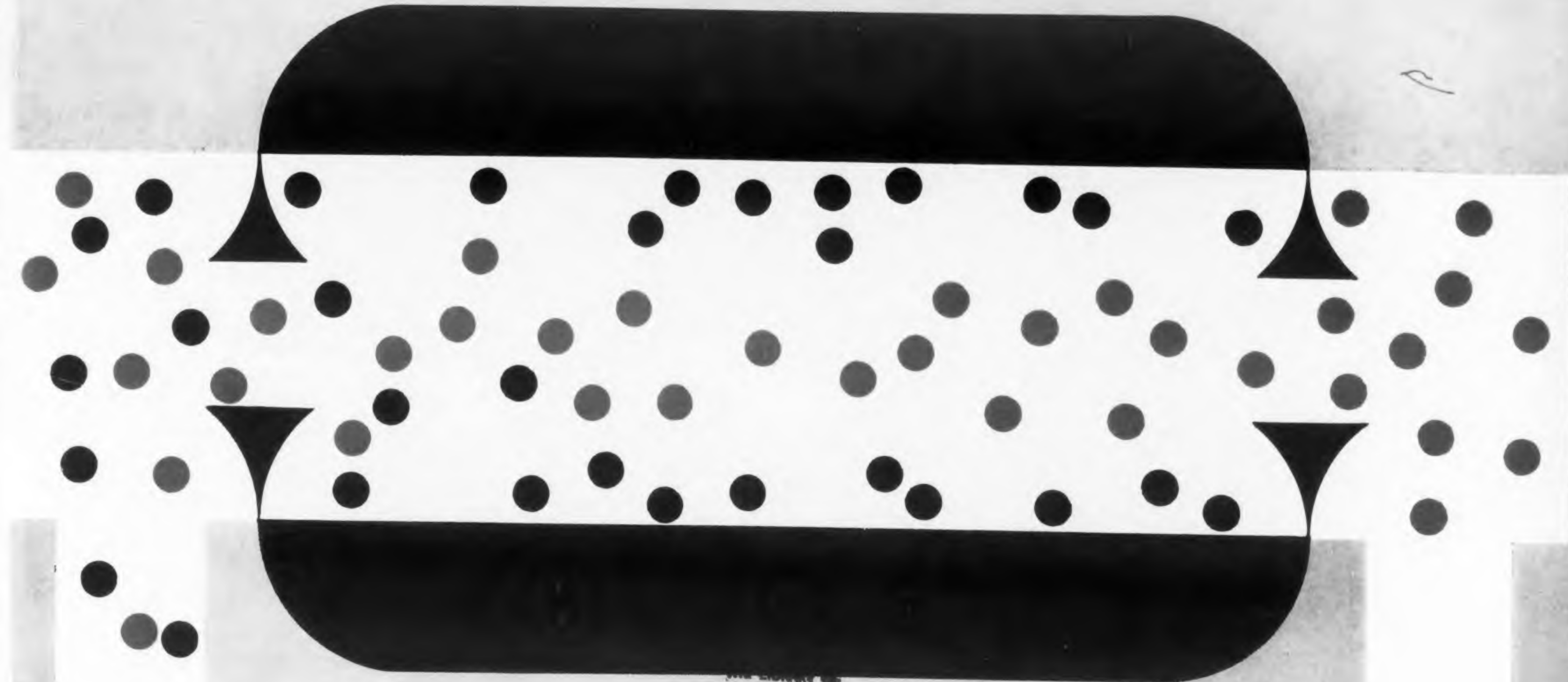
MARCH 19, 1958

ELECTRONIC DESIGN



Maser is Here! .... page 28

COVER STORY

Maser is Here!—For Sale p 24

An important technological breakthrough is the first commercial Maser, a portable, sealed ammonia type. The Maser oscillator generates a 23.8701294 kmc signal with unprecedented accuracy and stability. Maser provides the world's most accurate time.

VHF Matching Network Design . . . . . p 20

Mr. Sanderson presents here a new method of designing optimum bandpass filters and matching networks. The method involves a plot of impedance against frequency on a Smith chart. Since the design equations use no approximations, the method is valid for narrow and wide band networks.

Feedback Amplifier Design with the Nichols Chart . . . p 32

The Nichols Chart, is a useful design tool like the Bode chart or phase-attenuation curves. Unlike these, it allows the designer to obtain closed loop data directly from open loop information. Mr. Wade's article will save a lot of time in feedback amplifier design.

Thyristor . . . . . p 48

The Thyristor is a new transistor that behaves much like a thyratron. It can be triggered "on" and "off" with low power and has a collector voltage drop of only about 0.5 volts during conduction. It is almost a perfect switch having a collector current rise and fall time of less than 0.1 microsecond. Characteristics and circuit applications are described.

ELECTRONIC DESIGN

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	10	20	30	40	100	110	120	130	140	200	210	220	230	240	300	310	320	330	340	400	410	420	430	440	500	510	520	530	540
1	11	21	31	41	101	111	121	131	141	201	211	221	231	241	301	311	321	331	341	401	411	421	431	441	501	511	521	531	541
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58	68	78	88	98	158	168	178	188	198	258	268	278	288	298	358	368	378	388	398	458	468	478	488	498	558	568	578	588	598
59	69	79	89	99	159	169	179	189	199	259	269	279	289	299	359	369	379	389	399	459	469	479	489	499	559	569	579	589	599

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Number
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NBP BPA

ELECTRONIC DESIGN is published bi-weekly by Hayden Publishing Company, Inc., 830 Third Avenue, New York 22, N. Y., T. Richard Gascoigne, President; James S. Mulholland Jr., Vice-President & Treasurer; and David B. Landis, Secretary. Printed at Hildreth Press, Bristol, Conn. Accepted under section 34.6. P. L. & R. authorized. 30,000 copies this issue.

New Speed...Versatility...Reliability...

TRANSISTORIZED DIGITAL MAGNETIC TAPE HANDLER MODEL 906

Optimum performance in virtually all tape handling applications

The advanced design of the completely transistorized Potter Model 906 Tape Handler provides improved performance in virtually any tape handling application.

Replaceable Capstan Panel permits use as Perforated Tape Reader with a remarkable new brake capable of stopping on the stop character at speeds up to 1000 characters per second. Using a small vacuum loop buffer, Model 906 features:

- **Complete front accessibility—single panel construction**
- **Pinch rollers capable of 100 million start-stop operations**
- **In-line threading, end of tape sensing and tape break protection**
- **Speeds up to 150 ips**
- **As many as 4 speeds forward and reverse**
- **Capable of continuous cycling at any frequency from 0 to 200 cps without flutter**
- **Rewind or search at 400 ips**
- **3 millisecond starts**
- **1.5 millisecond stops**
- **Tape widths to 1-1/4"**
- **Up to 47 channels**
- **All functions remotely controllable**

The 906 may be supplied with a transistorized Record-Playback Amplifier featuring a separate module for each channel. Electronic switching from record to playback function is available as an optional feature.

Other Potter products include Transistorized Frequency Time Counters, Magnetic Tape Handlers, Perforated Tape Readers, High Speed Printers, Record-Playback Amplifiers and Record-Playback Heads.

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Potter

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ENGINEERING REVIEW

For more information on developments described in "Engineering Review," write directly to the address given in the individual item.

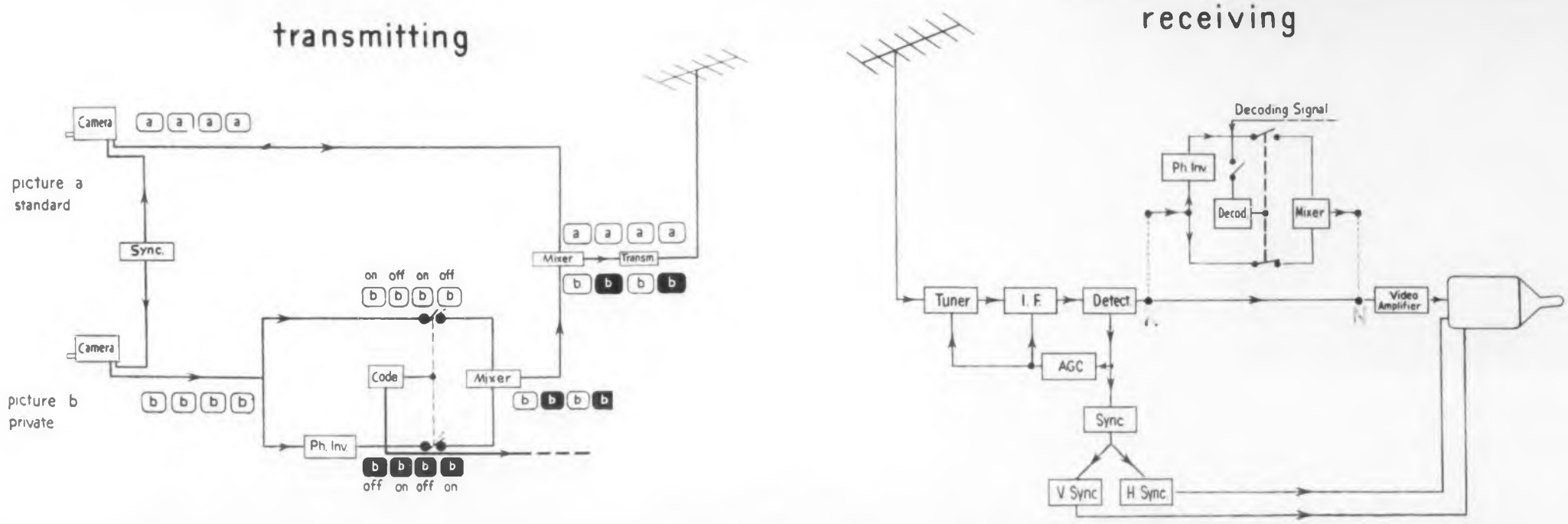
Two Signals Simultaneously Televised Over One Channel

A compatible television system which would enable two different programs to be broadcast simultaneously on the same channel was demonstrated by Blonder-Tongue, Newark, New Jersey.

The technique of multiplexing the signals in this system, dubbed Bi-Tran, is pictorially represented in the accompanying diagram. Programs A and B are submitted to the transmitter. All of the frames of A are of the same polarity. B offers an alternating polarity sequence due to the phase inverter and the coding box. The coding box contains a gating circuit.

Standard receivers equipped with the decoding circuit indicated across points KN would pick up both signals. A detailed account of how visual translation of programs A or B is accomplished is illustrated on the following page. With a decoding signal applied an alternating polarity pattern of signal A results. Because of phosphor persistence and eye retentivity the alternating pattern will cancel out and picture B will be observed.

(Continued on following page)



Both signals A and B, of the same and alternating polarity sequence, will be received by standard sets containing the additional circuitry across KN.

Which ceramic characteristics do you need . . .

Characteristic	Material								
	Electrical Porcelain	Steatite	Fused Quartz	Magnesia	Cordierite	Glass Bonded Mica	Raytheon R-95 High Alumina	Forsterite	Zircon
Dielectric Constant (1 mc)	6-7	5.5-6.5	3.7	5.8	4-5	7-8	9	6.5	9
Power Factor (1 mc)	.009	.0008	.00035	.0008	.008	.002	.001	.0002	.0014
Loss Factor (1 mc)	.055	.004	.0013	.004	.03	.016	.009	.0014	.013
Water Absorption (%)	0-1.0	0-.01	0	16	3-8	0.5	0.0	0-.01	0-.01
Tensile Strength (p.s.i. x 10^{-3})	2.6	13	8	2.8	3	8	25	10	10
Flexural Strength (p.s.i. x 10^{-3})	11	20	—	6	7-10	18	45	12	18.5
Compressive Strength (p.s.i. x 10^{-3})	30-65	65	200	48	50-95	25	250	80	80
Dielectric Strength (volts/mil)	100-200	250	200	65	200	245	450	250	200
Hardness, Moh's scale	7.5	7.5	5	6	7	—	9	7.5	8
Modulus of Elasticity (p.s.i. x 10^{6})	10	14	4	—	5	—	42	—	21
Specific Gravity	2.4	2.6	2.2	3.0	2.5	—	3.7	2.8	3.7
Linear Thermal Expansion 20-100°C (in./in./°C x 10^{-6})	3.6	6	.20	9.4	2.5-4	—	6.2	8.5	2.5-5
T_E Value (°C)*	—	450°-800°	—	—	750°	—	980°	990°	700°

*T_E is that temperature at which the volume resistivity reaches 1 Meg.

Approximate characteristics of "electronic" ceramic materials. Source: manufacturer sales literature

Reprinted from Electronic Design, November 1, 1956

How Raytheon R-95 High-Alumina Ceramic can save you money—do a better job

See Raytheon at the I.R.E.— Booths 2611-2614

Consider well the unusual properties present in Raytheon R-95 High-Alumina Ceramic. If your needs are for a less specialized material, you may find a satisfactory performer at lower cost.

However, when you require a material with remarkably *high resistance to high temperature, shock and vibration; high dielectric strength* and *high electrical resistance at all temperatures; extreme hardness; high mechanical strength* and *positive sealing capability*—then you will surely want to be familiar with the ratings of Raytheon's R-95. Proper application of this superior material assures continuing design and assembly economy, particularly where ceramic seals are a factor.

Ceramic parts manufactured from Raytheon R-95 High Alumina are available, either alone or as hermetic ceramic-to-metal assemblies, in accordance with your specifications. The assemblies can be soft or hard soldered into your production in your own plant.

Send sketches or drawings outlining dimensions and tolerances, together with operational conditions. We will be pleased to supply information and help on any of your ceramic needs.

Write for complete specification sheet and your copy of *Ceramics in Electronic Design*, comprehensive questions and answers on the growing role of ceramics in modern design. No cost or obligation, of course.

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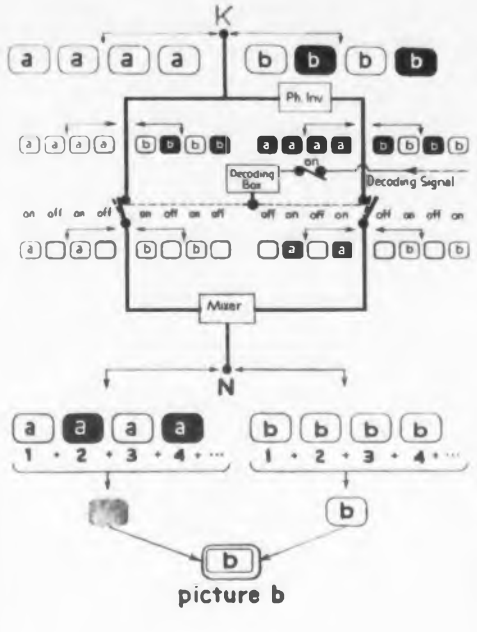
Excellence in Electronics

Ceramic Sales **Waltham 54, Massachusetts**

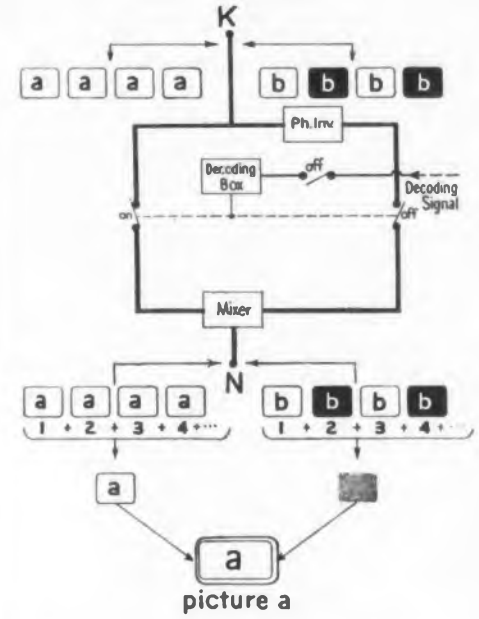
ENGINEERING REVIEW

private program b



picture b

standard program a



picture a

Here is a detailed account of how either program A or B may be observed. Application of decoding signal will produce program B.

On the other hand, with no decoding signal introduced, the standard program A will be viewed.

As yet efforts have not yet been extended in developing a multiplexing system for sound transmission. Development engineers have indicated, however, that the problem is "not too difficult."

Blonder-Tongue, which originally presented the system to the FCC last September, has invited Commission members to witness their

demonstration. If the system proves feasible to the FCC, licensed channels may apply for Bi-Tran and use it in a limited area for experimental purposes.

It is suggested that the Bi-Tran System could be adapted for educational public service, medical TV, and military and uhf applications.

Physicists Baffled by Neutron Characteristics

The protons and neutrons of atomic nuclei have been explored to within 30 millionths of a billionth of a centimeter of their cores by Stanford University physicists. Both appear to consist of clouds of mesons growing denser toward the center. Both clouds are equal in magnetic size, each with an average radius 8×10^{-14} cm.

These findings were discussed at a meeting of the American Physical Society of New York. Recent measurements have verified the magnetic size equality of neutrons and protons. Physicists are at a loss to reconcile the neutron's unexpectedly large magnetic size with its small charge size. It implies that present theories upon which their ideas of the atom are based may not be valid for studies of such fine dimensions. The nuclear probe used by the Stanford group was an electron beam of energies varying from 500 to 650 mev. It's target was the deuteron nucleus of deuterium. A revolving 55-ton magnetic spectrometer was used at the target end as the measuring device.

Transistorized frequency converter with cooling fins gives the benefits of high-frequency lighting: ballast size, weight and losses are drastically reduced. Small 1500 cycle ballast is compared to low frequency ballast; the transistorized power source will handle 32 forty-watt lamps.

ENGINEERING REVIEW

Microminiature Torroidal Coil Winder

A machine which can wind coils on torroidal cores almost invisible to the naked eye has been developed by Stanford Research Institute. Most machinery on the market makes use of a split bobbin (or circular mandrel) that is first placed through the hole in the core through which the coil is to be wound. In such cases, the size hole through which a coil can be wound is limited to a dimension slightly larger than the combined size of the finished coil and the bobbin. Also, it would be impossible to wind a coil through two adjacent holes in the same surface.

The new machine is capable of winding coils whose outside diameter is equal to the diameter of the hole through which they are wound either from the center to the outside of the core, or through two adjacent holes in the same core. The ability of the machine to wind such coils is not impaired by the diameter-to-length ratio of hole or holes through which the coil is to be wound. For example, it is possible to wind a coil through

"Pinhole" Coil Winder developed by Stanford Research Institute's Computer Development Group. Core is held in clamp immediately to left of operator's hand

/pical coils wound on the "Pinhole" Coil Winder.

