Active Duty. Box 3929 W.

EDITOR—PUBLICATIONS MANAGER

B.S. in Physics; 10 years technical writing experience, including 4 years as supervisor; 3 years teaching radio and television repair, laboratory and theory; holder of 1st class radiotelephone license; excellent mathematician; working knowledge of French, German and Russian; expert typist and stenographer. Desires position as editor of electronics publication or as supervisor in publications section of electronic equipment manufacturer. New York City area preferred. Box 3930 W.

PATENT ADMINISTRATION

Age 40. Engineering and Law degrees. 9 years experience prosecuting and preparing patents in the complex electronics arts in radio, radar, TV, scopes, UHF, VHF fields. Desires position in small company or law firm anywhere in U.S. Box 3931 W.

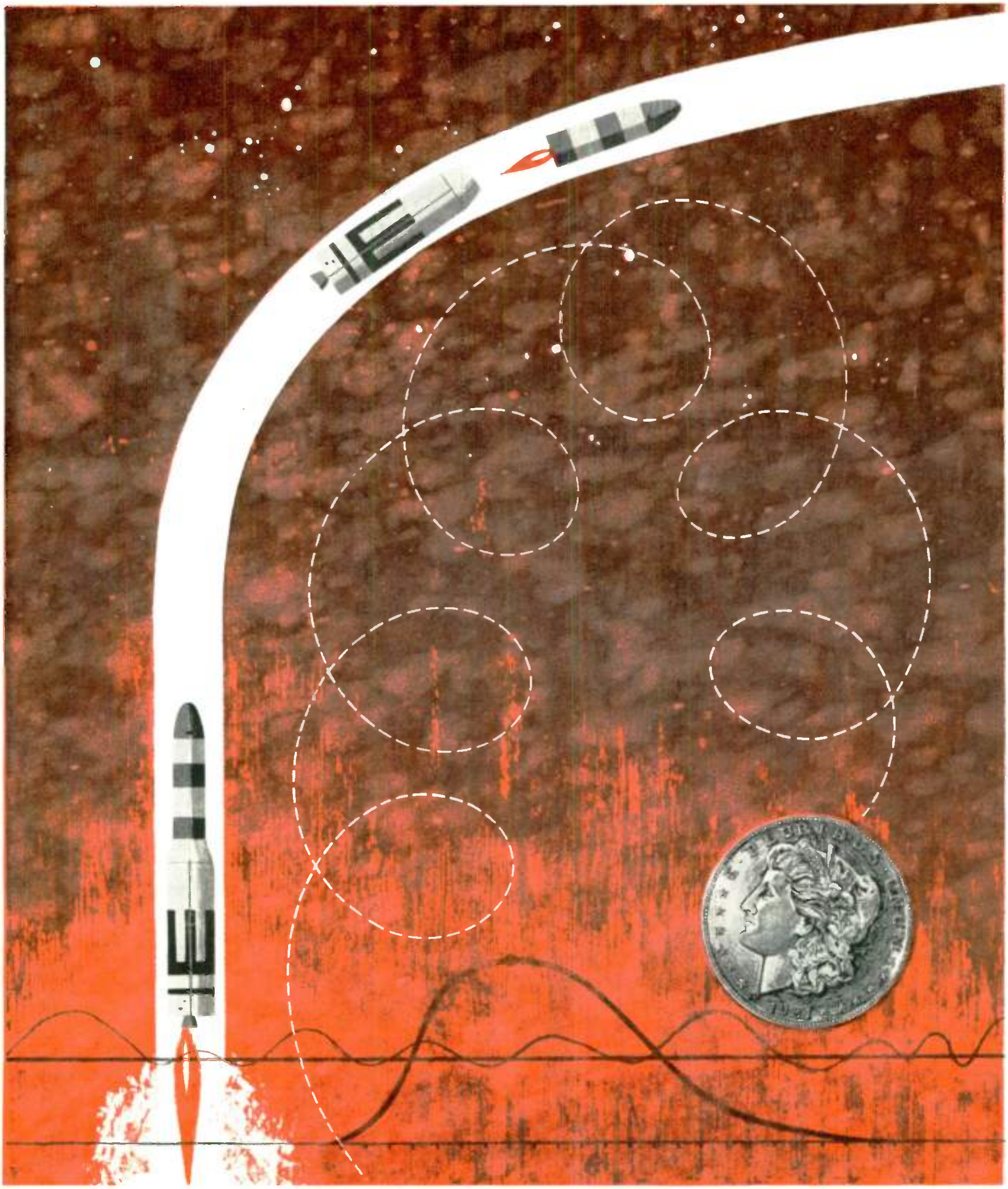
ENGINEER—PILOT

Age 27; BSEE, 1961; 6 years experience piloting USAF all-weather interceptors; presently Assistant Operations Officer, Instrument Flight Examiner, and Instructor Pilot in F-102A and T-33A Aircraft of an ADC Squadron; 1500 Jet hours. Desires position as aircrew member testing airborne electronic equipment. Box 3932 W.

DIGITAL COMPUTER ENGINEER

MEE. Experienced in all phases of digital computer engineering, including significant supervisory, circuit design, logical design, system de-

(Continued on page 358A)



BUT, MONSIEUR BERTRAND, OUR COINS HAVE MEMORIES!

You said, "A coin has neither a memory nor a conscience." The reliability of our inertial guidance systems depends on their having both. Thus our reliability engineers must go beyond your venerable formulae in developing dependable guidance packages for missiles like Titan.

If the application of existing theory into usable reality challenges you, and if you have a BS, MS or PhD in EE, ME, Physics or Math, please contact Mr. F. B. Allen, Director of Scientific and Professional Employment, 7929 S. Howell, Milwaukee 1, Wisconsin.

AC SPARK PLUG ⚛ THE ELECTRONICS DIVISION OF GENERAL MOTORS

Positions Wanted

(Continued from page 356A)

velopment. Extensive magnetic core experience. 12 years experience, including sales, executive, college teaching. Patents. Desires stimulating, forward looking work. Box 3933 W.

MANAGER, GRADUATE ENGINEER AND PILOT

10 years experience in weapon and automation systems R & D. Desires managerial position in small, technically oriented company. Available in June. Resume upon request. Box 3934 W.

Positions Open

The following positions of interest to IRE members have been reported as open. Apply in writing, addressing reply to company mentioned or to Box No. . . . .

The Institute reserves the right to refuse any announcement without giving a reason for the refusal.

Proceedings of the IRE
I East 79th St., New York 21, N.Y.

OVERSEAS POSITIONS

Robert College, Istanbul, Turkey, presents a challenge in education in a vital part of the world. West and Middle East are contributing side by side to the development of a young and vigorous nation. Opportunities are available in engineering, business administration and economics, the sciences, and the humanities. Graduate degrees required. Address inquiries to Dr. Howard P. Hall, Dean of Faculty, Robert College, Bebek Post Box 8, Istanbul, Turkey with copy to Near East College Assoc., 548 Fifth Ave., New York 36, N. Y.

TEACHING—ELECTRICAL ENGINEERING

Teaching in Electrical Engineering. Background in power distribution, rotating machinery, and/or automatic control theory. General undergraduate E.E. program. Prefer M.S. or B.S. with experience. Appointment effective February 1961. Address: Head, Electrical Engineering Dept., College of the Pacific, Stockton, Calif.

ASSISTANT DIRECTORS & SENIOR SCIENTIFIC OFFICERS

A growing Institute, the national laboratory in India for electronics, has 4 senior research positions open, with opportunities to lead research and development groups in the fields of vacuum tubes, electronic instrumentation, communications and solid state devices. A Ph.D. degree or M.S. with experience in industrial research is required. Attractive housing and good educational facilities for children are also available. Apply Amarjit Singh, Assist. Director-in-Charge, Central Electronics Engineering Research Institute, Pilani (Rajasthan) India.

ENGINEERS & TEACHERS

The University of Denver's College of Engineering and Research Institute are seeking electronic engineers and physicists with Ph.D. or D.Sc. degrees for research and teaching positions in the areas of electromagnetic wave propagation, antenna research, thin film and solid state electronics, circuit development, servomechanisms and

(Continued on page 360A)

● ELECTRONIC ENGINEERS AND SCIENTISTS:

* In Martin's Infrared Radiation Laboratory, a zone leveler is used to grow single-crystal detectors.

Lighting the way for your professional future!

Martin, the leader in missile/space technology, has new openings for PROJECT SUPERVISORS and SENIOR DESIGN ENGINEERS to work in challenging and diversified fields. These significant opportunities include assignments in *radar . . . sonar . . . infrared . . . circuit design . . . instrumentation . . . reliability analysis . . . solid state physics . . . test equipment design . . . guidance and navigation systems . . . acoustics . . . transistor circuitry . . . communications . . . optics . . . human factors*. There also are other openings at various levels of experience.

You will enjoy the *way of work* at Martin's, where the engineer sets his own pace—with exceptional advancement assured for the exceptional engineer or scientist. You also will enjoy the good life in Maryland—known as "America in Miniature," where cultural advantages, ideal family living, outdoor sports and fabulous seafood abound.

WRITE
giving brief outline of your education and experience to
MR. J. W. PERRY
Professional Employment, Dept. 10

MARTIN
BALTIMORE 3, MD.

Positions Open

(Continued from page 358A)

infrared techniques. Also available are overseas field engineering assignments in Japan, Australia, South America and South Africa for periods of 1 to 2 years. Address inquiries to C. A. Hedberg, Head, Electronics Div., Denver Research Institute, University of Denver, Denver 10, Colo.

ELECTRONIC ENGINEERS AND PHYSICISTS

An expanding R&D laboratory has openings for qualified engineers and physicists to participate in and direct research and development programs in the microwave tube area. This is an opportunity for competent individuals who are interested in the direction of R&D programs at the leading laboratories in the country as well as participating in microwave in-house research. Salary from \$7560 to \$12,210, depending on experience and training. Send complete resume to Box 2038.

ENGINEERS

Expanding opportunities for research and graduate instruction at master's and doctor's level. Steady growth has created a need for highly qualified persons with a doctor's degree and a background of research and teaching in one of the following fields: mechanical dynamics; metallurgy; thermodynamics; applied physics; mathematics (statistics and operations research); electrical engineering (electronics and control). Contact Dean of the Hartford Graduate Center, Rensselaer Polytechnic Institute, East Windsor Hill, Conn.

ENGINEER OR PHYSICIST

Engineer or physicist to head Electronics Dept. of large bio-medical research institute in New York City. Knowledge of radiation physics detectors and circuits essential. Job involves design of new instruments and supervising maintenance. Send complete resume to Box 2040.

MICROWAVE SPECIALISTS

Microwave engineers needed for research and engineering in precision measurement. This work is in connection with the expanding Ordnance Calibration Program for which Frankford Arsenal has world-wide responsibility. Engineers are needed to evaluate and apply newest microwave techniques to attenuation, power and impedance measurement both pulse and cw. Development of specialized equipments in a modern, fully equipped microwave lab. is offered. Salaries to \$10,635. Federal Civil Service benefits and requirements. Apply Recruitment Office, Frankford Arsenal, Bridge and Tacony Sts., Phila. 37, Penna. Refer to ad by Mr. A. Bruno.

EE'S, PHYSICISTS

Expanding electronics concern has prestige position for qualified patent attorney to join its legal staff. LL.B. preferred but will consider minimum 2 years of law study. Ability to work closely with scientific and management people essential. Salary to \$15,000. Northeast location. Please forward complete resume to Box 2041.

PROFESSOR OR ASSOCIATE PROFESSOR

Professor or Associate Professor with salary to \$11,000 for session of two semesters. This fully accredited well-equipped E.E. Dept. needs one or two senior-level staff members with high qualifications. Ph.D. essential, to ensure full participation in graduate program and research activities. Prefer experience in electron devices, solid state or computer electronics, but other specialties considered. Medium size engineering college (700 undergraduate students) in brand new building. Exceptionally good retirement plan. Numerous sources of extra income. Pleasant living and working conditions in attractive uncrowded city. Address inquiries to Robert A. Chipman, Chairman, E.E. Dept., University of Toledo, Toledo 6, Ohio.

TEACHING AND RESEARCH

Opening for Electrical Engineer with Ph.D. to supervise graduate research and do some teaching. Research experience in microwave or semiconductors desirable. Private research or consultation encouraged. Excellent salary and rank arrangements. Department offers work leading to Ph.D. Position available Sept. 1961 or sooner. Apply Chairman, E.E. Dept., Vanderbilt University, Nashville 5, Tenn.

NOISE RESEARCH ENGINEERS

As a result of recent rapid expansion, Quan-Tech Laboratories—a leading manufacturer of equipment for the measurement and analysis of component noise—has openings for imaginative E.E.'s interested in this important new field. Address replies to Chief Engineer, Noise Research Div., Quan-Tech Labs, Inc., 60 Parsippany Blvd., P.O. Box 187, Boonton, New Jersey. Tel. Deerfield 4-8500.

STATISTICAL COMMUNICATION THEORIST

Senior Staff opportunity to initiate and direct advanced research programs in such areas as statistical communication and information theory; automatic pattern recognition and processing; adaptive, self-organizing learning systems; bionics; advanced computer theory. Contact J. R. Campbell, Chief Scientist, Chance Vought Electronics Div., P.O. Box 1500, Arlington, Texas.

OPERATIONS RESEARCH SPECIALIST

Establish and direct operations research activity. Analyses and recommendations must be provided for both (a) operational application of present products, and requirements for potential future products, and (b) intra- and inter-departmental operations. Contact J. R. Campbell, Chief Scientist, Chance Vought Electronics Div., P.O. Box 1500, Arlington, Texas.

ASSISTANT OR ASSOCIATE PROFESSOR

Assistant or Associate Professor with Ph.D. in Electrical Engineering or Physics. Interest in electronics, microwaves, solid state or circuit theory. Active research and graduate program with opportunities for outside consulting. Send resume to W. P. Smith, Chairman E.E. Dept., University of Kansas, Lawrence, Kansas.

TEACHING POSITIONS

PROFESSORS all levels. Ph.D. required. Solid-state, electromagnetics, and engineering analysis especially. Income with research, competitive with industry. Graduate program as large as undergraduate. Mile high, dry climate.

INSTRUCTORS, Associates, Assistants for teaching and research part-time positions while working for M.S. and S.Sc. Large graduate program assures variety of offerings. Apply Chairman, E.E. Dept., University of New Mexico, Albuquerque, New Mexico.

BROADCAST ENGINEER

Long term European assignment with private organization engaged in construction and operation of large high-powered shortwave radio stations. Top qualifications, experience and executive ability desired. Good salary plus overseas benefits. Inquiries treated in confidence. Reply to Box 2043.

ASSOCIATE PROFESSOR

Electrical Engineering faculty being expanded in relatively new and rapidly growing department, with positions available to rank of Associate Pro-

(Continued on page 362A)

Not necessarily in words and syllables but in electronic impulses, relayed by orbital, lunar and interplanetary communications systems.

Scientific advancement depends upon the ability of man to overcome the limitations of current knowledge. These limitations are being pushed aside at the Amherst Laboratories by new concepts for aerospace communication and instrumentation systems.

The role that microwave and millimeter wave technology will assume in future aerospace systems is being shaped through state-of-art advances achieved by our technical staff.

PROFESSIONAL STAFF APPOINTMENTS *in Microwave Communication Systems are available for Electronic Engineers, Physicists and Mathematicians with advanced degrees and creative desire.*

You are invited to direct inquiries in confidence to Mr. E. Schlichter, Manager, Microwave and Aerospace Systems Department, Amherst Laboratories . . . or call NF 3-8315 for information. All inquiries will be acknowledged promptly.

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AMHERST LABORATORIES

Shrinking the Universe . . . through Communications

Positions Open

(Continued from page 361A)

fessor with initial salary range to $6000 for base year of 9 months, depending upon education and experience. Further opportunity for research and other programs in this industrial area. Preferred background emphasis in field and circuit theory, electronic systems and control. Address full background to Chairman, E.E., University of Bridgeport, Bridgeport 4, Conn.

ELECTRONICS SECTION HEAD

Cornell Aeronautical Lab. has an attractive opening as technical supervisor of a section involved in the solution of complex problems associated with the electronics field, especially in the areas of weapon systems, reconnaissance and surveillance, and guidance and control. Position holds outstanding opportunities for growth from an already well established research program, both by way of personnel and highly successful technical projects. Horizons not limited by marketing and sales. The Laboratory provides a desirable combination of the best features of industry as to financial and equipment resources coupled with a university-associated atmosphere for constructive R&D activity at the highest level. Salary range starts at $13,500 depending on qualifications and experience. Send complete resume to F. L. Rentschler, Cornell Aeronautical Lab. Inc., 4455 Genessee St., Buffalo 21, N.Y.

ELECTRONIC ENGINEER

Electronic engineer to teach lecture and laboratory courses. Up-to-date knowledge of the field required. Working and living conditions excellent; salary and opportunity good. Write to Dean of Engineering, California State Polytechnic College, San Luis Obispo, Calif.

ASSOCIATE PROFESSOR AND DIRECTOR

Associate Professor and Director of Research in Electrical Engineering. To have the responsibility for developing a research program including the securing of research contracts and the directing of research activity. Salary depending on experience and academic background. Write to Head, E.E. Dept., South Dakota School of Mines and Technology, Rapid City, South Dakota.

TWO ELECTRONIC ENGINEERS

Good theoretical background, one with at least 7 years' experience, and the other with at least 2 years' in research and/or development. Excellent career possibilities in rapidly expanding industry. Congenial atmosphere. Call Personnel Dept. Riverview 9-4800. Massa Div. Cohu Electronics, Inc. 280 Lincoln St., Hingham, Mass.

PLAN IN ADVANCE!

Use this issue of *Proceedings of the IRE* to make your plans well before you get to the convention and show. Decide which technical sessions and social events you want to attend, and what exhibits at the show you will find of most interest. Advance planning will save you a great deal of time and effort, and will insure that you do not miss seeing or hearing about that one new product or technique which may be of vital importance to you in your work during the next year.

C is for COMMUNICATIONS

Communications and data handling are essential functions of any modern tactical weapons system. Minneapolis-Honeywell Ordnance Division, through broad experience in the development and production of weapons systems and components, offers unusual opportunities for professional growth to engineers experienced in RF and solid state circuit design, weapons systems analysis, programming and evaluation.

Especially challenging opportunities await EE's to participate in development of more sophisticated communications systems to control tactical weapons. EE degree required with RF, UHF, VHF circuit design experience. Antenna and coupler design and microwave knowledge or experience is most desirable. Experience with pulse techniques and/or FM-Doppler radar system also valuable.

Honeywell offers you the opportunity for growth coupled with a stability of diversification in all phases of industry. Here is your chance to associate with a company that is engineering and research-minded and world-wide in scope.

Select the areas of your interest and send your résumé or request for further information to: Mr. Allan J. McInnis, Professional Manpower Staff, Ordnance Division, Honeywell, 600 Second Street N., Hopkins, Minnesota.

Honeywell

Military Products Group

To explore professional opportunities in other Honeywell locations, coast to coast, send your application in confidence to Mr. H. D. Eckstrom, Honeywell, Minneapolis 8, Minnesota.

Whom and What to See at the IRE Show

(Continued from page 352A)

Sprague Electronic Co. Booths 2416-2424
235 Marshall St.
North Adams, Mass.

N. W. Welch, C. G. Killen, ▲ D. B. Peck, ▲ Sid Chertok, ▲ W. M. Allison, ▲ W. F. Arnold, J. C. Balderson, G. M. Burbrink, C. Chase, ▲ A. J. Christopher, Jr., ▲ S. M. Church, M. L. Clifford, ▲ G. B. Devey, J. P. Driscoll, A. B. Dall, J. E. Fitzgerald, J. Flanagan, N. J. Gal, F. Garlington, ▲ H. F. Geiling, E. G. Geissler, Jr., R. F. Graf, H. D. Hazzard, ▲ L. A. Hermansen, R. W. Holmes, C. Hewison, C. W. Janton, Jr., J. D. Kowalsky, C. J. Lamont, W. C. Lamphier, A. Coumont, K. Blanchard, P. Maynard, E. Jones, C. T. Lempke, N. M. Levinson, J. C. P. Long, A. G. Martin, J. S. Mathews, W. E. McQueenie, R. K. Morse, J. P. Newton, Jr., R. Peters, A. H. Postle, B. P. Rosen, G. W. Russell, ▲ F. S. Scarborough, J. P. Sheridan, R. W. Swift, D. Simonds, R. D. Tatro, A. A. Tiezzi, G. V. Tremblay, J. J. Tucker, S. J. Ulcickas, Jr., J. S. Upton, ▲ R. C. Wagner, ▲ R. R. Warriner, H. F. White, L. I. Wurzel

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Silicon and germanium transistors; metal film, carbon film, precision wirewound, power-wire wound resistors; pulse-forming networks; digital circuit assemblies, wiring boards; pulse transformers; magnetic shift registers; piezo-ceramics; high temperature magnet wire; ceramic-base printed circuits; tantalum, paper, plastic film, ceramic, mica, aluminum electrolytic capacitors; interference filters; packaged component assemblies; lab standard capacitors; capacitance bridges; RFI locators; precision wave filters; precision toroidal inductors; capacitance and inductance decades.

Spyraflo, Inc., Booth 4519
Captive nylon bearings. See: Penn Engineering & Mfg. Corp.

Stability Capacitors, Ltd., Booth 1822
Silvered mica capacitors. See: British Radio Electronics, Ltd.

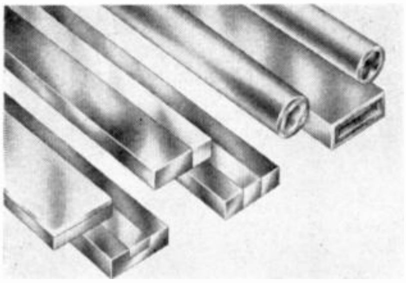
Standard Electrical Products Co., Div. of General Electronic Control, Inc., Booths 2741-2743
2240 E. Third St.
Dayton 3, Ohio
▲ C. W. Holmes
Transformers, variable transformers, motor-driven variable transformers, automatic voltage regulators, aircraft electrical components.

Standard Electronics Div., Dynamics Corp. of America, Booth 1202
R. F. Kelley, Z. P. Giddens, ▲ C. L. Allen
Broadcast transmitters, AM-FM-TV

Elevators at north and east sides of the main lobby take you direct to the **Fourth Floor**

Standard Metals Corp., Booth 4119
262 Broad St.
North Attleboro, Mass.

Lloyd W. Chase, Edward F. Brown, Bertel V. Hoecke, Lloyd W. Chase Jr., Donald Kingman, Chris Jaffe, Anthony Belaski, Everett Bowder, Lester Wall



Precious and laminated sheet, wire and tube. Silver clad base metals, collector rings, cored and clad metals, precision thin gage metals, silver solder flushed flat stock, solid coin silver and coin silver lined waveguide tubing. Precision double ridged waveguide tubing. Precision and special waveguide tubing.

Standard Pressed Steel Co., Booths 4528-4530
Jenkintown, Pa.

Charles Candy, James Harkins, Howard King, Walter Kobe, Marshel Moorhouse, Joseph St. Pierre, A. W. Scott, Herbert Wenger

Semiconductor caps and bases (including brazed bases). Industrial fasteners (regular and micro size), including socket screws, locknuts, clinch nuts and steel collars. Also swage nuts, pressure plugs, shoulder screws and spring pins. See also International Electronic Industries, Inc., Booth M-2.

State Labs, Inc., Booth 2339

See: Ericsson Corp.

(Continued on page 366A)

Whom and What to See at the IRE Show

(Continued from page 365A)

Herman D. Steel Co., Booth 4034
See: Swiss Jewel Co.

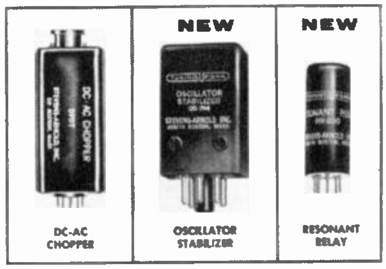
Stepper Motors Division, Booth 1600
See: Land-Air, Inc.

Sterling Precision Corporation, Booth 1426
5 Sintsink Drive East
Port Washington, N.Y.

Vincent Giagni, Robert Marks, Thomas McMahon, Richard Jennings, Anthony Palattella

Electromechanical products including differentials, clutches, bearings, clamps, dials, limit stops, shafting, speed reducers. Sub-contracting including gear trains, actuators and servo assemblies.

Stevens-Arnold Inc., Booth 2934
7 Elkins Street
South Boston 27, Mass.



(1) Twin-contact dc-ac choppers; (2) dc drive choppers; (3) ultra-high speed relays; (4) low drift vibrating reed capacitance modulators; (5) tuning fork oscillator stabilizers; (6) tuning fork resonant relays.

Stevens Mfg. Co., Inc., Booth 2327
P.O. Box 1007
Mansfield, Ohio

▲ Walter C. Stevens, George H. Rouse, W. Chandler Stevens, Jr., R. Hutchison Stevens, R. L. Seibold, J. G. Jessen

Complete line "Certified" thermostats designed for electronic applications, snap-acting, narrow differential (can be made on special order to total spread of 8°F, including calibrating tolerances and differential), long life, small size, semi-enclosed and hermetically sealed, tested to MIL specs. Also, complete line positive acting strip type and snap-acting, semi-enclosed and epoxy sealed thermostats.

George Stevens Mfg. Co., Inc., Booths 4218-4220
6022 North Rogers Avenue
Chicago 46, Ill.

George Stevens, Jack Stevens, Paul R. Cappello, John Sadorf, Jack Egan

Complete line coil winding machinery featuring for first time Model 515 bobbin winder for long, high production windings; also Model 405-AM transformer winder, 314-AM bobbin winder, continuous resistor winder Model 209. *Model 46-MCI automatic indexing armature winder, Model 600-AM laboratory winder, as well as others.

(Continued on page 368A)

▲ Indicates IRE member.
* Indicates new product.
† Exhibitor is servicing IRE Engineers through the IRE Package Plan.

Whom and What to See at the IRE Show

(Continued from page 366A)

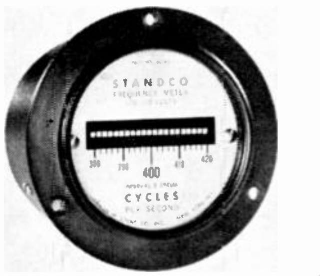
Stewart Stamping Company, Booth 4039
630 Central Park Ave.
Yonkers 4, N.Y.

B. W. Sterenfeld, Gilbert Boas, Ralph Robinson, Harold Berger

High-speed, high-production metal stamping, wire heading and wire forming. Automatic swedging and welding for capacitors, resistors, rectifiers, transistors and other electronics manufacturers. Complete toolshop.

Herman H. Sticht Co., Inc., Booth 3236
27 Park Place
New York 7, N.Y.

F. J. Dugan, P. Palmer, A. H. Volker, R. H. Sticht

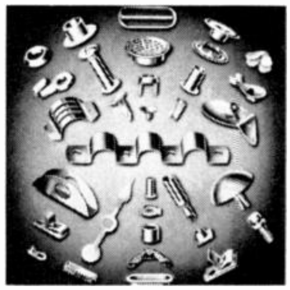


Vibrating Reed Frequency Meter

"Vibron" vibrating capacitor electrometers, exceptionally high stability and minimal zero drift. Model 20-A megohmmeter (range 20 million megohms). "Megohmer" insulation testers. High intensity stroboscope. "Standco" vibrating reed frequency meters and tachometers "Chronotest" millisecond, microsecond time meters. Electromagneto stopwatches, Tachometers: Centrifugal, chronometric, electrical types. Elapsed time meters. "Statigun" (static measuring instrument).

Edwin B. Stimpson Co., Inc., Booth 4008
70 Franklin Ave.
Brooklyn 5, N.Y.

Franklin Rau, Joseph Thornton, John Tresay, Ralph Hector



Eyelets, grommets, washers, rivets, hole plugs, stampings, and other miscellaneous metal articles. Various types of attaching machines.

F. J. Stokes Corp., Booth 4418
5500 Tabor Road
Philadelphia 20, Pa.

David E. Stokes, W. James Weaver, Harold H. Brehouse, Nelson T. Smith, William J. Fisher, Ralph H. Stalbaum, William J. Leighton, Charles M. Hammer

Component Test Facility for reliability testing of space-borne components under combined environments of altitude and temperature. Completely packaged, the new Stokes facility is designed to exceed exacting government specifications and achieving conditions of extremely low pressure and varying temperatures. See also: International Pump & Machine Works.

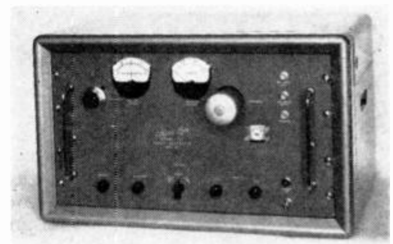
(Continued on page 376A)

Whom and What to See at the IRE Show

(Continued from page 368A)

Strainsert Co., Booth 2839
See: Polyphase Instrument Co.

Strand Labs, Inc., Booth 3007
294 Centre St.
Newton 58, Mass.
C. W. Batson, D. S. Romano, ▲ M. W. P. Strandberg, ▲ H. J. Riblet



MM Range Stabilized Generator

Full spectrum coverage, L-band to Ka-band, extremely stable microwave signal generators. *Octave bandwidth, 'S' band generator. *Millimeter range (Ka-band) generator. Specialized microwave test equipment and systems. Magnetic measurement equipment and microwave spectroscopy equipment. See also: Microwave Development Labs.