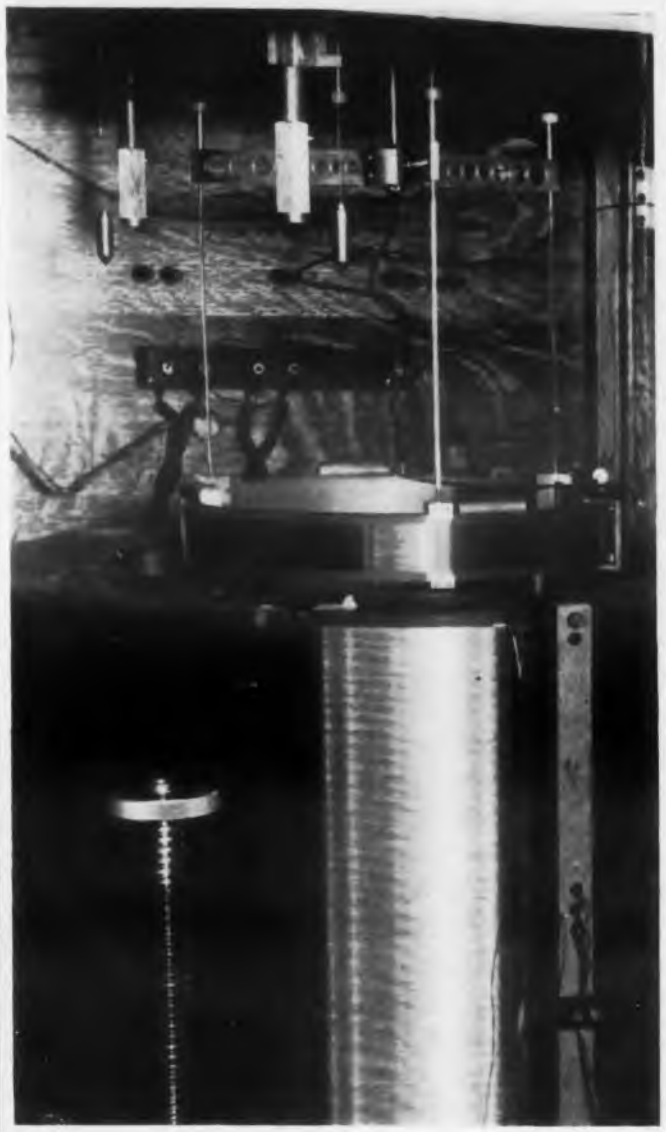
vo 0.010 in. holes spaced on 0.060 in. centers in 3 in. thick core.

The wire forming the coil is made to pull itself rough the hole or holes through which the coil wound. The set-up time on the laboratory odel of this machine is about the same as on a andard commercial torroidal winding machine d can be reduced drastically on a production odel. Actual winding time per turn is about ual to a standard commercial machine.

In continuing development of the machine, I is hoping to achieve a completely automatic mponent-winding mechanism.

multaneous Transmission of elephone, TV Signals Feasible

Stacking or double decking television and phone circuits has proved to be feasible and nomical where telephone circuit require- nts are limited and system lengths range from to 1000 miles. In a report delivered at the ter meeting of the AIEE, H. E. Curtis of the Telephone Labs, New York; U. C. P. hlendorf and A. J. Wade of the Bell Tele- ne Company of Canada, Montreal, Que. re- ved a successful field experiment conducted he Bell Telephone Laboratories early in 1954 1133 mile TD-2 route, from Halifax to Vic- , Canada, using standard telephone and ision terminal equipment. In this experi- t, two conventional highpass-lowpass filters used to combine and separate the signals ne TD-2 terminals. Field results indicated two or three telephone supergroups, of 60 nels each, could be stocked in the 6 to 7 mc n above the television signal.



Helical coil balance used in the National Bureau of Standard's original determination and re-evaluation of the standard ampere. The large outer coil has a tap at the center so it is actually two coils. The small coil which is shown on top of the larger coil is lowered to the mid-point when the evaluation is taking place.

Drift of the Standard Ampere Measured at NBS

A recent experiment at the National Bureau of Standards has shown that the standard ampere maintained by the Bureau has drifted no more than a few parts per million in the last 15 years. Such a small apparent change may well be due to slight errors in measurement so that the standard ampere may actually have remained perfectly stable since its original evaluation in 1942.

Because of the importance of precise electrical measurements to modern science and industry, the Bureau maintains permanent primary standards of two basic electrical quantities, voltage and resistance. From these basic electrical standards, the Bureau has derived other standards for all electrical quantities in use today. Be-

cause current is transitory, the primary standard ampere cannot be kept in the form of a material object such as the standard cells that maintain the volt or the standard resistors that maintain the ohm. Each time the standard ampere is required, it must be obtained anew from the standard volt and the standard ohm by use of Ohm's law. However, a gradual change might sometimes occur in the standard cells or the standard resistors. One method of checking the stability of these standards is to compare the standard ampere derived from them with the "absolute" ampere, that is, the ampere obtained experimentally in terms of mechanical units of length, mass, and time.

In the present determination, R. L. Driscoll and R. D. Cutkosky of the Bureau staff measured the standard ampere in absolute amperes using two different sets of apparatus. One was the current balance used in the 1942 evaluation; the other was a Pellat type electrodynamometer, which was introduced to reduce the possibility of systematic errors. The standard ampere was found to equal 1.000008 absolute amperes by the current balance method and 1.000013 absolute amperes by the Pellat instrument. The weighted mean of these two values is 1.000010 absolute amperes, but in this mean there is an uncertainty of 5 parts per million. If no accidental errors were made in either the original or the present evaluation and if all systematic errors remained fixed, then the value of the current yielded by the electrical standards of resistance and voltage has decreased by 6 parts per million. On the other hand, known sources of accidental error in the current balance determinations could easily account for the apparent drift.

Hand Cream Cures Motor Rash!

Silicare by Revlon, a product formulated with Dow Corning Silicones, has found its place on the small-motor production line. It cuts motor rejects besides eliminating serious skin irritations experienced by motor winders. Until recently, almost every one of 60 women winding motors at Stator Electric Co. at Woodside, N.Y. was suffering from one form or another of skin rash, apparently caused by handling these components. The cream, a heavy but greaseless liquid, was simply rubbed into the hands and arms until it disappeared. The motor rejection rate dropped from 20 per cent to near-zero.

Correction

A decimal point lost in the shuffle may have given some a wrong impression of the linearity of Beckman-Helipot's series 5000 potentiometers. The figure is ±0.5 per cent, not the ±5 per cent which appeared in the January 22 issue.

ENGINEERING REVIEW

Higher Strength Mylar Tape For Recording

A new tempered Mylar tape has been developed by DuPont, and is being tested by Audio Devices, Inc., 444 Madison Ave., N.Y.C., as replacement for double-length magnetic recording tape. The new material called "50-Mylar-T" is six-tenths of a mil thick, compared to a half-mil for standard Mylar.

Double-length tape tends to stretch or break by machine tensions. A special prestressing process realigns the molecules, increasing from two pounds to four pounds the tension needed to stretch a tape made of the material, and from three pounds to six pounds the tension needed to break it. The much higher yield strength of the new tempered Mylar is expected to make the double-length, thin tape useable on machines exerting a high tension. Quantity production of the new tape is expected to begin in a few months.

Electronic Highway Control

An electronic highway control system developed by RCA has been successfully tested on a 300 experimental highway at Lincoln, Nebraska. The RCA system consists basically of a series of electronic detector units buried in and along the highway, and a guidance cable buried in the center of a traffic lane along the length of the road. The detector units, in which signals are generated by the passage of vehicles, are used to activate various systems of warning lights and can eventually be combined with simple receivers and automatic equipment in vehicles to control speed and braking. The guidance cable radiates a constant signal which is employed in conjunction with a car receiver and automatic steering equipment to keep a vehicle centered in its lane.

The system includes provision

◀ CIRCLE 10 ON READER-SERVICE CARD

for a radio "tail warning" that extends any desired distance behind each passing vehicle to warn or control following cars equipped with receivers, or to operate warning lights along the roadside.

The next logical step, according to RCA vice-president Dr. V. K. Zworykin, is the construction of an enlarged test facility which would permit testing the various features of the system at full scale and at normal speeds with completely controlled experimental vehicles. Such a facility should be at least two miles in length and be constructed with means for performing tests needed for determining the optimum length and shape for the warning "tail," the optimal dimensions and installations for the detector units, the comparative performance of different types of detectors, and the proper functioning of other components of the complete system.

Transistorized Land Mine Detector Has Greater Sensitivity

A new light-weight transistorized land mine detector has been developed by Texas Instruments Inc. for the U.S. Army, with reportedly great increased sensitivity over detectors currently in use.

The transistorized detector also has a much longer battery life and higher reliability under rugged field conditions. Use of transistors also has permitted miniaturization of the device to the point where all parts except the antenna can be carried under the operator's clothing. This is considered of special importance where the detector is to be used in Arctic regions. The detector also is fungus proof for advantageous use in the tropics.

Texas Instrument's Apparatus Division worked with the Engineering Development Laboratories, Corps of Engineers, Ft. Belvoir, Va., in developing the transistorized land mine. The unit is currently in pilot production.

CIRCLE 11 ON READER-SERVICE CARD ➤

WASHINGTON REPORT

Herbert H. Rosen

DOD Enlarges Use of Industry's Technicians

A unified policy for hiring civilian technicians for military jobs has been established by the Department of Defense. Until now, the individual services have conducted programs under their own self-originated instructions. Examples are the Air Force contracts for the operation of Cape Canaveral and the DEWline. The Navy's Tech Rep program is also a variation on the same idea.

Under a new directive signed by Defense Secretary McElroy, certain guidelines are set down for buying the services of industry's technicians and engineers. As defined in the directive: "Industrial and Commercial Technical Services are those services pertaining to the installation, operation, and maintenance of weapons, equipment, and systems, including the instruction of personnel therefrom which are made available to the Military Services by industrial and commercial organizations through the utilization of their technically trained personnel. These services are provided either by specific contractual arrangements between the using military Service and the supplier, or are covered as part of the overhead or percentage of end item cost in the procurement contract."

The personnel mentioned are either equipment technicians, instructors, or more broadly qualified Tech Reps. Some will be designated to work only on the equipment manufactured by the company they represent. Others will not have this limitation, and will be allowed to work on any equipment for which they qualify.

While each Service may select the contractor to perform these jobs, the selection is guided by the DOD directive. In general, the contractor should be a manufacturer of equipment or systems for the Department of Defense. The contractor could also be a firm of design, maintenance, or consulting engineers engaged in a defense or commercial equipment engineering project.

The technicians and engineers who join the military units will be under the control of their companies. But, they will simultaneously be subject to the direction and supervision of the contracting military department. This means they will be subject to the rules, security regulations, and privileges of Service personnel.

ARPA Director Named

Less than a week after Congress struck all mention of Defense's Advanced Research Projects Agency from the supplemental appropriations bill, Secretary of Defense Neil McElroy appointed an Agency director. He named Roy Johnson, Vice President of General Electric, to the post. Johnson is scheduled to start his job full time on April 1. Meanwhile, he will serve only two or three days a week.

His responsibilities have been very broadly defined so as to give the director and the Agency wide latitude. He will:

- Direct R & D projects designated by the Secretary of Defense;
- Arrange for performance of R & D by any other Federal Agency;
- Contract with individuals, private entities, educational, research, or scientific institutions;
- Contract for or acquire "such research, development, and test facilities and equipment as may be approved by the Secretary of Defense."

Johnson's first job will be to hire a well-rounded scientist to be his technical director. Next, he will have to assemble a staff of engineers and scientists familiar both with Government procedure and space technology.

Although no detailed program has been developed for ARPA, it is thought that the first project Johnson will handle will be the antimissile missile. The responsibility is now shared by the Army and the Air Force. The Army must develop the launching mechanisms and vehicle. The Air Force, the electronics. Actually, the Army and Air Force are working on competing electronic guidance and ground equipment systems. This is a demonstration of necessary duplication.

For the remainder of this fiscal year, ARPA has a budget of $10 million from which to pay salaries and perform a small number of projects. After June 30, and if Congress is as generous as it was with the supplemental request, Johnson will have $340 million to play with.

US-USSR Arrange Technical Exchange

Within the next two years, scientists and engineers from Russia and the U.S. will be touring each other's countries. They will deliver lectures and hold seminars. Some will conduct joint studies, probably only in the basic sciences.

This is the intent of an agreement signed recently between the U. S. and the USSR. Very likely, the electronics industry will be involved in the exchanges now being developed.

Both countries have agreed to promote the exchange of publications in science and technology between scientific institutions and societies. Individuals are also invited to participate.

MEETINGS

Mar. 27-29: Ninth Biennial Electrical Industry Show and Fifth Electrical Maintenance Conference

Shrine Exposition Hall, Los Angeles, Calif. Some of the topics to be discussed are maintenance to prevent breakdown, maintenance of electrical and electronic equipment and maintenance of lighting to assure peak output. For more details write Paul H. Henrichs, Southern California Edison Co., P.O. Box 351, Los Angeles, Calif.

Mar. 31-Apr. 2: AIEE South West District Meeting

Tulsa, Okla. For information send to the AIEE, 33 West 39th St., New York, N.Y.

Mar. 31-Apr. 2: Instruments and Regulators Conference

University of Delaware, Newark, Del. Sponsored by the IRE, ASME, AIChE, and ISA. For details send to E. M. Grabbe, P.O. Box 45067, Airport Station, Los Angeles 45, Calif.

Apr. 2-4: ASME Conference on Automatic Optimization

University of Delaware, Wilmington, Del. AIEE, IRE, ISA, AIChE with professional groups analogous to the IRE will participate in the conference by sponsoring technical papers centered around the theme, "Automatic Optimization." For details write W. E. Vannah, Control Engineering, 330 W. 42nd St., N. Y. 36, N. Y.

Apr. 8-10: Sixth National Conference on Electromagnetic Relays

Oklahoma State University, Student Union Building, Stillwater, Okla. Sponsored by the National Association of Relay Manufacturers. Papers will include the results of individual investigation by the authors. More information may be obtained from Charles F. Cameron, Dept. of Electrical Engineering, Oklahoma State University, Stillwater, Okla.

Apr. 8-10: Symposium on Electronic Waveguides

Auditorium of Engineering Societies Bldg., 33 W. 39th St., New York. Sponsored by IRE, PGED and PGMTT, and the Department of Defense Research Agencies. The symposium will deal

with the interaction of electromagnetic fields and electron or plasma beams in general waveguide regions. The symposium covers the fields of electron beams, plasmas, and electromagnetics to compare the rather widely disparate theories and techniques employed to describe the wave phenomena encountered in the interaction of such fields. For further information contact the Polytechnic Institute of Brooklyn, 55 Johnson St., Brooklyn 1, New York.

Apr. 10-12: IRE South West Regional Conference and Electronics Show

San Antonio Hotel and Municipal Auditorium, San Antonio, Tex. Write for details to J. O. Parr, Jr., 202 Janis Ave., San Antonio, Tex.

Apr. 14-16: Conference on Automatic Techniques

Statler Hotel, Detroit, Mich. Sponsored by the IRE, AIEE, and ASME. Information may be obtained by writing to J. E. Eiselein, Radio Corporation of America, Bldg. 10-7, Camden 2, N.J.

Apr. 17-18: Second Annual Technical Meeting of the Institute of Environmental Engineers

Hotel New Yorker, New York. A display of the earth satellite model and an address by Kurt R. Stehling, Propulsion Head of the Vanguard Missile Project, Naval Research Laboratory, will highlight the meeting. Write Institute of Environmental Engineers, 9 Spring St., Princeton, N. J., for further information.

Apr. 22-24: 1958 Electronic Components Conference

Ambassador Hotel, Los Angeles, Calif. Sponsored by the IRE, AIEE, EIA, and WCEMA. With "Reliable Application of Component Parts" as its main theme, the conference has been planned to cover the following general topics: resistors, capacitors, and dielectrics; transistors and solid state devices; component reliability; electron tubes and their application; and progress with materials. For complete information write to David M. Knox, Packard-Bell Electronics Corp., 12333 W. Olympic Blvd., Los Angeles 64, Calif.

Apr. 24-26: URSI Spring Meeting

Willard Hotel, Washington, D. C. Sponsored by the PGAP, PGMT&T, PGCT, PGIT, PGI, and URSI. For information, contact John P. Hagen, Naval Research Lab., Washington 25, D. C.

MEETINGS

Apr. 28-30: AIMEE Middle Eastern District Meeting

Washington, D. C.

Apr. 30-May 1-2: 7th Regional Technical Conference & Trade Show

Hobbies Bldg., State Fair Grounds, Sacramento, Calif. Write Ewald W. Berger, 3421 58th St., Sacramento 20, Calif. for information.

May 1-8: ASTE Tool Show

Convention Center, Philadelphia, Pa. A complete integrated technical program of papers, panels, seminars, plant tours, and related activities will be offered. For further information, write Richard Gebers, Public Relations Manager, 10700 Puritan, Detroit 38, Mich.

May 4-7: 4th National Flight Text Instrumentation

Park-Sheraton Hotel, New York City. Sponsored by the Instrument Society of America. Coverage of all phases of instrumentation for aircraft testing will be offered including sessions on helicopter and power plant instrumentation. Three sessions will be specifically devoted to Missile Instrumentation. Another session will be spent on the instrumentation for ground testing of aircraft and aircraft systems. Theme of the Symposium is "More Data Per Dollar." For details write P.O. Box 113, Bethpage, N. Y.

May 5-7: AIEE Great Lakes District Meeting

Michigan State University, East Lansing, Mich.

May 6-9: Western Joint Computer Conference

Ambassador Hotel, Los Angeles, Calif. Cosponsored by IRE, ACM, and AIEE. Theme of the conference will be "Contrasts in Computers," with panel discussions on controversial aspects of modern computers. For more information write David Parry, 6363 Wilshire Blvd., Los Angeles 48, Calif.

May 13-15: AIEE East Central District Meeting

Huntington, W. Va.

EDITORIAL

We Refuse To Boast

Sometimes the urge to toot our own horn is almost irresistible. Lately we have been tempted to boast about our foresight in translating and abstracting important Russian engineering articles as early as August 1955.

Sometimes, in moments of forgetfulness, we want to sing our own praises, and tell the world how, long before Sputnik, we engaged one of the country's foremost scientific translators, Mr. J. George Adashko, to abstract articles from Russia's leading electronics journals for ELECTRONIC DESIGN.

When, three years ago, we shouted from the rooftops

"Let's read what the Russians are writing. They refer to our scientific works, and they've probably learned a lot from us. Let's read their literature, if only to learn what they are up to technologically."

we felt that someday everybody would be echoing us.

● President Eisenhower, in his education message to Congress on January 27th asked for funds to help improve foreign language study in our schools. Marion B. Folsom, Secretary of Health, Education and Welfare, following the president, estimated that 10,000,000 Russians are studying English, while fewer than 8,000 Americans are studying Russian.

● Also in January, the U.S. Department of Commerce requested $300,000 to initiate a Foreign Technical Information program to set up a central clearinghouse to collect, evaluate and distribute valuable foreign scientific and technical literature for American scientists and engineers.

● Last August the National Science Foundation granted $70,000 for translating three of the Russian journals which ELECTRONIC DESIGN has been reviewing regularly—*Radiotekhnika, Elektrosvyaz'*, and *Radiotekhnika i Electronika.*

● Last month, General Electric, the Mohawk-Hudson Council on Educational Television, and the Northeastern branch of the American Chemical Society began teaching Russian on television.

We are gratified to see these developments and to note the leap in reader interest in our Russian Translations. It was Sputnik that started the ball rolling, but we are elated that we were among the first to see the need. The temptation is great indeed, but we refuse to boast.—GR

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The basic Hallamore voltage controlled subcarrier oscillator unit, HEC-0161, can be instantly converted to any IRIG telemetering channel by plug-in channel selectors, HEC-0164, and output filters, HEC-0165. Plug-in units for non-standard channels and bandwidths can be supplied. For complete specifications and operational data, write Hallamore Electronics Company, Dept. 24J, 8352 Brookhurst Avenue, Anaheim, Calif.

HALLAMORE ELECTRONICS COMPANY *a division of the SIEGLER CORPORATION*

CIRCLE 17 ON READER-SERVICE CARD

VHF Matching Network Design

A. E. Sanderson
Aircraft Radio Corp.

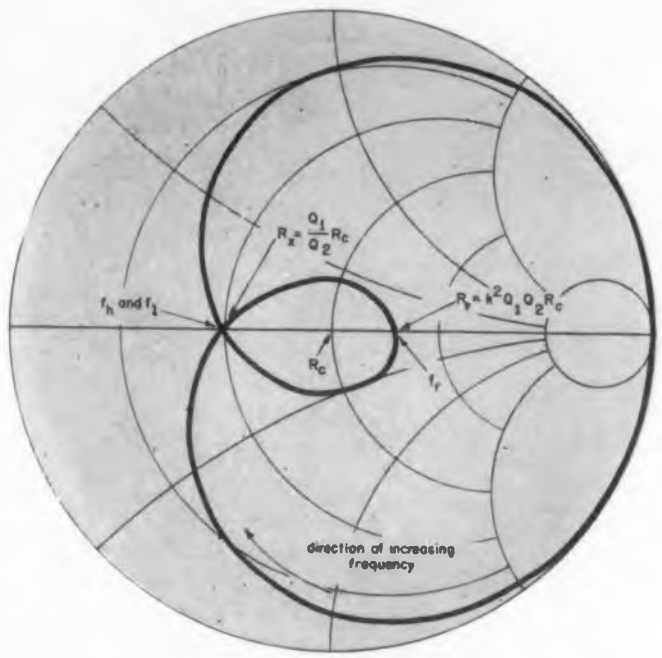


Fig. 1. Input impedance curve of two over-coupled, synchronously tuned circuits.

A NEW METHOD of designing optimum bandpass filters and matching networks utilizes the analysis of a curve of input impedance vs frequency plotted on the Smith chart. The method is valid when loaded Q's are much less than unloaded Q's, and means are given to check this condition. It is valid for narrow band *and* wide band networks because the design equations involve no approximations. A vhf impedance or admittance bridge and associated generator and detector are required, as well as a vhf transmission line calculator[1] to remove the unavoidable effect of line length between the bridge and the network under design.

Two typical problems which can be handled by this method are:

- Using one tuned circuit as a matching section, match a quarter-wave resonant antenna to a 50 ohm transmission line. Keep the vswr *as low as possible* over the band 118 to 148 mc.
- Design a double tuned bandpass filter to match a 500 ohm resistive load to a 50 ohm transmission line. Keep the vswr 2:1 or less over the band 118 to 148 mc. Use the *highest possible* Q's in the design to obtain the best skirt selectivity.

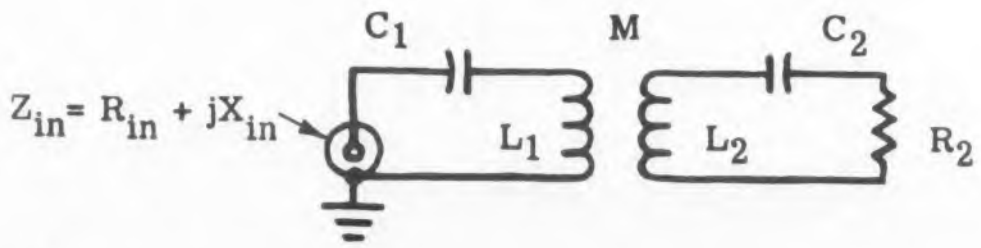


Fig. 2. Circuit for the mathematical analysis of synchronously tuned coupled circuits.

Exact values for the circuit Q's and for the coefficients of coupling can be obtained for these and similar problems.

At high frequencies, the effective values of capacity and inductance are usually different from their nominal values. Stray capacity and lead inductance become important; ordinarily the first model of a network will not give the desired response. This method will point out which components to change in value, and how much to change them, to compensate for these effects and bring the network into agreement with the theoretical response it should have.

Circuit Analysis

Consider the input impedance of the circuit shown in Fig. 2. Straightforward analysis yields:

$$R_{in} = \frac{\omega^2 M^2}{R_2^2 + X_2^2} R_2; \qquad (1)$$

$$X_{in} = X_1 - \frac{\omega^2 M^2}{R_2^2 + X_2^2} X_2;$$

where $X_1 = \omega L_1 - 1/\omega C_1$, and $X_2 = \omega L_2 - 1/\omega C_2$

A plot on the Smith chart of $Z_{in} = R_{in} + jX_{in}$ from zero to infinite frequency is shown in Fig. 1 for overcoupled circuits both resonant at f_r. From this it can be seen that the input impedance curve forms a loop. The size and placing of this loop can be related easily to Q_1, Q_2 and k.

Note that Z_{in} is a pure resistance at three frequencies: the resonant frequency f_r, at a higher frequency f_h and at a lower frequency f_l. The resistance at resonance is R_r. The crossover falls on the resistive axis, and the crossover resistance is designated R_x. Equations (1) and (2) can be solved for R_r and R_x by solving for R_{in} with $X_{in} = 0$.

$$R_r = k^2 Q_1 Q_2 R_c \qquad (3)$$

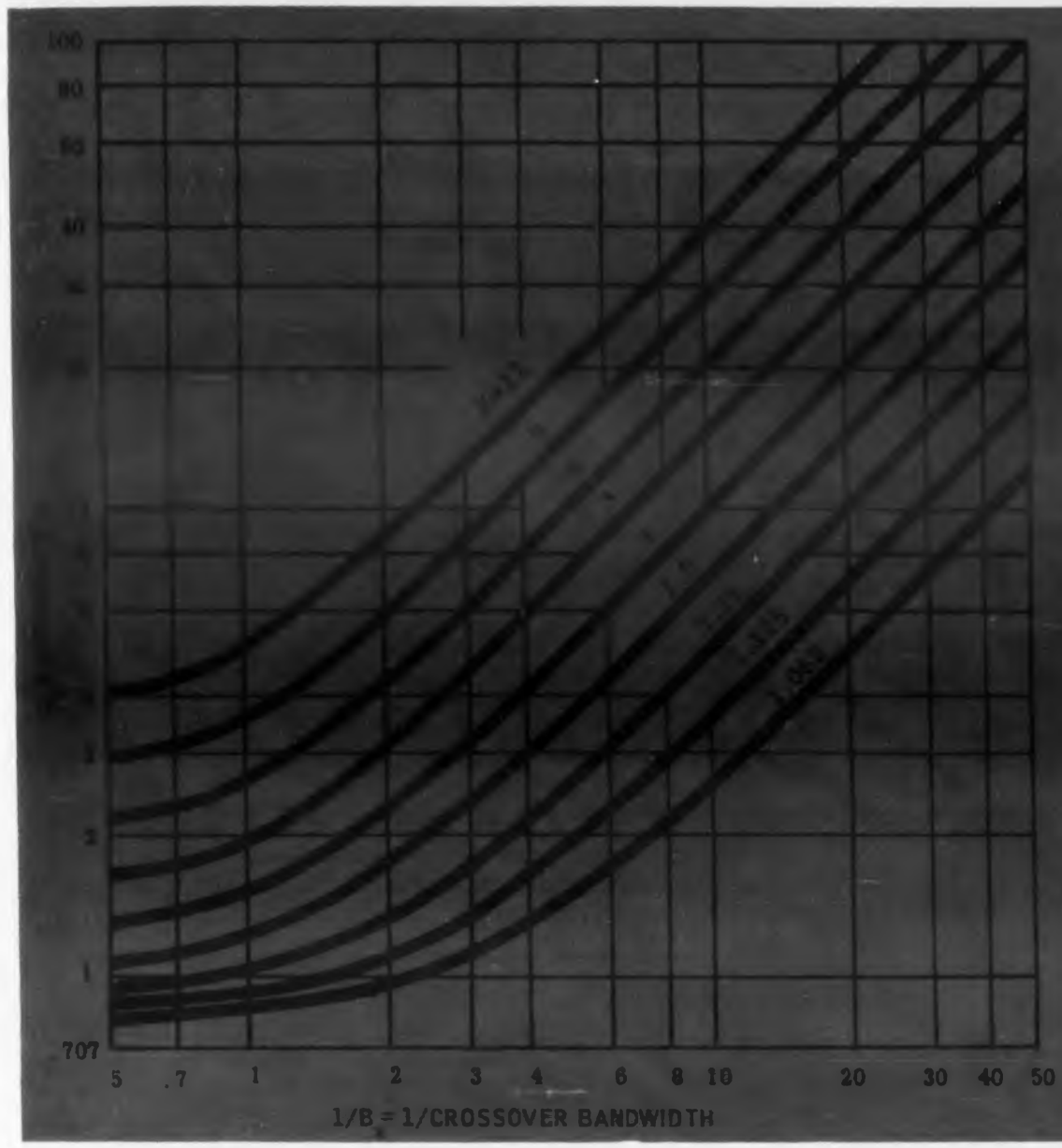
$$R_x = (Q_1/Q_2) R_c \qquad (4)$$

where R_c is the characteristic impedance of transmission line, to which all measurements are normalized, and

$$Q_1 = \frac{\omega_r L_1}{R_c}, \; Q_2 = \frac{\omega_r L_2}{R_2}, \; k^2 = \frac{M^2}{L_1 L_2},$$

$$\omega_r = 1/\sqrt{L_1 C_1} = 1/\sqrt{L_2 C_2}$$

Equations (3) and (4) prove several interesting things about the loop. As the coefficient of coupling, k, is varied, the loop grows and shrinks, but the point of crossover remains fixed. As Q_1 is varied, the loop is shifted to the left or right, but its size is held constant. As Q_2 is varied, the size of the loop changes, but the center of the loop does not move. Each of the variables, Q_1, Q_2 and k, has a separate and distinct effect upon the loop, so that it is possible to tell *exactly what is wrong with a network under design* by analyzing a curve of its input impedance.



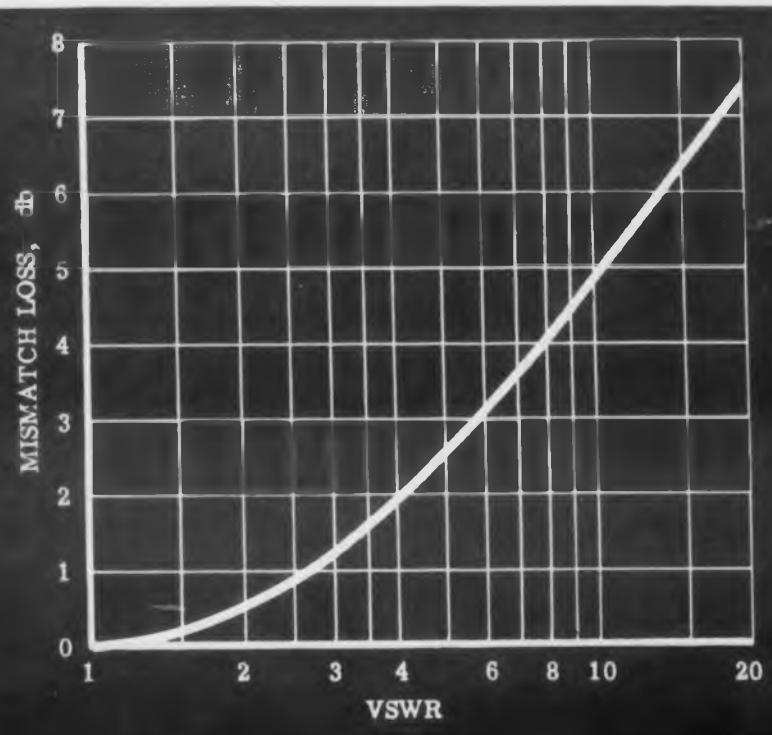


Fig. 3. Solution of problem 2. Match 50 ohm cable to 500 ohm resistive load, over band of 118 to 148 mc. Keep VSWR less than 2.

It is possible for two networks to have the same size and placing of the loop and yet have different bandwidths, so a bandwidth must be assigned to this figure. Using the two frequencies associated with the crossover, a new term will be defined as *crossover bandwidth*, B_x.

$$B_x = 2\frac{f_h - f_l}{f_h + f_l} \tag{5}$$

This is the frequency difference divided by the *average* of f_h and f_l rather than the geometric mean. An exact expression for B_x has been derived:

$$B_x = \frac{2}{A + \sqrt{A^2 - 1}} \tag{6}$$

$$\text{where } A = \frac{2\,Q_2^2 - 1}{\sqrt{(\gamma - 1)\,(4\,Q_2^2 - 1)}} \tag{7}$$

and γ is the loop ratio: the ratio of the maximum resistive component of the input impedance to the resistance at the crossover point.

$$\gamma = R_{max}/R_x.$$

Since the maximum resistive component of the impedance does not occur quite at resonance,

$$R_r = R_{max}\,(1 - 1/4\,Q_2^2) \text{ and}$$
$$\gamma \cong R_r/R_x = k^2\,Q_2^2.$$

These equations show another unusual feature of the loop. Both the crossover bandwidth and the loop ratio are independent of Q_1.

Equation (6) is plotted exactly in Fig. 3. The left hand axis corresponds to a bandwidth of 2, which would be a high-pass or low-pass network having the specified value of γ. This always requires that $k = 1$, so the network reduces to a conventional three-element filter. For most purposes an approximate formula is sufficiently accurate, and easy to remember:

$$B_x = \frac{\sqrt{\gamma - 1}}{Q_2} \tag{8}$$

The curve of Fig. 2 is uniquely determined by specification of R_r, γ, f_h and f_l. The question remains as to what position of the curve will give optimum results for a particular design problem. Two general cases need to be considered. In one case a reactance associated with the load limits the match which can be obtained over a specified bandwidth. In the other case a specified maximum limit on mismatch over a specified bandwidth sets an upper limit on the magnitude of the Q's which may be used.

General Case 1

Q_2 is fixed. Q_1 and k are variable. Minimum vswr is realized for a specified bandwidth when the loop is made to encircle the R_c point symmetrically, so that

$$R_x/R_r = R_c/R_{max}$$

Those frequencies which fall on the loop are within the passband, so that B_x equals the specified bandwidth, and $\sqrt{\gamma}$ equals the maximum vswr within the band. Having specified Q_2 and B_x, the lowest possible γ is determined from Fig. 3, or by solving approximate eq (8) for γ:

$$\gamma = (B_x\,Q_2)^2 + 1.$$

Solving for Q_1 and k explicitly:

$$Q_1 = Q_2/\sqrt{\gamma} \text{ and } k = 1/Q_1.$$

In practice, Q_2 may not be known in advance. It

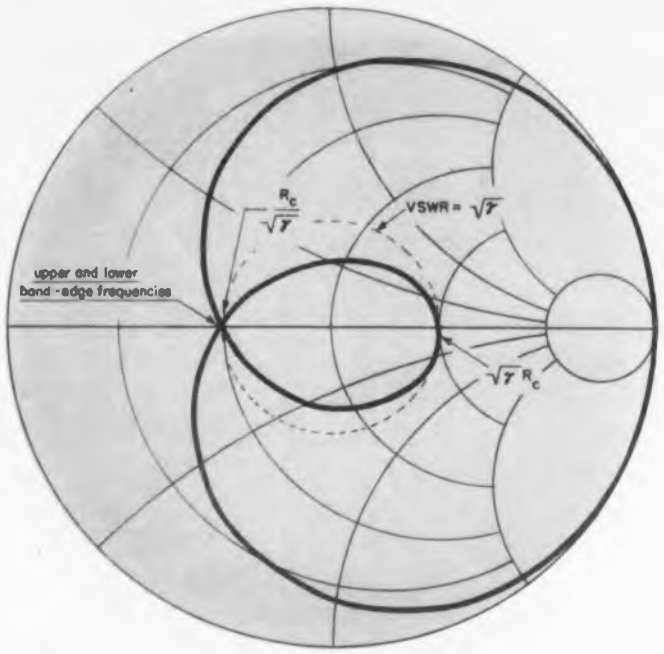


Fig. 5. Impedance curve for minimum VSWR, given fixed bandwidth and secondary circuit Q.

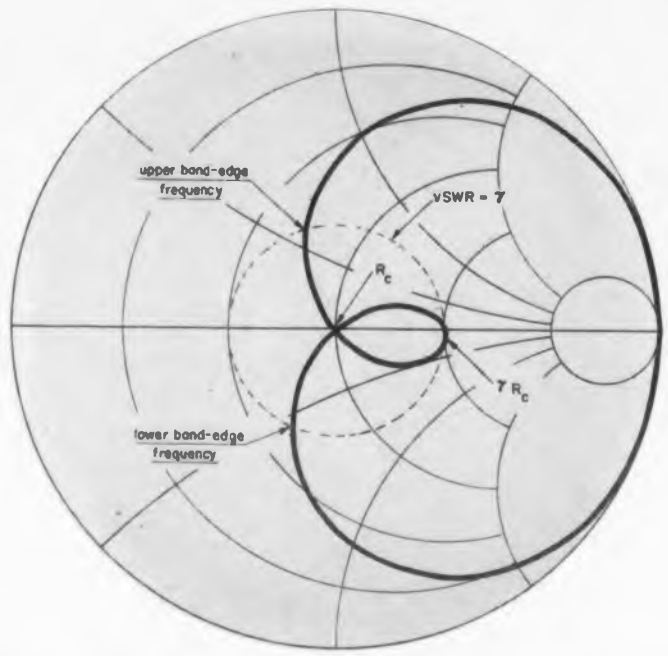


Fig. 6. Impedance curve for highest possible circuit Q's, given fixed bandwidth and secondary circuit Q.

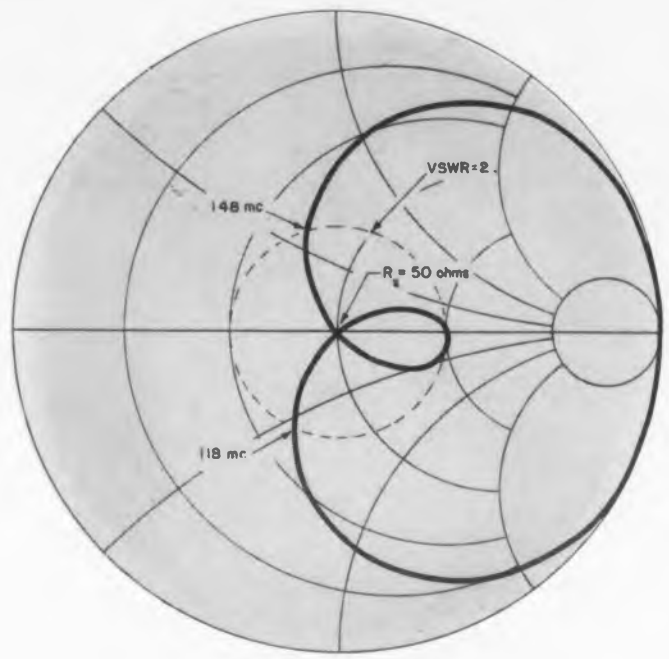


Fig. 8. VHF Matching network design.

may be possible to measure Q_2, but it is better to calculate it from measured values of B_r and γ and after a trial network has been constructed.

General Case 2

R_2 is fixed. Q_1, Q_2 and k are variable. Both bandwidth and maximum vswr within the band can be specified. In order to determine what vswr is tolerable, the relation between vswr and mismatch loss in db is shown in Fig. 4. Maximum mean Q, and therefore maximum skirt selectivity, is realized when $Q_1 = Q_2$. This requires the crossover to be at R_c. The maximum vswr at the center of the band equals γ, and the passband includes those frequencies which fall within the circle of vswr $= \gamma$. Specified bandwidth equals $\sqrt{2} \cdot B_r$ for moderate bandwidths, and the error is less than 1 per cent for a bandwidth of 1.0.

Solving for Q_1, Q_2 and k explicitly:

$$\gamma = vswr_{max}$$

$$Q_1 = Q_2 = \sqrt{\gamma - 1}\; B_r \text{ and } k = \sqrt{\gamma}\; Q_1$$

Tune Up Considerations

Inspection of the impedance curve will determine if both circuits are tuned to the same frequency. Detuning the primary to a lower frequency results in shifting the loop to a lower position on the Smith chart. A properly tuned network has two equal minima on the vswr vs frequency curve; the axis of symmetry of the loop must therefore pass through the center of the chart. In practice, stray effects may cause this *crossover axis* to be tilted, although the network is properly tuned. In this case, base all calculations upon the intersections of the impedance curve with the crossover axis, rather than the horizontal axis.