Stromberg Time Corp., Booth 1726
See: General Time Corp.

R. H. Sturdy Co., Inc., Booth 1629
See: C & K Components, Inc.

H. W. Sullivan, Ltd., Booths 3406-08
Laboratory standards. See: British Industries Corp.

Sumitomo Shoji, N.Y., Inc., Booth 3949
See: Nippon Electric Company, Ltd.

Superior Electric Co., Booths 2722-2732
83 Laurel St.
Bristol, Conn.
R. J. Caccavelli, K. Lang, O. Mahannah, R. B. Shackelford, M. Stokem, J. S. Louden, B. G. Deming, C. Downey, J. P. Bradley, J. E. Cann, N. P. Babcock, F. X. Bevins, E. Crapser, R. Atwood, H. Carlson, D. Milliot, R. M. Mosher, E. S. Williams, P. R. James, H. W. Lorenson, A. G. Muller, R. E. Spencer
*All new 40 volt and 3.75/5.5 ampere types "Powerstat"® variable transformers; 480 kva "Stabiline"® automatic voltage regulators; *1000 va "Flexiformer"® packaged transformer primaries; *"Slo-Syn"® synchronous motors with pulse-to-step translator; *metal grounding, fluted Lexan, *double assembly "Superior 5-Way"® binding posts; magnetic amplifiers.

Surf Chemical Co., Inc., Booths 4417-19
Extruded teflon. See: Driver-Harris Co.

Sutton Publishing Co., Inc., Booth 4415
See: Electronic Equipment Engineering

Swiss Jewel Company, Booth 4034
Lafayette Building
5th & Chestnut Sts.
Philadelphia 6, Pa.
William W. Woolford, P. N. Steel, Jr.
Swiss Jewel Co.: Sapphire jewel bearings and products. Herman D. Steel Co.: Precision components, Swiss screw machine products, pinions, gears, pivots, and clockwork mechanisms.

(Continued on page 372A)

▲ Indicates IRE member.
* Indicates new product.
† Exhibitor is servicing IRE Engineers through the IRE Package Plan.

APL offers

unusual opportunities

in

microelectronics

A new group of scientists and engineers has been formed at the Applied Physics Laboratory of the Johns Hopkins University to perform highly advanced research and development work in solid state microelectronics. The objective: to explore new techniques and methods to produce reliable microelectronic functions for wide application in missiles, satellites, radar, adaptive computers, etc.

Solid State Theory The position requires a Ph.D. with two or more years of experience in solid state theory. You will apply the principles of dielectrics, conducting materials, and semi-conductors to the analysis of integrated electronic circuits. This is a new area of activity with unusual opportunities for rapid personal and professional advancement.

Semi-Conductor Devices, Prototype Production An opening with exciting possibilities. You will establish a semi-conductor laboratory and work freely within broad policy directives. Funds have been allocated for the laboratory. Duties include making integrated semi-conductor electronic circuits on a laboratory basis. B.S. plus three years of experience in this field desirable.

Circuit-Systems Analysis Position involves microelectronic system and circuit analysis and design, as well as maintaining close working relationship with prototype fabricator and user groups. Applicant must have a B.S. in electronics or physics and approximately five years of experience in system and/or circuit analysis.

**For details about these positions,
direct your inquiry to:
Professional Staff Appointments**

The Applied Physics Laboratory
The Johns Hopkins University

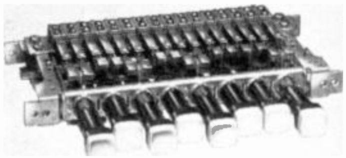
**8603 Georgia Avenue, Silver Spring, Md.
(Suburb of Washington, D.C.)**

Whom and What to See at the IRE Show

(Continued from page 370A)

Switchcraft, Inc., Booth 2825
5545 N. Elston Ave.
Chicago 30, Ill.

▲ **W. L. Larson, F. O. Dumke, W. E. Dumke, J. R. Bailey, T. L. Dowell, K. D. Kline, L. Galin, C J. Schultz, P. G. Andersen, W. G. Butler**



Illuminated "Multi-Switch" Series 21000

Illuminated "Multi-Switch," Series 21000. New square concave buttons in variety of colors. Choice of Lamps 6v, 28v, and 115 volt neon. Unlimited number of circuit and lighting arrangements. *Illuminated "Push-To-Lock, Push-To-Release, Push-Button Switch," Series 15000L single station. Convertible to momentary action. Incorporates same illuminating features as 21000 Series.

† See PROCEEDINGS OF THE IRE—Jan., March, May, Aug., Sept., Nov. (1960), Jan., March (1961) for further information on our products.

See 1961 IRE DIRECTORY, page 554, for complete information on our products.

Sylvania Electric Products Inc., Electroluminiscent Display Devices, Booths 2326 and 2419
Seneca Falls, N.Y.

M. Krawitz, I. Greenberg, D. Cole

High reliability electroluminiscent panels are composed of segments of electroluminiscent lamps insulated from one another and individually terminated. Type AN-150 has 14 segments that produce the complete alphabet, 0-to-9 numerics, a decimal point, and other mathematical symbols. Type NU-150 consists of nine segments.

Sylvania Electric Products Inc., Electronic Tube Div., Booths 2322-2324, 2415-2417
1740 Broadway
New York 19, N.Y.

C. Jacobs, R. Shields, F. Cannizzaro, J. Taylor, W. Dixon

5-inch industrial "Bonded Shield" cathode ray tube features a permanent built-in reference scale on an integral reflection-free safety panel, is typical of the newest concept in cathode ray tube construction. Designated Type SC-3076, the new Sylvania tube offers maximum image visibility, wide angle viewing, simplified mounting and styling, decreased reflection, protection against breakage, simplified tube face cleaning, and a self-contained writing surface.

† See PROCEEDINGS OF THE IRE—Feb., March, May through Dec. (1960), Feb. through Dec. (1961) for further information on our products.

See 1961 IRE DIRECTORY, pages 50 and 51, for complete information on our products.

(Continued on page 374A)

Whom and What to See at the IRE Show

(Continued from page 372A)

Sylvania Electric Products Inc., Lighting Products Div., Booths 2330-2332
60 Boston St.
Salem, Mass.

F. Kowalik, E. Gilchrist, R. Sanders, F. Pettee, A. Plaisted, C. Nelson

Our electrical transformers can be "tailored" to provide exact electrical characteristics while producing size and weight savings of 2 to 30 per cent. Named Flexi-core, the transformers may be produced in any size, at present, up to 18 × 18 × 36 inches.

Sylvania Electric Products Inc., Microwave Device Operations. Booths 2328 & 2421
500 Evelyn Ave.
Mountain View, Calif.

R. Jordan, D. Welsh, R. Stonesifer, R. Kost

*New series of compact, temperature-compensated, waveguide ferrite isolators for common carrier and commercial communication systems, are a feature of Sylvania's Microwave Device display. Designated FD-7511 through FD-7516, they are mounted in WR-75 waveguide for maximum utility in X-band communication systems. Made in versions providing 20, 40, or 60 db isolation in the 10.7 to 11.7 Gc frequency range, and 25, 40, or 60 db isolation in the 12.2 to 12.7 Gc frequency range.

† See PROCEEDINGS OF THE IRE Feb., March, May, July, Aug., Sept., Nov., Dec. (1960) for further information on our products.
See 1961 IRE DIRECTORY, pages 48 and 49, for complete information on our products.

Sylvania Electric Products Inc., Semiconductor Div., Booths 2423 and 2425
100 Sylvan Road
Woburn, Mass.

J. Grant, J. Sweeney, E. Schlener, J. Spitzer, M. Groll, R. Swanson, D. Smith

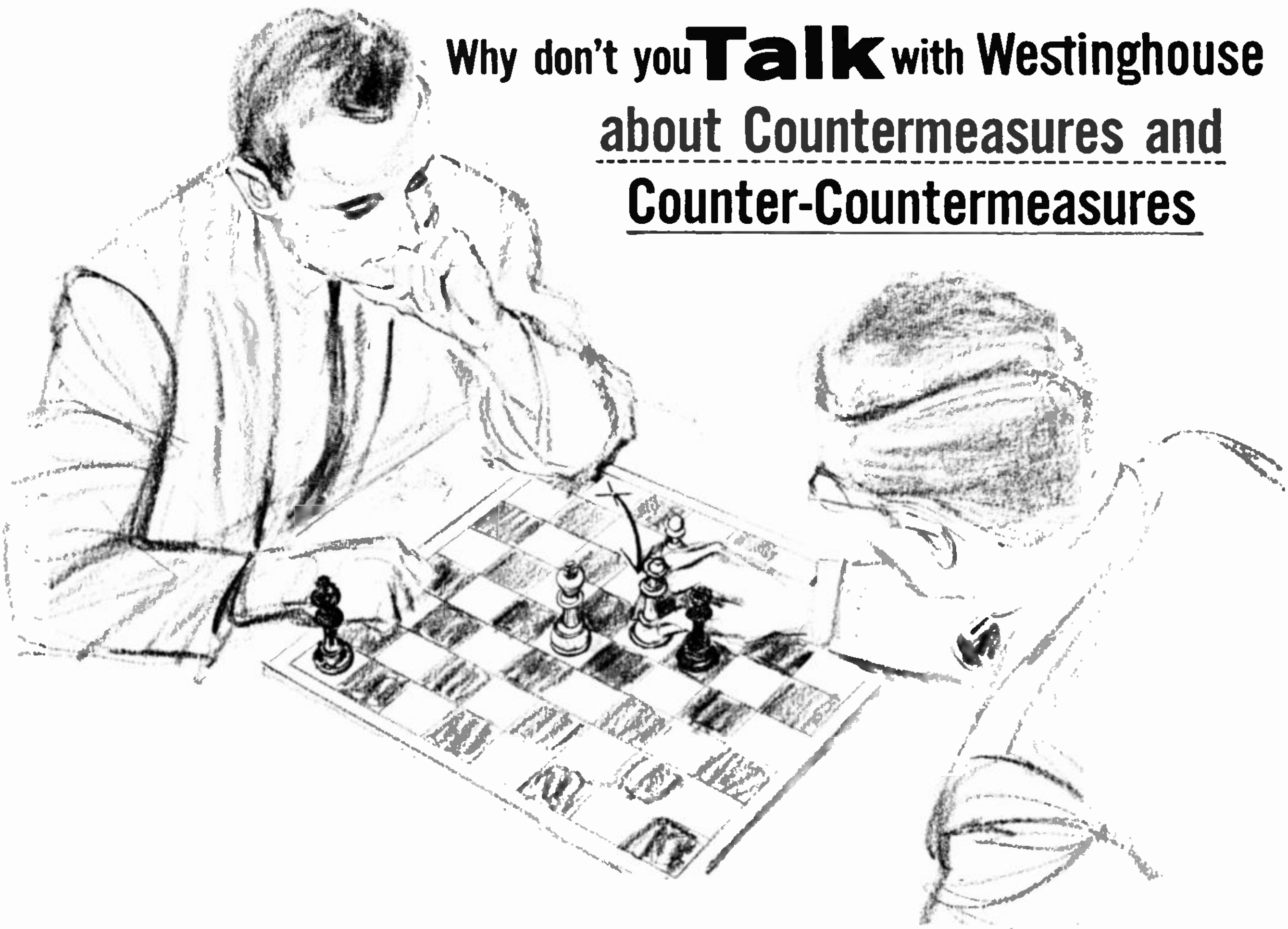
*Microwave silicon epitaxial varactor diodes with cutoff frequencies as high as 150 kmc at minus 45 volts breakdown voltage. High Q, high breakdown voltage diodes in a double-ended ceramic package, and in the "Micro-Min" construction, exhibit frequencies as high as 100 kmc and capacitance values as low as 0.15 pf at minus 6 volts.

Synthane Corporation, Booths 4421-4423
12 River Road
Oaks, Pa.

Russell B. Galloway, C. L. Johnson, H. Widdop, J. M. Price, R. Palmer, H. Weiss, M. B. Firehock, T. Muench, J. K. Johnson, F. W. Hansell, D. Garrison, M. Phinney, R. Hunsberger

High pressure laminated plastics sheets, rods, tubes, fabricated parts, molded laminated and molded macerated forms, high temperature resistant phenolic laminates. *Flame retardant copper clad laminates for printed circuits.

Why don't you Talk with Westinghouse about Countermeasures and Counter-Countermeasures



Planning the moves ahead while retaining a high degree of flexibility is necessary to keep the free world out front in the research and development of ECM and ECCM.

Searching for weak spots in the aggressive systems which represent a threat to the free world and devising effective countermeasures and counter-countermeasures are important assignments at Westinghouse-Baltimore.

Why don't you talk with Westinghouse about current opportunities which include:

1961 Represents 75 years of Service & Achievement by Westinghouse

- **Electronic Countermeasures**
- **Physical Countermeasures**
- **Electronic Counter-countermeasures**
- **Microwave Techniques**
- **Radio Frequency Control**
- **Pulse Circuitry**
- **Semiconductor Circuitry**
- **Research Design & Development**

Attending the IRE Show?

Be sure to visit us at the Career Center.

Send resume to: Mr. J. F. Caldwell, Dept. 377

Westinghouse

BALTIMORE

P.O. BOX 746 **Baltimore 3, Maryland**

AIR ARM • ELECTRONICS • ORDNANCE

Whom and What to See at the IRE Show

(Continued from page 374A)

Synthetic Mica Co., Booths 2517-2519
See: Mycalex Corp. of America

Syntron Company, Semiconductor Div., Booth 2525
Homer City, Pa.

▲ N. P. Bosteo, J. I. Scott, ▲ Ted Suito, ▲ R. P. Muldoon, G. P. Lemoniades, Harold Bigelow, S. E. Brayshaw, ▲ G. E. Weber

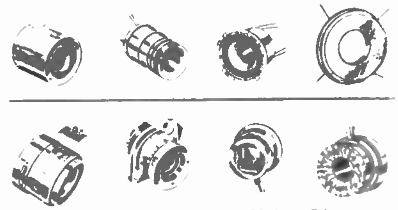
Silicon rectifiers and diodes. Silicon photoelectric cells. *Silicon "Power-Point"®. Selenium rectifiers and valves (standard). "Surge-Stop"® transient suppressors. *Selenium cells and stocks, high lensity.

† See PROCEEDINGS OF THE IRE—Jan., March, May, July, Sept., Nov. (1960) for further information on our products.
See 1961 IRE DIRECTORY, page 506, for complete information on our products.

▲ Indicates IRE member.
Indicates new product.
† Exhibitor is servicing IRE Engineers through the IRE Package Plan.

Syntronic Instruments, Inc., Booth 2711
100 Industrial Road
Addison, Ill.

Dr. Henry Marcy, Robert Bank, Eugene Jenzen, George Harris



Industry's Broadest Yoke Line

The industry's broadest yoke line: Newest designs. Just about any type CRT yoke can be designed and built by Syntronic deflection yoke specialists. Complete line already tooled for quantity production. Also custom designed to your exacting requirements. Focus coils.

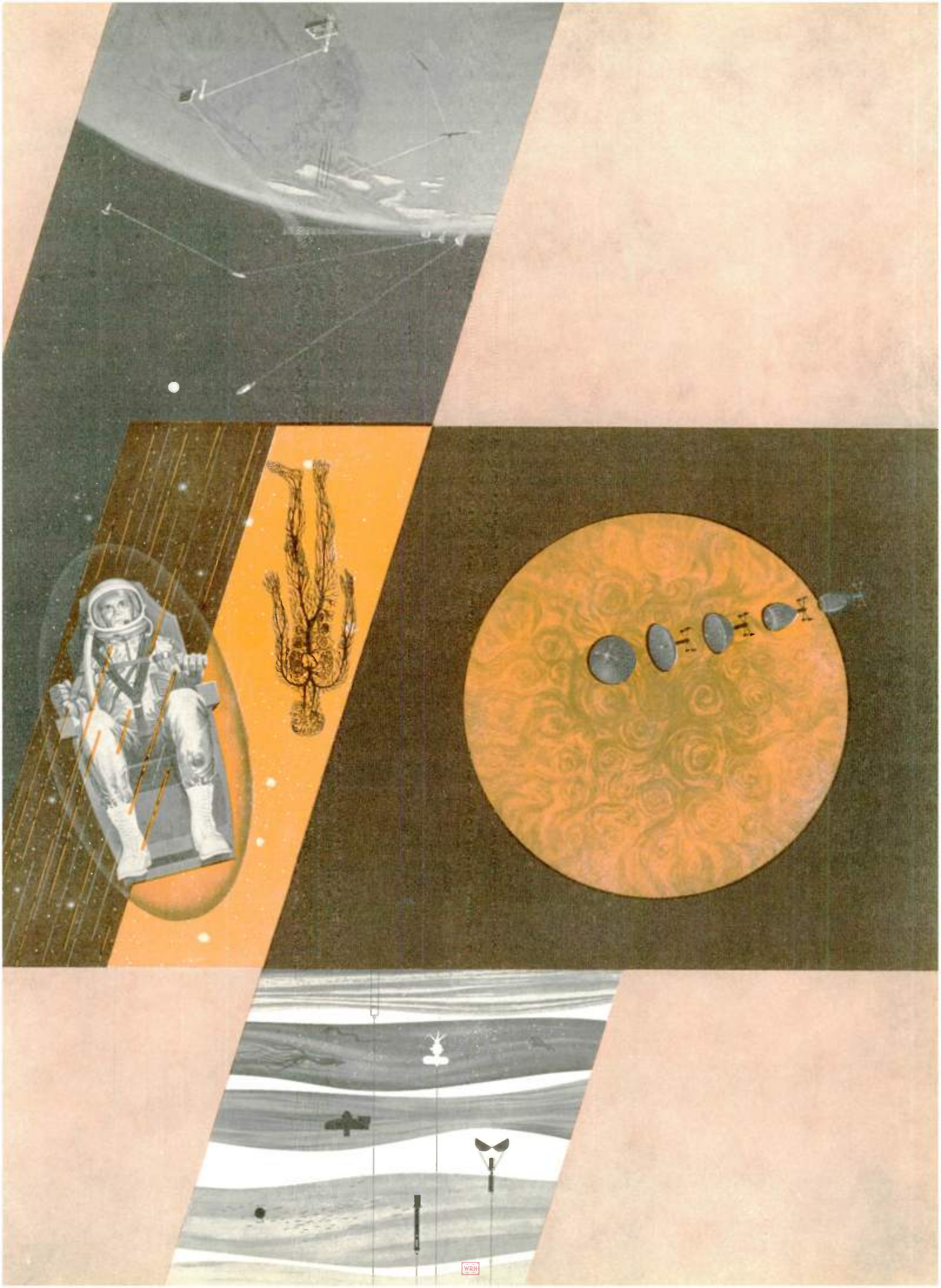
† See PROCEEDINGS OF THE IRE—Jan., March, May, July, Sept., Nov. (1960), Jan., March (1961) for further information on our products.
See 1961 IRE DIRECTORY, page 404, for complete information on our products.

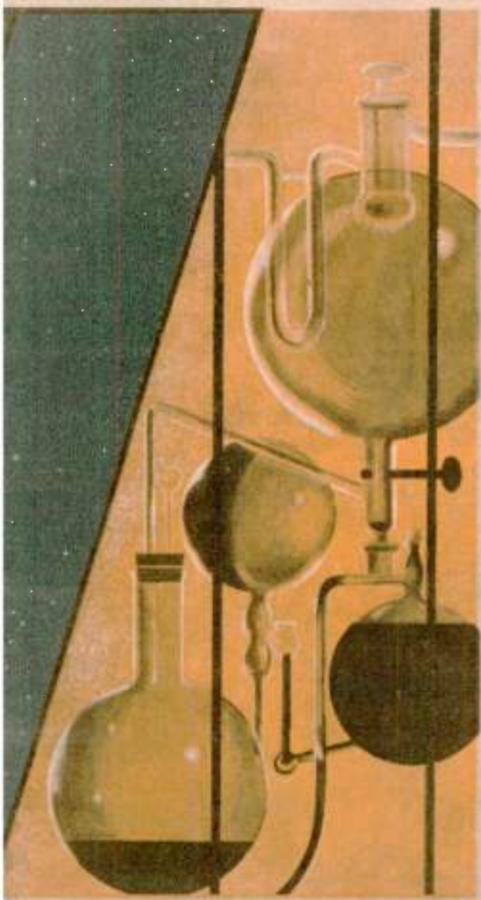
Systron-Donner Corp., Booths 3925-3927
950 Galindo St.
Concord, Calif.

James R. Cunningham, Ralph L. Manildi

10 mc solid state counter-timer with frequency extender for measurement to 500 mc and over. All electronic digital voltmeters and complete line of voltmeter accessories. 1 mc counter-timer, and limit detector. Digital modules for data recording systems.

(Continued on page 380A)


WRH



Whom and What to See at the IRE Show

(Continued from page 376A)

TRW Components Company, Div. of Thompson Ramo Wooldridge Inc., Booth 1320
8433 Fallbrook Ave.
Canoga Park, Calif.

See: Good-All Electric Mfg. Co., Div. of TRW Components Company.

TRW Computers Company (formerly Thompson-Ramo-Wooldridge Products Co.), Booths 1435-1635

See: Thompson Ramo Wooldridge, Inc.

Tapco Group, Booths 1435-1635

See: Thompson Ramo Wooldridge, Inc.

Tarzian, Inc., Sarkes, Booth 1730

See: Sarkes Tarzian, Inc.

Tech Laboratories, Inc., Booth 2120
Bergen & Edsall Blvds.
Palisades Park, N.J.

▲ E. Nachman, G. J. Van Baaren, J. G. Douglas, M. Bjorndal

*Miniature rotary switches, switch test equipment and harness test equipment. Special solenoid operated switches, hermetically sealed. Rotary switches manually operated. Attenuators. Splicing blocks and special test equipment.

Technical Appliance Corp., Booth 1207
1 Taco St., P.O. Box 38
Sherburne, N.Y.

▲ H. H. Brown, ▲ Tore Lundahl, ▲ Robert T. Leitner, Douglas Vining, ▲ George Sleeper, ▲ Richard E. Powers

Antenna systems including complete installation. Antennas point-to-point, ground based, airborne, microwave communications, rigid coaxial transmission line, telemetry systems, television. RF development to specific needs. Complete engineering, manufacturing and test facilities including 3000' long range test site equipped with automatic recording equipment and major support structures.

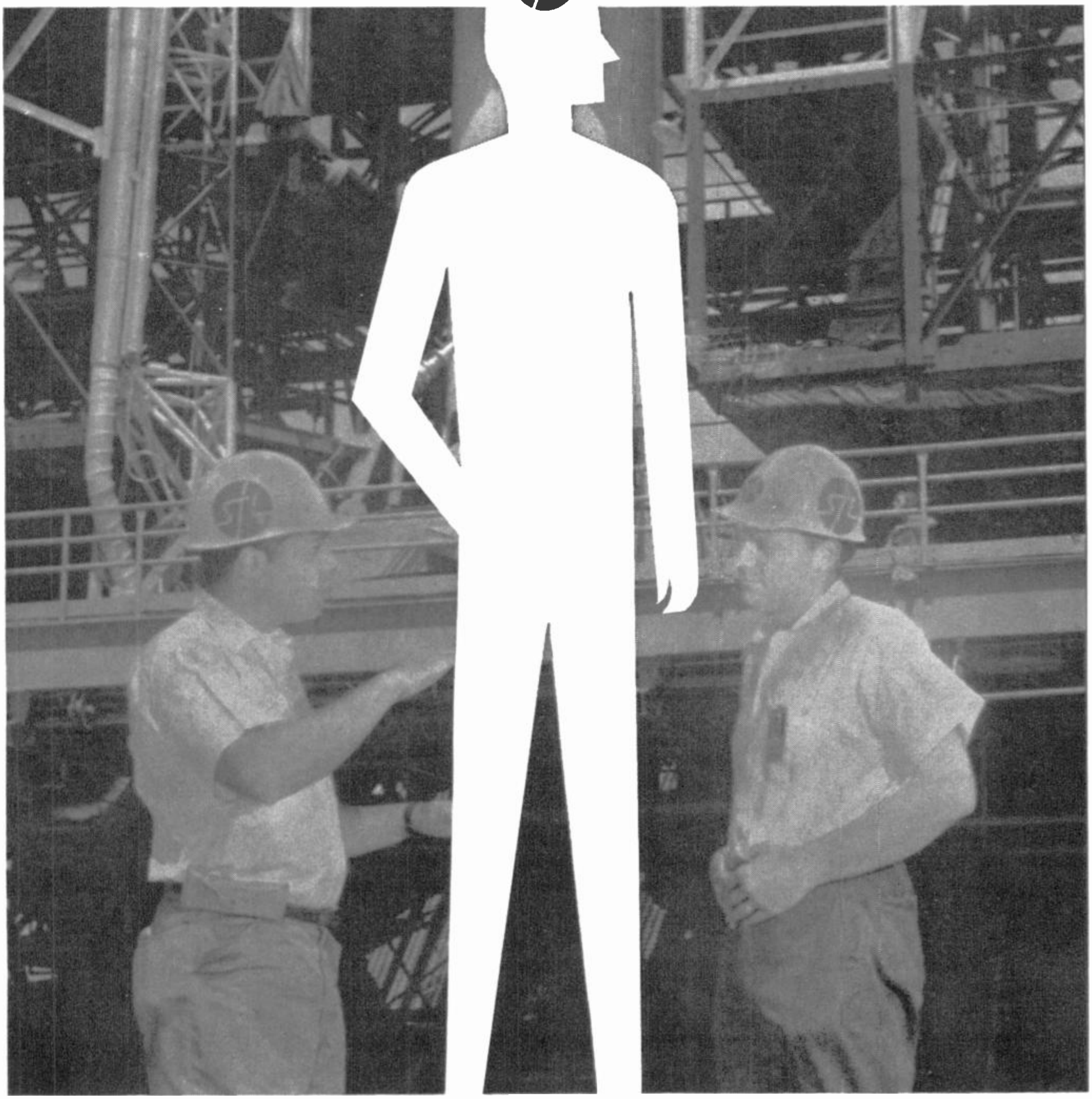
Technical Devices Company, Booth 4234
11242 Playa Court
Culver City, Calif.

Mel Allen, Ray Roe, Walt Sanders, Perry Lohse, Ray Johnson, Edna O'Brien

"Mark V" component lead former. "Mark II" wire cutter and stripper. T.D. circuit board fixture. Rototilt work positioner. T.D. lead extractor. Rotomaster chassis holder.

(Continued on page 382A)

▲ Indicates IRE member.
* Indicates new product.

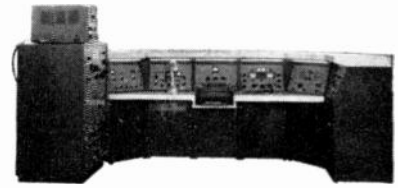


Whom and What to See at the IRE Show

(Continued from page 380A)

Technical Materiel Corp., Booths 3901-3903
700 Fenimore Rd.
Mamaroneck, N.Y.

W. J. Galione, E. A. Matson, Jr., W. L. Deans, P. C. Munroe, H. J. Geist, D. W. Carter, J. J. Caputo, D. A. Hillman, M. K. Yurko, W. Shalag, J. Lintzenich, D. V. Carroll, H. Ashdown, A. Sheffield



Transmit Receive Facility

Complete communication systems. Sideband transmitting and receiving stations. Sideband transmitters, 1 to 40 kw. Frequency synthesizers. Sideband diversity systems. Antenna tuning systems. Remote controlled transmitters and receivers. Antenna multicouplers. Complete engineering facilities.

†

See PROCEEDINGS OF THE IRE—May through Dec. (1960), Jan. through May (1961) for further information on our products.

See 1961 IRE DIRECTORY, pages 344-345, for complete information on our products.

Technical Operations, Inc., Booth 1719

See: Power Sources, Inc.

Technical Wire Products, Inc., Booth 4056
48 Brown Ave.
Springfield, N.J.

▲ O. P. Schreiber, ▲ S. Nellis, R. L. Hartwell, M. S. Pringle

"Fuzz Button"—super-reliable electric contact for dry circuit work and anti-bounce characteristics in relays, "Tecknit" RFI gaskets in strips, "Duogaskets" and "Duostrips" for combination pressure and RF sealing. "Techstrip"—RF gasketing with integral attachment method, complete shielded enclosures, chassis, racks, "Duolastic" RF and pressure sealing material, conductive glass, shielded air filters.

Technicraft Division, Electronic Specialty Co., Booth 1218
116 Waterbury Road
Thomaston, Conn.

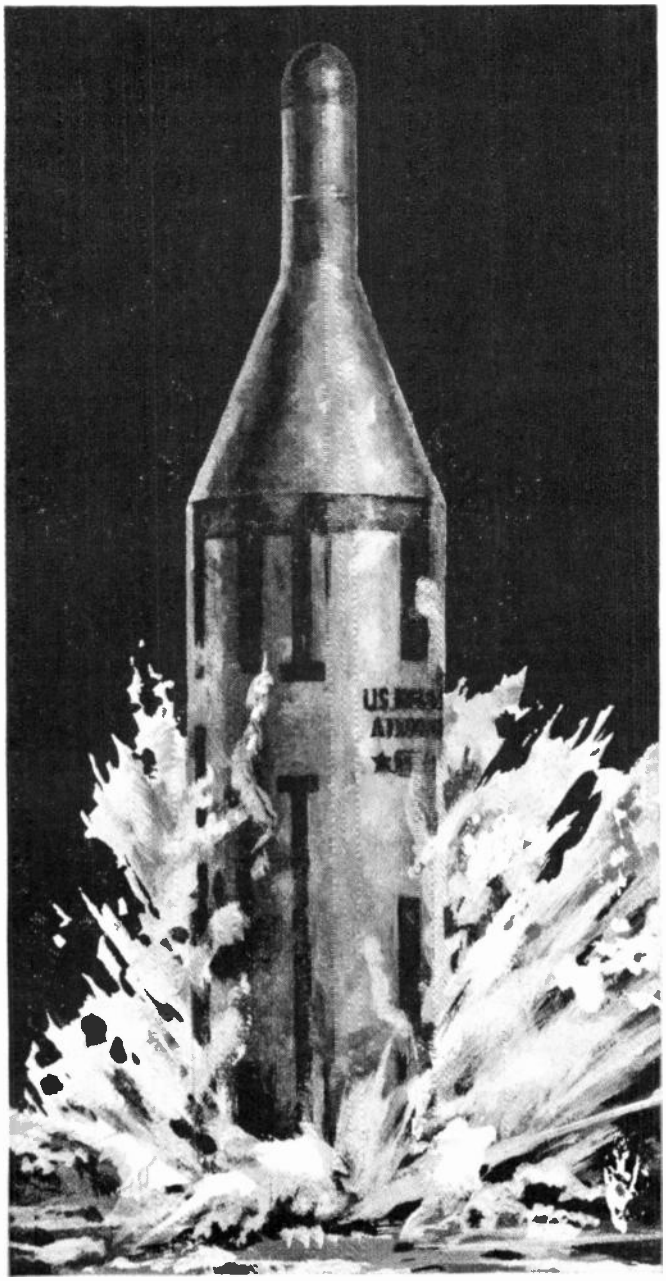
John Stinson, J. R. Nye, ▲ E. Pfund, ▲ A. Moltz, ▲ J. Garner, R. Jacques

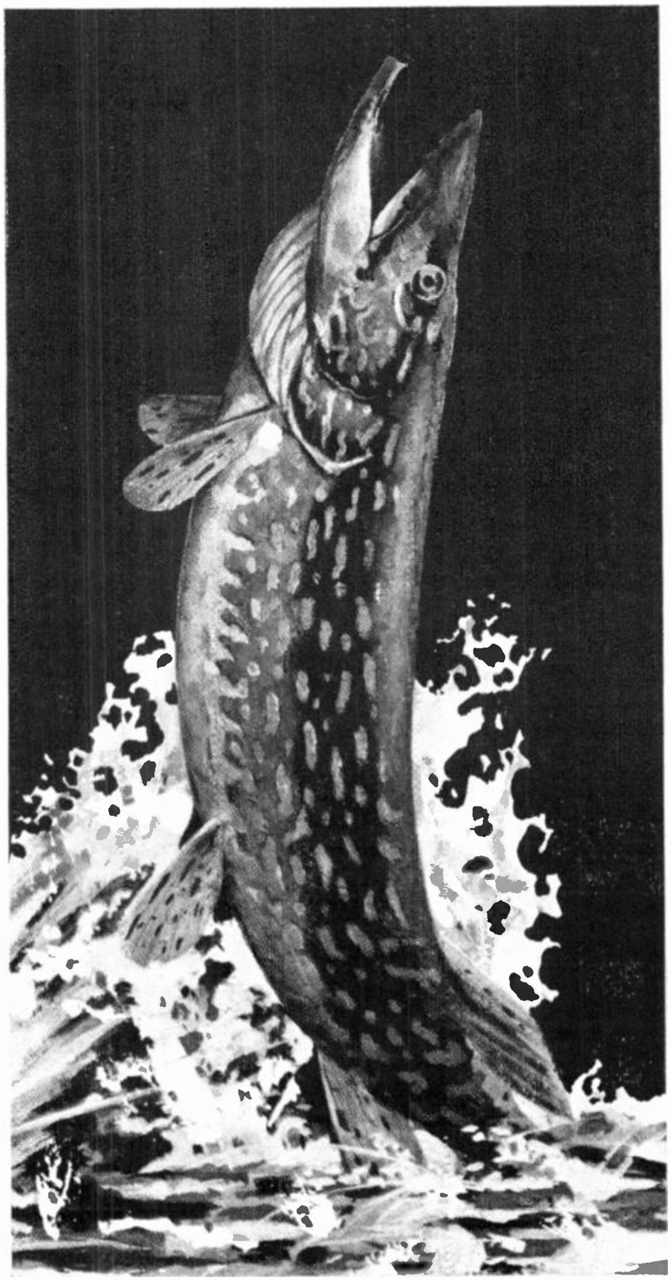
High temperature coax—1000°. High pressure flexible waveguide—L Band—45#. High temperature waveguide—flexible—2000°. Research into state-of-the-art microwave devices.

(Continued on page 384A)

A complete listing of all registrants at the IRE Show and Convention, showing company affiliation and local hotel, is posted on the back wall of the mezzanine on the west side of the first floor.

Honeywell Aero... for the best of both





CLIMATE FOR CREATIVITY—Honeywell Aero is now producing inertial platforms for the Polaris Missile. In addition Aero Division Engineers have created an Electrically Suspended Gyro for use on Polaris launching submarines, which is capable of providing accuracies never before achieved in an inertial navigation system. This project is typical of the creative concepts and ideas which are being evolved and further developed into working hardware at Honeywell Aero. We invite you to share in this creative atmosphere where there is ample opportunity for a man of imagination, drive and talents to grow in professional stature and have his accomplishments recognized and rewarded.

CLIMATE FOR ENJOYMENT—Spectator or participant, you'll find whatever sport interests you in the Minneapolis area. For example, this is the heart of America's finest fresh water fishing country. At the end of a busy day or week you can angle for pike, bass, trout, or scrappy panfish in the more than 80 lakes within 25 miles of Minneapolis. Fishing is just one aspect of the many recreational, educational, social, and cultural pleasures you and your family will enjoy when you work at Honeywell's Aeronautical Division in Minneapolis. For information on specific openings, write: Mr. James H. Burg, Technical Director, Aeronautical Division, 2618 Ridgway Road, Minneapolis 40, Minn.

Honeywell

H *Military Products Group*

To explore professional opportunities in other Honeywell operations, coast to coast, send your application in confidence to: Mr. H. T. Eckstrom, Honeywell, Minneapolis 8, Minn.

Whom and What to See at the IRE Show

(Continued from page 382A)

Technology Instrument Corporation, Booths 2317-2319
531 Main St.
Acton, Mass.

▲ Hollis L. Gray, Jr., ▲ David C. Lawton, Edward Beaudry, Mike Redovian

Precision potentiometers, trimmers, single and multiturn linear and non-linear; *Gold Seal carbon film fixed resistors; wirewound resistors, miniature delay lines, electronic magnetic dry particle clutches and brakes, packaged precision drives, miniature flexible couplings, adjustable slip clutches and space instrumentation components.

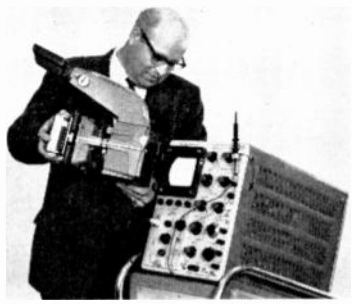
Technology Instrument Corporation of Acton, Booths 3825-3827
(Formerly Acton Laboratories)
533 Main St.
Acton, Mass.

▲ Leroy C. Bower, ▲ Stanley Swanson, Robert Griffin, Cecil Hanson, Herbert Cohen, Joseph Frissora

Phase meters and standards, impedance meters, transmission and delay measuring sets, wide band amplifiers, commutators, dc-dc converters, miniature solid state voltage regulators, sequence timers, sun seeking and sun sensing systems, micrometeorite detection systems, photometers, time delay integrating acceleration switches.

Tektronix, Inc., Booths 3511-3517
P.O. Box 500
Beaverton, Ore.

▲ Byron Broms, Dale Brous, ▲ Ted Brandt, ▲ George Edens, Bill Ewin, ▲ Dan Guy, Dick Herdman, ▲ Bill Kladke, ▲ John Kobbe, Fred Lenczynski, ▲ Cliff Moulton, ▲ Bill Polits, ▲ Oz Svehaug, ▲ Eb vonClemm, ▲ Norm Winningstad



*New C-12 Camera

*New oscilloscope cameras, new sampling 'scope, *new plug-in units for Tektronix oscilloscopes, *new KMC oscilloscope, *new militarized oscilloscope, *new low-frequency oscilloscopes, *new scope-mobile, *new probe, dual-beam X-Y oscilloscope, other instruments.

Telecomputing Corporation, Booth 2126
915 North Citrus Ave.
Los Angeles 38, Calif.

Eugene Glarson, ▲ Bernie N. Fisher, ▲ John H. Weaver, ▲ E. B. Fredericks, ▲ Joseph Kleiman, ▲ David T. Kimball, Donald A. Ramage, Robert E. Poole, H. Wardein, A. H. Fogelman, J. Conway, John Rix, ▲ Melvin Kline

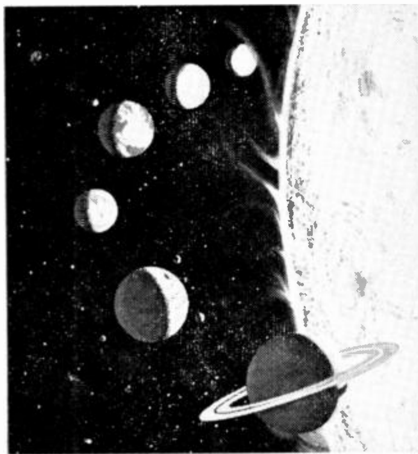
Relays, capacitors, magamps, filters, Telepoxy, Telesolv, Telepak (angular shaft digitizer), phasesolver, Submin rate gyros, submin spring energized gyros, delay lines, air traffic control beaconry, electromechanical counters, tape perforators, data processing equipment, hysteresis motors.

Telemeter Magnetics, Inc., Booth 1900

See: Ampex Computer Products Co.

(Continued on page 387A)

▲ Indicates IRE member.
* Indicates new product.



SENIOR TECHNICAL SPECIALISTS

NAA's Space and Information Systems Division is rapidly extending its capabilities into all phases of research in the nation's developing space and communications program. Top level positions are available to specialists in information systems technology to assist in achieving the Division's goals in the information systems fields. Require individuals experienced in developing and managing information systems programs. These specialists will coordinate the activities of other information systems specialists and engineers to assure that they meet overall objectives. They will also prepare study programs, plan facilities, prepare proposals and direct development programs for the Division. If you have the experience and qualifications, and have an intense interest in information systems, address a letter or resume to us for more information.

P. R. Cunningham, Manager
Employment Services
12214 Lakewood Blvd.
Downey, California

SPACE AND INFORMATION SYSTEMS DIVISION
North American Aviation

SEMICONDUCTOR ENGINEERS and SCIENTISTS

SHOCKLEY TRANSISTOR
(Unit of Clevite Transistor)

Offers career opportunities to experienced engineers. Key posts immediately available for:

- PHYSICISTS
- PHYSICAL CHEMISTS
- METALLURGISTS
- ELECTRONIC ENGINEERS
- MECHANICAL ENGINEERS
- CHEMICAL ENGINEERS

Challenging work assignments involving fundamental research and development, circuit design and applications, manufacturing and product engineering, process engineering and supervision.

For further information concerning career opportunities call R. E. Caron, Engineering Placement Director, COLLECT at DA 1-8733 or send résumé in complete confidence to him at

Shockley TRANSISTOR
335 San Antonio Road
Mountain View, California

ELECTRONICS ENGINEERS

Engineers with B.S. or M.S. degrees in E.E. or engineering physics from accredited engineering schools are needed to develop and design sophisticated electronics associated with analytical instruments.

Candidates should have 3-5 years experience with vacuum tube and solid state circuits, good mathematical background, and ability to analyze problems arising in instrumentation development. Salary commensurate with ability.

Located in one of the most desirable parts of the metropolitan Los Angeles area.

Send reply to:
Dr. C. E. Berry
Director of Engineering
Analytical & Control Division
Consolidated Electrodynamics Corporation
360 N. Sierra Madre Villa
Pasadena, California

$$P_n(t)=e^{-\lambda t}\frac{(\lambda t)^n}{n!}$$

MANAGER
NEW
STOCHASTIC PROCESSES
LABORATORY

This is an opportunity to initiate and direct studies in mathematical statistics at the doctoral level, aimed at formulating and solving problems of human and systems behavior, in order to lay a theoretical foundation for future development of advanced communications systems.

Current study problems include stochastic behavior of linear and nonlinear systems, stochastic learning processes, theoretical development of fault detection in complex physical systems by statistical mathematics, and statistical theory of identification and diagnosis of random distributions of objects immersed in fluids—both infinite and finite.

Work is carried on in the academically free environment of a new research facility of a large Eastern electronics firm which provides broad leeway for individual theoretical and experimental investigations.

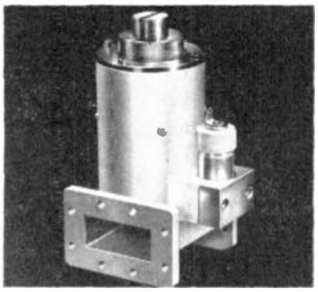
If you have a PhD in engineering and a strong mathematical background, or if you have a PhD in mathematics with an interest in engineering, your inquiry is invited—in confidence, of course. Box 2016, Institute of Radio Engineers, 1 East 79th St., New York 21, N.Y.

Whom and What to See at the IRE Show

(Continued from page 384A)

Telerad Division of The Lionel Corporation, Booth 1427
Route 69
Flemington, N.J.

G. George, C. Watkins, H. J. Eyerman, W. McCaffery, E. A. Kiely



*RF Wavemeter—High Frequency-Temperature Stability

Rigid and flexible waveguide from 1.7 to 18 kmc, rigid coaxial line $\frac{7}{8}$ through $6\frac{1}{8}$, rotary joints, *high stability wavemeter, microwave antennas, beacon test sets, directional couplers, mixers, duplexers and special microwave plumbing.

Teletronics Laboratory, Inc., Booths 3615-17

See: Crosby-Teletronics Corp.

Television Utilities Corp., Division of Nord, Booth 3123
300 Denton Ave.
New Hyde Park, L.I., N.Y.

Eugene Kron, David Sigler, David Harris, ▲ Charles Odom, Laurence Kupler, Paul Glasgow, Ken Worthington, Charles Connors, Stanley Farber, Frank Kreisher, John Schenkel, Henry Bardong

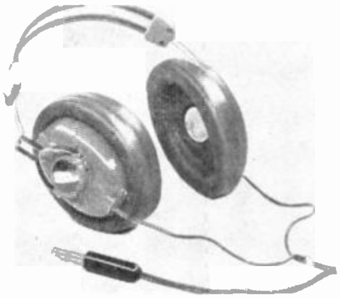
Televise without camera or light: "Cameraless" TV for transmitting of microfilm, data, information. Unique process of transmitting and remote viewing of microfilm and enlarging to more than 60 times aperture size. Also video amplifiers, sync generators, kinescope recorders, flying spot scanners.

Telewave Labs., Inc., Booths 3301-07

See: Polarad Electronics Corp.

Telex, Inc., Booth 1721
1633 Eustis St.
St. Paul, Minn.

Kenneth McCrimmon, Pete Millunzi, Robert Buelow, ▲ Robert Sell, Paul Brinke, Dean Flygstad, A. J. Ryden, A. P. Pitzl, Ordean Kiltie, William Weir



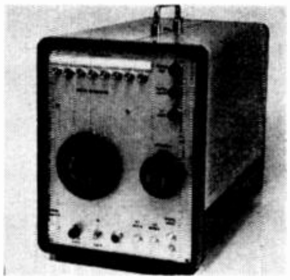
Communications Accessories Div.: Language learning, communications, dictating and high-fidelity headsets, including the Telex Magna-Twin, Twinset, Boom-Mike headset, TeleTwin, Monoset, Dynaset, Tele-Fi, Tele-Set, Earset, TV Listener, pillow speakers, miniature jacks and plugs, hospital intercoms. Special Products Div.: General purpose switch, multiple array switch, low voltage neon indicator light, encapsulation.

(Continued on page 388A)

Whom and What to See at the IRE Show

(Continued from page 387A)

Telonic Industries, Inc., Booth 3826
60 N. First Ave.
Beech Grove, Ind.
C. R. Wainwright, L. W. Abbott, R. L. Welsh



*New Portable Cabinet Design

Sweep and signal generators from 1 to 2500 megacycles with as much as 4 watts output, turret and toggle switch attenuators, RF detectors and coaxial switches, available on 24 hour delivery with Jet Order Service. 0 to 900 mc; 1300 to 2400 mc; 500 to 1000 mc; 3 to 4 watt output; *VHF-TV in unique portable cabinet. Telonic Engineering Corp.: Lowpass, bandpass, tunable RF filters.

Telrex Labs., Booth 1317
Asbury Park, N.J.
▲ M. D. Ercolino, Ralph Ercolino, C. C. Ercolino, George Meyers

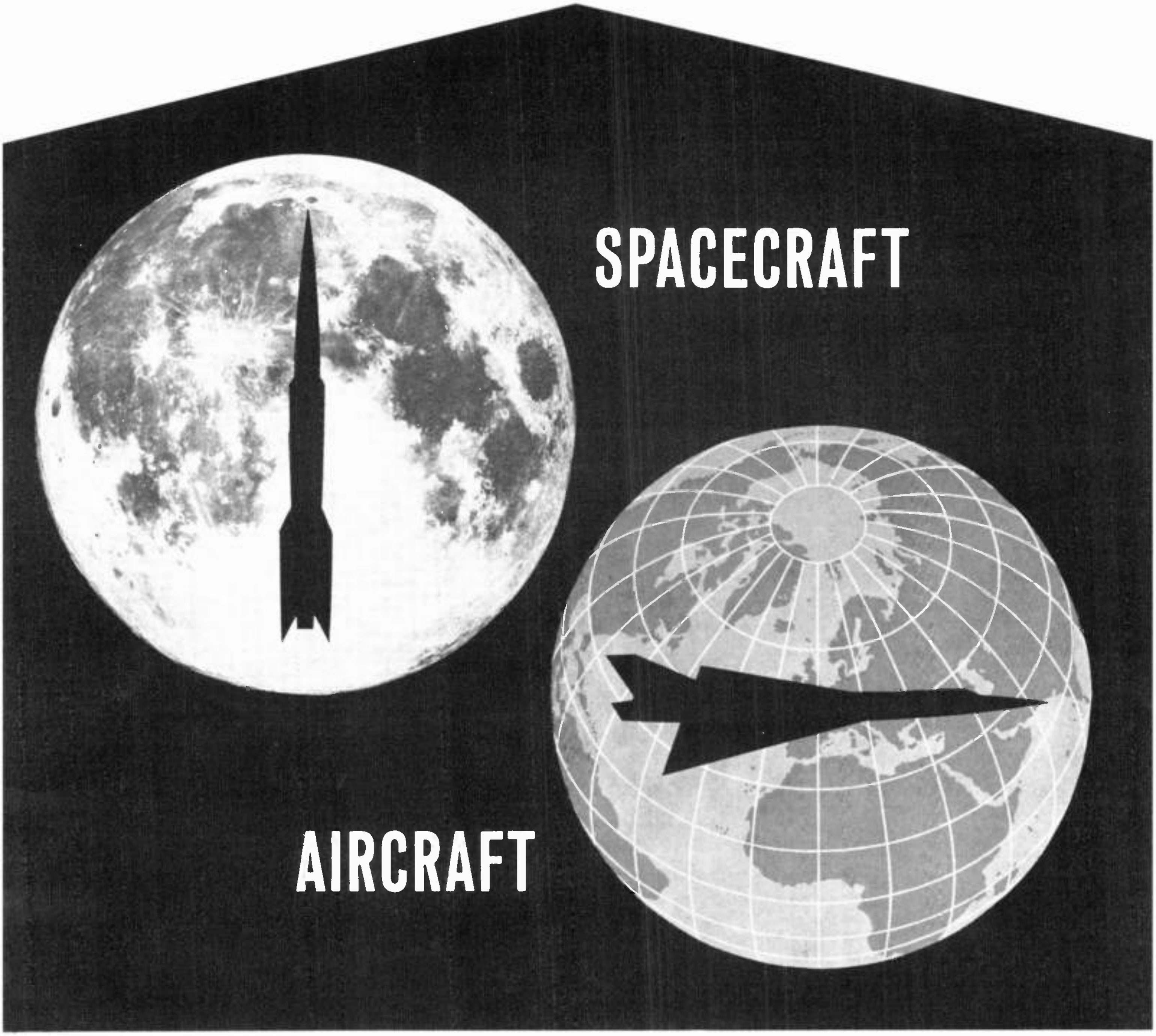
Antennas and systems for government, commercial or amateur service. "Beamed-Power"-balanced-pattern arrays. Manufacturers of antennas, rotators, indicators. Consultants, designers for complete antenna systems, "Spiralray" antennas. *397RIS rotator. *TC-99 Tri-band.

Temco Electronics, Div. Temco Aircraft Corp., Booths 3802-3806
See: Ling-Temco Electronics, Inc.

(Continued on page 390A)

Show Hours
10 a.m. to 9 p.m. daily
Monday through Thursday
March 20-23, 1961

Display your badge or pocket card with your name prominently. Even your competitors will welcome you. Every visitor is important to every exhibitor. Help him to know who you are so he can serve you better. By reading your badge he can more swiftly estimate what will interest you and show it to you.



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Lockheed California Division has expanded its already great resources at Burbank. For it now encompasses, under one roof, the two vast worlds of Spacecraft and Aircraft.

This typifies Lockheed policy to steadily advance the state of the art through basic research in related and scientific fields.

Result? Now—more than ever—Lockheed offers Scientists and Engineers uncommon opportunities; equips them with every modern facility; gives them freedom to explore and express new ideas; makes possible greater individual recognition.

Now being designed and developed in Spacecraft and Aircraft are: Hypersonic interceptors; V/STOL; supersonic interceptors; limocopters; missiles; manned spacecraft; and satellites.

Scientists and Engineers of outstanding talent are now invited to participate in this new, dual enterprise. Immediate openings are available to: Aerodynamics engineers; thermodynamics engineers; dynamicists; electric research engineers; servosystem engineers; electronic systems engineers; biophysicists; infrared physicists; hydrodynamicists; ocean systems scientists; physio-psychological research specialists; mammalian culture research specialists; and radiation hazards specialists.

Write today to Mr. E. W. Des Lauriers, Manager Professional Placement Staff, Dept. 1803, 2402 N. Hollywood Way, Burbank, California.

LOCKHEED

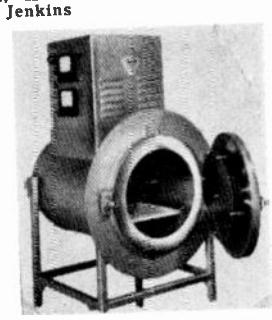
CALIFORNIA DIVISION

Whom and What to See at the IRE Show

(Continued from page 388A)

Temperature Engineering Corp., Booth 4139
U.S. Highway No. 130
Riverton, N.J.

Sidney H. Perlman, Norman Burstein, Barry Perlman, Harold Ottbrini, Robert Harkins, Rolland Jenkins



400° Vac-U-Therm® Oven

Packaged controlled atmosphere enclosures, fabricated from steel or stainless steel—with welders, vacuum bakeout, test facilities, production flow for processing semiconductors, controlled rectifiers and other hermetically sealed components. Packaged high vacuum pumping systems with vacuum ovens. Evaporator-dry box, soak ovens, semiconductor and life test equipment. *dryers.

M. Ten Bosch, Inc., Booth 1315
80 Wheeler Ave.
Pleasantville, N.Y.

M. Ten Bosch, George Bannerman, Herbert Bredemeier, John Corneal, Raymond Frowd, Paul Lang, William Povall, James Taylor

*New model 1810-0500, servo amplifier power supply, the only transistorized, plug-in servo amplifier power supply selling under $100 and designed for industrial automation applications where modest cost and high reliability are essential. We also are showing "Servo Building Blocks," the popular LQR unit, rotor balancer, air data computers, other airborne components.

Tenney Engineering, Inc., Booths 3118-3120
1090 Springfield Rd.
Union, N.J.

Martin G. Schletter, Robert H. Brown, Edward Lavine, Edward Singer, Ralph Sansone, Fred Hermann, Frank Gardner, Jerome Perlstein, Anthony Posella, William Dunn

Space environmental simulator and orbital simulation equipment along with standard test chamber. In addition, variable speed drive electronic control regulator. Amplifiers, audio frequency test equipment, converters, power supplies.

Your registration admits you to the show for all four days, and to all technical sessions at the Coliseum and the Waldorf-Astoria. Be sure to keep your badge or pocket card with you at all times on the floor. Registrations are not transferable.

Tensolite Insulated Wire Co., Inc., Subsidiary of Carlisle Corp., Booth 4330

West Main St.
Tarrytown, N.Y.

Lou Barton, Charlie Beran, Don Dombrowsky, Bill Euerle, John Fay, ▲ George Heller, Frank Marocco, George Melody, Gene O'Neill, Dick Ruhling, Walt Samsonoff, Frank Wrobleski

Teflon Cable and Cable Assemblies

*New ML and teflon magnet wire, teflon tape, teflon insulated wire and cable to MIL-W-16878, NAS-703, etc., multiconductor cable, cable assemblies and harnesses, MIL-C-17 teflon coaxial cable, MIL-W-7139 airframe wire, vinyl coated wire specialties, bondable teflon, ribbon cable and other specialty insulated wire and cable to military and customer specifications

Tensor Electric Development Co., Inc., Booth 3945

1873 Eastern Parkway
Brooklyn 33, N.Y.

Tim Sutton, ▲ Gerald Starr, ▲ Jay Monroe, Ray Mazurek, ▲ Bruce Erlichman, ▲ Martin Gindorf

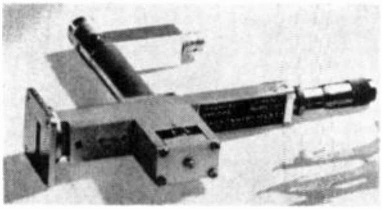
Model 5846 Arbitrary Function Generator

Manufacturers of precision test equipment: Exhibiting Model #5880 incremental analyzer, Model 5846 arbitrary function generator, Model #5890 ac-dc reference source, Model #5900 precision work lamp.

Texas Instruments Incorporated, Apparatus Division—Government Products Group, Booths 1409-1421

P.O. Box 6015
Dallas 22, Tex.

A. L. Coulson, P. Gomez, K. P. Dowell, L. Strom, B. Bailey, Grant Dove, H. Mayer, W. McGalliard



Parametric Amplifier

Microwave assemblies, missile/space command and communications systems, combat surveillance, systems, undersea warfare equipment.

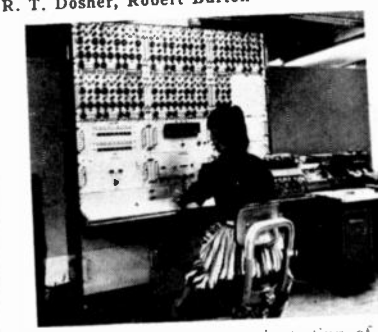
(Continued on page 392A)

Whom and What to See at the IRE Show

(Continued from page 391A)

Texas Instruments Incorporated, Apparatus Division—Industrial Products Group, Booths 1409-1421
P.O. Box 6027
Houston 6, Tex.

C. W. Nimitz, Jr., O. F. Henning, T. L. Wilson, C. A. Maloney, Raymond Fara, Leonard Gilmore, Robert Broderick, R. L. Atmar, R. T. Dosher, Robert Burton



*"Tact" System for automatic testing of transistors, other semiconductors and components. The "recti/riter" and "servo/riter" strip-chart recorders. *Power supplies. *A-D-A converters. *Industrial controls.

Texas Instruments Incorporated, Geosciences & Instrumentation Div., Booths 1409-1421

See: Texas Instruments Incorporated, Apparatus Division-Industrial Products Group

Texas Instruments Incorporated, Metals & Controls Inc., a Corporate Division, Booths 1409-1421
34 Forest St.
Attleboro, Mass.

E. O. Vetter, B. O. Haun, Jr., H. F. Rice, Jr., H. M. S. Swift, R. Kondrat, R. Murphy, J. A. Bole, M. J. Payton, R. W. McGahey, H. R. Greene, I. E. Slawson, B. A. Bosher, R. A. Schultheiss, J. Meloni

"Klixon"® circuit breakers for cable and component protection, disc type precision thermostats for high reliability applications, miniature snap-acting hermetically sealed limit switches, precision thermal protectors, special switch and thermostat packages, General Plate clad metals, materials for semiconductors and electron tubes, collector and slip rings, ball welded electrical contact assemblies.

(Continued on page 394A)

Be sure to see all four floors for a complete view of 800 new ideas!