It is sometimes useful to know, in tuning up, that the resonant frequency of the secondary is roughly equal to $(f_h + f_l)/2$. In general it is faster to use some independent method to tune up.[2]

Alternate Circuits

The above results can be generalized to apply to any pair of coupled circuits. The method of coupling the two circuits together has no effect upon the curve shapes; it may be T or π, inductive or capacitive, or any other. The choice depends upon the practicability of the required component values, and the relative steepness required of the selectivity curve above the band to that required below the band.

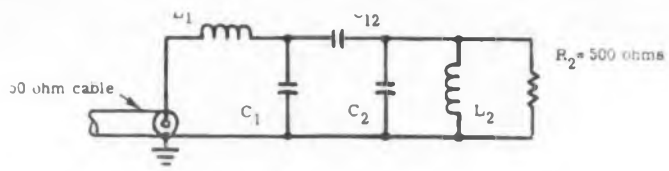


Fig. 7. Circuit for the solution of problem 2.

If the primary circuit is connected in parallel across the source, instead of in series as shown, then the curves will be rotated 180 deg from the positions shown. This will invert the formulas for R_x, R_r and γ as follows, using primes to denote parallel connection.

$$R'_x = (Q_2\, Q_1)\, R_c,\; R'_r = R_c\, k^2\, Q_1\, Q_2,\; \gamma \cong R'_x\, R'_r.$$

The remaining formulas are unaffected.

Design Procedure

Once the network configuration has been decided upon, the input impedance curve can be sketched on the Smith chart by inspection. The connection of the primary circuit determines whether the curve will be series type or parallel type. In either case frequency will always increase in the clockwise direction around the curve and around any loops which are formed. The required behavior within the passband determines R_x and R_r and enables the curve to be completed.

Using the calculated values for Q_1, Q_2 and k, numerical values are calculated for each of the circuit elements. The network is constructed using components having these nominal values, tuned up, and an impedance curve is taken. In general the result will not be very close to the optimum curve due to stray effects. From this first curve the true values of Q_1, Q_2 and k are calculated, and then the effective values of L and C of all the individual components. All components whose effective values do not agree with the required values are removed. They are replaced by components whose nominal values are above or below the required values by such an amount that their effective values when placed in the circuit will equal the required values. For example, if a nominal 10 μμf capacitor calculates to have 14 μμf effective capacity in the circuit, remove it and replace it with a nominal 7 μμf condenser.

An impedance curve on the second network should agree closely with the optimum curve. If it does not, the above steps are repeated. *Convergence on the desired result is very rapid because all the components are being tested simultaneously and independently. The method points out which components are in error, and tells exactly how much of a correction is required.* Trial and error procedures are eliminated.

After the construction of a network, it is necessary to determine whether substantially all of the power being delivered into its input is going into the load. This will be true only if the unloaded Q's of the network are high compared to the loaded Q's.

To check this condition, remove the terminating load from the network. This may be a crystal mixer, a radiating antenna or a vacuum tube input impedance, for example. The vswr is measured over the band. Then the load terminals are shorted together, and the vswr measurements repeated. Power loss will be approximately 1/vswr, where vswr is the smallest of the values determined above. For example, if the vswr becomes as low as 10, the power loss will be about 0.5 db.

Numerical Example

The solution of *Example 2* will be used as a numerical example. The circuit of Fig. 7 was chosen for convenience. The primary L and C are in series, so the impedance curve will be the series type as shown in Fig. 8. Since the load is resistive, the Q's will be equal and the crossover will be at 50 ohms. Specified bandwidth is 30 mc, so crossover bandwidth, B_x, will be $30/\sqrt{2}$ or 21.2 mc, divided by the center frequency, 133 mc.

$$B_x = 1/6.27.$$

The vswr will be 2 at resonance, so $R_r = 100$ ohms. Since $R_r = 50$ ohms, $\gamma = 2$. Using these values of B_x and γ, a value of $Q_2 = 6.4$ is obtained from Fig. 3. Therefore, $Q_1 = 6.4$. From the equation for k, we have $k = \sqrt{2}/6.4 = 0.22$.

Applying these values of Q_1, Q_2 and k to this circuit:

$\omega_r L_1 = 50 \times 6.4 = 320$ ohms $\qquad L_1 = 0.38\ \mu h$

$\omega_r L_2 = 500/6.4 = 78$ ohms $\qquad L_2 = 0.094\ \mu h$

$$\frac{1}{\omega_r(C_1 + C_{12})} = 320 \text{ ohms} \qquad C_1 + C_{12} = 3.8\ \mu\mu f$$

$$\frac{1}{\omega_r(C_2 + C_{12})} = 78 \text{ ohms} \qquad C_2 + C_{12} = 15.2\ \mu\mu f$$

$$k = \frac{C_{12}}{\sqrt{(C_1+C_{12})\,(C_2+C_{12})}} = 0.22 \qquad \begin{aligned} C_{12} &= 1.7\ \mu\mu f \\ C_1 &= 2.1\ \mu\mu f \\ C_2 &= 13.5\ \mu\mu f \end{aligned}$$

Now the network must be constructed, measured, and effective values calculated for all components. The proper replacement of all components not producing the required effective values will yield a network whose input impedance will be a close approximation to Fig. 8.

References

1. VHF Transmission Line Calculator, A. E. Sanderson. *Electronics*, Dec. 1955, p. 168. This calculator is available in red or black from Radio Activities, Inc., Boonton, N.J.
2. Alignment of Filters, M. Dishal. *Proc. IRE*, Nov. 1951, p. 1448.
3. An Admittance Chart, H. M. Wasson. *RCA Report LB-976*.

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MASER is Here

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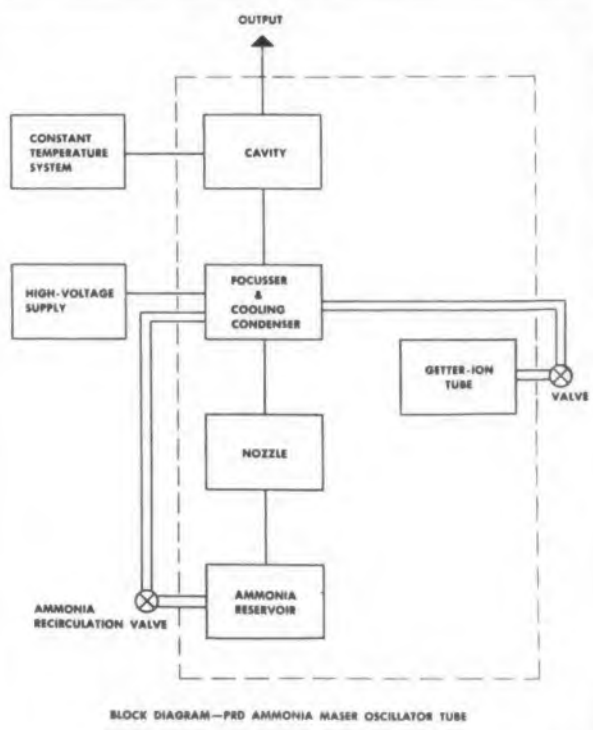
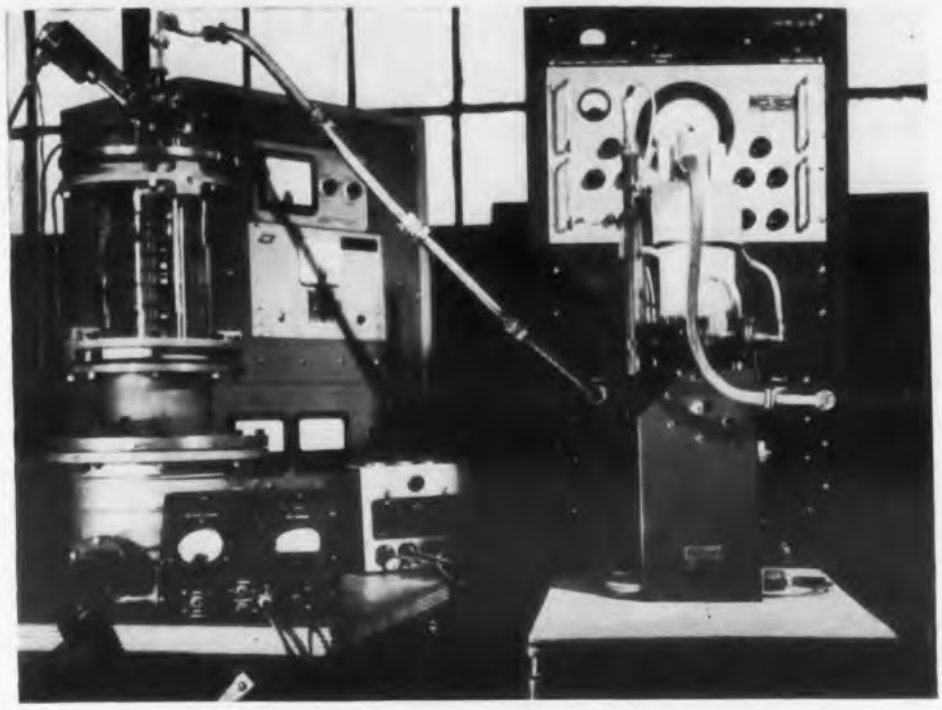


BLOCK DIAGRAM—PRD AMMONIA MASER OSCILLATOR TUBE

Block diagram illustrating the operation of Maser.



Maser at work.

Masers just to investigate their properties. Polytechnic Research & Development Co., Inc. of 202 Tillary St., Brooklyn, N.Y., has built the first units for sale, and portable ones at that. They weigh only 20 pounds and occupy 1/4 cubic foot.

These Masers are sealed ammonia types. They may have important applications in space guidance and navigation, coded communications and Doppler navigation. They have excellent potential as basic research tools for establishing new theories and re-evaluating existing theories in physics, chemistry and other branches of science.

An ammonia type Maser directs the flow of ammonia molecules within a low pressure system into an electrostatic field. Liquid nitrogen cools a condensation chamber surrounding the field. This field focuses the molecules in the upper energy states and beams them into a high Q resonant cavity operating in the TM^{010} mode. Lower energy molecules are deflected away from the cavity and condense on the chilled (!) chamber walls.

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You can operate this Maser more than 500 hours without breaking the vacuum seal, and then an additional 500 hours, after replacing some inexpensive parts. Maser's shelf life is at least one year.

More information is available if you turn to the Reader's Service Card and Circle **21.**

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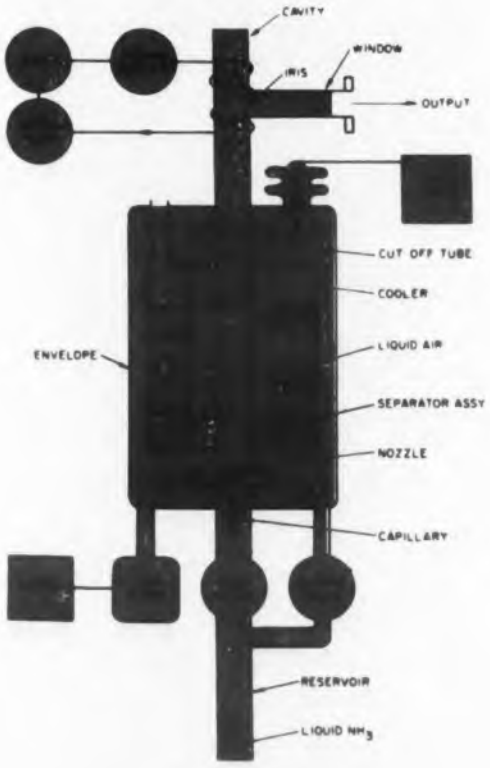

Cross-section of Maser.

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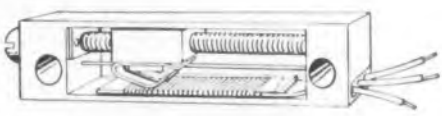

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CIRCLE 23 ON READER-SERVICE CARD

Zener Diode Characteristics

THIS LIST of 321 Zener diodes, one section of D.A.T.A.'s semi annual complete Semiconductor Diode and Rectifier list, has been compiled by Derivation and Tabulation Associates, Inc., West Orange, N.J. These Zener diodes are listed by their electrical characteristics, in order of minimum Zener voltage, maximum Zener voltage, type number.

Zener diodes are intended for use in applications where it is important to maintain a constant dc voltage level. They can be used to great advantage in conjunction with transistors and magnetic amplifiers to correct characteristic variations brought about by temperature changes. Silicon Zener diodes can maintain a constant voltage level under conditions of high temperature, severe shock, and vibration.

The Zener breakdown is similar to the action of glow-discharge gas tubes. Accumulation of current carriers make possible a high reverse current flow. In fact, beyond the breakdown point, the silicon diode has almost identical characteristics to the gas regulator tube; it may be considered the semiconductor equivalent. The effect can be used in exactly the same manner to maintain a constant voltage output.

From Fig. 1° shows that a constant voltage drop exists over a wide range of current, and the reverse resistance is extremely low. The slope of the curve

$$\frac{\Delta E_Z}{\Delta I_Z}$$

illustrates in general the regulation ability of the diode, and may be expressed as resistance. It is equivalent to a fraction of an ohm for low voltage Zener diodes, up to several hundred ohms for higher voltage types.

The Zener diode has many advantages over the gas-discharge tubes: Zener diodes are available with any required voltage up to 1000 v, while gas tubes are limited to specific values between 60 and 150 v. In a Zener diode, minimum starting potential and working potential are virtually the same. Photoelectric effects are negligible for encapsulated Zener diodes. Zero temperature coeffi-

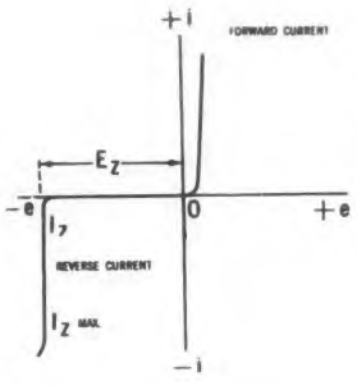

Fig. 1. Typical voltage drop and reverse resistance.

°Figures and information from International Rectifier Corporation literature.

MANUFACTURERS

BTHB—British Thomson-Houston Export Co., Ltd., Rugby, Warwickshire, England.
INT. RECT. — International Rectifier Corp., 1521 East Grand Ave., El Segundo, Calif.
STCB§—Standard Telephones and Cables Ltd., Connaught House, 63 Aldwych, London WC 2, England.
TEC—Transitron Electronic Corp., Melrose 76, Mass.
TII — Texas Instruments Inc., Semiconductor Products Div., 6000 Lemmon Ave., Dallas 9, Texas.
WEC—Western Electric Co., Inc., Radio Div., 120 Broadway, New York 5, N.Y.
SEM—U.S. Semiconductor Products, Inc., 3536 West Osborn Rd., Phoenix, Arizona.

ZENER REFERENCE DIODES

In order of Min. E_{b1}, Max. E_{b2}, and type no.

Type No.	Zener Voltage Range Min. E_{b1} (volts)	Max. E_{b2} (volts)	@ I_z (ma)	Dynamic Impedance Z (ohms)	@ I_z (ma)	Max. Diss. (mw)	Max. Temp. (°C)	Mfr.
SJDX9/3	2.5	3.5	10				250	BTHB
Z2A33	2.5	4.0	20	30	20	750	100	STCB
IN471[d]	3.0	3.9	5.0	50	10	200	200A	HSD
650C0	3.5	3.9	5.0			150	150A	TII
SJDX9/4	3.5	4.5	10				250	BTHB
650C1	3.6	4.0	5.0			150	150A	TII
3Z3.9	3.6	4.3		.50	150	3500		INT. RECT.
10Z3.9	3.6	4.3		.25	500	10W		INT. RECT.
IZ3.9	3.6	4.3		1.0	50	1000		INT. RECT.
MZ3.9	3.6	4.3		1.5	25	500		INT. RECT.
ZZ3.9[d]	3.6	4.3		3.0	22	350		INT. RECT.
Z2A47	3.6	5.8	20	25	20	750	100	STCB
650C2	3.7	4.1	5.0			150	150A	TII
IN472[d]	3.7	4.5	5.0	45	10	200	200A	HSD
650C	3.7	4.5	5.0			150	150A	TII
650C3	3.8	4.2	5.0			150	150A	TII
650C4	3.9	4.3	5.0			150	150A	TII
650C5	4.0	4.4	5.0			150	150A	TII
650C6	4.1	4.5	5.0			150	150A	TII
650C7	4.2	4.6	5.0			150	150A	TII
651C0	4.3	4.7	5.0			150	150A	TII
SV121	4.3	4.7	10	55	10	250	150	TEC
SV1004	4.3	4.7	10	55	10	750	150	TEC
SV2004	4.3	4.7	1000	.50	1000	10W	150	TEC
3Z4.7	4.3	5.1		.50	125	3500		INT. RECT.
10Z4.7	4.3	5.1		.25	400	10W		INT. RECT.
IZ4.7	4.3	5.1		1.0	40	1000		INT. RECT.
MZ4.7	4.3	5.1		1.5	20	500		INT. RECT.
ZZ4.7[d]	4.3	5.1		4.0	18	350		INT. RECT.
IN473[d]	4.3	5.4	5.0	35	10	200	200A	HSD
651C	4.3	5.4	5.0			150	150	TII
SV5	4.3	5.4	10	55	10	250	150	TEC
SV804	4.3	5.4	150	55			150	TEC
SV904	4.3	5.4	2000	.50			150	TEC
651C1	4.4	4.8	5.0			150	150A	TII
651C2	4.5	4.9	5.0			150	150A	TII
SJDX9/5	4.5	5.5	10				250	BTHB
651C3	4.6	5.0	5.0			150	150A	TII
651C4	4.7	5.2	5.0			150	150A	TII
651C5	4.8	5.3	5.0			150	150A	TII
SV122	4.8	5.3	10	55	10	250	150	TEC
SV1005	4.8	5.3	10	55	10	750	150	TEC
SV2005	4.8	5.3	1000	.50	1000	10W	150	TEC
651C6	4.85	5.36	5.0			150	150A	TII
651C7	4.94	5.46	5.0			150	150A	TII
651C8	5.0	5.6	5.0			150	150A	TII
651C9	5.1	5.7	5.0			150	150A	TII
3Z5.6	5.1	6.2		.75	110	3500		INT. RECT.
10Z5.6	5.1	6.2		.40	350	10W		INT. RECT.
IZ5.6	5.1	6.2		1.5	35	1000		INT. RECT.
MZ5.6	5.1	6.2		2.3	17.5	500		INT. RECT.
ZZ5.6[d]	5.1	6.2		5.0	14	350		INT. RECT.
652C0	5.2	5.8	5.0			150	150A	TII
SV123	5.2	5.8	10	20	10	250	150	TEC
SV1006	5.2	5.8	10	20	10	750	150	TEC
SV2006	5.2	5.8	1000	.70	1000	10W	150	TEC
IN474[d]	5.2	6.4	5.0	20	10	200	200A	HSD
652C	5.2	6.4	5.0			150	150	TII
652C1	5.3	5.9	5.0			150	150A	TII
652C2	5.4	6.0	5.0			150	150A	TII
Z2A68	5.4	8.5	20	15	20	750	100	STCB
652C3	5.5	6.1	5.0			150	150A	TII
SJDX9/6	5.5	6.5	10				250	BTHB
652C4	5.6	6.2	5.0			150	150A	TII
652C5	5.7	6.3	5.0			150	150A	TII
SV124	5.7	6.3	10	20	10	250	150	TEC
SV1007	5.7	6.3	10	20	10	250	150	TEC
SV2007	5.7	6.3	1000	.70	1000	10W	150	TEC
652C6	5.8	6.4	5.0			150	150A	TII
IN429	5.9	6.5	7.5	20	7.5	200	200A	HSD
652C7	5.9	6.5	5.0			150	150A	TII
652C8	6.0	6.6	5.0			150	150A	TII
652C9	6.1	6.7	5.0			150	150A	TII
653C0	6.2	6.8	5.0			150	150A	TII
SV125	6.2	6.8	10	8	10	250	150	TEC
SV1008	6.2	6.8	10	8	10	750	150	TEC
SV2008	6.2	6.8	1000	.80	1000	10W	150	TEC
3Z6.8	6.2	7.5		1.0	100	3500		INT. RECT.
10Z6.8	6.2	7.5		.50	300	10W		INT. RECT.
IZ6.8	6.2	7.5		2.0	30	1000		INT. RECT.
MZ6.8	6.2	7.5		3.0	15	500		INT. RECT.
ZZ6.8[d]	6.2	7.5		10	12	350		INT. RECT.
IN475[d]	6.2	8.0	5.0	10	10	200	200A	HSD
653C	6.2	8.0	5.0			150	150	TII
SV7	6.2	8.0	30	8.0			150	TEC
SV806	6.2	8.0	90	8.0			150	TEC
SV906	6.2	8.0	1200	.80			150	TEC
653C1	6.3	6.9	5.0			150	150A	TII
653C2	6.4	7.0	5.0			150	150A	TII
653C3	6.5	7.1	5.0			150	150A	TII
SJDX9/7	6.5	7.5	10				250	BTHB
3Z8.2	7.5	9.1		1.5	80	3500		INT. RECT.
10Z8.2	7.5	9.1		.75	250	10W		INT. RECT.
IZ8.2	7.5	9.1		3.0	25	1000		INT. RECT.
653C4	6.7	7.4	5.0			150	150A	TII
SV126	6.7	7.4	10	8	10	250	150	TEC
SV1009	6.7	7.4	10	8	10	750	150	TEC
SV2009	6.7	7.4	1000	.80	1000	10W	150	TEC
653C5	6.8	7.6	5.0			150	150A	TII
653C6	7.0	7.8	5.0			150	150A	TII
SV127	7.1	7.9	10	8	10	250	150	TEC

Following Type No.

r — Military use only

d — Double Anode Zener Types

Following Temp.