Your firm not listed?

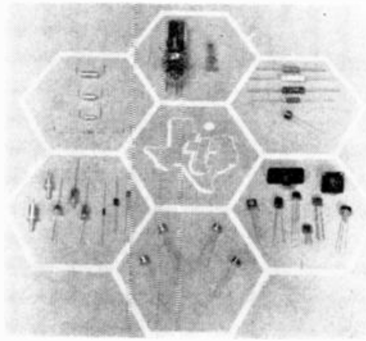
If you would like to become an exhibitor in the IRE show, write for information to IRE Exhibits Dept., 72 W. 45th St., New York 36.

Whom and What to See at the IRE Show

(Continued from page 392A)

Texas Instruments Incorporated, Semiconductor-Components Division, Booths 1409-1421
13500 N. Central Expressway
P.O. Box 5012
Dallas 22, Tex.

Mark Shepherd, Dick Hanschen, Jay R. Reese, Jim McDade, Harry Owens, C. R. Rockwood, Mike Corboy, Ed Brierty, Dick Lee, Ken Davis, Bob Votteler, Bob Marlowe, Charles Clough, Wayne Dean, Jess Moore, Jim Bender, Wally Potter, Cliff Baker, Mart Kasischke, Al Girardot, Al Alexander



Silicon transistors (epitaxial, "μmesa," small signal, switchers, medium power and power), germanium transistors (mesa and alloy switchers, consumer RF, audio, power), diodes and rectifiers (silicon, gallium arsenide varactors), precision resistors, tantalum capacitors, infrared detectors, light sensors, "Sensistor"® silicon resistors, "Solid Circuit" semiconductor networks, silicon material.

† See PROCEEDINGS OF THE IRE Jan. through Dec. (1960), Jan. through April (1961) for further information on our products.

See 1961 IRE DIRECTORY, page 394, for complete information on our products.

Textron Electronics, Inc., Booths 2337, 3107-3109 & 3108-3110

See: California Technical Industries, GC Electronics Co., MB Electronics

---

Thermal Controls, Inc., Booths 1621 & M-5

Thermal time delay relays. See: Hermetic Seal Corp. & Connector Seals Corp.

Thermal Wire of America, Booth 4127
Keeler's Bay
South Hero, Vt.

H. Corbin, Jr., M. Moon, M. Ziter, O. Corbin, W. Legge, G. Lawrence, T. Parizo, L. Lavigne, S. Norton, B. Hall, M. Schwartz

Teflon insulated magnet wire, teflon lead wire, cables, coaxial cables, tubing.

Thermo Electron Engineering Corp., Booth 3944
85 First Ave.
Waltham 54, Mass.

▲ Lawrence T. Sullivan, ▲ Peter G. Pantazelos, Kenneth R. Stephens, Dr. Pierre Brosens, John Psarouthakis, Lazaros Lazaridis

Vacuum and cesium thermionic converters for direct conversion of heat to electricity.

(Continued on page 396A)

Keep this book for future reference, so you will be able to remember "Who made it?" and discover "Where can I reach them now?"

A message of significance to the leading microwave scientists of TOMORROW ...a message you should act on TODAY!

Sylvania's Microwave Device Operations on the San Francisco Peninsula now has programs of advanced development underway in the microwave device field. This work offers a rare opportunity to outstanding microwave specialists—an opportunity to assume overall responsibility for exploration in the fields of high power traveling wave tubes employing periodic structures, high power klystrons, and ferrite devices. The men who carry these programs forward should preferably have a Ph.D and several years of relevant experience.

You are invited to investigate now by writing to Dr. J. S. Needle at the address below. (Similar opportunities in the field of magnetrons and special purpose tubes also exist at the Microwave Device Operations in Williamsport, Pennsylvania.)

MICROWAVE DEVICE OPERATIONS

P. O. BOX 997, MOUNTAIN VIEW, CALIFORNIA

SYLVANIA

Subsidiary of **GENERAL TELEPHONE & ELECTRONICS**

6866

Whom and What to See at the IRE Show

(Continued from page 394A)

Thomas & Betts Co., Inc., Booth 1921
36 Butler St.
Elizabeth, N.J.

J. O'Donnell, E. Dixon, M. Haupt, E. Dowling, Robert Croghan, E. Finn, ▲ Richard Grant, Martin Schneck, V. J. Brennan, R. Shay, D. Lownes, P. Garippa

Stakon terminals and connectors, grounding sheath connectors and adapters, Ty-Raps cable ties and straps, insulated and non-insulated strip terminals and attaching machines, *Pos-E-Kon and *Post-E-Flex flat conductor cable connectors and accessories.

Thomas Electronics, Inc., Booth 2913
118 Ninth St.
Passaic, N.J.

Robert S. Klonfas, Ivan J. Posner, ▲ Nicholas Broderick, ▲ Kenneth Hoagland, Augie Daber, ▲ Peter Seats, Edward Lisovicz, Gerald R. Cornell, Michael Goriscak, Charles Livingstone, Bernard Waxenbaum, Joseph Snack

L.V. non-aluminized screens for low voltage applications (will produce up to 10 F.L. at 500v). *Tubes manufactured for transistorized application. Low voltage aluminized tubes with 1.5 kv breakthrough. Representative tubes of line encompassing over 250 registered types.

Thomas & Skinner, Inc., Booth 2921
1120 East 23rd St.
Indianapolis 7, Ind.

James C. Skinner, Robert Fulton, Edward Cronk, Rollin J. Millar

Magnets: Alnico, cast, sintered, Sincomax, barium ferrite. Laminations: Transformer, motor, Orthosil, silicon steel—24, 18, 14, 6, 4, 2 mil. Wound Cores: Single phase, three phase, toroidal, Orthosil, silicon steel—12, 5, 4, 2, 1 mil. Tapes: Orthosil, silicon steel—12, 5, 4, 2, 1 mil.

Thompson Products, Booths 1435-1635

See: Thompson Ramo Wooldridge Inc.

Thompson Ramo Wooldridge, Inc., Booths 1435-1635
8433 Fallbrook Ave.
Canoga Park (Los Angeles), Calif.

C. H. Wacker, B. C. Keach, H. A. Jacobus, W. F. Keith, K. J. Hayes, H. N. Sachar, D. A. Schonmayer, J. R. Rector

AN/UYK-1 stored logic digital computer, command destruct receiver, telemetry calibrator, closed-circuit television cameras and monitors, IF transformers, ceramic capacitors, fixed capacitors, rectifiers, microwave switching devices, image converter camera, atomic clock, auxiliary power units, medical amplifiers, static inverters, video telemetry transmitter, space capsule amplifiers, analog computer elements, waveguide and coaxial switches, speed controls, antenna couplers, multiphase unbalance protective devices.

See also Good-All Electric Mfg. Co. & Pacific Semiconductors, Inc.

Three Point One Four Corp., Booth 1124
24 Woodworth Ave.
Yonkers, N.Y.

J. J. Root, M. Odlibak, Harold Kay, Walter Anderson

"Chlorivolt" miniature batteries deliver large peak currents (10 amps/sq. in.). Recharged at 1 amp/sq. in. Rapid depolarization, withstands shorts for sustained periods, recovers full potential in fractions of second. 5 sizes. Silver-chloride, magnesium, zinc, sea water activated batteries also available.

Times Facsimile Corp., Booths 1610-18

See: Westrex Corp.

Tinnerman Products, Inc., Booths 4207-4211
P.O. Box 6688
Cleveland 1, Ohio

R. R. Byar, L. H. Flora, S. A. Gaylord, W. H. Gibbons, E. E. Griger, C. R. Hesse, F. E. List, R. H. Hansen, D. M. Hager, H. C. Bodine, T. M. Landfear, W. F. Brophy

Complete line of more than 10,000 variations of "Speed Nut" brand fasteners. Special emphasis on fasteners for radio, television and electronics applications. Actual product assemblies will be on view, as well as special demonstrations of newly developed fasteners.

Tinsley Instruments, Ltd., Booths 3409-3411

Precision electrical instruments. See: Sensitive Research Instrument Corp.

Titanium Alloy Mfg. Div., Booth 4518

Titanates and zirconates. See: National Lead Co.

Toko Radio Coil Laboratories, Ltd., Booth 1923

See: Japan Electric Industry

(Continued on page 398A)

▲ Indicates IRE member.
* Indicates new product.
† Exhibitor is servicing IRE Engineers through the IRE Package Plan.

A STUDY FROM LIFE FOR RYAN BY D. MILLSAP

THE ELECTRONICS ENGINEER

One component in the world of electronics is as old as creation: MAN. A very special breed of man: the Engineer. Without him, no new application of the art, no improvement of the old, no bold departure from tradition. No aeronautics. No electronics. No... Ryan. This is why we hold the Engineer in overwhelmingly high regard, seek him out with unrelenting search, provide him with optimum conditions in which to conduct research and development. Indeed, without him the Ryan Electronics Center could not maintain its position of leadership in electronics. With him, no ceiling can be set on what Ryan can do, no limit fixed on his horizon or ours. No place else is there more urgent need or brighter future for the qualified engineer, and your inquiry is invited. Send resume in confidence to George Gerner, professional employment.

RYAN ELECTRONICS A DIVISION OF RYAN AERONAUTICAL COMPANY

5650 KEARNY MESA ROAD, SAN DIEGO 12, CALIFORNIA

Whom and What to See at the IRE Show

(Continued from page 396A)

Torotron Corp., Booths 2241-43

Toroidal inductors, filters, and magnetic amplifiers. See: Douglas Microwave Co., Inc.

Torrington Company, Booth 4117
59 Field St.
Torrington, Conn.

R. S. Keppelman, V. C. Bockus, C. R. ter Kuile, A. J. Kinsella, E. L. Lancaster, William Shannon, E. W. Pearson, J. A. Juhas

Relay cores, header pins, semiconductor wire leads, connector contact pins, rectifier cable leads, solderless wire wrapping bits, miscellaneous special machined pins and leads produced to customer specifications.

Torrington Manufacturing Co., Booth 1924
Torrington, Conn.

▲ Adam M. Wilczenski, T. G. Thompson, G. Merrow, H. Foeller, A. E. McDade

Centrifugal, axial, vane axial blower units for electronic, airborne, military cooling requirements.

Tower Construction Co., Booth 1223
2700 Hawkeye Drive
Sioux City, Iowa

L. J. Tokarczyk, E. H. Moore, Harry Fair, ▲ M. M. Lasensky

High rigidity towers and reflectors for microwave.

Towne Laboratories, Booth 4131

See: Affiliated Manufacturers, Inc.

Trak Electronics Company, Inc., Booths 3803-3805
59 Danbury Rd.
Wilton, Conn.

John L. Gray, Raymond E. Fredrick, Walter L. Gustavson, George W. Korper, Douglas A. Worth, G. James McCulloch

Transistorized antenna multicoupler for 2-32 mc; *50-100 mc panoramic receiver; Morse to teleprinter code converter; Incereductor RF saturable reactors; wideband RF transformers, shift registers; solid state tuned oscillators; microwave oscillator cavities; microwave noise tubes; radar performance monitor; tunnel diode curve tracer.

Transducer Corp. of Puerto Rico, Booths 3405-07

See: Potter Instrument Co., Inc.

Transicoil Division, Daystrom, Inc., Booth 1805
Montgomery County
Worcester, Pa.

▲ William Hargreaves, ▲ Dwight Bloser, Frank Hagen, ▲ Pete Yeannakis, ▲ Samuel Lapidge, George Ganczarski, John J. Gattoline, Cliff Conkling

*Temperature-stable lightweight synchro, pancake synchro, *inertially damped motors, *acceleration-damped motors, *high performance motors and motor tachometers, *size 5 motors and motor tachometers, *complete line all frame sizes temperature-compensated motor tachometers, *new line of "short" motors and motor tachometers, *Miniaturized servo amplifiers.

Transistor Specialties, Inc., Booth 3242
Terminal Dr.
Plainview, N.Y.

▲ Daniel J. Mindheim, ▲ George Slusarchyk, John De Mayo, Chester Reitzel, Howell Hicks

Model #361 Apti-meter 1 mc. Model 361R Apti-meter 1 mc. *Model #365R Apti-meter 10 mc.

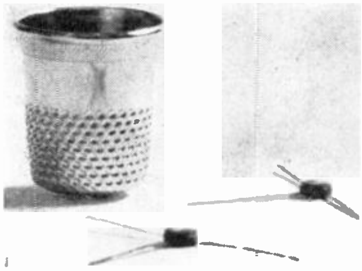
(Continued on page 400A)

Whom and What to See at the IRE Show

(Continued from page 398A)

Transitron Electronic Corp., Booths 1220-1224
168 Albion St.
Wakefield, Mass.

H. T. Neavitt, Lawrence W. King, ▲ Gunther Rudenberg, ▲ William Slusher, Dana Robinson, Peter Jenner, Charles Hill, Thomas Clark, Harold Zoolalian, Francis Bigda, Eric Jackson, Lou Kauffeld, Stanley Karandanis, Arthur DeVenturi, Stewart Peters, Walter Barth, Robert Haase, Burt Green, Paul Walsh, Harry Schefe, Fred Hoctor, Leon Alward



Transitron's Microtransistors

View a cross-section of our line of semiconductor devices, including: Germanium diodes, tunnel and backward diodes; silicon transistors, diodes, rectifiers, controlled rectifiers and switches, *microtransistors, microdiodes, regulators, references, encapsulations, and thermoelectrics.

▲ Indicates IRE member.
* Indicates new product.
† Exhibitor is servicing IRE Engineers through the IRE Package Plan.

Travco Associates, Inc., Booths 1230-1232
45 North Station Plaza
Great Neck, N.Y.

T. Greenburg, S. Benerofe

Magtrol: Subminiature friction clutches, brakes, hysteresis clutches (stationary coil), dynamometers; Arnoux: Power supplies, temperature probes, *umbilical connectors, telemetry equipment, *projection decade counter, *PCM signal simulator; Georator: "No-Brush" 400 cycle generators; Naybor: *6PDT miniature relay.

Triad Transformer Corp., Booths 1610-1618 & 1709-1717

See: Litton Industries, Inc.

Trio Laboratories, Inc., Booth 3033
DuPont Dr.
Plainview, L.I., N.Y.

John R. Crawford, Harold D. Miller, Nicholas A. Christian, H. Grey, Knuth, ▲ Jay S. Salz, Jerry Worthing

Rack mounting ¼% true RMS VTVM. Complete line miniature vacuum tube and transistor instruments specially designed for panel-mounting. Available in single and multi-range, military and commercial models. Voltage comparator, *Model 204-1, portable ac VTVM Model 109-2, Model 130-1 1% accuracy panel-mounting ac VTVM.

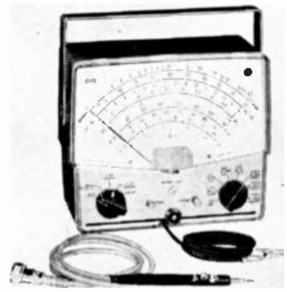
(Continued on page 402A)

Whom and What to See at the IRE Show

(Continued from page 400A)

Triplett Electrical Instrument Co., Booth 2426
286 Harmon Rd.
Bluffton, Ohio

W. R. Triplett, N. A. Triplett, M. M. Triplett, A. W. Daschke, George Salmons



Model 850 Electronic Volt-Ohmmeter

Electrical measuring instruments (panel and portable types), instrument relays, complete lines of test equipment for electronic, electrical, radio and television. Special industrial, electrical, electronic test equipment and instruments.

Tru-Connector Corp., Booth 1116
416 Union St.
Lynn, Mass.

▲ Robert A. Peters, James J. O'Neil, Jr., Robert F. Hoff

RF coaxial connectors, all series from subminiature to submarine hull fittings including TNC, QDS, QDL—Wire-lok connectors for Styroflex, Styrofil, Foamflex and rigid-line cable.

Tru-Ohm Products Div., Model Engineering & Mfg., Inc., Booth 2305
3426 West Diversey
Chicago 47, Ill.

Mel M. Jones, Bill Griffin, Ray Vanderspool, John Kinnaw

Resistors and power rheostats, *economy rheostat, *300 watt rheostat, *S.AL type resistors.

Tucor, Inc., Booths 3803-3805

Microwave noise tubes. See: Trak Electronics Co., Inc.

(Continued on page 404A)

▲ Indicates IRE member.
* Indicates new product.
† Exhibitor is servicing IRE Engineers through the IRE Package Plan.

First and Second floors—Components

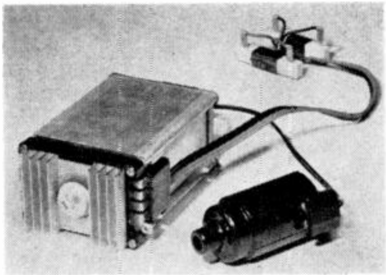
Third floor—Instruments and Complete Equipment

Fourth floor—Materials, Services, Machinery

Tung-Sol Electric, Inc., Booths 2334-2336, 2427-2429

1 Summer Ave.
Newark 4, N.J.

J. M. Malone, R. S. Whitlock, William Dickey, G. Hughes, L. May, William Mead, T. Stokes, R. Zimmerman, W. Ohlsen, G. Quinn, P. Johnson, Jr., W. Roberts, C. Weeks, D. Wolter



EI-IV Electronic Ignition System

EI-IV electronic ignition system. "Cold Weld" transistors and *silicon rectifiers, special purpose and industrial tubes including new types *6587A, *7455, *7813, *7802WB, *7719, *7607, *7851, *7236, *7892, *6977. Equipment utilizing some of these will be shown. Entertainment types *6CW5, 12FR8, 12FX8, 5881, and 6550 matched pairs. Tung-Sol's readout lamps, exciter lamps, and *662 flasher will be displayed, as well as cathode ray picture tubes.

† See PROCEEDINGS OF THE IRE—Jan., March, May, July, Sept., Nov. (1960), Jan., March, May, July, Sept., Nov. (1961) for further information on our products.

See 1961 IRE DIRECTORY, pages 74 and 75, for complete information on our products.

Whom and What to See at the IRE Show

(Continued from page 402A)

Tweezer-Weld Div., Booth 4428

See: Federal Tool Engineering Co.

Twin Lock, Incorporated, Booth 1113

1024 West Hillcrest Blvd.
Inglewood 1, Calif.

Frank A. Kasala, William Bryan, Charles F. Krause, Jr., C. Parke Masterson, Joseph Lavoratta

Terminal blocks and components.

USECO, Inc., Booths 1610-18 & 1709-17

See: Litton Industries, Inc.

Ucinite Company, Div. United-Carr Fastener Corp., Booth 2536

459 Watertown St.
Newtonville, Mass.

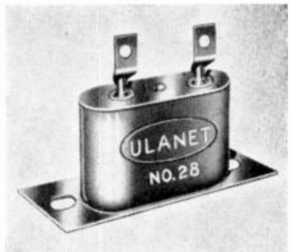
O. H. Bramhall, W. Dolan, Hector Petri, E. B. Mitchell, R. W. Fraser, R. Hartsock, A. Kontrimas

Switches, printed circuit connectors and components, test jacks, banana pins, plugs and jacks, vibration isolators, indicator lights, printed circuit switches.

George Ulanet Co., Booth 2119

413 Market St.
Newark 5, N.J.

H. Ulanet, A. W. Burke, Charles McQuoid, H. Hippe



Complete line of thermostats and thermal timers, miniature hermetically sealed surface sensing precision thermostats, for electronic and aircraft applications. FM model capsule thermostats.

Ungar Electric Tools, Electronic Div. of Eldon Industries, Inc., Booth 4135

1475 E. El Segundo Blvd.
Hawthorne, Calif.

William L. Nehrenz, Robert E. Greenwood, Al Knowles

Complete *new line of soldering tools.

Unholtz-Dickie Corp., Booth 3926

2994 Whitney Ave.
Hamden 18, Conn.

▲ Donald S. McCluskey, Karl Unholtz, Gerald Reen, John Dickie, Walter Jarowey, Norman Ponge, Robert Kennedy, Chet Vincentz

Unified vibration test systems including automatic control featuring economical expandability. *Dial-A-Gain double integrating vibration meter with calibrated gain adjustment to give indication and standardized signal of 1 volt per inch and 1 volt per G for recording.

Uniform Tubes, Inc., Booth 4035

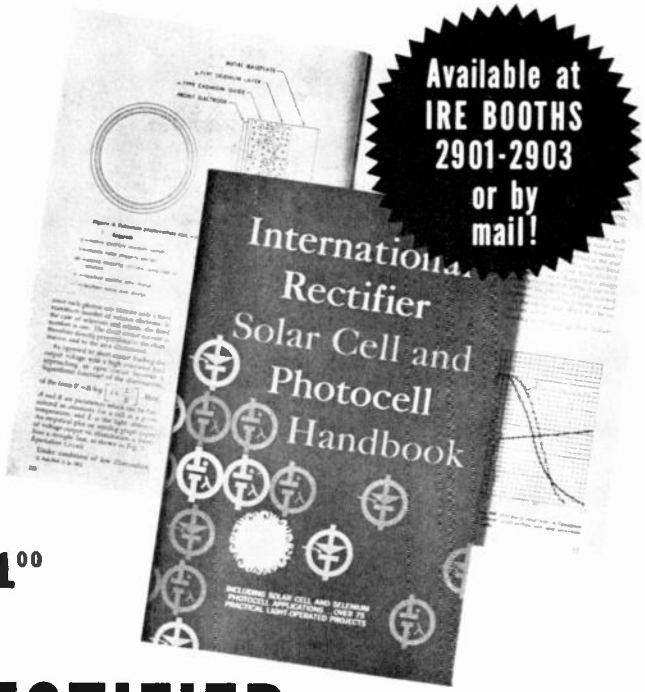
Level Rd.
Collegeville 2, Pa.

D. T. MacNair, A. B. Mainwaring, G. Hattersley, J. W. Brown, B. G. Allerton, E. Fagerlund, G. E. Clauser

Manufacturer of metal tubing and fabricator of tubular parts including glass to metal sealing alloys, beryllium copper, stainless and low carbon steel, aluminum, brass, copper, nickel alloys, precious metals, columbium and tantalum. Sizes .005 to .625 O.D. and .0005 to .035 wall.

(Continued on page 406A)

A SPECIAL OFFER IN CONJUNCTION WITH THE 1961 IRE SHOW!



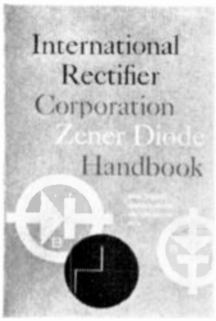
GET YOUR COPY OF THIS ALL NEW
SOLAR CELL AND PHOTOCELL HANDBOOK

This 112-page technical manual features full descriptions of over 75 practical light-operated circuits . . . contains projects and demonstrations of both selenium photocells and silicon solar cells . . . includes chapters on basic photovoltaic theory, photocell performance characteristics, radiation theory, and infrared and ultraviolet photocell applications . . . contains data on silicon solar cells and their use on satellites and space vehicles.

REGULAR PRICE: $2.00

SPECIAL INTRODUCTORY IRE SHOW PRICE: $1.00

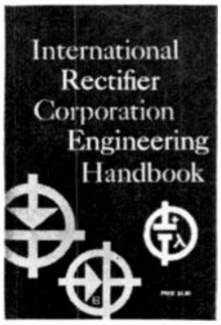
INTERNATIONAL RECTIFIER
IRE COMBINATION
HANDBOOK OFFER!



ZENER DIODE HANDBOOK

Zener Handbook contains over 100 pages of semiconductor theory, detailed and illustrated examinations of design considerations, thermal and operating characteristics, zener diode AC, DC, Audio, RF, computer, instrumentation, and circuit protection applications.

REGULAR PRICE: $2.00
SPECIAL IRE SHOW PRICE: $1.00



RECTIFIER ENGINEERING HANDBOOK

Engineering Handbook contains 125 pages of practical rectifier engineering data. Includes chapters on first principles of semiconductors, elimination of surge voltage breakdowns, design of fins for cooling semiconductors, and many more. A compendium of valuable information.

REGULAR PRICE: $2:00
SPECIAL IRE SHOW PRICE: $1.00

WITH THE COUPON BELOW THIS COMBINATION OFFER ENTITLES YOU TO

ANY ONE OF THESE HANDBOOKS $1.00
ANY TWO HANDBOOKS FOR $1.75
ALL THREE HANDBOOKS $2.00

Available at the "Handbook Corner," Booths 2901-2903, or by Sending a Check or Money Order with the Coupon to
INTERNATIONAL RECTIFIER CORPORATION
This offer expires May 1, 1961

HANDBOOK COMBINATION

International Rectifier Corporation, El Segundo, California:

Enclosed is check or Money Order for $______ for the Handbooks checked.

- ☐ Solar Cell and Photocell
- ☐ Zener Diode
- ☐ Rectifier Engineering

Name______________________________

Company____________________ Title__________

Address____________________________

Home Address_______________________

VISIT BOOTHS 2901-2903 AND SEE "TECHNOLOGY FOR SPACE"

A Unique Display of Advanced
Bio-Electronic Systems, Astro-Power Systems,
and Semiconductor Devices

FREE ZENER DIODE WALL CHART

Whom and What to See at the IRE Show

(Continued from page 104A)

Unimax Switch, Division Maxson Electronics Corporation, Booths 1208-1210
Ives Rd.
Wallingford, Conn.

J. Martinez, R. W. Maier, D. Schwarzkopf, J. Baldyga, E. Scovel

Precision snap acting switches. General purpose, sealed, high temperature, *heavy duty, *binary coded *metal cased, high sensitivity, open blade, immersion proof environment free reset, subminiature toggle, special actuator. Special assemblies. For military and industrial use. Special design services.

Union Carbide Consumer Products Co., Div. of Union Carbide Corporation, Booths 2401-2403
270 Park Ave.
New York 17, N.Y.

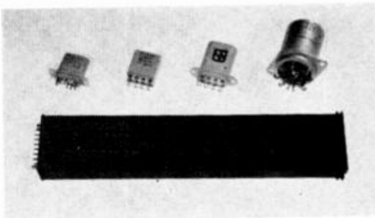
D. B. Ashway, C. P. Barry, R. S. Burgess, D. B. Cameron, H. E. Carpenter, S. R. Converse, H T. Duffy, H. R. Erskine, H. J. Harlow, F. B. Pipal, C. J. Sullivan

"Eveready" batteries, energizers for transistor radios, cathodic envelope type batteries, radio and electronic equipment batteries, rechargeable batteries, alkaline batteries.

See also Kemet Company.

Union Switch & Signal Division of Westinghouse Air Brake Co., Booths 2122-2124
Braddock Ave.
Pittsburgh 18, Pa.

P. K. Eckhardt, H. J. Myers, K. E. Doriot, N. Essick, P. D. Keiser, G. A. Dawes, J. W. Hansen, F. E. Baxter



Double Throw Relays & "Readall" Readout Instrument

Precision-made miniature and subminiature relays for use in vital applications requiring compactness and optimum reliability. Featuring the *new 2 PDT general purpose crystal case relay; a *new 4 PDT, 10-ampere miniature relay with exceptionally sturdy terminals and husky contacts; a *new Type S sensitive relay and a sealed case 64-character readout instrument.

United-Carr Fastener Corp., Booths 2535-2536

See: Cinch Mfg. Company and Ucinite Co.

United Catalog Publishers, Inc., Booth 4424
60 Madison Ave.
Hempstead, N.Y.