A — Ambient

B — Junction

S — Storage

cients may be obtained and they may be shunted by large values of capacitance without danger of oscillation. They have small size and weight, and are very rugged.

Fig. 2 shows the typical use of the Zener diode in a dc regulating, or reference circuit. The diode shunt regulator draws variable current through the resistor R, dependent upon the load requirements. As the load increases or decreases, the Zener shunt element will

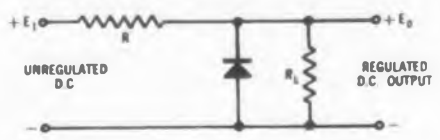

Fig. 2. Zener diode in reference circuit.

draw more or less current. The net result is a practically constant output voltage across R_L. The constancy of this voltage is dependent then upon the impedance of the Zener diode, i.e.; the slope of

$$\frac{\Delta E_Z}{\Delta I_Z}$$

The regulation factor with respect to load variations will be

$$\frac{\delta E_O}{\delta R_L} \frac{E_O}{R_L}$$

Resistor R should be so selected that the current in the diode does not exceed I_Z max or exceed the maximum power dissipation rating if the load R_L were removed. In practice I_Z is chosen as approximately 20 per cent of I_Z max and as a shunt regulator, will absorb current vibrations between the I_Z and I_Z max limits.

The maximum current which can flow through the diode is limited by the heat generated at the junction. Thus, the use of a Zener diode as a voltage regulator is limited only by its rated current handling capabilities.

The Zener regulator provides a low impedance bias supply for use with both vacuum tubes and transistors. Figs. 3 and 4 illustrate its use as a cathode bias element. Fig. 3 provides a bias for the amplifier that is close to cut-off. As long as a small current is flowing to cause a breakdown within the diode, current through the tube will be insufficient to

ZENER REFERENCE DIODES

In order of Min. E_{b1}, Max. E_{b2}, and type no.

Type No.	Zener Voltage Range: Min. E_{b1} (volts)	Max. E_{b2} (volts)	@ I_z (ma)	Dynamic Impedance: Z (ohms)	@ I_z (ma)	Max. Diss. (mw)	Max. Temp. (°C)	Mfr.
SV1010	7.1	7.9	10	8	10	750	150	TEC
SV2010	7.1	7.9	1000	.80	1000	10W	150	TEC
653C7	7.2	8.0	5.0			150	150A	TII
653C8	7.4	8.2	5.0			150	150A	TII
MZ8.2	7.5	9.1		4.5	12.5	500		INT. RECT.
ZZ8.2[d]	7.5	9.1		15	10	350		INT. RECT.
SJDX9/8	7.5	8.5	10				250	BTHB
IN225[d]	7.5	10.0	.20			150	150A	HSD
IN1313	7.5	10.0				150	150A	HSD
653C9	7.6	8.4	5.0			150	150A	TII
SV128	7.6	8.4	10	15	10	250	150	TEC
SV1011	7.6	8.4	10	15	10	750	150	TEC
SV2011	7.6	8.4	1000	.80	1000	10W	150	TEC
Z2A100	7.8	12.2	20	20	20	750	100	STCB
IN430	8.0	8.8	10	15	10	250	150A	HSD & INT. RECT.
IN430A	8.0	8.8	10	15	10	250	150A	HSD & INT. RECT.
IN430B	8.0	8.8	10	15	10	250	150A	HSD & INT. RECT.
SV129	8.1	8.9	10	15	10	250	150	TEC
SV1012	8.1	8.9	10	15	10	750	150	TEC
SV2012	8.1	8.9	1000	.80	1000	10W	150	TEC
654C9	8.5	9.5	5.0			150	150	TII
SJDX9/9	8.5	9.5	10				250	BTHB
SV131	8.6	9.5	10	15	10	250	150	TEC
SV1013	8.6	9.5	10	15	10	750	150	TEC
SV2013	8.6	9.5	1000	.80	1000	10W	150	TEC
SV132	9.0	10.0	10	15	10	250	150	TEC
SV1014	9.0	10.0	10	15	10	750	150	TEC
SV2014	9.0	10.0	1000	.80	1000	10W	150	TEC
IN1351	9.0	11.0	500	2.0	10	10W	155A	HSD
IN226[d]	9.0	12.0	.20			150	150A	HSD
IN1314	9.0	12.0				150	150A	HSD
SV11	9.0	12.0	20	50			150	TEC
SV810	9.0	12.0	60	50			150	TEC
SV910	9.0	12.0	800	1.5			150	TEC
ZZ10[d]	9.0	11.0		25	8	350		INT. RECT.
10Z10	9.0	11.0		1.25	200	10W		INT. RECT.
3Z10	9.1	11.0		2.5	70	3500		INT. RECT.
IZ10	9.1	11.0		4.5	20	1000		INT. RECT.
MZ10	9.1	11.0		6.8	10	500		INT. RECT.
IN1351A	9.5	10.5	500	2.0	10	10W	155A	HSD
655C9	9.5	10.5	5.0			150	150	TII
SV133	9.5	10.5	5.0	50	5.0	250	150	TEC
SV1015	9.5	10.5	5.0	50	5.0	750	150	TEC
SV2015	9.5	10.5	500	1.5	500	10W	150	TEC
IN1352A	10.5	11.6	500	2.0	10	10W	155A	HSD
SV134	10.5	11.6	5.0	50	5.0	250	150	TEC
SV1016	10.5	11.6	5.0	50	5.0	750	150	TEC
SV2016	10.5	11.6	500	1.5	500	10W	150	TEC
IN1353	10.8	13.2	500	2.0	10	10W	155A	HSD
3Z12	11.0	13.0		4.0	50	3500		INT. RECT.
10Z12	11.0	13.0		2.0	170	10W		INT. RECT.
GA52931[r]	11.0	13.0	40	6.0	10	500	135	WEC
IZ12	11.0	13.0		7.5	15	1000		INT. RECT.
MZ12	11.0	13.0		12	7.5	500		INT. RECT.
ZZ12[d]	11.0	13.0		40	7.5	350		INT. RECT.
IN227[d]	11.0	14.5	.20			150	150A	HSD
IN1315	11.0	14.5				150	150A	HSD
IN1353A	11.4	12.6	500	2.0	10	10W	155A	HSD
SV135	11.4	12.6	5.0	70	5.0	250	150	TEC
SV1017	11.4	12.6	5.0	70	5.0	750	150	TEC
SV2017	11.4	12.6	500	2.0	500	10W	150	TEC
IN1354	11.7	14.3	500	2.0	10	10W	155A	TEC
Z2A150	11.8	18.2	20	45	20	750	100	STCB
IN1354A	12.4	13.7	500	2.0	10	10W	155A	HSD
SV136	12.4	13.7	5.0	70	5.0	250	150	TEC
SV1018	12.4	13.7	5.0	70	5.0	750	150	TEC
SV2018	12.4	13.7	500	2.0	500	10W	150	TEC
3Z15	13.0	16.0		7.5	40	3500		INT. RECT.
10Z15	13.0	16.0		4.0	140	10W		INT. RECT.
IZ15	13.0	16.0		15	13	1000		INT. RECT.
MZ15	13.0	16.0		23	6	500		INT. RECT.
ZZ15[d]	13.0	16.0		60	5	350		INT. RECT.
SV137	13.3	14.7	5.0	70	5.0	250	150	TEC
SV1019	13.3	14.7	5.0	70	5.0	750	150	TEC
SV2019	13.3	14.7	500	2.0	500	10W	150	TEC
IN1355	13.5	16.5	500	2.0	10	10W	155A	HSD
IN228[d]	13.5	18.0	.20			150	150A	HSD
IN1316	13.5	18.0				150	150A	HSD
SV5	13.5	18.0	14	120			150	TEC
SV815	13.5	18.0	40	120			150	TEC
SV915	13.5	18.0	600	3.0			150	TEC
GA52932[r]	14.0	16.0	60	7.0	10	1000	135	WEC
IN1355A	14.3	—15.8	500	2.0	10	10W	155A	HSD
SV138	14.3	15.8	5.0	120	5.0	250	150	TEC
SV1020	14.3	15.8	5.0	120	5.0	750	150	TEC
SV2020	14.3	15.8	500	3.0	500	10W	150	TEC
IN1356	14.4	17.6	500	3.0	10	10W	155A	HSD
IN1356A	15.2	16.8	500	3.0	10	10W	155A	HSD
SV139	15.2	16.8	5.0	120	5.0	250	150	TEC
SV1021	15.2	16.8	5.0	120	5.0	750	150	TEC
SV2021	15.2	16.8	500	3.0	500	10W	150	TEC
3Z18	16.0	20.0		15	35	3500		INT. RECT.
10Z18	16.0	20.0		7.5	110	10W		INT. RECT.
IZ18	16.0	20.0		30	10	1000		INT. RECT.
MZ18	16.0	20.0		45	5	500		INT. RECT.
ZZ18[d]	16.0	20.0		80	4	350		INT. RECT.
SV141	16.2	17.9	5.0	120	5.0	250	150	TEC
SV1022	16.2	17.9	5.0	120	5.0	750	150	TEC

Following Type No.

r — Military use only

d — Double Anode Zener Types

Following Temp.

A — Ambient

B — Junction

S — Storage

ZENER REFERENCE DIODES

In order of Min. E_{b1}, Max. E_{b2}, and type no.

Type No.	Zener Voltage Range			Dynamic Impedance		Max. Diss.	Max. Temp.	Mfr.
	Min. E_{b1} (volts)	Max. E_{b2} (volts)	@ I_z (ma)	Z (ohms)	@ I_z (ma)	(mw)	(°C)	
SV2022	16.2	17.9	500	3.0	500	10W	150	TEC
IN1357	16.2	19.8	500	3.0	10	10W	155A	HSD
GA52933r	17.0	19.0	55	7.0	10	1000	135	WEC
IN229d	17.0	21.0	.20			150	150A	HSD
IN1317	17.0	21.0				150	150A	HSD
GA52999r	17.0	23.0	150	5.0	10	1000	135	WEC
IN1357A	17.1	18.9	500	3.0	10	10W	155A	HSD
SV142	17.1	18.9	5.0	200	5.0	250	150	TEC
SV1023	17.1	18.9	5.0	200	5.0	750	150	TEC
SV2023	17.1	18.9	500	3.0	500	10W	150	TEC
IN1358	18.0	22.0	150	3.0	10	10W	155A	HSD
SV143	18.1	20.0	5.0	200	5.0	250	150	TEC
SV1024	18.1	20.0	5.0	200	5.0	750	150	TEC
SV2024	18.1	20.0	500	3.0	500	10W	150	TEC
SV144	19.0	21.0	5.0	200	5.0	250	150	TEC
SV1025	19.0	21.0	5.0	200	5.0	750	150	TEC
SV2025	19.0	21.0	500	3.0	500	10W	150	TEC
IN1358A	19.0	21.0	150	3.0	10	10W	155A	HSD
GA52934r	19.0	21.0	50	7.0	10	1000	135	WEC
IN1359	19.8	24.2	150	3.0	10	10W	155A	HSD
3Z22	20.0	24.0		22.5	30	3500		INT. RECT.
10Z22	20.0	24.0		12	90	10W		INT. RECT.
IZ22	20.0	24.0		45	9	1000		INT. RECT.
MZ22	20.0	24.0		70	4.5	500		INT. RECT.
ZZ22d	20.0	24.0		125	3.5	350		INT. RECT.
IN230d	20.0	27.0	.20			150	150A	HSD
IN1318	20.0	27.0				150	150A	HSD
SV24	20.0	27.0	10	300			150	TEC
SV824	20.0	27.0	27	300			150	TEC
SV924	20.0	27.0	400	8.0			150	TEC
IN1359A	20.9	23.1	150	3.0	10	10W	155A	HSD
SV168	20.9	23.1	5.0	300	5.0	250	150	TEC
SV1033	20.9	23.1	5.0	300	5.0	750	150	TEC
SV2044	20.9	23.1	150	8.0	150	10W	150	TEC
IN1360	21.6	26.4	150	3.0	10	10W	155A	HSD
IN1360A	22.8	25.2	150	3.0	10	10W	155A	HSD
SV169	22.8	25.2	5.0	300	5.0	250	150	TEC
SV1034	22.8	25.2	5.0	300	5.0	750	150	TEC
SV2045	22.8	25.2	150	8.0	150	10W	150	TEC
3Z27	24.0	30.0		30	25	3500		INT. RECT.
10Z27	24.0	30.0		15	70	10W		INT. RECT.
HZ27	24.0	30.0		7.0	40	5000		INT. RECT.
IZ27	24.0	30.0		60	7	1000		INT. RECT.
MZ27	24.0	30.0		90	3.5	500		INT. RECT.
ZZ27d	24.0	30.0		200	3	350		INT. RECT.
IN1361	24.3	29.7	150	3.0	10	10W	155A	HSD
SV171	24.7	27.3	5.0	300	5.0	250	150	TEC
SV1035	24.7	27.3	5.0	300	5.0	750	150	TEC
SV2046	24.7	27.3	150	8.0	150	10W	150	TEC
IN231d	25.0	32.0	.20			150	150A	HSD

Type No.	Zener Voltage Range			Dynamic Impedance		Max. Diss.	Max. Temp.	Mfr.
	Min. E_{b1} (volts)	Max. E_{b2} (volts)	@ I_z (ma)	Z (ohms)	@ I_z (ma)	(mw)	(°C)	
IN1319	25.0	32.0				150	150A	HSD
IN1361A	25.7	28.4	150	3.0	10	10W	155A	HSD
IN1362	27.0	33.0	150	4.0	10	10W	155A	HSD
IN1362A	28.5	31.5	150	4.0	10	10W	155A	HSD
IN1363	29.7	36.3	150	4.0	10	10W	155A	HSD
HZ33	30.0	36.0		10	30	5000		INT. RECT.
IN232d	30.0	39.0	.20			150	150A	HSD
IN1320	30.0	39.0				150	150A	HSD
IN1363A	31.4	34.7	150	4.0	10	10W	155A	HSD
IN1364	32.4	39.6	150	5.0	10	10W	155A	HSD
IN1364A	34.2	37.8	150	5.0	10	10W	155A	HSD
IN1365	35.1	42.9	150	5.0	10	10W	155A	HSD
IN233d	37.0	45.0	.20			150	150A	HSD
IN1321	37.0	45.0				150	150A	HSD
IN1365A	37.1	41.0	150	5.0	10	10W	155A	HSD
IN1366	38.7	47.3	150	6.0	10	10W	155A	HSD
IN1366A	40.9	45.2	150	6.0	10	10W	155A	HSD
IN1367	42.3	51.7	150	7.0	10	10W	155A	HSD
HZ47	43.0	51.0		20	22	5000		INT. RECT.
IN1322	43.0	54.0				150	150A	HSD
IN1367A	44.7	49.4	150	7.0	10	10W	155A	HSD
IN1368	45.9	56.1	150	8.0	10	10W	155A	HSD
IN1368A	48.5	53.6	150	8.0	10	10W	155A	HSD
IN1369	50.4	61.6	150	9.0	10	10W	155A	HSD
IN1323	52.0	64.0				150	150A	HSD
IN1369A	53.2	58.8	150	9.0	10	10W	155A	HSD
IN1370	55.8	68.2	50	12	10	10W	155A	HSD
IN1370A	58.9	65.1	50	12	10	10W	155A	HSD
IN1371	61.2	74.8	50	14	10	10W	155A	HSD
HZ68	62.0	75.0		60	14	5000		INT. RECT.
IN1324	62.0	80.0				150	150A	HSD
IN1371A	64.6	71.4	50	14	10	10W	155A	HSD
IN1372	67.5	82.5	50	20	10	10W	155A	HSD
IN1372A	71.3	78.8	50	20	10	10W	155A	HSD
IN1373	73.8	90.2	50	22	10	10W	155A	HSD
IN1325	75.0	100				150	150A	HSD
IN1373A	77.9	86.1	50	22	10	10W	155A	HSD
IN1374	81.9	100	50	35	10	10W	155A	DSH
IN1374A	86.5	95.6	50	35	10	10W	155A	HSD
IN1375	90.0	110	50	40	10	10W	155A	HSD
IN1326	90.0	120				150	150A	HSD
HZ100	91.0	110		180	10	5000		INT. RECT.
IN1327	110	145				150	150A	HSD
HZ150	130	160		370	7	5000		INT. RECT.
GA52935r	130	170	20	100	10	1000	135	WEC

Following Type No.

r — Military use only

d — Double Anode Zener Types

Following Temp.

A — Ambient

B — Junction

S — Storage

energize the relay. When the grid is made more positive, it can be seen that the bias will remain constant even though the tube current increases. This is in contrast with conventional cathode resistor bias which would result in an ever increasing bias as tube current goes up. Fig. 4 illustrates how fixed bias for two tubes or transistors in a single-ended push-pull servo-amplifier may be provided. This is a simple, highly efficient circuit with a minimum of components.

For more information on DATA's Service, circle Reader Service No. 25.

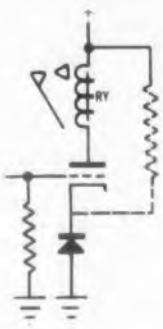

Fig. 3. Zener diode used as cathode bias element.