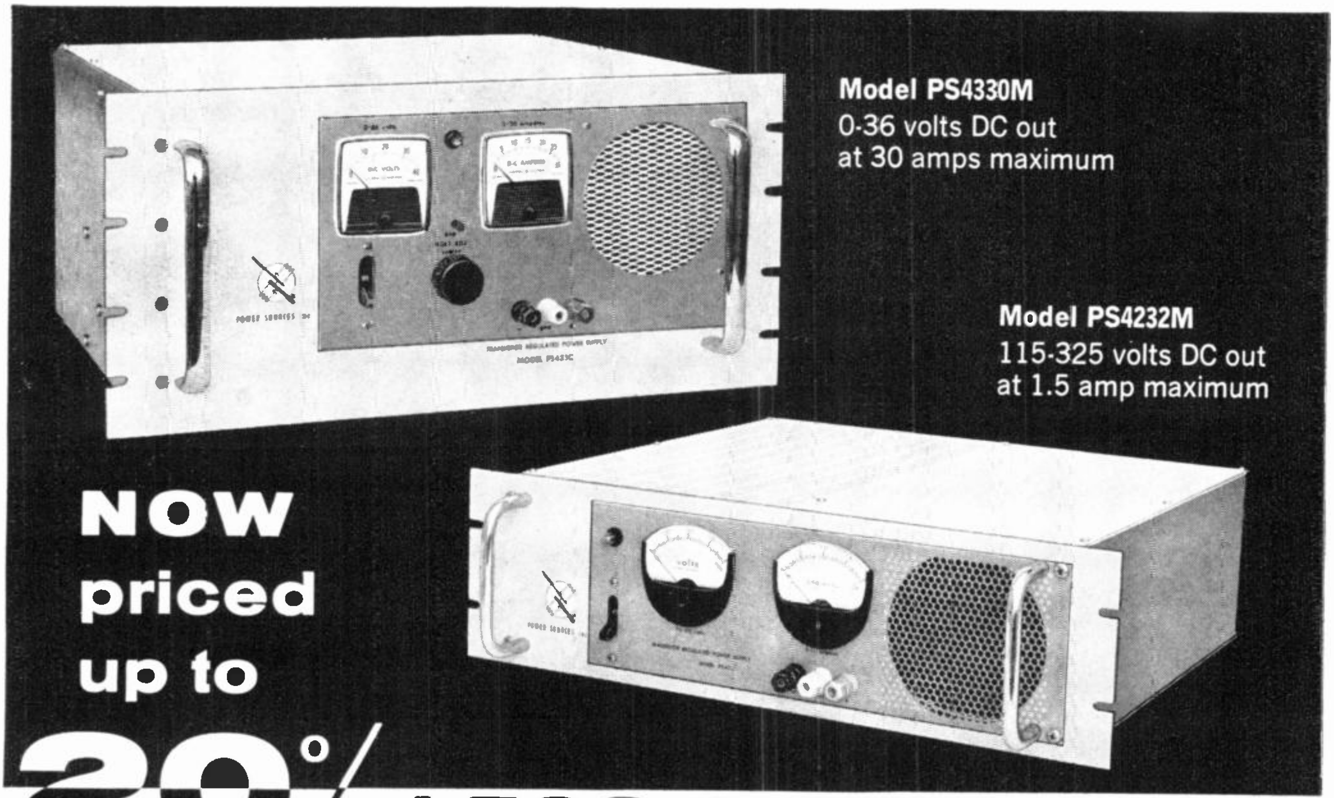
Arthur I. Rabb, Samuel Roth, Harry Birse, ▲ Irving J. Frisch, George Siegel, Robert J. Males, Curtis Glanville, Ray Smyth, George Kerner, Lee Swift, Jr., Dave Rafkin, Bill Pattis, Bernard Gittelman, Chet Waddell, Stewart McIntyre

1961 edition—eem—Electronic Engineers Master. 1961 edition—The Radio-Electronic Master—catalog of standard products sold by electronic parts distributors. "Electronic Products" Magazine—industry's only new products monthly. eem File System—industry's first and only method of filing product data.

United Electronics Co., Booths 3802-3806

See: Ling-Temco Electronics, Inc.

(Continued on page 108A)



NOW priced up to 20% LESS than comparable power supplies

CONSIDER . . . POWER SOURCES two new lines of power supplies . . . one high and one low voltage. *Both* lines feature the exclusive POWER SOURCES, INC., regulator circuit that fully protects transistors *without* DC fuses or circuit breakers. This means total protection for supply and load without limiting current.

WEIGH . . . the importance of a warranty that covers both lines for *five full years*. And this includes all semiconductor components.

ADD UP . . . other POWER SOURCES advantages such as Transient-Free Output . . . Cooling Systems designed for long life, trouble-free operation . . . Compactness . . . New low prices. And . . . 10-day delivery!

ASK YOURSELF . . . "Aren't these the benefits I've been looking for in a transistor-regulated power supply?" Then . . .

WRITE OR PHONE . . . today, for complete specifications on POWER SOURCES high and low voltage solid state power supplies.

SPECIFICATIONS	LOW VOLTAGE			HIGH VOLTAGE		
	MODEL PS4305M	MODEL PS4315M	MODEL PS4330M	MODEL PS4222M	MODEL PS4230M	MODEL PS4232M
Voltage Range (VDC)	0-36	0-36	0-36	32-215	90-300	115-325
Current Range (amps)	0-5	0-15	0-30	0-1.5	0-1.5	0-1.5
AC Input (Volts)	105-125	105-125	105-125	105-125	105-125	105-125
AC Input (CPS)	50-60*	50-60*	50-60*	50-60*	50-60*	50-60*
Regulation-Line (105-125V)	0.025%	0.025%	0.025%	0.1%	0.1%	0.1%
Regulation-Load (0 to full load)	0.05%	0.05%	0.05%	0.1%	0.1%	0.1%
Cooling	Free Air Convection	Forced Air	Forced Air	Forced Air	Forced Air	Forced Air
Ripple (RMS) in Millivolts	1	1	1	3	3	3
Panel Height	3½"	5¼"	8¾"	5¼"	5¼"	5¼"
Price	$525	$825	$1375	$685	$7[illegible]0	$750

(Note: If meters not desired deduct $30 and drop "M" from model number)

*400 cps available on order

Specify POWER SOURCES BY

POWER SOURCES, INC.
BURLINGTON, MASSACHUSETTS

See a demonstration. 1961 IRE Show. Booth 1719.

Whom and What to See at the IRE Show

(Continued from page 406A)

United Mfg. Company, Booths 1208-10
See: Masson Electronics Corp.

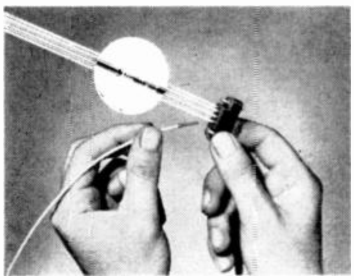
United Mineral & Chemical Corp., Booth 1631
16 Hudson St.
New York 13, N.Y.
Herbert Rosenthal, Fred Barry, Ed Wiest, Ted Getz, Terry Koncelik, Alexander Imich, Anita Rosenhan, ▲ Herbert Rosenberg

Resistors: Carbon deposited, wire-wound; Resistor Cores: Steatite, porcelain; Sockets: 7 and 9 pin miniatures, octals, printed circuit; Capacitors: Ceramic; Rheostats: Wire-wound; Insulation Materials: Ceramic. High purity elements for solid state semiconductors and other applications: Germanium and others.

United Shoe Machinery Corporation, Booth 4241
140 Federal St.
Boston 7, Mass.
R. H. Bliss, P. E. McGinness, R. D. Dexter, F. W. Bowers, F. C. Eyer, E. K. Seitz, E J. Speer, F. C. Cummings
Component inserting machine with optional inserting units for inserting resistors and diodes in PW boards.

U.S. Ceramic Tile Co., Booth 4105
Ceramaflex, a rubber-based ceramic tile. See Diamonite Products Mfg. Co.

U.S. Components, Inc., Booth 2805
1320 Zerega Ave.
New York 55, N.Y.
▲ A. Jackson, ▲ B. A. Jackson, S. Nalbantian, H. Nalbantian, E. Klinger



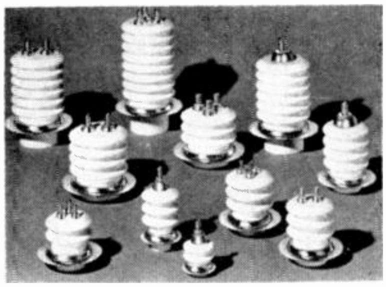
New concepts in electronics make critical the need for high reliability ultra-miniature and subminiature connectors in fields of astrionics, avionics, communications, and computers. Also featuring miniature, screwlock, power, printed circuit, modular, solderless, hermetically sealed, Remi closed entry snap-in connectors, and printed card receptacles.

U.S. Engineering Co., Booths 1610-1618 & 1709-1717
See: Litton Industries, Inc.

▲ Indicates IRE member.
Indicates new product.
† Exhibitor is servicing IRE Engineers through the IRE Package Plan.

U.S. Gasket Co., Booths 2814-2816
See: Garlock, Inc.

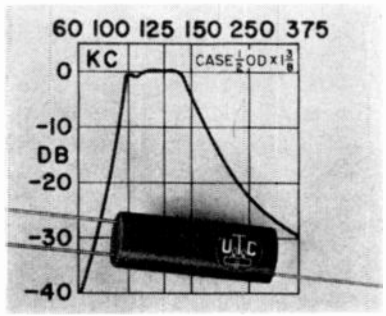
U.S. Stoneware Co., Alite Division, Booths 2238-2240
Orrville, Ohio
J. M. W. Chamberlain, Howard Farkas, H. Frahme, W. E. Coykendall Jr., Walter Perkins, Walter Tarnacki



Standard High Voltage Bushings

Alite high temperature, vacuum-tight, high alumina ceramic-to-metal seals. Standard and custom high voltage bushings, feed-through terminals and cable end seals. High amperage network transformer bushings. Alite-to-sapphire seals and components for infrared sensing devices.

United Transformer Corp., Booths 2413-2414
150 Varick St.
New York 13, N.Y.
Hank Russell, Joe Barreca, Walt Rooney, Bob Soevyn, Ted Craige, Sid Dzik, Charles Separk, Austin Profeta, Joe Harris



Miniaturized High Frequency Filter

Electric wave filters, high Q coils, magamps, reactors, transformers to military and commercial specifications. Standard line includes over 1000 items available through your local distributor for immediate use. Bulk of production is to customer specification. Keynote: Miniaturization, design, engineering, quality, reliability.

†

See PROCEEDINGS OF THE IRE—Jan. through Dec. (1960), Jan. through March (1961) for further information on our products.
See 1961 IRE DIRECTORY, second cover, for complete information on our products.

Unitek Corp., Booth 4527
See: Weldmatic Division

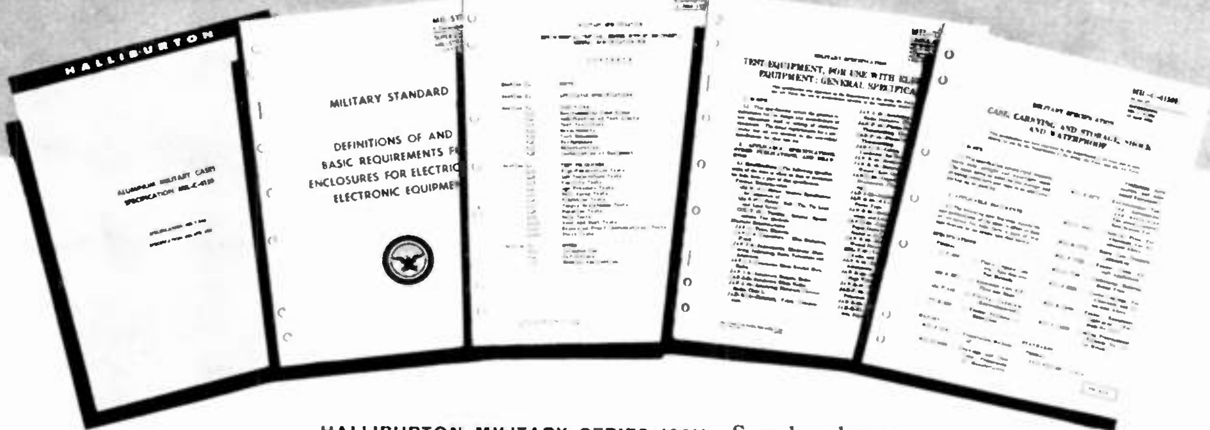
Universal Controls Corp., Booths 2218-2220
See: C. P. Clare & Co.

Universal Dynamics Div., Booth 4129
See: Acoustica Associates, Inc.

(Continued on page 410A)

HALLIBURTON ALUMINUM CASES

FOR MILITARY AND INDUSTRIAL APPLICATIONS . . . TO SPECIFICATIONS

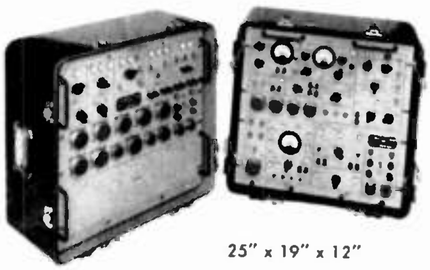


HALLIBURTON MILITARY SERIES 120H—Seamless drawn, heat treated aluminum, Series 120H Cases . . . available in all sizes . . . provide watertight, airtight and shockproof, heavy duty reusable cases for the carrying, transit and storage of aerial cameras, electronic controls and devices, aerological equipment, navigation instruments and other military equipment. The performance characteristics of these cases comply with the environmental conditions of humidity, extremes of temperature, fungus, salt laden atmosphere, shock, tumbling and submersion, in accordance with the provisions of Military Specification MIL-C-4150E. Series 120H Cases also conform to the construction and performance requirements of Specifications MIL-T-945A, MIL-STD-108C, Class I, Type Watertight, as electronic instrument and/or combination cases, MIL-T-4734, MIL-T-4807, MIL-E-4970, and other applicable standards.

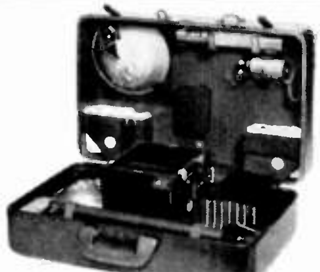
INDUSTRIAL AND MILITARY CASES FOR SPECIAL APPLICATIONS – HALLIBURTON SERIES 100X— Designed and manufactured for the carrying of photographic, electronic and medical equipment, scientific instruments, and similar apparatus, in accordance with the specific requirements of industry and governmental agencies.

25" x 23" x 20"

13" x 21" x 6½"



25" x 19" x 12"



13" x 18" x 6"

31" x 20" x 17"

HALLIBURTON ENTERPRISES, INC.

MANUFACTURING DIVISION

MILITARY AND INDUSTRIAL SALES DEPARTMENT

4724 SOUTH BOYLE AVENUE • LOS ANGELES 58, CALIFORNIA • TELEPHONE LUdlow 8-3181

Whom and What to See at the IRE Show

(Continued from page 408A)

Universal Electronics Co., Booth 1119
1720 Twenty-second St.
Santa Monica, Calif.

Edward Lacey, Dr. Sidney Riggs, Gene Cahn, Sam Weiss, William Friedman, Frank Cote, Bob Duncan

Light weight portable transistorized power supply, rating 0-35 volts, 0-1 ampere, features economy price $189.50 each, delivery from stock.

Universal Instruments Corp., Booth 4019 & Room 610
139 East Frederick St.
Binghamton, N.Y.

Perry J. Wilson, Gordon Mayo, Gerald D. Minnick, J. D. Ahearn, F. H. Lawson

Universal lead straightening and taping machines. Bowl feed equipment. Electronic testing and orienting units. Diode comparator.

Universal Mfg. Co., Inc., Booths 4004-4005
1168 Grove St.
Irvington 11, N.J.

William A. Bernau, Anthony O. Vicari, Richard Hillebrand, Rudy Fahrbach

New Model "S" with transistorized in-line digital read-out counter and inductance comparator. *New TVW Machine for toroidal deflection yokes. New toroidal slider-type LAB model. *New bank winding machine for variable auto-transformers. Model U-14 heavy toroidal winding machine.

Universal Toroid Coil Winding, Inc., Booths 4004-4005
See: Universal Mfg. Co., Inc.

Universal Winding Co., Booths 4323-4325
See: Leesona Corp.

Utica Drop Forge & Tool, Div. Kelsey-Hayes Co., Booth 4006
2415 Whitesboro St.
Utica 4, N.Y.

F. L. Marshall, F. J. Stiefvater, W. I. Pugh, H. Neff, C. Ellingwood, R. C. Bryan, L. T. Bryan, R Dunn, A. Kuflan, J. L. Lewis, B. Foxhall, R. Luneau

Special pliers for electronic assembly work. Midget pliers. Custom made tools for specific applications. Insulated thin blade screwdrivers. Hand powered tools for wrapping solderless connections and SW-1 *new "Stripwright" wire stripping tool.

Utrad Corp., Booths 1610-18 & 1709-17
See: Litton Industries, Inc.

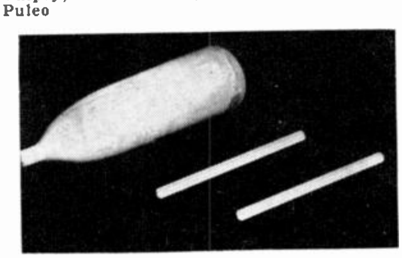
Vacuum-Electronics Corp., Booths 3313-3315
Ames Court and Terminal Way
Plainview, L.I., N.Y.

Howard White, Marvin Eisenberg, Peter Belezza, George Shinbrot, Leon J. Atamian, Richard Laken

Mass spectrometer leak detector. Automatic high vacuum pumping station. High vacuum gages. Valves and accessories. Calibrators for leak detection. Quick couplings, gage tubes, baffles, cold-traps, and flanges.

Valpey Crystal Corporation, Booth 1133
1211 Highland St.
Holliston, Mass.

T. S. Valpey, Jr., Nelson Piper, ▲ Richard S. Valpey, O. E. Lussier, Jr., Norman Gillin, Sal Puleo



Ruby Rods for Laser

Precision optical pieces fabricated from ruby, natural and fused quartz and synthetic materials for infrared and other optical applications. Quartz crystals for frequency control, ultrasonics and filters. Packaged oscillators and temperature control ovens.

D. Van Nostrand Co., Inc., Booth 4505
120 Alexander St.
Princeton, N.J.

David Philips, Peter H. Fagnano, Mulford Colebrook, Dayton Beguelin, E. M. Crane, Jr.

Electronic publications.

Vari-L Company, Inc., Booth 2209
207 Greenwich Ave.
Stamford, Conn.

▲ J. L. Kiser, Joe H. Kiser, R. J. Ferrer, R. B. Holcomb, Kenneth Osgood

Vari-L electrically variable inductors, sweep oscillators, receiver front-end assemblies.

(Continued on page 412A)

**SEE US AT
IRE SHOW BOOTHS
1211-13-15**

A three year test proves that our ultra long life **NIXIE**® tubes have 100* times longer life than any other electronic readout.

Consider this, then add the factors of lowest cost, smallest size, lightest weight, lowest power, most readable, and we feel you will agree **NIXIE** tubes are, beyond the shadow of a doubt, the finest in-line readouts ever made.

*Life tests prove 20,000 hours life on one number without a single failure. In a decimal readout, this represents a minimum life of 200,000 hours. Since no failures have occurred to date, the figures quoted are minimums. Write for the Readout Fact Finder, an engineering comparison of all readout devices.

ANOTHER ELECTRONIC CONTRIBUTION BY

Burroughs Corporation

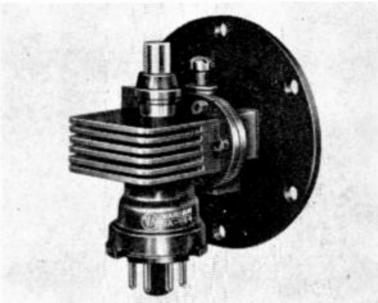
ELECTRONIC TUBE DIVISION

Plainfield, New Jersey

CN

Varian Associates, Booths 2708-2720
611 Hansen Way
Palo Alto, Calif.

▲ C. G. Rockwood, ▲ W. G. Wagener, ▲D. G. Clifford, ▲ W.M. Silhavy, T. J. Curtis, Chandler Murphy, ▲ H. Myrl Stearns, ▲ Emmet Cameron, ▲ Edward Herrold, ▲ Dr. Louis Malter, ▲ P. I. Corbell, R. E. Stark, A. E. Acker, J. W. Summers, R. A. Constable, Patrick Dorney, Carl Larson, Richard Barck, J. Filmer, W. R. Patton, Ray Kent, John Moore, William Rice, Renn Zaphiropoulos, Ray Brunson



Varian VA-244 Reflex Klystron

Reflex klystrons, traveling wave tubes, power klystrons ranging in frequency from 0.4 to 10.0 kmc at powers up to 75 kw cw or 8 megawatts peak; waveguide arc detectors, water loads, microwave mixers, frequency stabilizing cavities; high vacuum systems, pumps and components; spectroscopy equipment, strip chart recorders. See also: Bomac Laboratories.

† See PROCEEDINGS OF THE IRE—Feb., March, June, Aug., Oct., Dec. (1960), Jan. through Dec. (1961) for further information on our products.

See 1961 IRE DIRECTORY, pages 116 and 117, for complete information on our products.

Whom and What to See at the IRE Show

(Continued from page 410A)

Varo, Inc., Booth 1733
2201 Walnut St.
Garland, Tex.

J. R. Gilmer, M. Schwenk, M. C. Baird, W. Bonds, J. B. Steed, Frank Desmond

Missile and aircraft electronics equipment, including solid state and rotary power supplies, transistorized control systems, magnetic components, *infrared devices, frequency standards, optics, and microcircuitry.

Vascoloy-Ramet Div., Booths 4021-4022
See: Fansteel Metallurgical Corp.

Vector Electronic Co., Booth 1513
1100 Flower St.
Glendale 1, Calif.

▲ R. R. Scoville, F. L. Hill, E. L. Buck

*Low-cost pre-programming patchboards; patchboards; *plug-in cases for transistor and tube circuits; printed circuit connector pins, prototype and production cards; experimental circuit set-up materials; test adapters, transistor and socket turrets; pre-punched terminal board, printed circuit card modules.

VecTrol Engineering, Inc., Booths 2416-2424
Industrial controls. See: Sprague Electric Co.

Veeco Vacuum Corp., Booths 3313-3315
See: Vacuum-Electronics Corp.

Veeder-Root, Inc., Booth 3910
70 Sargeant St.
Hartford 2, Conn.

R. F. Quinn, C. C. Lombardi, F. J. Swords, W. T. Heydt, T. J. McLaughlin, A. T. Russo, R. W. Moller, T. L. Ellis

Counting and computing devices for all counting requirements.

Vemaline Products Co., Booth 2116
511 Commerce St.
Franklin Lakes, N.J.

Donald R. Contant, Richard Chapman, William Cordts, Robert Homan, John Gum, William Hochkeppel, F. Van Harken, Kenneth Bender, Raymond Martin, William Venema

*Heat sinks, *heat dissipators, knobs, panel-handles, *waterproof cable clamps, servo components, footswitches, handswitches, dust-free assembly chambers.

Vent-Rak, Inc., Booth 4001
See: Chassis-Trak, Inc.

Vernistat Division, Perkin-Elmer Corporation, Booth 2810
783 Main Ave.
Norwalk, Conn.

Lionel Robbins, F. B. Hutchinson, James F. Balderson, E. W. Dunstan

Vernistat® precision ac potentiometers, adjustable function generators, variable ratio transformers, "Plug-in" nonlinear ac potentiometers, *dc adjustable function generators, Vernitester®—potentiometer linearity tester, 34-pole, 101-position switch.

Victor Adding Machine Co., Booth 3829
3900 N. Rockwell St.
Chicago 18, Ill.

George W. Hasbach, ▲ George E. Sandgren, Robert E. Daniel, Robert E. Mercier

Remote automatic printers, scanners, calculators and tape punches, electrical output keyboards and printers, all Digit-Matic products.

▲ Indicates IRE member.
* Indicates new product.
† Exhibitor is servicing IRE Engineers through the IRE Package Plan.

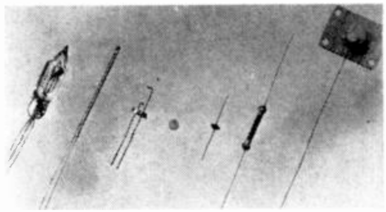
Victoreen Instrument Co., Booths 2301-2303
5806 Hough Ave.
Cleveland 3, Ohio

William A. McCarthy, Alan E. Over, ▲ Donald O. Ward, Roy Herter, Richard C. Hahn

Corotrons, hi-meg resistors, hi-voltage regulators, *geiger tubes, electrometer tubes, *hi-voltage vacuum regulator tubes, gas diodes, *quality capacitors, missile components.

Victory Engineering Corporation, Booth 1423
Springfield Rd.
Union, N.J.

B. J. Oppenheim, ▲ M. Sapoff, W. B. Huston, J. M. Ruskin, F. J. Mascuch, J. S. Bacek, J. Gecsey, J. W. Koleszar, R. Brocko, J. Conlon



Matched/Interchangeable Thermistors

Precision, high reliability thermistors and varistors; matched and interchangeable thermistors; thermal conductivity cells; high pressure thermistor probe assemblies; *indoor-outdoor temperature indicators; Hypsometers; thermistor hypodermic needles, catheters, LOX thermistors; thermal, electronic and physical sensing devices.

Vitramon, Inc., Booths 2605-2607
Box 544
Bridgeport 1, Conn.

▲ Barton L. Weller, Clifford H. Tuttle, Jr., Harlan P. Tripp, ▲ Arthur L. Baldwin, Frank E. Baron, Edmund A. Bolton, Robert W. Millar, Robert F. Hostage, Paul W. Hagerty, George N. Salvia, Charles B. Allen, Edward D'Elia

Solid state porcelain "VY" capacitors to 6800 mmf; stability low loss, low noise, high frequency operation at 200°C. Ambients "VK" microminiature ceramic capacitors to 10,000 mmf; 200 vdc rating; 150°C operation; modular case design; including uncased units; axial and radial lead configuration.

Vitro Electronics, Div. of Vitro Corp. of America, Booths 3917-3919
919 Jesup-Blair Drive
Silver Spring, Md.

J. F. Whitehead, ▲ A. S. Clarke, ▲ R. E. Grimm, K. B. Redding, R. P. May, R. C. Curry, P. Dudney, M. L. Bandler, T. W. Maskell, D. H. Steinweg, C. Hall, W. H. Kimbell

Telemetry receivers, preamplifiers, multicouplers, broadcast and television equipments. Spectrum display units, range extension units, jacks, jack strips and broadcast items.

Don't wear yourself out

carrying heavy loads of literature. Use the "Lead-Master" system, and exhibitors will send literature direct to your home or office, as given on your registration card. Simply circle the appropriate number on the "Lead-Master" card and leave it with us in the Col'seum Lobby as you go.

Vogue Instrument Corp., Booth M-16
2350 Linden Blvd.
Brooklyn, N.Y.

M. Nirenberg, R. Strum, P. Cara, M. Sekerich

Infinite Resolution Wire Wound Potentiometers

Wire wound infinite resolution .01% linearity single and multi-turn precision potentiometers resistance range 1 ohm to 100 k ohms. Infinite resolution linear ganged potentiometers, instrument gears, gear trains and differentials.

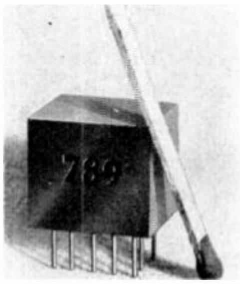
Wales Strippit, Inc., Unit of Houdaille Industries, Inc., Booth 4010
Akron, N.Y.

Norman F. Weyland, Joseph L. Stella, William A. Schrader, Arthur H. Strickland, Arthur R. MacVittie, Carl H. Sorensen, Joseph J. Miranto, John Clegg, Bruce W. Cameron, Willis H. Armitage, Russell A. Johnson

Printed circuit punching machine in operation; complete line of press tooling for punching and notching radio, TV and electronic chassis, control panels, switchboards and instrument cabinetry; precision drilling-layout machine and a screw feeder will also be in operation.

Walkirt Co., Booth 1824
141 West Hazel St.
Inglewood 3, Calif.

▲ Wes Kirchoff, Dixie Kirchoff, Lee Lebowitz, Bill Spenser, George Chaulk, ▲ Chuck Hinxman, ▲ Bob Richter, Phil Castillo, Bill Sather



***High Reliability Micromodule Circuitry**

"789 Series" miniature modules (7/16 × 8/16 × 9/16) high reliability MIL-spec, 125°C, digital and logic modules, rated to 10 mc. Other miniature and plug-in circuit modules, including binary counters, flip-flops, gates, multivibrators, etc.

Wall Manufacturing Co., Booths 1301-1303
P.O. Box 71
Grove City, Pa.

M. A. Silverman, H. H. Sherman, Norman Wittman, Theodore R. Moreton, C. J. (Jim) Green, Ben Solomon, Steve Fisher, Lou Silverman, Alex Shoenwald, E. G. Oppenheimer

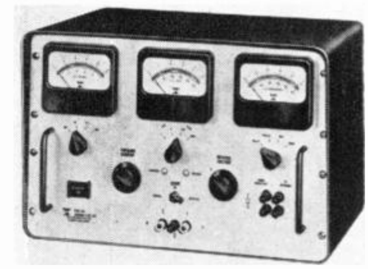
Featuring a one-ounce ac-dc soldering pencil along with other size soldering pencils and industrial, laboratory and technician electric soldering pencils. Also a complete line of industrial electric soldering irons. Ac-dc electric soldering guns and other electronic soldering devices.

(Continued on page 414A)

Whom and What to See at the IRE Show

(Continued from page 413A)

Wallson Associates, Inc., Booth 3006
912 Westfield Ave.
Elizabeth, N.J.
▲ J. P. Wallenstein, L. J. Rose, ▲ P. D. Radin, P. J. Marshall, H. J. Goldstein, M. Elkinson, G. Dravis



Dynamic Rectifier Analyzer, Model 170

Semiconductor test equipment and instrumentation in all power ranges. Automated high vacuum systems. On display: New dynamic rectifier analyzer, rectifier surge tester, life test switching modules, thermal resistance measuring equipment for semiconductor devices, solid state ignitron controller.

Walsco Electronics, Booth 2337
Drives, chemicals. See: GC Electronics Co.

Waltham Horological Corp., Booth M-22
See: Ken-Tron Corp.

Waltham Precision Instrument Co., Inc., Booths 4300 & 2216
See: Boesch Mfg. Co., Inc. and Electro-Mec Div.

Wang Laboratories, Inc., Booth 3221
12 Huron Dr.
Natick, Mass.
F. Lawrence Gosnell, Richard Stockbridge, ▲ Dr. An Wang, ▲ Dr. G. Y. Chu, Robert Crane, Robert Julian, Enrico De Crecenzo
"Logibloc" digital modules: Series 200—to 200 kc, Series 500—to 5 mc. *Block tape reader: 6-32 lines (or more) per block with retracting brush head to protect when loading tapes. *Transistorized programmed pulse generator. Encoders. *Stepping motor control.