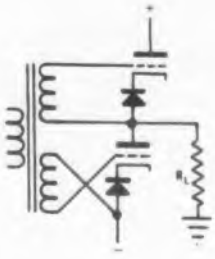

Fig. 4. Zener diode as fixed bias.

ZENER REFERENCE DIODES

In order of Min. E_{b1}' Max. E_{b2}' and type no.

Editor's Note: The data in this table arrived late and was not incorporated in the overall tabulation. Western Electric also supplies various types of Zener Diodes to qualified military contractors.

Type No.	Zener Voltage Range			Dynamic Impedance		Max.	Max.	
	Min. E_{b1} (volts)	Max. E_{b2} (volts)	@ I_z (ma)	Z (ohms)	@ I_z (ma)	Diss. (mw)	Temp. (°C)	Mfr.
Z-3.9	3.6	4.3	5	30				SEM.
Z-4.7	4.3	5.1	5	25				SEM.
Z-5.6	5.1	6.2	5	10				SEM.
Z-6.8	6.2	7.5	5	10				SEM.
Z-8.2	7.5	9.1	5	25				SEM.
Z-10	9.1	11.0	5	50				SEM.
Z-12	11	13	1	70				SEM.
Z-15	13	16	1	100				SEM.
Z-18	16	20	1	150				SEM.
Z-22	20	24	1	200				SEM.
Z-27	24	30	1	300				SEM.
Z-33	30	36	.2	400				SEM.
Z-39	36	43	.2	600				SEM.
Z-47	43	51	.2	800				SEM.
Z-56	51	62	.2	1000				SEM.
Z-68	62	75	.2					SEM.
Z-82	75	91	.2					SEM.
Z-100	91	110	.2					SEM.
Z-120	110	130	.2					SEM.
Z-150	130	160	.1					SEM.
Z-180	160	200	.1					SEM.
Z-220	200	240	.1					SEM.
Z-270	240	300	.1					SEM.
Z-330	300	360	.1					SEM.
Z-390	360	430	.1					SEM.
Z-470	430	510	.1					SEM.
Z-560	510	620	.1					SEM.

Z types are rated at 150 mw. U.S. Semiconductor also makes a 400 mw LZ series and a 200 mw ZT series in E_{zz} ranges of 3.9 to 22v.

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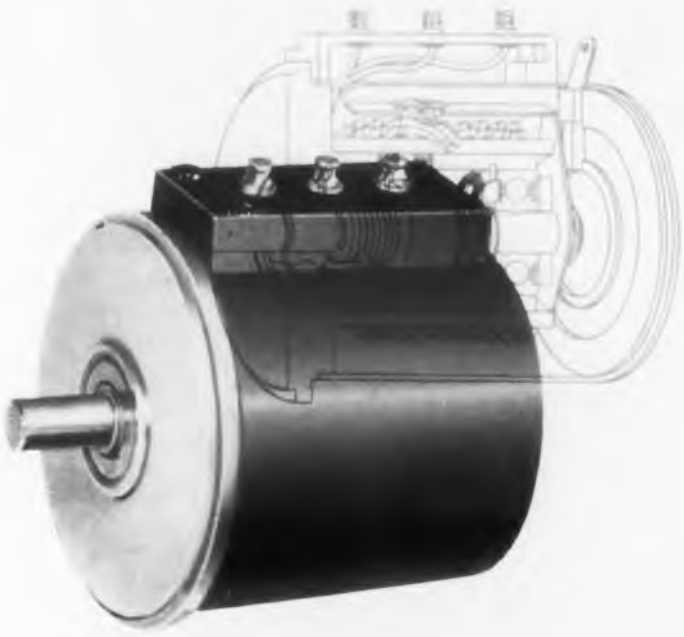

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Feedback Amplifier Design with the Nichols Chart

William D. Wade
The Magnavox Co.
Fort Wayne, Ind.

The Nichols chart, useful in servo and feedback amplifier design, provides advantages over more popular design aids. Unlike the Bode chart or phase-attenuation curves, it allows the designer to obtain closed loop data directly from open loop data.

THOUGH the Nichols Chart was derived for the design and stability analysis of servomechanisms, it is also a useful tool in solving stability problems of feedback amplifiers. It provides a convenient method of determining the gain of a complex closed loop directly from the gain of a complex open loop.

Derivation of the Nichols Chart

First, it is necessary to derive the open and closed loop gain. Fig. 1 shows a block arrangement of an amplifier without feedback. Here $Be_o = ABe_i$. If AB equals Y_1 then Be_o/e_i equals Y_1, which may be defined as the open loop gain.

In Fig. 2, the feedback loop is closed. Here $e_o = (e_i - Be_o)A$. From this equation it follows that $e_o(1 + AB) = e_iA$. The transfer function e_o/e_i equals $A/(1 + AB)$. If, again, $AB = Y_1$, then $Be_o/e_i = Y_1/(1 + Y_1)$ which is defined as the closed loop gain.

Note that the loop gain is the total gain through the loop. The amplifier gain, e_o/e_i, is the loop gain divided by B.

The Nicholas Chart ordinates are the magnitudes of the open loop gain in decibels; the abscissas are the phase shift angles of the open loop gain in degrees. Two families of curves are plotted. One is the constant phase shift curves of closed loop gain, the other, the constant magnitude curves. There is a point on the chart for every value of the open loop gain, $Y_1 = |Y_1| \angle Y_1$. This point also locates the corresponding closed loop gain

$$\left|\frac{Y_1}{1 + Y_1}\right| \angle \frac{Y_1}{1 + Y_1}$$

which can be read directly from the chart. For example, an open loop gain of +9 db $\angle -95$ deg corresponds to a closed loop gain of −0.5 db $\angle -20$ deg as shown in Fig. 5.

Nichols Chart—Advantages and Disadvantages

It is appropriate to compare the usefulness of the Nichols chart with the more familiar Nyquist diagram. One of the main Nichols chart advantages is that closed loop data may be read directly from open loop data. In most amplifiers, $1/B$ is constant over the useful band, and the gain curve is easily obtained by adding B db to the closed loop gain. Amplifier gain is not determined easily from the Nyquist diagram.

Stability information (in the form of closed loop gain) is available directly from the Nichols chart, whereas, the Nyquist diagram requires additional graphical analysis.

Unfortunately, the Nicholas chart is not yet available from companies who print graph paper. However, a single Nichols chart can be used for many amplifier problems.

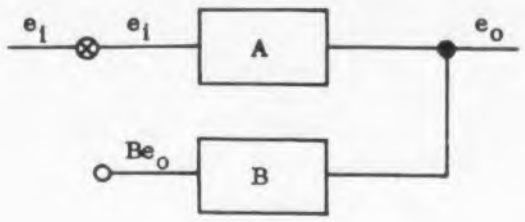

Fig. 1. Basic amplifier without feedback.

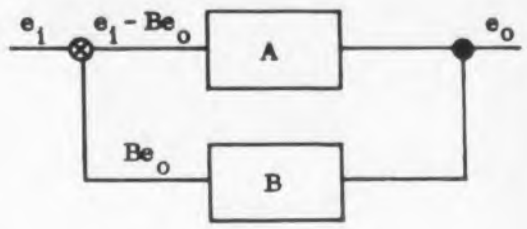

Fig. 2. Basic amplifier with feedback.

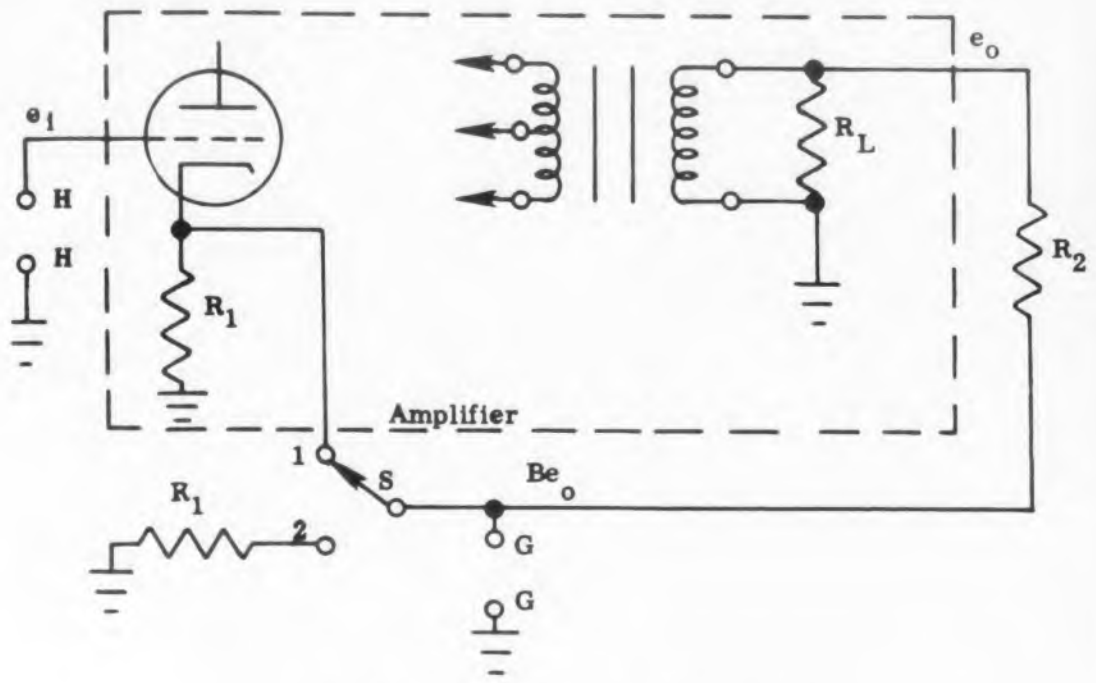

Fig. 3. Amplifier with 20 db of feedback.

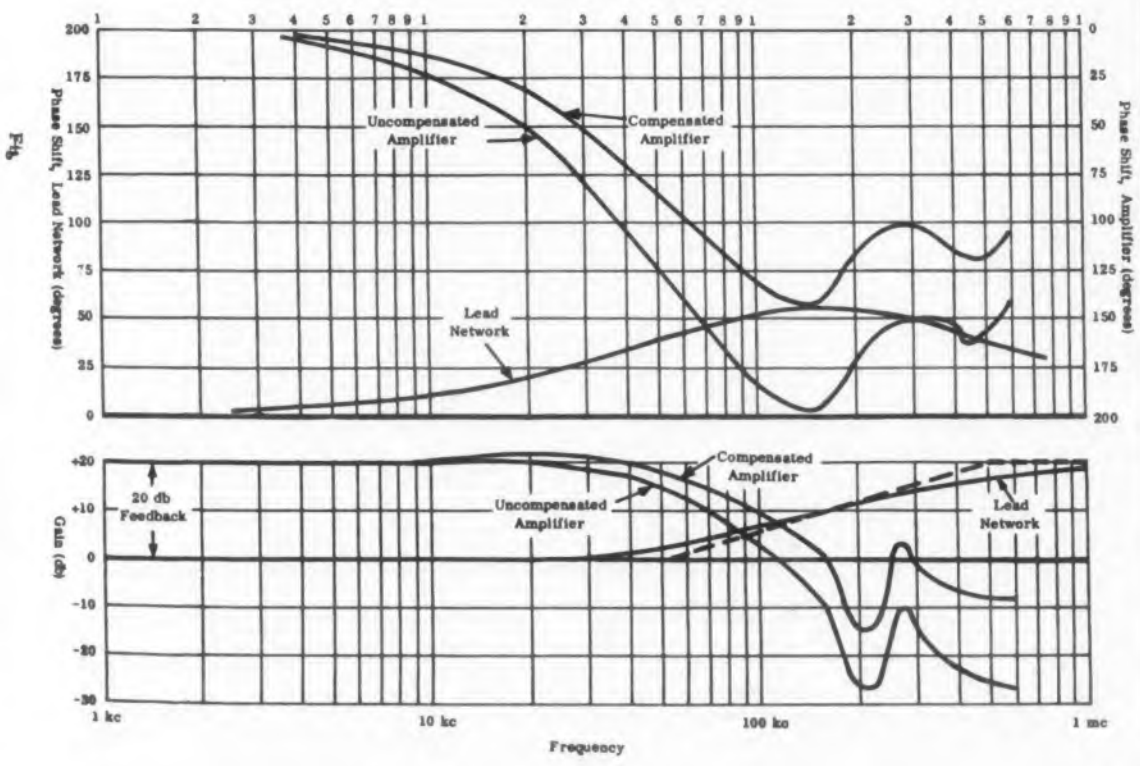

Fig.

Fig. 4. Attenuation—Phase shift curves.

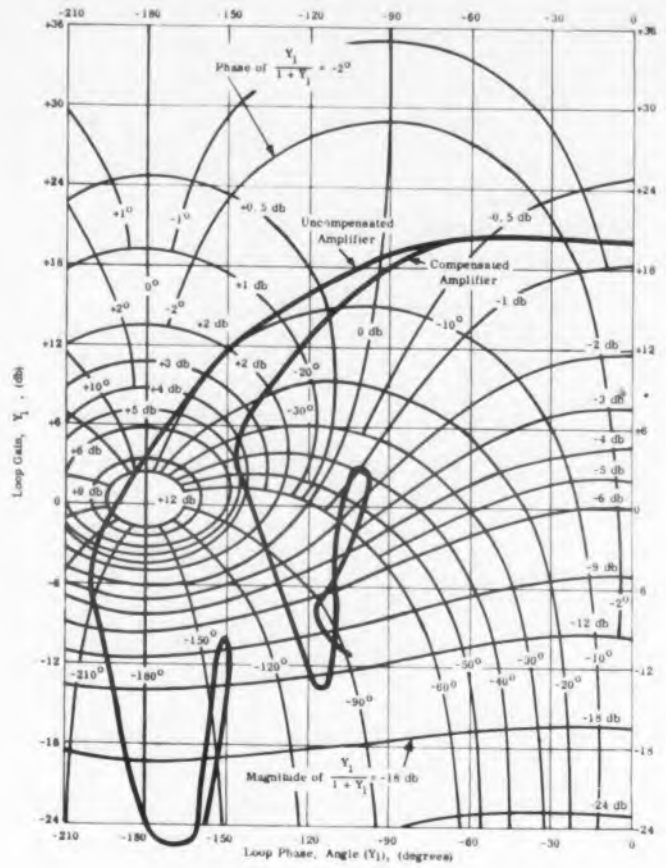

Fig. 5. Nichols chart with amplifier characteristics plotted.

A Practical Design Problem

Twenty db of feedback are to be applied to the amplifier of Fig. 3, i.e., at mid frequencies $|Y_1| = 20$ db. With the feedback loop connected, the amplifier oscillates at approximately 100 kc. Switch S is thrown to position 2 and the gain and phase shift between *HH* and *GG* are measured and plotted against frequency as in the "uncompensated amplifier" curves in Fig. 4. These values are also plotted on the Nichols chart of Fig. 5. Since, on the Nichols chart, the curve passes to the left of $Y_1 = 0$ db/−180 deg, the amplifier will oscillate when the feedback loop is connected.

A lead network, having the response indicated in Fig. 4, may be added to the amplifier to move the plot to a stable region to the right of $Y_1 = 0$ db/−180 deg. The "compensated amplifier" curves in Figs. 4 and 5 show the response with the lead network connected.

Corrective Networks

Lead Network

A lead network gives phase shift correction at the expense of attenuation for high frequency correction and it provides attenuation at the expense of phase shift for low frequency correction. A typical lead network is shown in Fig. 6. Here

$$\frac{E_o}{E_{in}} = \frac{R_2}{R_2 + \dfrac{-jX_c}{R_1 - jX_c}}$$

$$= \frac{R_2}{R_1 + R_2} \cdot \frac{j\omega CR_1 + 1}{j\omega \dfrac{CR_1R_2}{R_1 + R_2} + 1}$$

$$= \frac{R_2}{R_1 + R_2} \cdot \frac{j\omega T_1 + 1}{j\omega T_2 + 1}$$

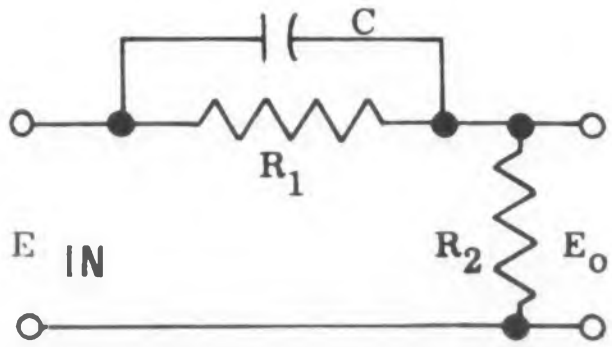

Fig. 6. A typical lead network.

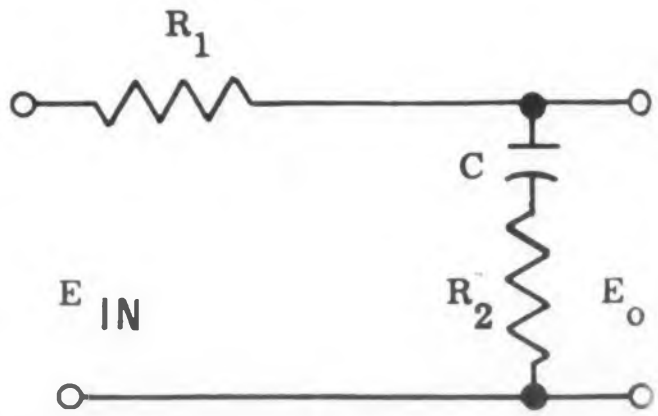

Fig. 7. A typical lag network.

$$T_1 = CR_1, \qquad T_2 = \frac{CR_1R_2}{R_1 + R_2}$$

$$f_1 = \frac{1}{2\pi R_1 C}, \qquad f_2 = \frac{R_1 + R_2}{2\pi R_1 R_2 C}$$

In the lead network required to stabilize the amplifier of Fig. 3, $f_1 = f_2/10 = 50$ kc and the maximum phase shift occurs at 160 kc. For any lead network where $f_2 = 10\ f_1$, the maximum phase shift is 55 deg and the maximum attenuation is 20 db.

Lag Network

A lag network gives attenuation at the expense of phase shift for high frequency correction, and provides phase shift at the expense of attenuation for low frequency correction. Fig. 7 illustrates a lag network.

General Design Considerations

- The algebraic signs of the angles on the Nichols Chart are for the analysis of the high frequency characteristics of an amplifier. When the low frequency characteristics are examined, all angles that are negative on the chart should be considered positive, and all positive angles should be considered negative.
- In general, the maximum gain of the closed loop on the Nichols chart should not exceed 1.5 db. The amplifier used as an example can be improved by adding a second lead network. This would move the plot on the Nichols chart farther to the right.
- The schematics of the lead and lag networks shown in Figs. 6 and 7 are rather idealized. In general, E_{in} contains a series impedance, and E_{out} contains a parallel impedance. The effects of these should be minimized through proper circuit design. For example, R_g in the lead network could be a grid resistor. In this case the impedance in the lead network should be high in comparison with the output impedance of the previous stage.
- The amplifier gain equals the loop gain multiplied by $1/B$. Although a corrective network can be made part of B, the network's gain variation should lie outside the audible frequency range.