Ward-Leonard Electric Co., Booth 2231
115 MacQuesten Pkwy, So.
Mt. Vernon, N.Y.
H. F. Littlejohn, J. E. Reagen, J. Smith, K. Howe, G. Platenyk, J. Sromovsky, A. C. Scribner, R. W. Lunstead, J. McCaffrey, H. Denman, R. D. Ward, L. Petersen, W. G. Judson, J. H. Leicht, H. T. Hayden, J. Scheib, S. E. McClure, A. E. Rosin, M. Black, V. Cerbone
*"Metohm"-molded metal film precision resistors, *miniaturized Axiohm power resistors in 7 sizes from 2 to 12.5 watts, Vitrohm power resistors and ring rheostats, MIL-R-26C resistors, Ny-line multi-pole relays, solenoid contactors, high current resistors and *load banks.

Wassco Glo-Melt Div., Booth 4033
Resistance type soldering equipment. See: American Electrical Heater Co.

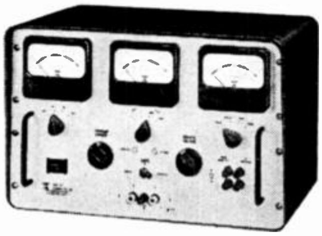
(Continued on page 418)

Show Hours
10 a.m. to 9 p.m. daily
Monday through Thursday
March 20-23, 1961

SEMICONDUCTOR TEST EQUIPMENT

To Accurately Evaluate Semiconductor Parameters

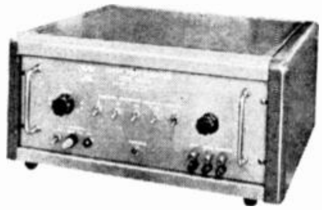
- Incoming Inspection
- Production Test
- Reliability Systems



20 AMPERE DYNAMIC RECTIFIER ANALYZER

- Forward current 1/5/20 amp. D.C. full scale
- Reverse voltage 250/1000V. peak
- Forward voltage drop 0-1, 0-5V.
- Reverse current from 1μa to 50ma. in four ranges
- Self-contained, no external load resistors
- Mirror scale 1% instruments
- Tests under actual operating conditions in accordance with Mil. Specs.

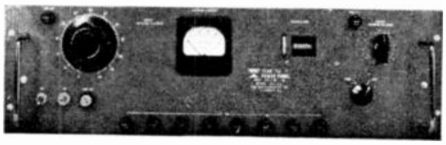
Model 170 **Price $855.00** **Delivery: Stock-2 Weeks**



75 AMPERE SURGE TEST ADAPTER

- Provides surge current test for silicon rectifiers in accordance with Mil. Specs.
- Continually adjustable to 75 amp. peak
- Self-contained, portable
- Single half wave sinusoidal pulse
- 660, 2500 and 6000 amp. units available
- 1% monitoring accuracy
- Automatic programming available

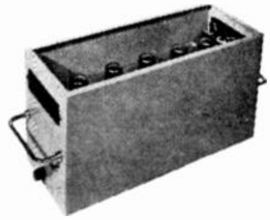
Model 142 **Price $725.00** **Delivery: Stock-2 Weeks**



MODULAR DYNAMIC TEST POWER SUPPLY

- Simulator circuit
- Forward current & reverse voltage adjusted independently
- Reduces operating costs by a factor of 50
- Capacity is 20 rectifiers 0.1 to 1 amp. or any combination up to 2 rectifiers, 10 amp. each
- Mirror scale 1% instruments

Model 154D **Price $800.00** **Delivery: 2 Weeks**



LIFE TEST MODULE

- Self-contained switching module
- Simulator circuit
- Units may be set up in parallel for testing above 10 amp.
- Reduces operating costs by a factor of 50
- Plug-in rack adapters available for 3, 4, and 5 modules
- Forward drop equalizing resistors

Model 180A **Price $250.00** **Delivery: Stock-2 Weeks**

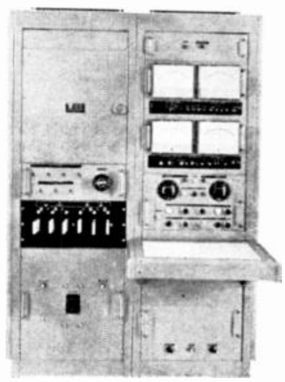
THERMAL RESISTANCE TEST INSTRUMENT

- Measures junction temperature
- Accuracy within 5% (under standard conditions)
- Heating current 1-5, 1-50 amps.
- Measuring current 1-100ma.
- 1% instruments
- Measuring pulse 100μ sec.
- Scope display included

Model 149 (Basic Unit) **Price $6200.00** **Delivery 6 Weeks**
Lower power units available

200 AMPERE DYNAMIC TEST SET

- Forward current 20/200 amp. D.C. full scale
- Reverse voltage 0/1500V. peak
- Forward voltage drop 0-5/10V. peak
- Reverse current from 2 μa to 250ma. in four ranges
- Self-contained, no external load resistors
- Mirror scale 1% instruments
- Tests under actual operating conditions in accordance with Mil. Specs.



Model 164 (Basic Unit) **Price $11,525.00** **Delivery 8-10 Weeks**

Complete Reliability Evaluation Systems Available

WALLSON ASSOCIATES, INC.

912-914 Westfield Avenue • Elizabeth, N. J. • FLanders 1-0700

Manufacturers of Semiconductor Test Equipment

See our full line of Semiconductor Test Equipment at Booth 3006

CBS Semiconductors

• NOW ORDER ALL YOUR COMPUTER SEMICONDUCTORS FROM ONE DEPENDABLE SOURCE

CBS Three Lines of Switching Transistors

MADT* Switching Transistors

Type	Min. BV CBO (Volts)	Typical fab Mc.
2N501	−15	250
2N501A	−15	250

MAT† and SBT° Switching Transistors

Type	Min. BV CBO (Volts)	Typical fab Mc.
2N393	− 6	50
2N1122	−12	100
2N1122A	−15	100
2N1411	− 5	85
2N1427	− 6	120
2N240(SBT)	− 6	60

NPN Switching Transistors—Core Driver and Logic Circuitry Types

Type	Min. BV CBO (Volts)	Typical fab Mc.
2N312	15	2
2N356	20	3
2N356A	30	3
2N357	20	6
2N358	20	9
2N377	25	5
2N377A	40	5
2N385	25	6
2N385A	40	6
2N388	25	8
2N388A	25	8
2N438	30	4
2N438A	30	4
2N439	30	8
2N439A	30	8
2N440	30	12
2N440A	30	12
2N444	15	1
2N445	15	3
2N446	15	8
2N447	15	10
2N556	25	1
2N558	15	3
2N634	20	8
2N635	20	12
2N636	20	17
2N1000	40	9
2N1012	40	5
2N1090	25	8
2N1091	25	12

ACTUAL SIZE

MADT* SWITCHING TRANSISTORS

CBS MADT transistors are PNP Germanium Micro Alloy Diffused-base types with optimized electrical characteristics for extremely fast switching service. Cadmium junctions increase dissipation capacity. Over-all quality exceeds MIL-S-19500.

MAT† & SBT° SWITCHING TRANSISTORS

CBS PNP Germanium Micro Alloy Transistors and Surface Barrier transistors are designed for computer switching circuits up to 5 mc. Low collector saturation voltage makes them ideal for Direct Coupled Transistor Logic Circuitry (DCTL). Good high frequency response permits a pyramiding factor of 5 at moderate switching speeds.

NPN SWITCHING TRANSISTORS—CORE DRIVER AND LOGIC CIRCUITRY TYPES

These CBS types are Germanium NPN Alloy Junction Transistors, possessing superior reliability. Construction features include: ruggedized package, and hermetic sealing in the welded JEDEC TO-5 package, which is designed particularly for automatic handling.

Special processing steps include thorough bake-out to stabilize gain and advanced surface chemistry techniques to seal out moisture and contamination. The welded package is equipped with flexible, plated leads designed for connection by soldering, welding or socketing.

*MADT: Micro Alloy Diffused-base Transistor.
†MAT: Micro Alloy Transistor.
°SBT: Surface Barrier Transistor.
Trade-Marks of Philco Corp.

AT THE IRE SHOW:

Use CBS "Facts-Phone" for direct dialing to applications engineering, customer service and other facilities at the CBS Electronics' Lowell plant. Get complete and immediate information on CBS Semiconductors for Computer Circuitry right at CBS Electronics' IRE booths 1401 and 1403. Be sure to see us at the Show!

for Computer Circuitry

CBS

Two Lines of Switching Diodes

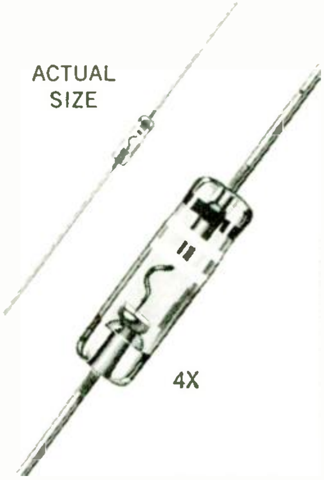
Bonded Germanium Diodes

Types	Peak Reverse Voltage (Volts)	Min. Forward Current (MA @ +1V)
1N95	− 75	10
1N96	− 75	20
1N97	−100	10
1N98	−100	20
1N99	−100	10
1N100	−100	20
1N107	− 15	150
1N108	− 60	50
1N117	− 75	10
1N118	− 75	20
1N273	− 30	100
1N276	− 75	40
1N278	− 60	20
1N279	− 35	100
1N281	− 75	100
1N283	− 20	200
1N287	− 60	20
1N288	− 85	40
1N289	− 85	20
1N298	− 85	30 @ 2V
1N447	− 50	25
1N497	− 30	100
1N498	− 50	100
1N499	− 65	100
1N500	− 75	100
1N631	− 70	100
1N634	−115	50
1N699	−105 @ 70°C.	100
1N770		15 @ 0.5V

Point-Contact Germanium Diodes

Type	Peak Reverse Voltage (Volts)	Min. Forward Current (MA @ +1V)
1N34/A	− 75	5
1N35	− 75	7.5
1N38/A/B	−120	4-25
1N48	− 85	4
1N51	− 50	2.5
1N52	− 85	4
1N54/A	−50/75	5
1N55/A	−170	4
1N56/A	− 50	15
1N58/A	−120	5
1N60	− 30	3
1N63	−125	4
1N64	− 20	—
1N65	− 85	2.5
1N67/A	−100	4
1N68/A	−130	3
1N75	−125	2.5
1N90	− 75	5
1N116	− 75	5
1N126/A JAN	− 75	5-25
1N127/A JAN	−125	3-25
1N128 JAN	− 50	3
1N191	−105	5
1N192	− 80	5
1N198 JAN	−100	4
1N290	−120	5
1N294	− 70	5
1N295	− 50	—
1N541	− 50	4.5
1N636	− 60	2.5
1N933	−100	4-17

BONDED GERMANIUM DIODES—CBS Bonded Diodes are specially designed to eliminate opens and shorts, major causes of failures in computer diodes. They are capable of withstanding extreme shock and vibration both during printed circuit assembly and through their operating life. They achieve 100% survival in a shock test that exceeds MIL specs!



Here is a wide variety of computer diodes offering a choice of high voltage, high reverse resistance, high conductance, fast reverse recovery or high temperature characteristics. The line also includes general-purpose types.

POINT-CONTACT GERMANIUM DIODES—CBS Point-Contact Germanium diodes possess outstanding efficiency plus long and reliable life. These diodes are fusion-sealed in miniature glass envelopes. This glass construction supplies "locked-in" electro-mechanical stability and dependability required to withstand the stresses imposed by severe environmental and operating conditions.

In addition to subminiaturization, the CBS Point-Contact diodes package provides a true hermetic seal for greater protection against moisture and contamination.

CBS **semiconductors**®

More Reliable Products through Advanced Engineering

CBS ELECTRONICS, Semiconductor Operations,
Lowell, Massachusetts • A Division of Columbia Broadcasting System, Inc.
Semiconductors • tubes • audio components • microelectronics

Sales Offices: Lowell, Mass., 900 Chelmsford St., GLenview 2-8961 • Newark, N. J., 231 Johnson Ave., TAlbert 4-2450 • Melrose Park, Ill., 1990 N. Mannheim Rd., EStebrook 9-2100 • Los Angeles, Calif., 2120 S. Garfield Ave., RAymond 3-9081 • Toronto, Ont., Canadian General Electric Co., Ltd., LEnnox 4-6311.

Whom and What to See at the IRE Show

(Continued from page 414A)

Waterman Products Co., Inc., Booths 3103-3104
2445-63 Emerald St.
Philadelphia 25, Pa.

▲ William Waterman, ▲ Joseph Boyle, ▲ Pete Plotkin, Herman Miller, John Gorman, Daniel Donahue

*Pocket*scopes® famous low-cost portable oscilloscopes. *Craft*scope® Model S-16-A most compact 5" scope available. *Pulse*scope® portable synchroscopes. *Rak*scopes® versatile rack mounted oscilloscopes. *Panel*scopes® small custom and standard monitors. *Primer*scopes® Models Mark I, Mark II, new in 1961. Full line "Rayonic" CRTs, standard and custom designs available.

Waters Manufacturing, Inc., Booth 1233
Boston Post Road
Wayland, Mass.

▲ Robert A. Waters, ▲ William B. Bartell, ▲ Thomas B. Dix, Jr., Howard Daziel, William B. Martz, Chris R. Musello

Torque Calibrator

Potentiometers, panel mounts, coil forms, slug tuned coil forms, torque watch gages, *torque calibrators, instruments, potentiometer test equipment.

Wave Particle, Division of Ramage & Miller, Inc., Booth M-23
150 S. Second St.
Richmond, Calif.

▲ Frank A. Miller, ▲ John H. Gallichotte

Electronically swept microwave signal sources using backward wave oscillators and voltage tunable magnetrons. 400 mc to 77.0 gc, traveling wave tube amplifiers, TWT preamplifiers for telemetering with noise figures of 4.5 db, *microwave levelers maintaining broad band power variations ± ½ db, radar target augmentors.

Waveforms, Inc., Booth 3220
333 Sixth Ave.
New York 14, N.Y.

A. E. Byers, J. F. Young, W. H. McDonald, A. Sobel

Audio and carrier oscillators, generators, ac VTVMs, square wave generators, transmission measuring sets (audio).

Wayne-George Corp., Booth 3231
588 Commonwealth Ave.
Boston 15, Mass.

▲ George H. Wayne, ▲ Malcolm M. Bittel, Sheldon W. Kennedy, ▲ Ralph Barcroft, Priscilla A. Smith

"Digisyn."® non-contacting, shaft position to digital encoders including direct-reading and incremental types ranging from 8 digit to 17 digit accuracy in a single revolution. *"Adcon" non-contacting digital transducers for direct indication of temperature, pressure and acceleration in digital form.

▲ Indicates IRE member.
* Indicates new product.

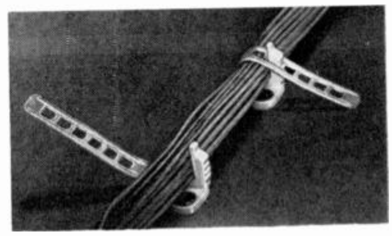
Wayne Kerr Corporation, Booths 3834-3836
1633 Race St.
Philadelphia 3, Pa.

G. G. Gouriet, G. L. Ball, F. L. Scott, L. Hughes

*Energless electrometer, f.s.d. 1mV–10 V and 10^{-15}–10^{-8}A, input impedance 10^{15} ohms. *Transfer function computer for measurement of control system performance. Precision impedance transformer bridges, 20 micro-ohms to 100,000 megohms, 50 cps to 250 mc. Signal generators and detectors, audio to video frequency. Vibration monitors, electronic thermometers, microwave test equipment.

Weckesser Company, Inc., Booth 4003
5701 Northwest Highway
Chicago 46, Ill.

Harry A. Ewalt, Ralph J. Farner, Jack Costello, R. V. Eustace, John Sohn, Charles W. Thomas



*New cable clamps

Electronic hardware: *New miniature and jumbo sizes nylon cable clamps; *new smaller teflon cable clamps; *new Tab-loc cable clamps; *new Nylatch cable clamps; *new sizes nylon strapping and mounting tabs; *35 new stock sizes molded nylon screws; *new molded half clips; *new strap clamps.

W. M. Welch Mfg. Co., Booth 4214
See: Welch Scientific Company

Welch Scientific Company, Booth 4214
1515 Sedgwick St.
Chicago 10, Ill.

John Gutsmiedl, Don Coglianese, Bill Dolke

Duo Seal vacuum pumps, vacuum gages and accessories. Densichron densitometers.

Weldmatic Division, Unitek Corporation, Booth 4527
950 Royal Oaks Dr.
Monrovia, Calif.

Ott W. Sailer, Alex H. Davidson, John Sosoka, Don A. Drake, Robert Ring, Louis A. Garten, Emmette F. Gumm, William E. Clark, Edward S. Drollinger, Philip L. Nace

Precision electronic welding equipment for use in assembly of component packaging modules. *Model 1040 precision butt welder. *Model 1046 new 13 watt-second power supply. *dual range power supply—13 and 1.3 watt-seconds. *freeze coating for component packaging, *pull tester.

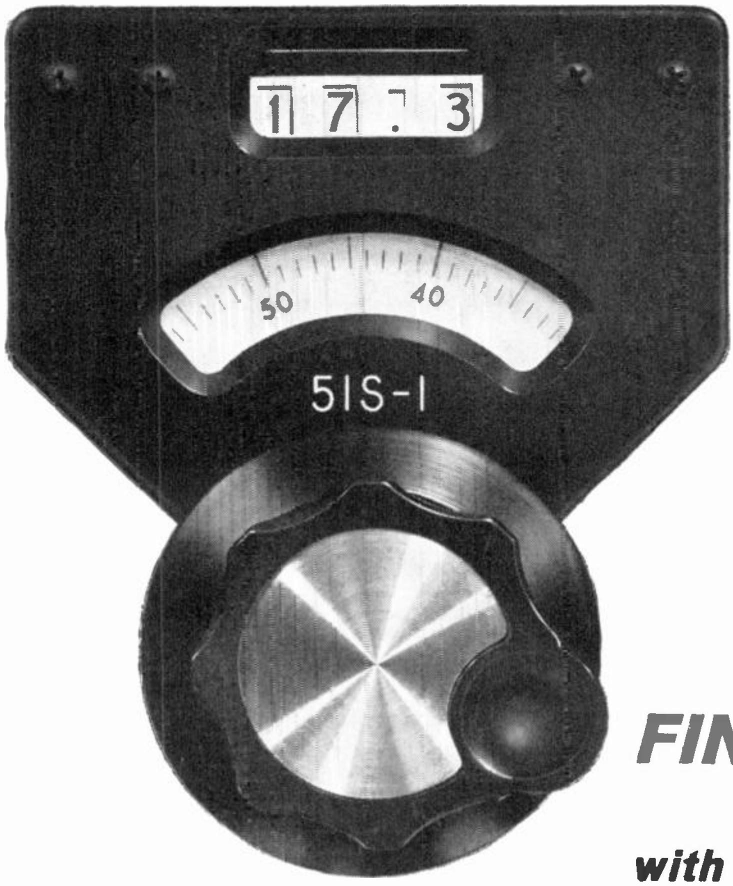
Weller Electric Corporation, Booth 4012
601 Stone's Crossing Rd.
Easton, Pa.

C. R. Robertson, Louis W. White, Joseph J. Barrese, John J. Johnstone

Magnastat controlled temperature soldering irons with advanced features for greater adaptability, longer life. Magnastat sensing device in tip automatically maintains correct soldering temperature. Soldering guns and kits available in both single and dual heat models from 100 watts to 275 watts.

(Continued on page 420A)

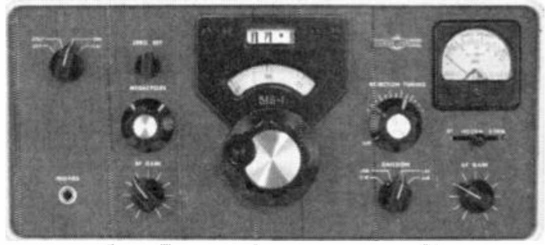
NEW FROM COLLINS — THE 51S-1



FINGERTIP TUNING

with accuracy. *The latest in a series of general coverage HF receivers features* **single sideband** *and AM reception with:* ***extreme dial accuracy,*** *visual setting within one kc throughout the range —* ***high frequency stability,*** *particularly suited to receiving pre-assigned frequencies —* ***optimum selectivity,*** *made possible by* ***Collins Mechanical Filters.*** ***Highest sensitivity*** *for difficult monitoring assignments — all in one compact, lightweight, easily installed unit.*

Write for descriptive brochure.



COLLINS

COLLINS RADIO COMPANY • CEDAR RAPIDS, IOWA • DALLAS, TEXAS • BURBANK, CALIFORNIA

SEE THE NEW COLLINS 51S-1 RECEIVER AT THE I.R.E. SHOW MARCH 20-23

Whom and What to See at the IRE Show

(Continued from page 418A)

Western Gold & Platinum Co., Booth 4031
525 Harbor Blvd.
Belmont, Calif.
Harry Mason, Peter Stefan, John Morse
High temperature, high purity ceramics. Low vapor pressure brazing alloys. Precious metals for semiconductors. Precious metal preforms, sheet and wire. Molybdenum tape. Silver paints. See also: Wilbur B. Driver Co.

Western Lithograph Co., Booth 4402
See: Westline Products Div.

Westinghouse Air Brake Co., Booths 2122-24 & 3943
See: Union Switch & Signal, Melpar, Inc.

First and Second floors—Components

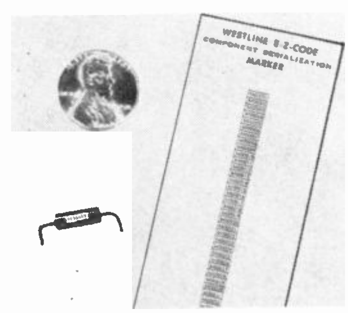
Third floor—Instruments and Complete Equipment

Fourth floor—Materials, Services, Machinery

Westinghouse Electric Corp., Booths 1402-1408, 1601-1607
3 Gateway Center
P.O. Box 2278
Pittsburgh 30, Pa.
Walter A. Johnson
Ultrasonics, static inverter vibrator system, image intensifiers, tubes (display storage, receiving, image pick-up, klystron, special purpose); Wescore and Hypersil cores, 400 cycle and control transformers, saturable core reactors, panel and switchboard instruments, transducers, transistors, Trinsitor controlled rectifiers, high voltage stacks, thermoelectric cooling, thermoelectric generator, molecular electronics.

Westinghouse Electric Corporation, Semiconductor Dept., Booths 1402-1408, 1601-1607
Youngwood, Pa.
F. G. Khoury, ▲ A. R. Mulica, A. M. Christian, J. L. DeFazio, W. F. Pochal
Trinsitor® controlled rectifiers, 100 A, 50 A, 16 A, 10 A, 5 A, 1 A; silicon high gain transistors, 10 A; silicon power transistors, 7.5 amp family and 30 amp family; complete rectifier line from ½ amp to 240 amps; *new ¾ amp diffused-double diffused rectifiers, complete line of high voltage silicon stacks; MIL-qualified rectifiers, 6, 12, 18, 35 A; thermoelectric coolers; thermoelectric generators, 5, 10, 50, 100 watts; PTC thermistors; Hall generators, molecular functional blocks.

Westline Products Division of Western Lithograph Co., Booth 4402
600 E. Second St.
Los Angeles 54, Calif.
Robert Richter, Bob Bohne, Ben Birken



Subminiature Components Identification

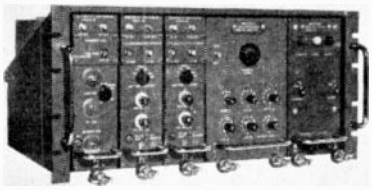
*New self-adhering component serialization marker identifies diodes, transistors, other circuit card components. Also E-Z-Code wire markers, miniature and subminiature for permanent identification of all size wires, harnesses, cables. "Shur-Code" pre-printed tubing and sleeving over wires for permanent identification. Standard and special materials. Stock and special labels and markers. Pipe, electrical and implant identification markers.

Weston Instruments Div., Daystrom, Incorporated, Booths 1708-1710 & 1809
614 Frelinghuysen Ave.
Newark 12, N.J.
▲ Art Boice, ▲ Gerry Allan, ▲ Jack Brown, ▲ Tom McGuire, ▲ Charles Gillman, ▲ Ralph Tatosian, ▲ Rex Vernon, ▲ Jake Ruiter, ▲ Bob Morris, ▲ Myron Frankel, ▲ Norm Schmidt
*Mag-TRAK® meter relay featuring maximum reliability. Multi-range portable instrument with ¼% accuracy. Calibrators. *⅛ watt Vamistor precision metal film resistors. Photo voltaic and photo conductive cells. *Matched line of ac and dc plastic and bakelite panel instruments. *Matched styling, low-cost, ac and dc ruggedized instruments with 100° deflection. *"Statnul"® anti-static solution.

▲ Indicates IRE member.
* Indicates new product.
† Exhibitor is servicing IRE Engineers through the IRE Package Plan.

Westrex Corporation, A Division of Litton Industries, Booths 1610-1618, 1709-1717
510 W. 58th St.
New York 19, N.Y.

L. H. Robinson, K. E. Clough, H. P. Bechtold, S. S. Levine, V. J. Gale, L. E. Truitt, D. C. Havens, K. McConnell, B. Luskin



Type 600 HF SSB Radio Receiver

World-wide research, manufacturing, sales and service organization specializing in radio communications, facsimile, recording, sound, oceanographic, and electronic equipment. New 600 HF SSB radio receiver. Magnetic heads, high speed punch tape reader, missile tape recorder, precision chronometers, recording paper, tube clamps, synchronous motors.

† See PROCEEDINGS OF THE IRE May through Dec. (1960), Jan. through March (1961) for further information on our products.

See 1961 IRE DIRECTORY, page 704, for complete information on our products.

Whittaker Gyro, Booth 2126
See: Telecomputing Corp.

John Wiley & Sons, Inc., Booth 1306
140 Park Avenue South
New York 16, N.Y.

Gene R. Davenport, Albert M. Dowden, Thurman R. Poston, George C. Thomsen

One of the leading publishers of texts and reference books in the engineering, science and mathematics fields displaying new and recent titles in these and related fields.

H. A. Wilson Div., Booths 4406-4414
See: Engelhard Industries, Inc.

Winchester Electronics, Inc., Booths 2121-2123
19 Willard Rd.
Norwalk, Conn.

Frank Cowe, Stephen Putnam, Herbert Sherman, Louis Bencze, Joseph Roos, William Kelly, Joseph Kempton

Connectors: Coaxial cable; electrical AN or MIL-C-5015; hermetically sealed or pressurized; interlock; miniature; power; printed circuit; RF; removable contact; solderless; subminiature. Connector Hardware: Hoods; shells; guides; plates; potting forms; pins and sockets; terminals. Tools.

Wind Turbine Co., Booths 1712-1714
248 E. Market St.
West Chester, Pa.

Kenneth B. Havens, ▲ Albert C. Veldhuis, Peter G. Park, Fred H. Lukens, John H. Windle, Harry Roberts, Alex Belevich

"Trylon" towers, antennas and components.

▲ Indicates IRE member.
Indicates new product.
† Exhibitor is servicing IRE Engineers through the IRE Package Plan.

Wright Division of Sperry Rand Corporation, Booth 3054
P. O. Box 2211
Durham, N.C.

W. D. Caffin, A. J. Boyajian, P. H. Trickey, O. E. Esval, H. W. Scudlo, R. G. Procopio, E. J. Moore, R. J. Neal, B. P. Overton

Servo motors, motor tachometers, torquers, spin motors, pancake elements, synchros, servo packages.

Wright Machinery Co., Booth 3054
See: Wright Division, Sperry Rand Corp.

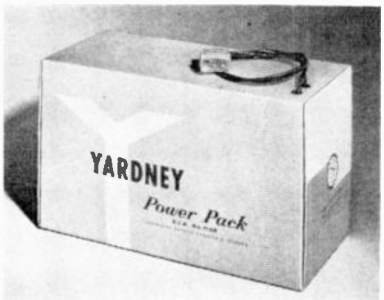
Wright Metalcoaters, Inc., Booth 4049
255 West St.
South Hackensack, N.J.

C. M. Wright, G. J. Brooks, John H. Culver, B. P. Poor, G. Rounds

Complete metal coating facilities for coating aluminum closures and castings by "Alu Sol" process. Hot dip tinning, centrifugal and handwiping, masking to specification, electro plating, fused tinning, electroless nickel. Continuous coating on wire, banding, and terminals. Kolene process for cleaning castings.

Yardney Electric Corporation, Booth 2127
10-52 Leonard St.
New York 13, N.Y.

Saul Padwo, ▲ Paul L. Howard, Stanley Fried, Sheldon L. Feld, James R. Cross, Philip Broad, Philip Rosler



Rechargeable "Silcad" for Portable Electronics

Yardney Silvercel batteries 1/6 weight, 1/5 size of ordinary batteries. High rate rechargeable Silvercel missile battery. Automatically activated Silvercel primary with minimum parts. Long-life Yardney Silcad rechargeable battery for portable applications. Large capacity sealed Silcad. Yardney sea-water battery. Also, products of Yardney Chemical, Inc.

Yokogawa Electric Works, Inc., Booth 3940
40 Worth St.
New York 13, N.Y.

▲ Toshi Sasaki, Kinichi Iwata, Yukio Horie, Bernard Fox, Karl A. Kopetzky, ▲ John C. Fisher

Extra Long Scale "Prince" Microammeter

"Prince" panel instruments. "EZ-Read" dial with extra long scale. "Loc-Qwik" one screw mount. Portable standards: TPF HF thermo instruments. CPF & SPF ac. MPF dc. DPB-1W dc-ac wattmeter. VPF tachometer. Insulation tester (L-5, hand cranking).

(Continued on page 422A)

Whom and What to See at the IRE Show

(Continued from page 421A)

York Metal Products, Inc., Booth 4239
350 Greenwich St.
New York 13, N.Y.
Alvan Bisnoff, Steve Bucek, Dave Fox, Claude Bisnoff
Custom precision sheet metal fabrication, chassis, panels, cabinets, instrument cases, racks, subassemblies, angle iron and aluminum weldments. Bracket fabrication and assembly. Complete finishing facilities, baking enamels, hammertones, wrinkles.

Zell Products Corp., Booth 1808
276-80 Main St.
Norwalk, Conn.
Burton B. Zell
Glass-to-metal hermetic seals—TO-18, TO-5 stems with "CD" gold plate (contaminant free) rectifier caps, multiheaders, end seals.

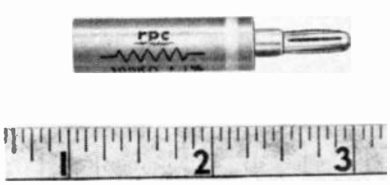
Zippertubing Co., Booth 4044
13000 South Broadway
Los Angeles 61, Calif.
Jay Cooley, Jack Mills, Bob Edwards, Walt Plummer
Zippertubing instant cable jacketing. RF shielding, thermal shielding, high and low temperature protection, chemical protection, abrasion protection.

NEWS New Products

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your IRE affiliation.

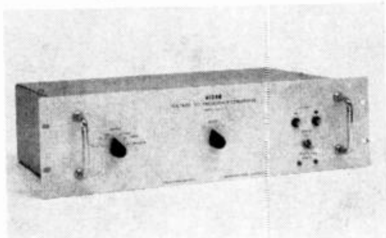
(Continued from page 52A)

Plug-in Resistor



A new plug-in resistor with a range from 1 K to 1 megohm is offered by **Resistance Products Co.,** 914 S. 13th St., Harrisburg, Pa., with 1 K, 10 K, 100 K, and 1 megohm as the key values. Color rings are in conformity with RETMA standards—red for 1 K, orange for 10 K, yellow for 100 K, and green for 1 megohm. Power dissipation of the resistor is $\frac{1}{4}$ watt at 60°C. Standard tolerance 0.1%. Female receptacle at opposite end of banana plug is machined of German silver to provide low contact resistance and long use. The resistor finds a variety of uses in computer patch-boards and its flexibility also enables efficient use as a voltage divider or probe resistor. For further information write to the firm.

Voltage to Frequency Converter



Completely transistorized, the Model 250 developed by **Vidar Corp.,** 2296 Mora Dr., Mountain View, Calif., offers ac and dc sensitivities from 0.1 to 1000 volts and resistance ranges from 1 K to 10 megohms. Accuracy is 0.1% for dc and resistance; 0.5% for ac between 50 cps and 100 kc. Choice of 0 to 10 kc or 0 to 100 kc frequency outputs. Range and mode selected manually or by external programmer. Panel is $5\frac{1}{4}$ inches high and package is $10\frac{1}{2}$ inches deep. There is 90-day delivery at $1,500 to $2,500 depending upon options required.

Rechargeable Nickel-Cadmium Cell

A development in the field of nickel-cadmium batteries, a rechargeable, hermetically sealed cell of 4 ampere hour capacity and with unusual energy in its size and weight has been announced by the **NICAD Div., Gould-National Batteries, Inc.,** St. Paul 1, Minn.

This addition to the firm's line of rechargeable cells and batteries is a 1.25 volt, standard "D" size cell, which can be discharged at loads up to 50 amperes and will supply hundreds of cycles of charge and discharge.

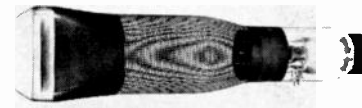
The new cell is adaptable for large current requirements and where space and weight are a premium such as portable, cordless equipment such as photo-flash equipment, satellite and missile applications, or as standby power.

The cells may be trickle charged to maintain full charge indefinitely and when connected in series form batteries of standard voltages. Hermetic sealing makes cells maintenance free. They can be charged and discharged in any position.

For complete information write to the firm.

Special C-R Tube For Transistorized Oscilloscopes

A new $3\frac{1}{4}$ by $2\frac{3}{4}$ inch flat-face cathode ray tube designed especially to meet space and power limitations of transistorized oscilloscopes is available from the **Electronic Tube Corp.,** 1200 E. Mermaid Lane, Philadelphia 18, Pa.



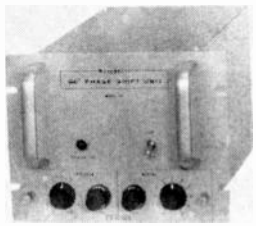
Designated ETC Type 31SBP, the new rectangular tube combines very low deflection factors with excellent light output at modest voltages. These unusual properties eliminate the need for multistage vertical amplifiers or large power supplies in the design of sensitive, wide-band oscilloscopes.

Built to MIL-E-1D specifications for use in portable oscilloscopes developed by ETC for the U. S. Navy, the Type 31SBP tube has a minimum useful scan of $2\frac{1}{2}$ horizontally and $2\frac{1}{4}$ inches vertically using electrostatic focus and deflection. A linear post accelerator and a geometry adjust electrode maintain deflection uniformity and minimum pattern distortion. Price: $150.00 each in small quantities.

Complete specifications are available on request.

90° Phase Shifter

This 90° Phase Shift Module (Model 401), a product of **Dytronics Co.,** 5485 N. High St., Columbus 14, Ohio, features an accuracy of 0.01° over a frequency range extending from 50 cps to 50,000 cps. The operating frequency is selected by the changing of plug-in units which are each designed for the particular frequency of operation. Each separate plug-in is provided with panel controls in order that the gain and phase shift may be calibrated to the required degree of accuracy. By using multiple phase shift modules, each phase shifter may be calibrated to an accuracy better than 0.01° by a primary method of calibration. Stability of the units assures long term accuracy.



Additional features of the Model 401 include unity gain, 115 volt rms output capacity, 50,000 ohm input impedance, 40 ohm output impedance, and 0.6 mv total hum and noise at the output. The Model 401 phase shifter may be used in a circuit together with summing transformers and ratio transformers where all phase angles from 0° to 360° may be generated with an accuracy approaching 0.01°.

Price of the Model 401 (console only) is $785.00, Model 401-P (Plug-in only), $265.00.

Availability is 2 weeks.

(Continued on page 424A)

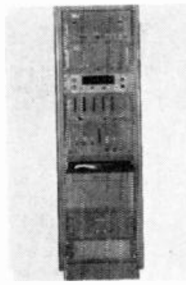
NEWS New Products

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your IRE affiliation.

(Continued from page 422A)

Gyro Test

A new inertial gyro test system is announced by **Northeastern Engineering, Inc.,** Manchester, N. H., an affiliate of Atlantic Research Corporation.

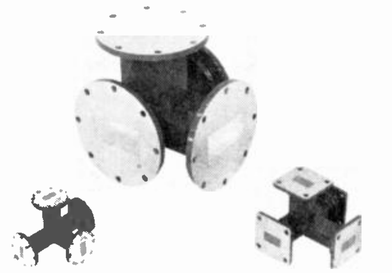


The newest data recording system, used with an M.I.T. "Type D" turntable, includes features unique to gyro testing: mean solar and sidereal time base generated by high stability oscillators at 50, 400, 1,000 cps and 10 kc with guaranteed stability of 5 parts in 10^8 per week; electronic digital voltmeter, with provision for printer read-out; six-digit, neon illuminated numeral timing unit; electronic averaging unit, to average out the gyro test table errors from the two photocell inputs; an eleven digit printer recorder; and electronic power supplies.

The data recording system shown in the photo will be used by a Military R & D facility for testing inertial guidance systems and components.

Hybrid Junction Tees

Waveline, Inc., Caldwell, N. J., announces the availability of a complete series of matched and unmatched hybrid junction tees (also known as E/H or Magic Tees). These junctions consist of a waveguide upon which a series and shunt waveguide arm are mounted at the exact midpoint. Special attention is given to the importance of holding the units' mechanical tolerances to extremely close limits to insure accurate alignment of the shunt and series arms as well as their perpendicularity to the main waveguide section.



Matched tees are equipped with appropriate iris or ramp matching devices. Design and fabrication techniques result in excellent reduction of VSWR values, relatively wide bandwidths. In addition, isolation between the shunt and series arms is greater than 35 db over the applicable frequency range.

All units are constructed of silver brazed brass which is silver plated and finished in instrument grey enamel and all arms are provided with standard waveguide cover flange connectors.

Thornbury Appointed by Metrolog

Metrolog Corp., 169 No. Halstead St., Pasadena, Calif., has formed a new operating division, Solid State Power Division, and has named James Thornbury as the divisional manager. Announcement of Thornbury's appointment came from the office of Dr. C. J. Breitwieser, president of the firm.

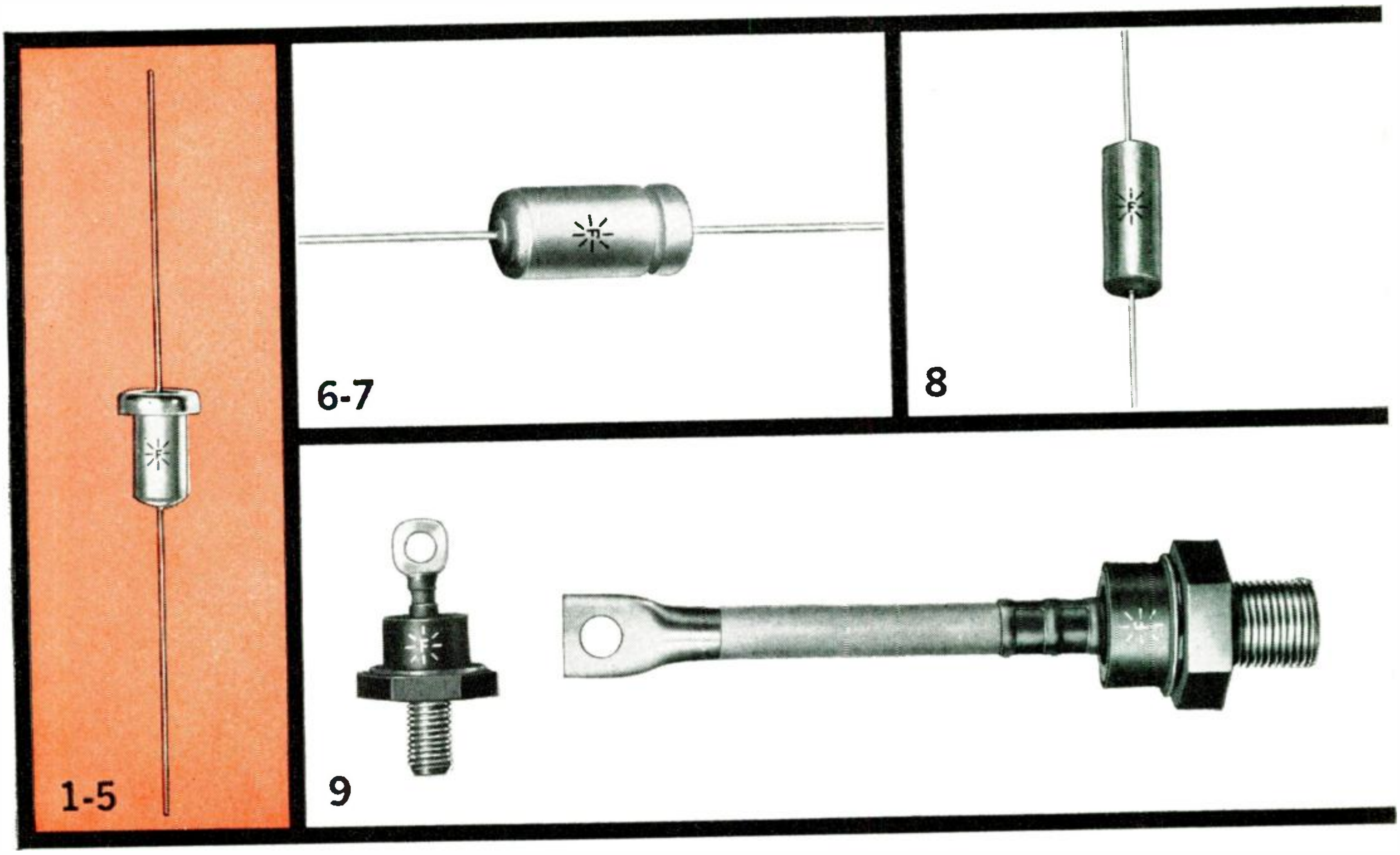
Thornbury has had over 12 years of related experience in the field of Solid State Systems and components development and engineering.

Dr. Breitwieser noted that the principal activities of the new division will be concerned with transistorized power components, custom designed and integrated to customer engineering requirements. The new division product capability complements the firm's line of 3 phase ac power supplies and servo analyzers.

Thornbury was president and founder of Lincoln Electronics Corp. and previously chief engineer of Carstedt Research. He has had other related technical management experience.

(Continued on page 428A)

FANSTEEL HIGH RELIABILITY



FANSTEEL TANTALUM CAPACITORS

In 1949, Fansteel introduced the first commercially available miniature, porous tantalum electrolytic capacitor. This capacitor was the result of more than 25 years of research into the film forming properties of tantalum and techniques for refining and fabricating the metal. Today, Fansteel's complete line of tantalum capacitors includes, in addition to the original PP type (with improved shock and vibration resistant properties), high temperature tantalum capacitors, pre-tested capacitors with certified reliability and solid tantalum types. From this broad line, it is possible to select a capacitor to meet virtually every requirement.

1. GOLD-CAP* TANTALUM CAPACITORS

Pre-tested for reliability with test results certified in writing. Gold-Cap Tantalum Capacitors are available in a wide range of ratings—2 μf to 330 μf—6V to 100V (−55° up to +125°C) and are supplied with a standard tolerance rating of ±10%.

2. PP TANTALUM CAPACITORS

Most widely used of all tantalum electrolytic capacitors. Meets MIL-C-3965B for vibration Grade 3 capacitors. Excellent low temperature characteristics—operating range −55° to +85°C at full rated voltage. Fansteel PP Tantalum Capacitors have outstanding frequency stability, negligible electrical leakage and are shock and vibration resistant. Capacity tolerance of ±10% is standard for Grade 1 PP capacitors.

3. HP TANTALUM CAPACITORS

For high temperature applications. Fansteel HP Tantalum Capacitors offer reliability and unexcelled stability over a −55° to +125°C ambient temperature range. In addition, HP types are able to withstand severe vibration and impact shock. Grade 1 HP capacitors have a standard capacity tolerance of ±10%.

4. All types of CL-44 and CL-45, conforming to MIL-C-3965B, are also available.

5. BLU-CAP* TANTALUM CAPACITORS

These economical units are designed to bring the benefits of tantalum capacitors to any commercial or military application where wider capacity tolerances (−15%, +75%) are permissible.

6. SP TANTALUM CAPACITORS

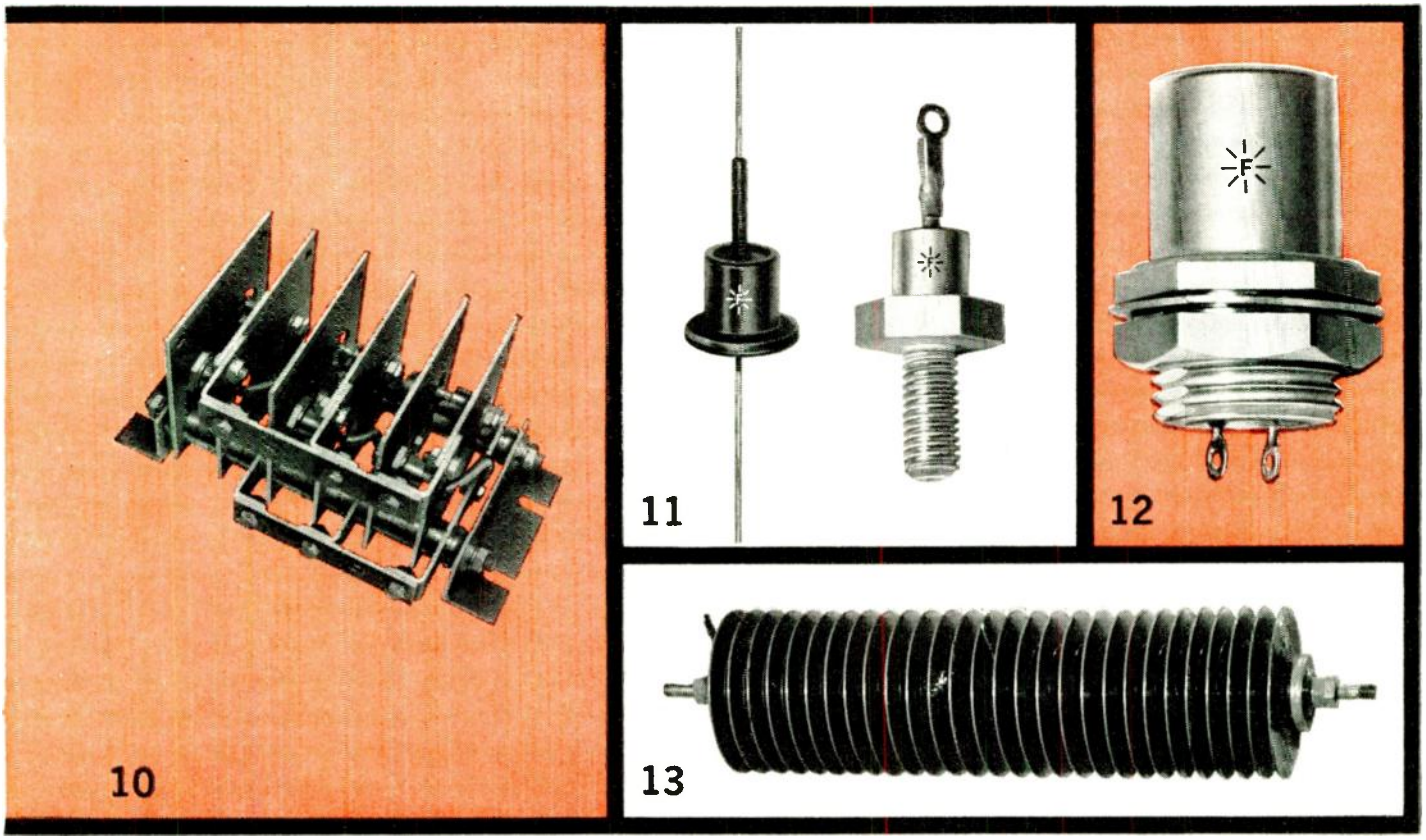
Fansteel SP Tantalum Electrolytic Capacitors offer same capacity ratings as the PP with the advantage of cylindrical cases.

7. All types of CL-64 and CL-65, conforming to MIL-C-3965B, are also available.

8. STA SOLID TANTALUM CAPACITORS

Unsurpassed performance reliability at operating temperatures up to 125°C. Hermetically sealed case affords full protection against the various environments encountered in use. A wide variety of ratings, consolidated

ELECTRONIC COMPONENTS



into four convenient sizes, cover the most complete line of solid tantalum capacitors available. Built to meet requirements of MIL-C-26655A.

FANSTEEL RECTIFIERS

Fansteel has been actively engaged in the development, engineering and production of dependable rectifiers since 1924, when Balkite Tantalum Rectifiers were introduced. As early as 1932, Fansteel conducted exploratory research work in selenium, as well as other types of metallic rectifiers. This extensive background has enabled Fansteel to continually broaden its line of rectifiers, offering designers and industrial users a full line of highly reliable components.

9. SILICON POWER RECTIFIER CELLS

Available in 20, 35, 50, 70, 160 and 240 Ampere Ratings.

10. SILICON RECTIFIER STACKS

These units provide a highly reliable d-c source for a wide range of power applications. Normally supplied in a single phase center tap, single phase bridge or three phase bridge configurations. Special assemblies can be built to specifications. (Unit illustrated has output rating of 700 volts at 147 kw.).

11. NEW! FANSTEEL SILICON ZENER VOLTAGE REGULATOR CELLS

- 1- and 10-watt power dissipation ratings
- Designed and process-selected to give sharp Zener characteristics and low dynamic resistance over entire operating current range
- Hermetically sealed
- All-welded, shock-proof cell

12. NEW! SILICON ZENER VOLTAGE REFERENCE ELEMENTS

- For applications from −55°C to +165°C
- High voltage stability
- Rugged construction

13. SELENIUM RECTIFIER STACKS

Practically unlimited life with no maintenance—instantaneous power with negligible leakage. Over 400,000 different stack combinations readily available in a broad range of power ratings. Selenium is still a practical semiconductor used by many designers where peak reverse voltages are troublesome.

Get more information on these new Fansteel Zener Diodes and other Fansteel components at the IRE Show. Visit us in Booth 4021-4022.

*Trade Mark

0312-101

FANSTEEL®

Fansteel Metallurgical Corporation, North Chicago, Illinois, U.S.A.

WHERE RELIABILITY DICTATES STANDARDS

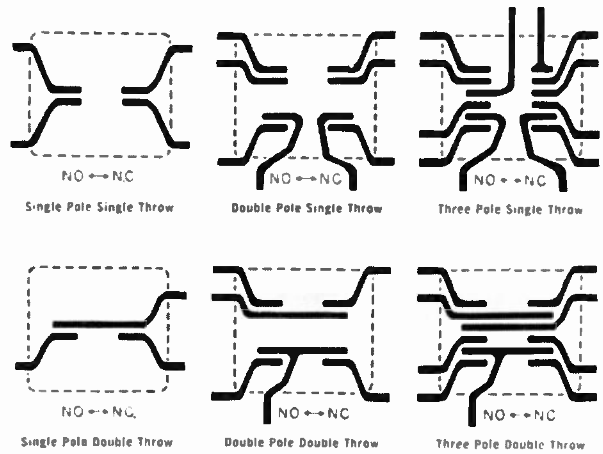
These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your IRE affiliation.

(Continued from page 424A)

Permanent Magnet Printed Contact Relay

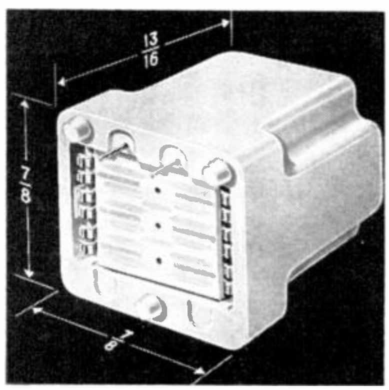
Improvements in relay performance, size reduction, and assembly installation techniques have about reached the end point in conventional relay structures, according to A. C. Bernstein of **Executone, Inc., Components Div., 47-37 Austell Pl., Long Island City 1, N. Y.** A radical departure in the classical design approach for relays has resulted in the Printact* relay, particularly adapted for printed circuit application.

Purpose of the new concept design is to save space and weight, reduce assembly time, and improve reliability. The Printact relay was developed to mount directly on a printed circuit board. Intermediate connections to fixed contacts are eliminated by doing away with the contacts themselves. The moving contacts on the relay armature assembly mate directly with conductors on the printed circuit board. The conductor pattern is designed by the user to meet his specific application problem.



The armature assembly carrying the moving contacts is held in position against the edge of one of the U-shaped fixed magnetic members by a small ceramic permanent magnet. Application of an electromagnetic field opposing the field of the permanent magnet causes the armature to rotate. The only moving part is the balanced armature assembly on which the contacts are mounted. The absence of mechanical linkages and return springs eliminates a major source of relay troubles and maintenance costs.

The relay is accurately positioned on the printed circuit board by studs which pass through punched holes in the board. It is held in position by a simple spring. Only the coil terminals require soldering.



The magnetic motor assembly is molded in a high-impact plastic. The ceramic biasing magnet is positioned between two U-shaped pole pieces made of No. 5 relay steel (cadmium plated and hydrogen annealed after forming). The pole pieces are assembled with the magnet between them to form an E-shaped structure with the coil (wound on a nylon bobbin) surrounding the center leg. The armature is normally biased against one leg of the E by the permanent magnet. When voltage is applied to the relay, the flux produced by the coil tends to attract the other end of the armature across the open air gap, at the same time bucking the flux of the permanent magnet and tending to cancel the attractive force across the closed gap. Sufficient current through the coil will cause the armature to rotate; removal of this current permits the permanent magnet to restore the armature to its first position.

The use of a permanent magnet, whose restoring force tends to decrease rather than increase as the armature rotates, accounts for the high sensitivity and enhances the snap action.

The armature and moving contact assembly consist of a No. 5 relay steel armature, a Mylar insulator, a high-impact plastic molding, and heat treated beryllium-copper springs with bar palladium contacts. The springs are pre-stressed during assembly to provide uniform contact pressure without any hand adjustment. All tolerances are picked up automatically by the pre-stressing of the springs and the form of the plastic mold. The balanced armature construction gives a high degree of freedom from shock and vibration.

The preferred printed wiring base material is glass cloth epoxy although other materials may be used. Conductor material is 2 ounce copper, 0.0028" thick, and the contact areas should be plated with rhodium over nickel, although other board and contact materials may be used. It should be noted that the contact rating for minimum life is based on the recommended printed circuit board material and contact structure.

*Registered T. M.

Wheatstone Bridge

Millivac Instruments, Division of Cohu Electronics, Inc., Box 997, Schenectady, N. Y., announces its new MV-276A Electronic Wheatstone Bridge, possessing digital accuracy (0.05%) and a wide measuring range, 1 ohm to 1,000 megohms. It has a "Calibrated Unbalance" which makes it possible to read many similar resistances directly without balancing each time. A portable 12×8×9 inch housing contains the complete bridge, electronic null detector and power source. Further details can be obtained by writing the manufacturer.

Delay Line

A 10 to 1 size and weight reduction is said to be achieved by **Valor Instruments, Inc.**, 13214 Crenshaw, Gardena, Calif., in delay line 2M1-5/5 over delay lines using conventional techniques.

The miniaturization is accomplished by a network design in which two coils are wound on each subminiature toroidal core plus the use of temperature compensating ceramic disc capacitors.

These are suited for missile, airborne, data processing, computer and similar applications.

Delay line 2M1-5/5 has low attenuation of 1% (0.008 db). This low insertion loss is accomplished by the use of subminiature toroidal inductors which enable relatively large values of inductance to be achieved with a low dc resistance. The high Q of the inductive elements and the capacitors yield a low loss delay line.

The total delay of model 2M1-5/5 is 0.2 μs. Other specifications are: Rise Time 0.04 μs; Characteristic Impedance 500 ohms; Temperature Coefficient 0.03%/°C; Size 0.25×0.4×1.75 inches.

Delivery is from stock to two weeks; price: quantity 1–9 $12.35.

(Continued on page 430A)

NEWS New Products

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your IRE affiliation.

(Continued from page 429A)

Semiconductor Alloys Bulletins

The physical properties of gold-germanium, gold-silicon and gold-antimony alloys are described in a series of technical data sheets available from **Alpha Metals, Inc.,** 56 Water St., Jersey City 4, N. J.

Designed for semiconductor engineers, each of these "Semiconductor Materials Data Sheets" contains a phase diagram of one of the foregoing alloys, a thorough description of its phase relationship and crystal structure, alloy properties and fabrication possibilities.

To receive this material, request Alpha Semiconductor Materials Data Sheets Nos. 8–10 from the firm.

Jones Appointed by Norden

Dr. Lawrence F. Jones has joined **United Aircraft Corporation's Norden Division,** Stamford, Conn., as chief—digital group in the engineering department, Carl F. Schaefer, engineering manager, announced recently.

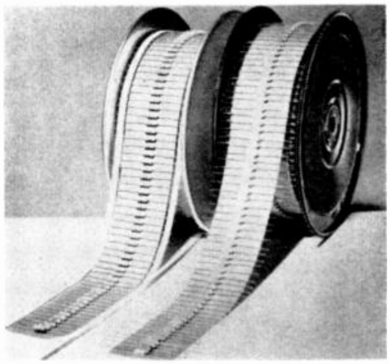
In this position, Dr. Jones will direct Norden's scientific research and development programs in digital devices and data handling systems. His duties also will encompass work on data processing equipment, including special purpose computers for bomb direction and scoring machines, data handling systems for weather forecasting and special data handling devices for processing radar signals.

Dr. Jones comes to Norden from Westinghouse Corp., Air Arm division at Baltimore, Md. where he had been advisory engineer in charge of the digital computer group since 1955. His responsibilities there included the design and development of the WEDISC computers. Also while at Westinghouse, he served as a consultant on computer techniques to the Johns Hopkins Applied Physics Laboratory.