For a reprint of this article turn to the Reader-Service card and circle **31.**

References

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2. Bode, H. W.; Network Analysis and Feedback Amplifier Design; D. Van Nostrand Co., New York, 1945.
3. Langford-Smith, F.; Radiotron Designer's Handbook; 4th Edition, Amalgamated Wireless Valve Co. Pty., Ltd., Sydney, Australia, 1953, pp. 359-364.
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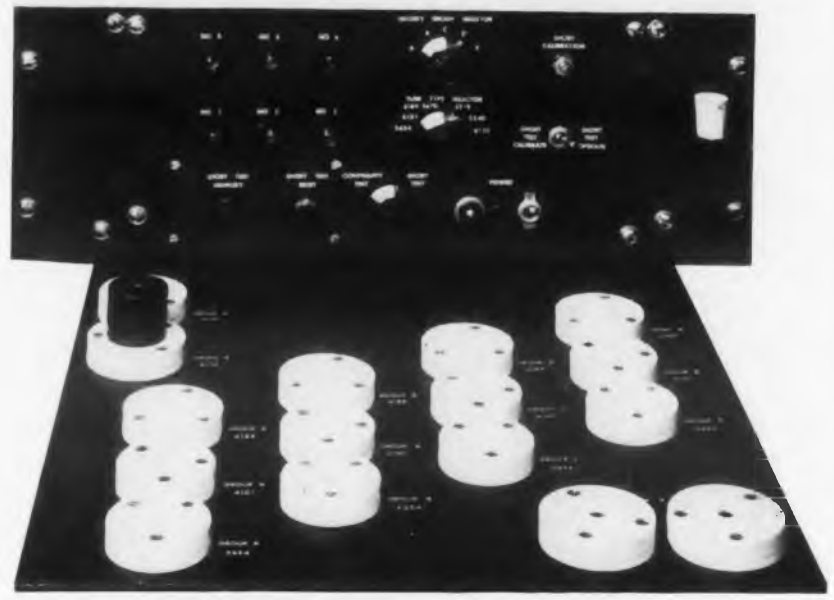


Short and Continuity Tester designed for rapid checking of seven tube types (5654/6AK5/6096, 6101/6J6WA, 6189/12AU7WA, 5670WA, 5718, 5840, and 6112). The first four types are 7 and 9-pin miniatures; the remaining three are subminiatures. Because testing of the first three types involved a great number of tubes in a large testing program, multiple positions were provided for these types for rapid short-continuity testing. Four tubes of a given type are plugged into the board. Then, while their heaters are being energized the operator switches a selector switch from one to another for testing. The cork mallet hanging at the right is for tapping tubes. The tester can readily be adapted to testing of other tube types than the seven types indicated above.

Rapid Testing of Tube Shorts and Continuity

MOST general-purpose tube testers fail as convenient instruments for rapidly testing large numbers of vacuum tubes for shorts and discontinuities. This failure prompted the development of a short-continuity tester at Armour Research Foundation which is a high-sensitivity device for rapid tube checking and includes provisions for plugging-in and testing up to four tubes of a given type at a time. It also contains a "memory" feature for tap shorts. Although this unit was designed for seven particular tube types, other types could be accommodated with minor wiring changes.

The short-testing provision in the conventional tester usually consists of a four- or five-position switch utilized in conjunction with a single neon-lamp circuit. To locate the shorted elements, the switch positions for which a glow is obtained are noted and then a table is referred to for pinpointing the short. There is no permanent indication for tap shorts. The G_m reading of the tester usually serves as the only continuity indication, and this is not always conclusive nor does it localize the discontinuity.

Short-Testing

The short-testing circuit of the newly developed tester has a "memory" characteristic whereby a permanent indication is given for an intermittent or "tap" short. In addition, the circuit will precisely localize all sustained shorts and those tap shorts in which the shorting time is sufficient for the human eye to sense the indication of the panel lamps. The precise localization is made by noting which lamp or lamps are ex-

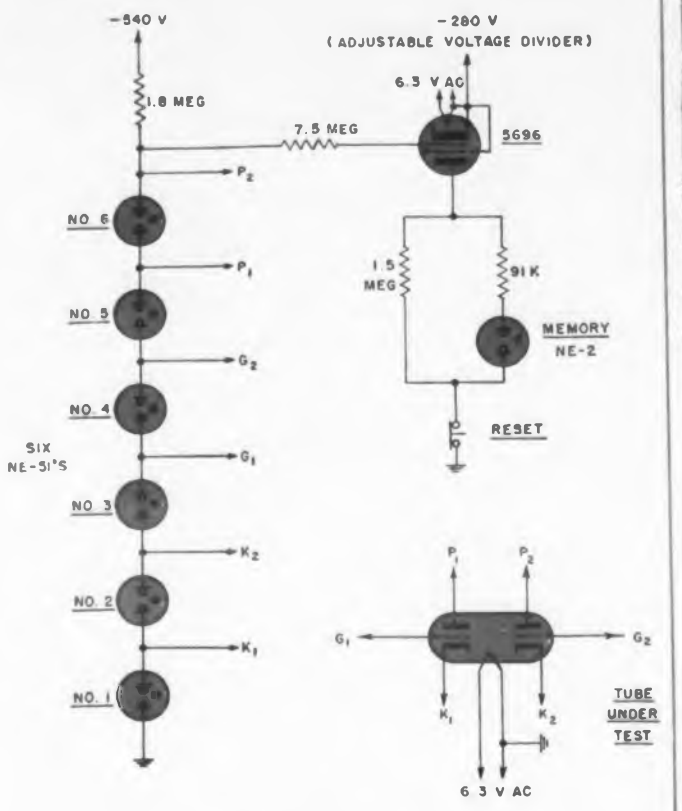


Fig. 1. Simplified short-testing circuit.

tinguished of six normally-glowing neon lamps. The "memory" indication is given by the glowing of a seventh, normally-extinguished lamp.

The sensitivity (maximum short resistance for indication) between any two elements of the tube under test is 220,000 ohms for the "memory" indication and approximately 400,000 ohms for the six-lamp localization display.

A simplified schematic diagram of the short-testing circuit (minus tube-type switching, tube-socket switching, etc.) is given in Fig. 1. The elements of the tube under test are connected to the junction points of the six series-connected

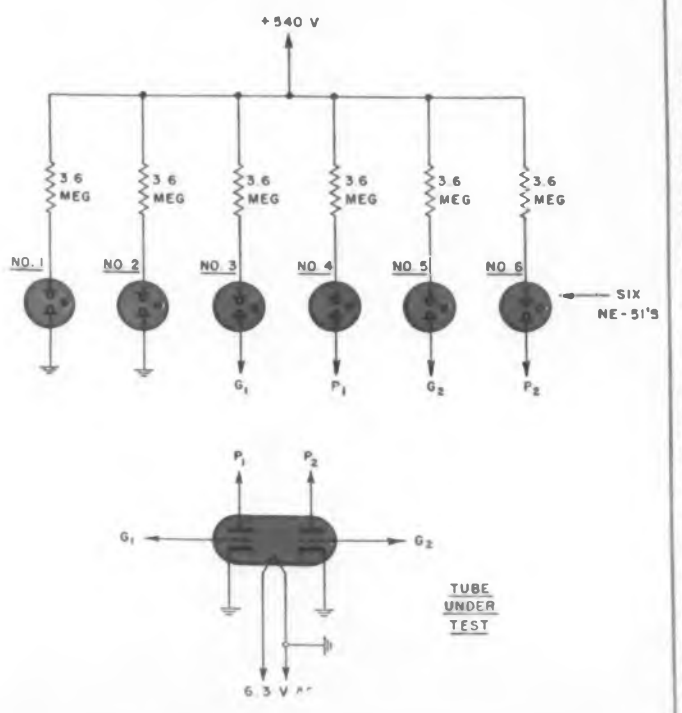
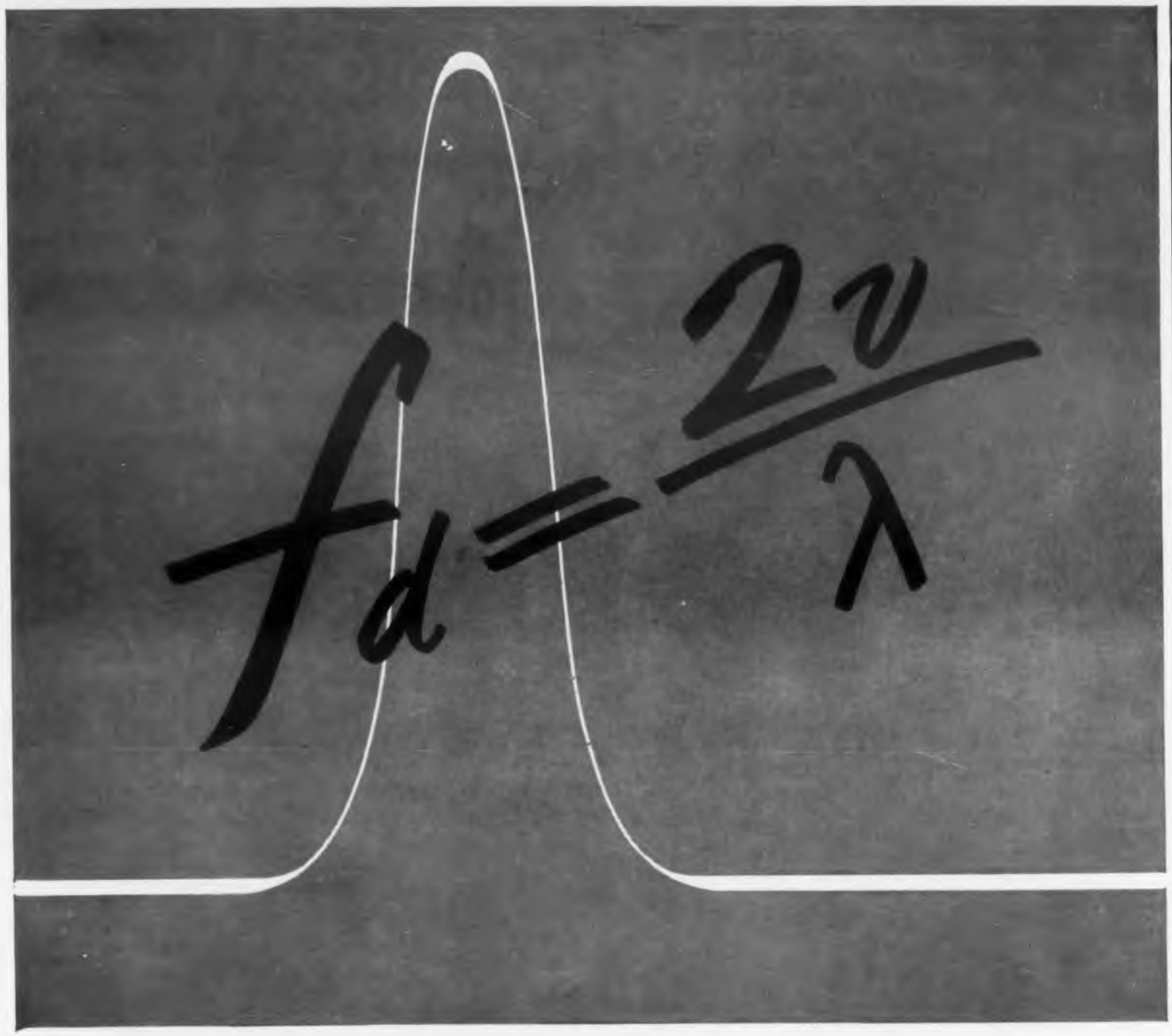


Fig. 2. Simplified continuity-testing circuit.



NE-51 lamps. The constant voltage drop of each of the neon lamps is approximately 50 v. The lamp current is fixed at approximately 0.133 ma by the —540 v source voltage and the 1.8 meg series-dropping resistor. If a resistance of approximately 400,000 ohms is placed between K_2 and G_1, for example, all of the Lamp No. 3 current would be routed through the resistance and the lamp would extinguish. This value of resistance, which is the lamp voltage divided by the series current, is thus the basic localization sensitivity of the short tester. If the shorting elements are non-adjacently connected, such as K_2 and G_2, Lamps Nos. 3 and 4 would extinguish and the sensitivity would be proportionately increased to 800,000 ohms. Since one side of the heater is grounded, a short between K_1 and heater, for example, would cause Lamp No. 1 to extinguish.

Memory Circuit. In connection with the "memory circuit," the grid of the Type 5696 thyratron is connected to the "top" of the No. 6 lamp (through the grid current-limiting resistor) which is at a constant potential without shorts; whereas the cathode is returned to a fixed voltage such as to bias the tube a certain amount beyond the negative critical voltage for firing. When a short of sufficient magnitude occurs between any of two elements of the tube under test, the thyratron grid becomes less negative, causing the tube to fire, which, in turn, causes the "memory" lamp to glow. The "memory" lamp continues to glow, of course, until the reset button is depressed, regardless of the voltage at the grid. The time-constant of the grid circuit (series resistance together with stray capacitance) is such that a short of duration of only about 100 μsec is sufficient at maximum sensitivity to fire the tube. Thus, the circuit is fast enough for practically all tap short defects encountered.

The change in voltage at the grid, ΔE, resulting from an adjacent element short of 220,000 ohms (maximum design sensitivity) can be computed from the following equation:

$$\Delta E = \frac{E_L R_2/R_1 + 6E_L - E_S}{1 + R_2/R_1}$$

Where:

E_L = Lamp voltage (approximately 50 v)
E_S = Supply voltage (—540 v)
R_1 = Resistance of adjacent-element short (220,000 ohms)
R_2 = Series-dropping resistor (1,800,000 ohms)

The value of ΔE obtained from the above equa-

tion is approximately 18 v. To this value must be added the negative critical grid voltage of the thyratron to obtain the grid-to-cathode bias voltage necessary for this sensitivity. The critical grid voltage for the 5696 (with suppressor grid tied to cathode) with the working plate voltage of approximately 300 v is −2.5 v. Thus the required negative grid bias is approximately 20.5 v. Since the nominal NE-51 voltage drop is 50 v, the quiescent voltage at the grid is close to 50 x 6 or −300 v. The cathode must be returned, then, to approximately −280 v. The sensitivity of the instrument to tap shorts is calibrated by adjusting the cathode potential with a voltage divider. A 220 kilohm resistor is switched across one of the series lamps and the cathode voltage is varied in a negative direction until the thyratron fires as observed by the NE-2 "memory" lamp. The actual negative grid bias as set by calibration measures very close to the computed 20.5 v.

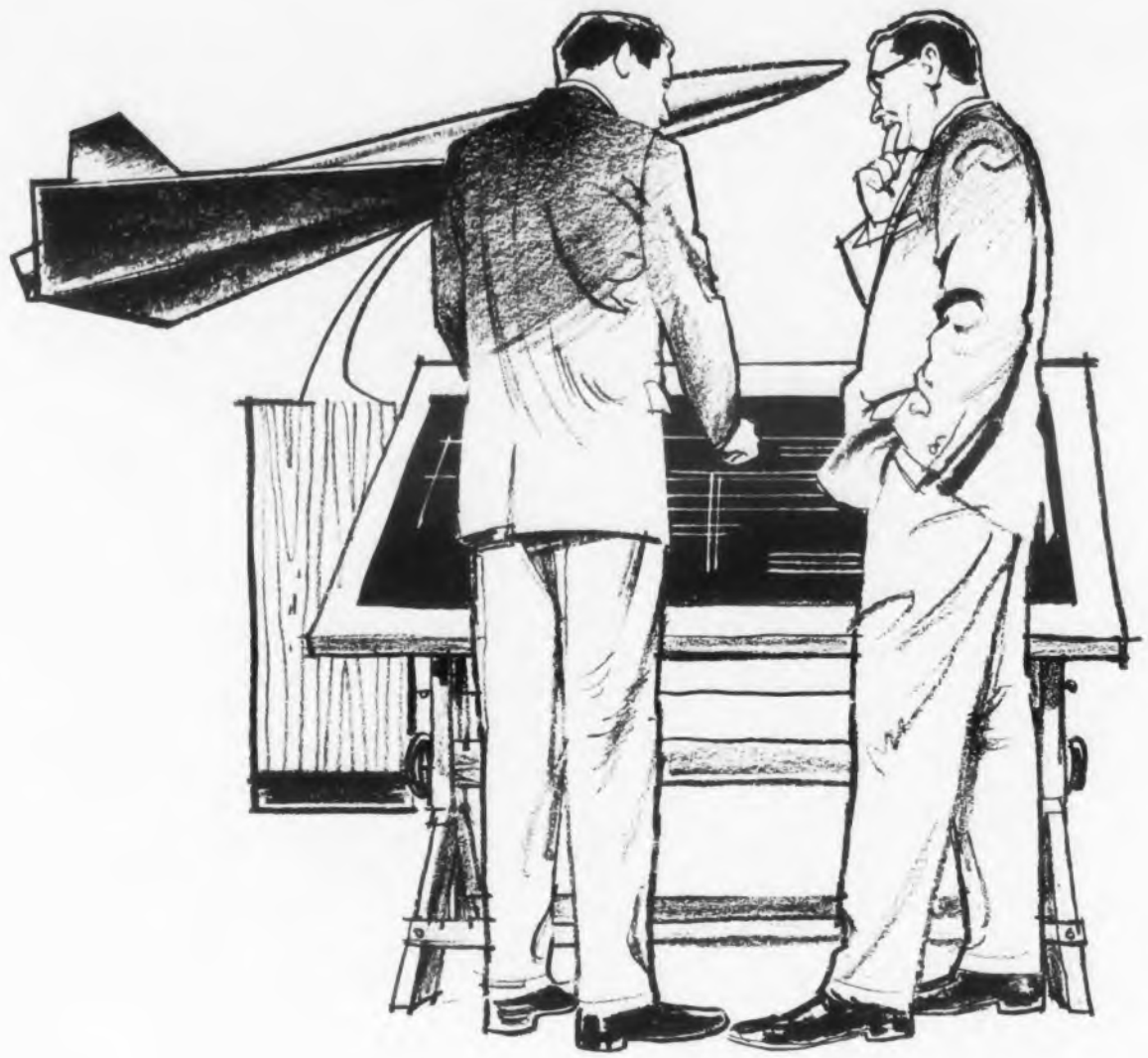
A regulated high voltage power supply is required because a 1 per cent change in cathode voltage gives roughly a 10 per cent change in "memory" sensitivity. The supply used in a recent application of the instrument was a Northeast Scientific Corporation (Cambridge, Mass.) Model RE-1602, a compact, relatively inexpensive supply having a regulation of about 0.01 per cent. This degree of regulation was actually better than required.

Continuity Testing

The continuity-testing circuit is quite simple. Emission from the hot cathode is utilized, all tube grids and plates being connected positively with respect to the cathodes. The same six NE-51 lamps are used with this circuit as with the short-testing circuit, and, as in the latter, all six lamps will glow with a non-defective tube under test.

A simplified schematic of the continuity-testing circuit is given in Fig. 2. The cathodes of the twin-triode under test are grounded and both grids and plates are connected to +540 v through an individual neon lamp and series-dropping resistor. If continuity is not present to a given element, its lamp will be out. For simplicity of operation, all neon lamps which are not utilized for the particular tube type under test, are energized by connection directly to ground. This is shown for lamps 1 and 2 in Fig. 2. Because of the large series-dropping resistors, the current through each element and lamp is fixed at approximately 0.13 ma, and all lamps glow equally.

The work described above was performed at Armour Research Foundation of Illinois Institute of Technology under sponsorship of the Air Materiel Command, and under technical direction of the Wright Air Development Center. It was reported by the engineer who developed the instrument, Mr. E. S. Gordon.