A native of New York City where he attended high school, Dr. Jones received his bachelor of science degree in chemical engineering from Massachusetts Institute of Technology in 1940. Six years later he received his Ph.D. degree in mathematics from MIT.

"Reel-Packs" for Resistors

A form of bulk packaging, the "Reel-Pack," from **Ward Leonard Electric Co.,** 35 South St., Mount Vernon, N. Y., supplies a means of storing, holding and positioning resistors for automatic feeding in automated assembly lines. Principle use at present is in conjunction with printed circuit boards for computers, guidance systems and similar electronic equipment.



Although there are many variations obtainable with "Reel-Packs," this firm has standardized on two basic methods, each using $10\frac{1}{2}$ inch diameter metal spools. In one case axial lead resistors are held by a single adhesive tape that makes direct contact with the enameled tube, while the second sandwiches the axial leads between two layers of tape.

Maximum capacity with standard reels is 1,000-three watt Axiohm resistors per reel, where larger size resistors, i.e. 5w or 10w, are required, the capacity is proportionally lowered.

Ceramic-to-Metal Sealing Alloy

Ceramiseal, an iron, nickel, cobalt alloy designed by **Wilbur B. Driver Co.,** 175 McCarter Highway, Newark 4, N. J., is suited for ceramic-to-metal sealing. This sealing alloy has expansion characteristics closely matching those of high temperature alumina ceramics. The low thermal conductivity of Ceramiseal, which approximates that of ceramics, minimizes thermal stresses during the rapid heating and cooling cycles. A 6-page brochure with details covering deep drawing, machining, pickling, bright dip solutions, cleaning solutions, and brazing is available on request.

(Continued on page 432A)

EMI / U.S. Ltd.

EMI

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Serving Science and Industry

EMI/U.S. Ltd. announces—
the acquisition of all operations and services of Hoffman Electron Tube of Westbury, L.I., N.Y.

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MARCH 20-23, 1961
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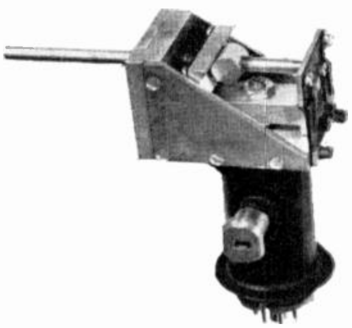


EMI Klystrons noted for stability, high power, and long life are available in integral cavity, and plug-in types covering the range from 0.5 to 40 Kmc.

Shown is one of the popular "Q" band integral cavity types available in the range from 12 to 40 Kmc.

EMI photomultipliers preferred throughout the world for low noise, stability, uniformity, and ruggedness are available in sizes 1″ to 15″ with many types of cathodes.

Illustrated is the 9536B also available with "S" type cathode processed for low thermionic emission.

Cathode Ray Tubes
EMI makes a wide variety of special purpose crts for radars, flying spot scanners, and many other applications.

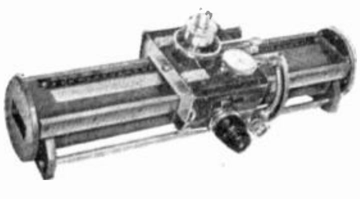
VIDICONS
Vidicons are available in many types including those for film, studio, high sensitivity types, UV, and IR versions.

Corona Stabilizers
EMI offers a very wide line of corona stabilizers useful in stabilizing supplies for crts, photomultipliers and Geiger-Mueller tubes. Available in ranges from 350 to 2,000 volts.

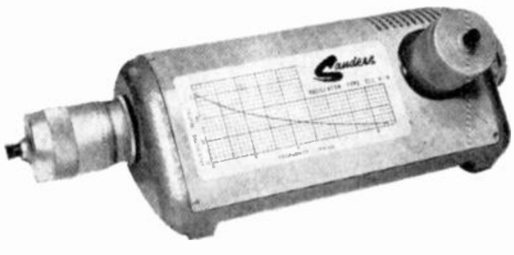
Barrier Grid Storage Tube
A tube type of considerable interest recently is the 9511A which has found application in the study of the working of the human brain.

W. H. SANDERS (ELECTRONICS) LTD.

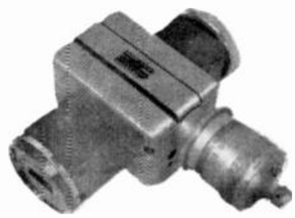
Illustrated are three of the outstanding precision microwave instruments manufactured by W. H. Sanders (Electronics) Ltd. of England. A complete microwave catalog is available on request.



Universal Standing Wave detector for VSWR measurements from 2-12.5 Kmc.



Coaxial Line Oscillators (3) covering range from 2-12 Kmc.



Precision Calibrated Attenuator, 5 models covering range from 3.95 to 17.5 Kmc.

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Westbury, L.I., N.Y.
Tel. EDgewood 3-6650

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West Coast Office
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Tel. HOllywood 2-6252

Complete EMI catalog, spring 1961 edition is available by request on your company letterhead.

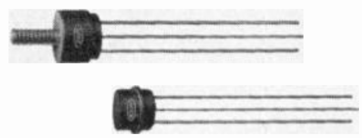
NEWS New Products

These manufacturers have invited PROCEEDINGS readers to write for literature and further technical information. Please mention your IRE affiliation.

(Continued from page 430A)

Silicon Controlled Rectifier

Solid State Products, Inc., 1 Pingree St., Salem, Mass., announces that a new silicon controlled rectifier series has been added to their line of low power PNPN devices.



This series—2N1595, 2N1596 and 2N1597—features voltage ratings to 200 volts, 10 ma firing, and complete MIL-S-19500 capability. The units are defined in Data Bulletin C415-03.

These types embody the SSPI cold-welded package—said to offer long-term reliability advantage, with no "sealed-in" solder flux or welded fumes. In addition, all leads are isolated, for maximum circuit flexibility with no need for mica washers or insulating hardware of any kind.

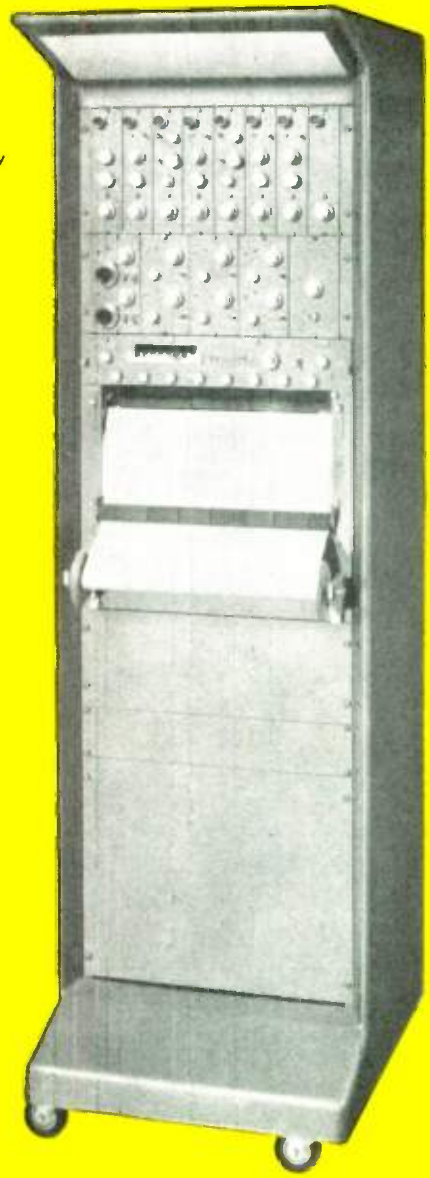
Medium-Voltage Isolated Supply

Three new low-capacitance isolated power supplies (Isoplys) with output ratings of 300 volts at 20 ma, 255 volts at 25 ma, and 215 volts at 25 ma respectively, are now available from **Elcor, Inc.,** Falls Church, Va. Featuring shunt-to-ground distributed capacitance of 25 $\mu\mu f$, these supplies may be inserted anywhere in a circuit in a manner similar to a battery, without requiring the grounding or by-passing to ground of one side of the output circuit. Hum and noise in ungrounded applications is less than 4 microvolts rms per kilohm impedance to ground. In addition to low capacitance, these power supplies also feature leakage resistance in excess of 100 kilomegohms and breakdown voltage in excess of 3000 volts.

The Offner Type R All Transistor Dynograph

provides greatest versatility

NEW
2 Channel DYNOGRAPH
See it at IRE Show Booth 3051



RP TWO CHANNEL
Compact, economical, convenient where only one or two channels are desired.

BMM/B CONSOLE
Features horizontal paper travel. Available as Type R or RC.

R SIXTEEN CHANNEL
Assemblies with 16 channels. 24 inch paper permits up to 24 channels on one inch centers.

RC DESK-TYPE CONSOLE
Medium gain assembly for computer write-out, telemetering, applications with input signal above 10 millivolts.

Write on your company letterhead for Bulletin 891, a 20 page, 2 color brochure giving you complete specifications, application data, etc.

VERSATILITY of assemblies—select the mounting best suited for your use.

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VERSATILITY of writing media—use ink, heat, electric interchangeably on one assembly—select the one most suited for the application.

The Offner Type R Dynograph Assembly is unmatched for sensitivity, accuracy, versatility—we invite you to compare it with any other high speed direct writing oscillograph.

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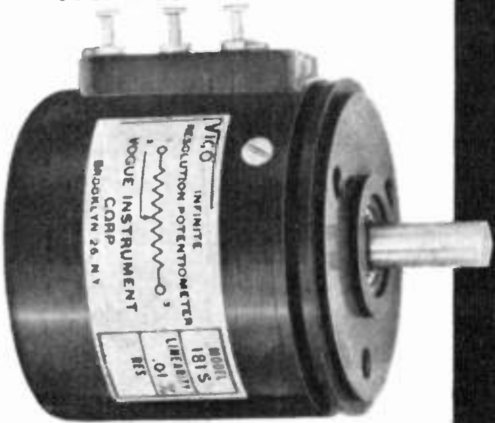
Model 100A

Model 106S



Model 181S

WIRE WOUND INFINITE RESOLUTION

*

BOOTH M16

IRE

Outstanding Features

- Infinite Resolution
- .01% Linearity
- Low Noise
- Long Life
- Low Torque
- Low Inductance and capacitance

	Model 100A & 106S	Model 181S
Maximum Resistance	6,000 Ω	30,000 Ω
Resolution	Infinite	Infinite
Linearity (independent)	.01%	.01%
Number of Turns	1 to 20	1 to 40
Power rating maximum	1.5 watts	8 watts

DESCRIPTION

The Vico infinite resolution wirewound potentiometers utilize a unique design in which a precious metal brush of extremely light contact pressure, slides across a single helically wound length of resistance wire. The precious metal brush follows the exact helical path of the resistance wire, thus no sliding or helical error occurs between the contact and wire, insuring extremely long wire life, a true stepless output, high accuracy, and low electrical noise.

The use of a non-metallic wire form of exceptional dimensional stability and low thermal coefficient of linear expansion, results in extremly high insulation resistance and low inductance and capacitance for use in A.C. circuitry.

APPLICATIONS

The Vico potentiometer's stepless output is ideally suited for use in high resolution servo systems and indicating systems where standard wirewound potentiometers cannot eliminate the "Hunting Problems" common to these systems.

CUSTOM MODIFICATIONS

Vico Potentiometers can be modified to specific customer requirements. Some of the available modifications include various shaft lengths, or shafts supplied with hobbed pinion ends, or pinned gears of aluminum, bronze or stainless steel to Agma Precision class 1, 2 or 3.

Shaft Rotations can be supplied in other than 360° increments.

ORDERING INFORMATION

Specifications listed are subject to change. When ordering, please refer to this data sheet number and specify model number, total resistance, and number of turns. **Delivery — from stock to 2 weeks.**

Write for full descriptive literature

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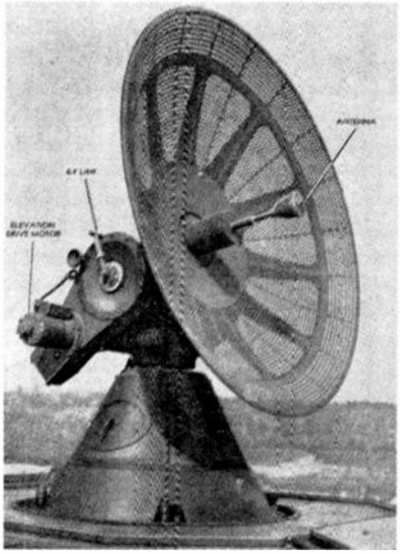

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Full azimuth and elevation sweeps. 360 degrees in azimuth. 210 degrees in elevation. Accurate to 1 mil. or better over system. Complete for full tracking response. Angle acceleration rate: AZ, 9 degrees per second squared EL. 4 degrees per second squared. Angle slewing rate: AZ 20 degrees per sec. EL. 10 degrees per sec. Can mount up to a 20 ft. dish. Angle tracking rate: 10 degrees per sec. Includes pedestal drives, selsyns, potentiometers, drive motors, control amplidynes. Excellent condition. Quantity in stock for immediate shipment. Ideal for missile & satellite tracking, antenna pattern ranges, radar systems, radio astronomy, any project requiring accurate response in elevation and azimuth.

Complete description in McGraw-Hill Radiation Laboratory Series, Volume I, page 284 and page 209, and Volume 26, page 233.

MIT MODEL 9 PULSER 1 MEGAWATT-HARD TUBE

Output pulse power 25KV at 40 amp. Max duty ratio: .002. Uses 6C21 pulse tube. Pulse duration .25 to 2 microsec. Input 115 volts 60 cycle AC. Includes power supply in separate cabinet and driver. Fully guaranteed as new condition. Full Desc. MIT. Rad. Lab. series "Pulse Generators."

MIT MODEL 3 PULSER

Output: 144kw (12kv at 12 amp). Duty ratio: .001 max. Pulse duration: .5 1 and 2 micro sec. Input: 115v 400 to 2000 cps and 24vdc. $325 ea. Full desc. Vol. 5 MIT Rad. Lab. series pg. 140.

2 MEGAWATT PULSER

Includes Rectifier xfmr 5800/7000V, 2.2/2.55-KV; Resonant charging choke 150 cy. 30H 12 Amp. Ins. 17KV; Capacitor network 17E2-2-300-25P2T; Capacitor, 04Mfd. 17KVDC; Transformer 4400V to 22,000V; Fil. Xfmr. & Filter choke 5.1V 18Amp. 6 H .21Amp. DC; 4C35 pulser, 3B24W (6 each), WL1B41 gap tube. Price new type MD-53/APS20C $1125.00

PULSE TRANSFORMER: Raytheon U-12016 .3mu sec., rep. rate 1000 cycles. Pri: 2kv 64 amps pk. Sec: 12.5kv 9.5 amps pk. and 200v. Oil immersed. $24.50 each.

VD-2 PPI REPEATER

Floor standing console with rotating yoke PPI. 7BP7CRT. 4, 20, 80, 200 mile ranges. Will display or repeat any PPI info locally for remote. New & complete. With inst. book $375 ea.

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2400 to 3400 coax freq. meter with resonance meter mfg. Sperry. As new. $125.

AN/AAS-6

Infrared Detection System, complete. New $5500.

EQUIPMENT VANS

Fully insulated, wired for 110vac with lights and outlets. Includes heater thermostat controls. 20 ft. long apx. 8 ft. wide, 10 ft. high. Fifth wheel for hauling by std. truck tractor. Buttressed walls for handling high roof torsion. 1 entrance door, 2 equipment doors. 4 wheel rear axle. Will hold 10 tons of equipment. Elevator from van floor to roof incl. in some units. Exc. condition $1500. Mfg. Freuheuf. Large quantity in stock.

SCHMIDT OPTICAL REPEATER

VG PROJECTION PPI CONSOLE: Will take any video PPI info, repeat and project on 28" square desk type console. Mfg. G.E. Ideal as plotting board, etc. Weighs 850 lbs complete. $350 ea.

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500kw. 1220-1359mcs. 160 nautical mile search range P.P.I. and A Scopes. MTI. thyratron mod. 5J26 magnetron. Like new. Complete system incl. spare parts and gas generator field supply.

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Lab for Electronics "Quad" type portable ground control approach radar system. 3cm. search and precision approach Search and hlight finder antennas. 2J51 magnetron. 4C35 pulser. 115V60CY AC. Complete systems in used, good condition.

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Complete X band system oper. from 115v 60cy ac with 40kw power output 2J55 magnetron. Ranges 0-1.5, 4, 16, 40 miles. Includes installation waveguide. An ideal system for lab school, demonstration or shipboard. $1800. New with spares.

10 CM. WEATHER RADAR SYSTEM

US Navy Raytheon. 275 KW peak output S band. Rotating yoke Plan position Indicator. Magnetron supplied for any S band frequency specified, incl. Weather Band. 4, 20 and 80 mile range. 360 degree azimuth scan. Sensitive revr using 2K28, 707B and 1N21B. Supplied brand new complete with instruction books and installation drawings. Can be supplied to operate from 32VDC or 115 volts. Price $975. Ideal for weather work. Has picked up clouds at 50 miles. Weight 488 lbs.

10KW 3 CM. X BAND RADAR

Complete RF head including transmitter, receiver, modulator. Uses 2J42 magnetron. Fully described in MIT Rad. Lab. Series Vol. 1, pps 616-625 and Vol. 11, pps. 171-185. $375. Complete X band radar system also avail. inclu. 360 deg. antenna, PPI, syn pwr supply. Similar to $17,000 weather radar now in use by airlines. $750 complete.

AN/APS-15B 3CM RADAR

Airborne radar. 40kw output using 725A magnetron. Model 3 pulser. 30 in parabola stabilized antenna. PPI scope. Complete system. $1200 each. New.

WESTERN ELECTRIC TD-2 MICROWAVE LINK 4 KMC CRYSTAL OSC.

Basic crystal oscillator multiplying thru 2C37 cavities and 416B cavities with crystal stability output 3700 4200 MCS. New

RT39/APG-5 & 15 10CM RADAR

Complete S band RF package. Lighthouse 2C40 xmtr 500 watts peak. 2C43 revr. TR. 829B pulser. miniature 6AK5 IF strip. Press. 12" dia., 24" lg. New with tubes $275. Ref: MIT Rad. Lab. Series Vol. 1, pg. 207.

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X BAND. CG 176/AP 20 db. Unidir. cplr. "N" output. Std. flanges. 1"x½" guide. $15.00.

X BAND. 24 db. Bi-directional 1¼"x⅝" guide. Type "N" output. Std. flanges. $22.50 ea.

S BAND. 27 db. Uni-directional, box type. "N" output. 3"x1½" guide. Std. flgs. $32 50 ea.

AN/APN-19 & 60 RADAR BEACON

10cm lighthouse osc. 2C40, low level converter receiver. Used for extending range of radars such as SCR584. Radar triggers beacon which emits 500 watt peak echo pulse. Complete $275. Transmitter only $175. Receiver only $95. Power unit only $35.

2.5 KW PRESS WIRELESS XMTR. Type PW-981A 2-23 mc. cw and freq. shift (teletype) MO 25 XTAL channels. Complete. $750.00.

CARCINOTRON

Type CM 706A Freq. 3000 to 4000 mcs. CW. Output 200 Watts minimum. New, with full guarantee.

RADIO RESEARCH INSTRUMENT CO.
550 FIFTH AVE.
NEW YORK
JUDSON 6-4691

F-28/APN-19 FILTER CAVITY

Jan. spec: Tuneable 2700-2900mc. 1.5db max. loss at ctr freq over band. Details: Insertion loss variable. Single tuned filter for freq channelling in radar beacon. Invar center tuning conductor ¾ wavelength. New $37.50 each.

2C40 LIGHTHOUSE CAVITY

AN/APW-11A transmitter cavity for 2C40. Complete S band coverage at max. power. Temperature compensated. New $77.50 ea.

SPERRY KLYSTRONS

SMX-32 Sperry Klystron Amplifier-Multiplier 9.0-10.5KMC. Amp. freq. multiplier; output power 1.5 to 2 watts at 9000 to 10,500mc; crystal stability drive freq. 4500 to 5250mc. New in original sealed cartons. Guaranteed 90 days. Regular price $925 ea. Our price $425 ea. 10% disc. on 2 or more.

SMC-11A Sperry Klystron Frequency multiplier. Output range 4610-4670mc. ½ to 1 watt. Crystal stability. Input range 773-778 (i.e. 2C39) mc. For direct control of microwave frequencies. New in original sealed cartons. Guaranteed 90 days. Regular price $1500 ea. Our price $495 ea. 10% disc. on 2 or more.

TOPWALL HYBRID JUNCTION. 8500-9600mc 1x.5 wg size. Broad banded better than 16%. Aluminum casting. $15.00 new. Crossover out put. 1x.5 wg size. $5.00 new.

BROAD BAND BAL MIXER using short slot-hybrid. Pound type broad band dual balanced crystal holder. 1x5 wg size. $25.00 new.

FLEXIBLE WAVEGUIDE

1"x½"x4" $5.00 ea.	1¼"x⅝"x12" $19.50 ea.
1"x½"x9" $10.00 ea.	3"x1½"x12" $55.00 ea.
1"x½"x24" $21.50 ea.	3"x1½"x18" $65.00 ea.

RG48 to ⅞ COAX. ADAPTER S Band 1½ x 3" W.G. to RG 44 U coax. New, $26.50.

COAX MIXER ASSEMBLY S BAND IN21 type crystal detector RF to IF. 'N' fittings, matching Slug, duplex couplings, mf. G.E. New, $18.50

KLYSTRON MOUNTS

3CM. Precision Tube Mount. Waveline model 688. X band shielded klystron mount PRD signal generator type. Complete with variable glass vane attenuator. Brand new. $205. list. Price $45.00. **S. band.** Type N output. Tunable over entire band. For Shepard type tube i.e. 726 w/socket & tube clamp. Mfg. GE. New, $15.00.

3KW 400 CYCLE SOURCE

Complete generator set 115vdc 4HP motor (easily swapped for standard GE or other 115v 60 cycle AC motor) speed regulated. Generator output 115 volts 400 cycle single phase 17.4 amps continuous duty Output electronically regulated. Built to rigid US Navy spec. In excellent condition. Price $225.00.

SUMMATION BRIDGE

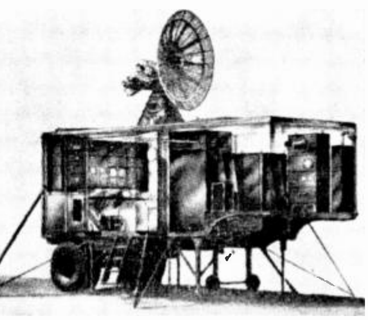
TS 731/URM. Portable, general purpose, field type, ruggedized wattmeter used to measure R.F. power output of radio, radar & navigation equips. A direct reading summation type circuit in which a bolometer acts as one arm of a D.C. Wheatstone bridge, at the same time providing correct resistivity termination for R.F. entering the wattmeter. Power supply: 115VAC, 1 ph. 50-1600 cy. Freq. range: 1000 to 4000 mcs with plumbing supplied. VSWR less than 1.3.—$395 ea.

10CM ONE MEGAWATT: RF head and modulator (4C35), $1200 ea.

SCR 584 RADARS 3 & 10 CM

AUTOMATIC TRACKING RADAR

Our 584s in like new condition, ready to go, and in stock for immediate delivery. Ideal for research and development, airway control, GCA, missile tracking, balloon tracking, weather forecasting, antiaircraft defense, tactical air support. Write us. Fully Desc. MIT Rad. Lab. Series, Vol. 1, pps. 207-210, 228, 284-286.



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COMPARE
THIS HIGH-SPEED, LOW-COST SWITCH
WITH ANY OTHER

Philco's Improved 2N1499A MADT®

ABSOLUTE MAXIMUM RATINGS

Storage Temperature	−65 to +100°C
Collector Voltage, V_{CB}	−20 volts
✓ Collector Voltage, V_{CES}	−20 volts
✓ Collector Current, I_C	−100 ma
Total Device Dissipation at 25°C	60 mw

ELECTRICAL CHARACTERISTICS (T = 25°C)

Static Characteristics	Min.	Typ.	Max.	
Collector Cutoff Current, I_{CBO} (V_{CB} = −5v)		1	3	μa
✓ Collector Cutoff Current, I_{CBO} (V_{CB} = −5v, T = 55°C)			18	μa
✓ Collector Breakdown Voltage, BV_{CBO} (I_C = −25 μa)	20			volts
✓ Collector Breakdown Voltage, BV_{CES} (I_{CES} = −25 μa)	20			volts
DC Current Amplification Factor, h_{FE} (V_{CE} = −0.5v, I_C = −40 ma)	20	50		
✓ DC Current Amplification Factor, h_{FE} (V_{CE} = −0.3v, I_C = −10 ma)	30	70		
Base Input Voltage, V_{BE} (I_C = −10 ma, I_B = −1 ma)	0.25	0.32	0.40	volt
Collector Saturation Voltage, V_{CE} (SAT) (I_C = −10 ma, I_B = −1 ma)		0.12	0.20	volt
Collector Saturation Voltage, V_{CE} (SAT) (I_C = −10 ma, I_B = −0.5 ma)		0.15	0.25	volt
✓ Base Input Voltage, V_{BE} (I_C = −10 ma, I_B = −0.5 ma)			0.34	volt
Dynamic Characteristics				
Output Capacitance, C_{ob} (V_{CB} = −6v)		1.5	3	pf
Rise Time, t_r (V_{CC} = −5v, I_C = −10 ma, I_{B1} = −2 ma)		25	60	nsec
Minority Carrier Storage Time Constant, τ_s (K'_s)I_B = −1 ma		100	120	pcb/ma
✓ Gain Bandwidth Product, f_T (V_{CE} = −3v, I_C = −5 ma)	100			mc

✓ Checks indicate specification improvements

Immediately available in quantities 1-999 from your Philco Industrial Semiconductor Distributor

Now with New, Tighter "Specs"

In high-speed switching circuits, this Philco MADT has a long record of reliable performance. It has always been manufactured to meet rigid specifications . . . not selected as a fall-out device.

Now . . . the 2N1499A is being produced to still tighter specifications, making it far more versatile and permitting greater freedom in circuit design.

New high current rating makes it suitable for line drivers, blocking oscillators, etc. Higher amplification factor (h_{FE}), makes NOR circuit design much easier. V_{BE} and V (SAT), guaranteed at 2 drive conditions, give tight control for all saturated circuit designs.

For logic circuits operating at rates up to 10 mc, it will pay you to get the facts on the improved Philco 2N1499A. Compare it . . . you'll find it impossible to beat in performance, reliability, versatility and price. Write Dept. PO1361.

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LANSDALE DIVISION, LANSDALE, PENNSYLVANIA

TRANSISTOR CENTER U.S.A.®

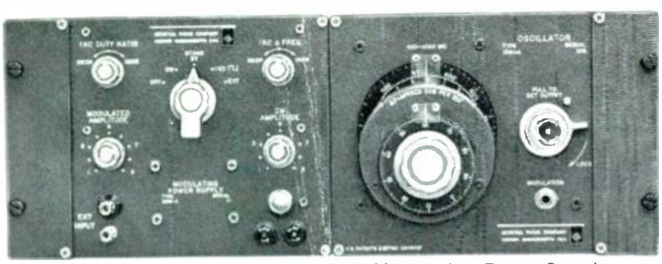
See us at IRE—Booths 1302-1308

a UHF OSCILLATOR

450 to 1050 Mc

Type 1361-A Oscillator........$285.

- Butterfly Tuning Circuit — no sliding contacts
- Frequency Scale Calibration Accuracy ±1%; constant 0.1% frequency change for each vernier division. Warm-up frequency drift is 0.2%, maximum.
- Modulation Capabilities — sine wave, square wave, or pulse from external source; 40v required to produce 30% sine-wave modulation.
- High Output — 100 mw minimum into 50-Ω load, adjustable at panel by calibrated 80-db attenuator.
- Complete Shielding, including use of ferrite-loaded filters and ceramic shaft, reduces stray fields to very low values.
- Sweep Drive Capability using G-R sweep and dial drives.
- Small Size: 8" x 7" x 8¼"; only 7 lbs.
- Power Supply Recommended: 1201-A Regulated Power Supply $85, for cw; 1263-B Amplitude Regulating Power Supply $355, for constant output level; 1264-A Modulating Power Supply (below).



Type 1361-A Oscillator and Type 1264-A Modulating Power Supply conveniently mount in a relay rack with Adaptor Plates, Type 480-P-416, $6.

NEW MODULATING POWER SUPPLY

. . . for high-level pulse and square-wave modulation of Vhf-Uhf Unit Oscillators.

OUTPUTS: Square Waves — adjustable from 160v to 210v; internally generated 850 to 1150 cps, with high stability; externally generated 20 to 50,000 cps from sine or square-wave source.

Pulses (externally generated) — 160v to 210v at rates up to 100 kc, pulse durations from 1.5 μsec to square wave (determined by external generator), less than 1.5 μsec rise and decay times for typical oscillator load, overshoot less than 5%.

Regulated DC — adjustable from 200v to 300v, 50 ma (max)

Unregulated AC — 6.3v; 2.1a (max)

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