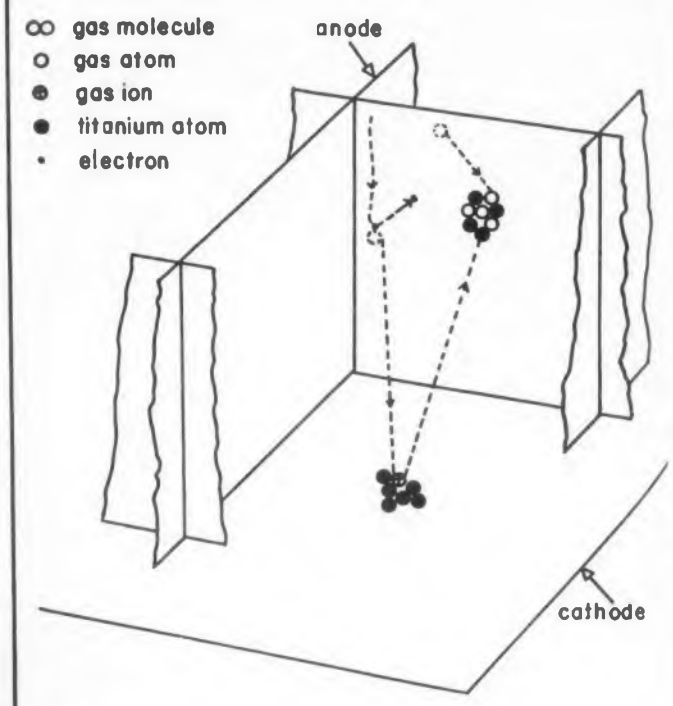
Completely Electronic

High Vacuum Pump

VACUUMS in excess of 1×10^{-9} mm are possible with this completely electronic high vacuum pump. The unit consisting of a permanent magnet and power supply has no movable parts.

Developed by Varian Associates, 611 Hansen Way, Palo Alto, Calif., the pump requires no oil vapor, cold traps, or vapor traps. Nor are additional pressure measuring devices needed for most applications, since pressure in the pump is calibrated in terms of pump current. If more than one pump is operated with a single supply, individual current meters must be provided to measure pressure.

Removal of the gas is achieved by the formation of a gettering layer of titanium atoms which combine with the gas atoms during the pumping



This cutaway view of the Vaclon high pressure pump depicts the action of the device. Electrons emitted from the cold-cathode are constrained by the magnetic field and collide with the gas atoms to produce a high density parallel ion current. Titanium atoms are emitted from the cathode after bombardment by the ion beam. A gettering layer is formed on the anode which unites with gas atoms.

No movable parts in this completely electronic ultra-vacuum pump.

process. Detailed operation of this process is illustrated in the cutaway diagram. Electrons emitted from the titanium cold-cathode plate are constrained by the magnetic field, increasing the electron path length. The ion current is therefore, greatly increased. High density, parallel ion beams defined by the cellular anodes bombard the cathode plates. Titanium atoms are ejected and these sputtered atoms are deposited on the anode cell walls. The gas atoms then combine with the titanium gettering layers.

Designated VacIon, the pump is started at a rough vacuum of 15 to 20 microns obtained with a conventional oil-sealed mechanical pump. The VacIon and system are valved off from the roughing pump after starting, making the system invulnerable in the event of a power failure. The starting pump may be shut off after the starting period.

The cellular anode construction offers greater effective sputtering area and cathode surface over a ring or simple cylinder design. The probability of trapping gas particles is increased, flaking is minimized, ion current density is increased, and a large number of field free regions are provided which increase sputtering.

In addition the total ion current is increased at any pressure and the discharge is permitted to persist to indefinitely low pressures at the applied voltage of 3 kv. This feature insures that the pumping speed will not fall to zero until extremely low pressures are reached. Pumping speeds of 10 liters per sec at pressures of 10^{-7} mm have been measured.

The ultra-high vacuum capabilities of the VacIon makes it particularly suitable for processing microwave tubes. Several large tubes have been constructed with the pump as an appendage. The pump is put through bakeout along with the tube and after pinchoff remains attached to it.

For more information on this device, turn to the Reader's Service Card and circle 38.

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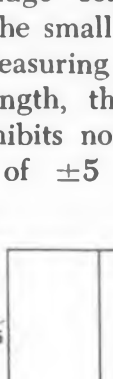
CIRCLE 40 ON READER-SERVICE CARD

Strain Gage Type

Miniature Accelerometer



Actual size of the accelerometer.

COMPACT design, using the strain gage principle of resistance wire in a balanced bridge configuration, has made possible the small size of this accelerometer. Measuring less than one inch overall length, the A52 accelerometer also exhibits notable characteristics: Ranges of ±5 g to ±100 g, linearity of ±1 per cent full scale, and a natural frequency of 200 cps for the ±5 g type up to 650 cps for the ±100 g range. The unit has an output of approximately ±32 mv (64 mv representing a full scale excursion) using an excitation voltage of 8 v dc or ac rms. Viscous fluid damping is 0.7 (±0.1) of critical at room temperature. The accelerometer's response to transverse acceleration is not more than 0.03 g per g within the rated range. The maximum allowable static acceleration is twice this rated range.

The A52 accelerometer, manufactured by Statham Instruments, Los Angeles, Calif., is based on the company's un-

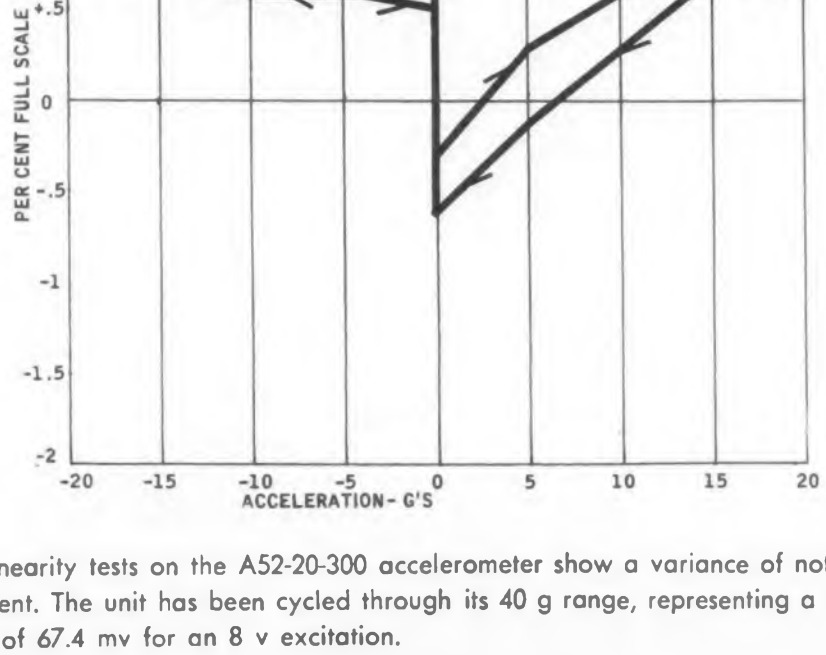


Fig. 1. Linearity tests on the A52-20-300 accelerometer show a variance of not more than ±1 per cent. The unit has been cycled through its 40 g range, representing a total output excursion of 67.4 mv for an 8 v excitation.

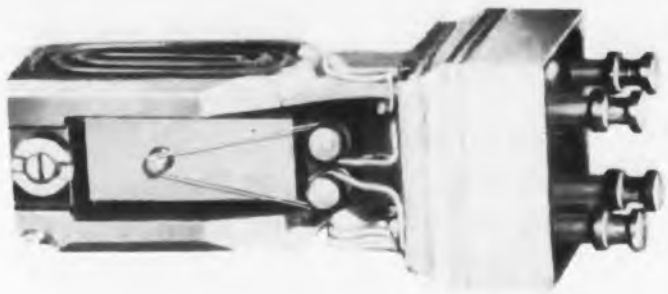


Fig. 2. The transducing element exposed, showing the resistance wire which makes up part of the balanced bridge circuit. The sensitive axis is at right angles to the exposed face. This is made possible by the cantilevered mounting of the central mass.

bounded strain gage construction. This consists essentially of four resistance wires arranged in a parallel fashion, and so attached to a moving element that displacement in either direction parallel with the wires will result in tension on two wires and relaxation of the other two. Since the resistance wires form a typical Wheatstone bridge, such displacement will result in an electrical unbalance.

In this particular accelerometer, the construction is slightly different, providing a sensitive axis at right angles to the longitudinal axis. In effect, the moving element or mass is cantilevered to provide a mechanical advantage; this, in part, enables the small size of the instrument. As shown in Fig. 2, two of the resistance wires are here represented by the inverted V, attached to two terminals at the bottom and around the insulator on the mass. The mass is attached by means of a cantilevered construction at the bottom; this consists of a very thin strip of metal which is machined from the beryllium copper mass itself. A similar arrangement of the resistance wires on the other side provide the balanced circuit configuration.

In operation, a small movement of the mass around the cantilever axis suffices to set up an electrical unbalance. The linearity of the output is mostly due to the lack of any frictional devices, such as a pivot or sliding element. This linearity is described in Fig. 1 for model A52-20-300 accelerometer, which has a total range of 40 g and a output of 67.4 mv full scale with 8 v excitation.

For more information on the A52 accelerometer, Circle *41* on the Reader's Service Card.

Here is the second part of Dr. Storm's article on non-linear magnetics. Part I, which appeared in the February 19th issue of ELECTRONIC DESIGN, discussed the basic nature of the saturable reactor (SR) and its applications without other circuit elements.

In this part, Dr. Storm discusses the SR used alone with a resistor (Section 3), and with an inductor (Section 4).

Applications of Non-Linear Magnetics

Herbert F. Storm
General Engineering Laboratory
General Electric Company
Schenectady, N. Y.

Part II

3 SR and Resistor R

Frequency Detector

Fig. 3-1A shows a saturable reactor primary winding connected across an ac bus. The resistance of winding *1* is lumped into *R*. Suppose the core flux φ is at negative saturation at $t = 0$ (points 1, Figs. 3-1 C and E). For t greater than 0, the instantaneous supply voltage e becomes positive (Fig. 3-1B), and the core leaves negative saturation. The core flux increases according to eq (2-1).

$$e_G = 10^{-8} N \, d\phi/dt \qquad (2\text{-}1)$$

A magnetizing current flows, causing a voltage drop across the circuit resistance R. The instantaneous gate voltage e_G may be smaller than the supply voltage e. Hence,

$$\Delta \Phi = \frac{10^8}{N} \int e_G \, dt \qquad (3\text{-}1)$$

The instantaneous output voltage e_o (Fig. 3-1D) follows from

$$e_o = e_G \, N_2/N_1 \qquad (3\text{-}2)$$

and the average output E_o for the first half-cycle is

$$E_o = \frac{2}{T} \int_o^{T/2} e_o \, dt \qquad (3\text{-}3)$$

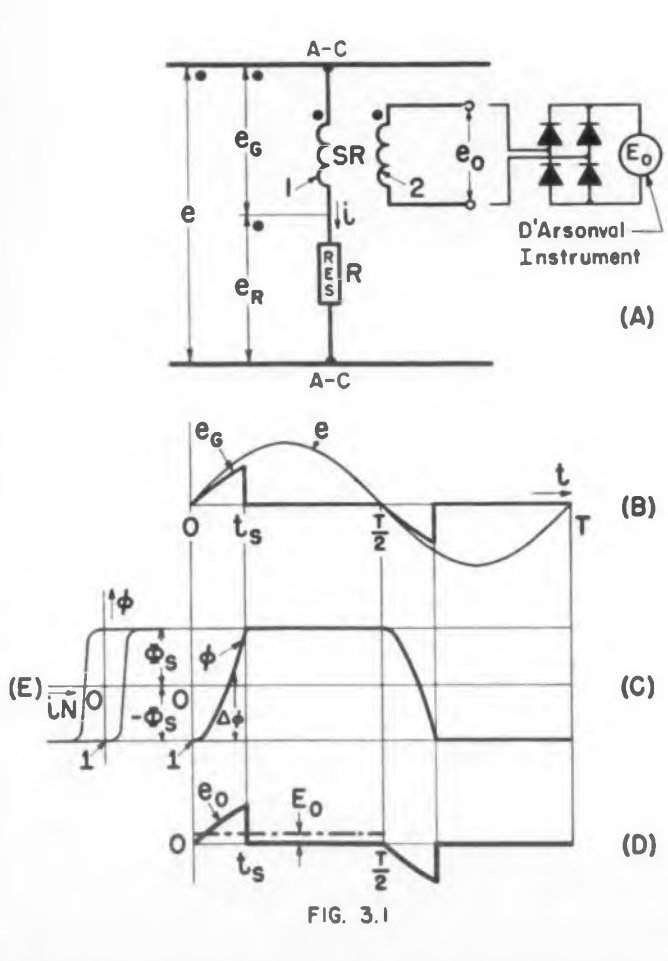


FIG. 3.1

Fig. 3-1. Voltage or Current Reference Circuit. (A) Circuit diagram, (B) Supply voltage e and gate voltage e_G, (C) Core flux, (D) Output voltage e_o, (E) Flux-current loop.

At $t = t_s$, the core saturates, ($\Delta\Phi = 2\Phi_s$, Fig. 3-1C), and it can be assumed that the core remains saturated for the duration of the half-cycle. Hence

$$E_o = \frac{2}{T}\frac{N_2}{N_1}\int_o^{t_s} e_G\, dt \qquad (3\text{-}4)$$

Substituting from eq (3-1) into eq (3-4), and for $\Delta\Phi = 2\Phi_s$, one obtains

$$E_o = 4 f \Phi_s N_2 10^{-8} \qquad (3\text{-}5)$$

where the supply frequency f replaces the period T. The events during the second half-cycle produce similar results. A D'Arsonval instrument energized through a loss-free rectifier (Fig. 3-1A) would read E_o.

The output voltage E_o is proportional to the supply frequency and is not affected by the magnitude of the supply voltage as long as the core saturates at least once each half cycle. The magnitude of R does not affect E_o, but merely controls the maximum value of current i (eq 2-4). If a current flows in the output circuit, the output voltage E_o is reduced only by the voltage drop in winding 2 of the SR, but is not affected by the voltage drop in R. As long as the saturation branches of the flux-current loop (Fig. 3-1E) are horizontal in the first and third quadrants, the width of the loop, and the shape of its flanks are irrevelant to the circuit operation.

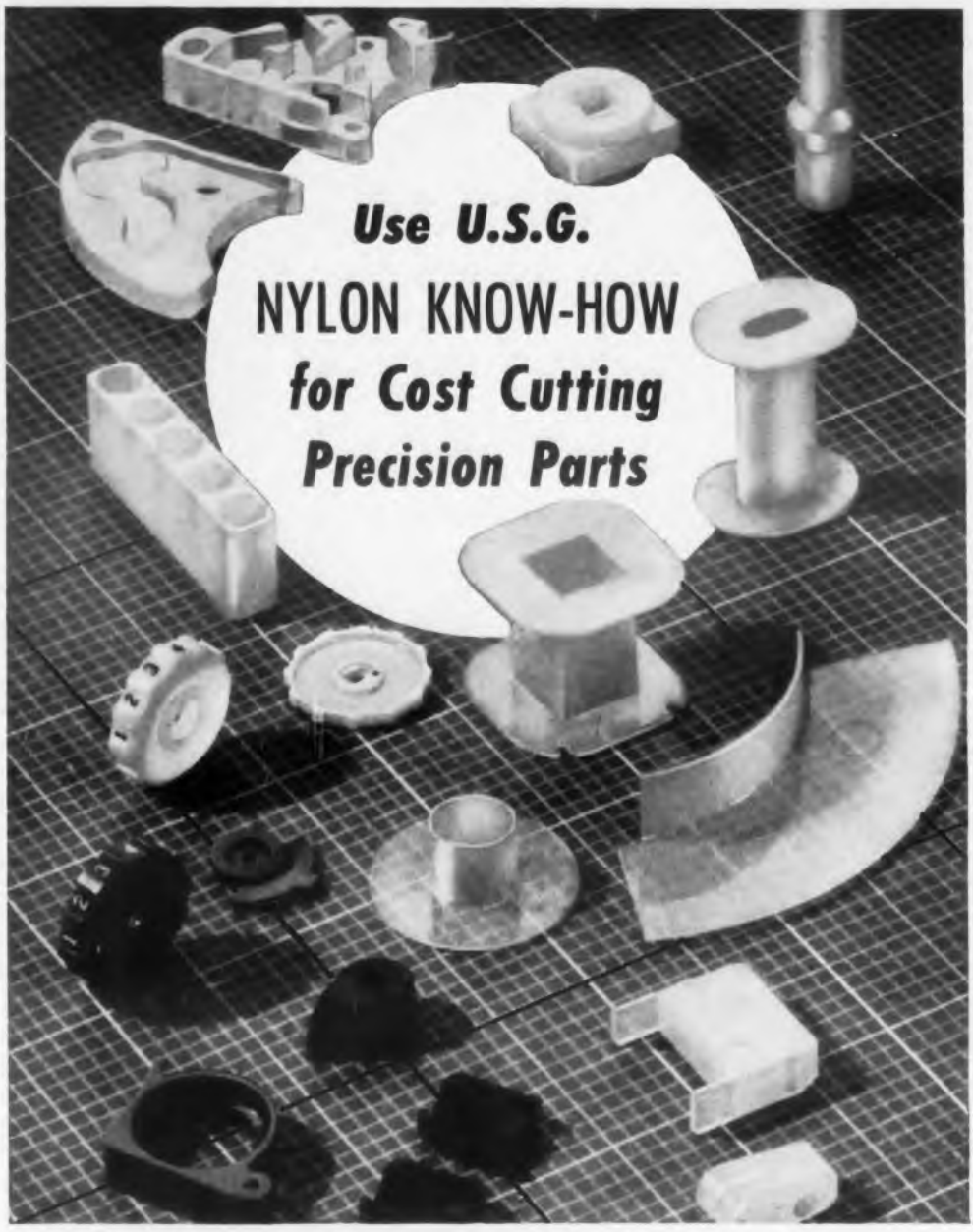
Practical applications of this circuit are in frequency regulators, frequency compensators, over- and under-frequency indicators and controllers.

Voltage or Current Reference

If the supply frequency f is constant, the output voltage E_o (eq 3-5) is also constant and the circuit of Fig. 3-1A can be used as the basis of a voltage or current reference circuit (Ref 3-1). If the supply frequency is variable, frequency compensation can be applied, for instance by the addition of linear reactors in the output circuit (Ref 3-2, 3-3). Reference 3-3 describes a circuit which holds the output current at 15 $\pm$ .02 ma dc with a 50 ohm load. The supply voltage varies from 100 to 140 v; the supply frequency varies from 360 to 440 cps; and the temperature from -55 to $+100$ C. In 15 cubic inches, the device weighs only 1.5 lb.

Firing Circuits for Thyratrons

For precise firing of grid-controlled mercury arc or gaseous rectifiers, a rapid rise of grid-cathode voltage is required. Such a voltage develops across R in Fig. 3-1 at the instant t_s of core saturation. This voltage e_R can be applied directly or by interposing a grid transformer to the grid-cathode circuitry (Ref 3-4).



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4 SR and Linear Inductor L

Peaking Circuit, Frequency Multiplier

The linear inductor L of Fig. 4-1A replaces the resistor R of Fig. 3-1A. Assuming zero resistance in the circuit, and an ideal, square flux-current loop for the core material (Fig. 4-1G), it can be seen, by inspecting the wave shapes in Fig. 4-1, that the supply voltage e appears as the gate voltage e_G. It produces the output voltage e_o at or near the crest value of the supply voltage, thus making this circuit far more effective for generating short pulses than the circuit of Fig. 3-1A.

The output voltage can be used for many applications such as where fixed input volt-seconds are needed (as in the counter and timer discussed in section 2). These pulses can also be used for the grid control of thyratrons. Furthermore, the substantial content of higher harmonics can be used for frequency multiplication.

Frequency Multiplier

By interposing a tuned filter between the *SR* and the load, as shown in Fig. 4-2, a current

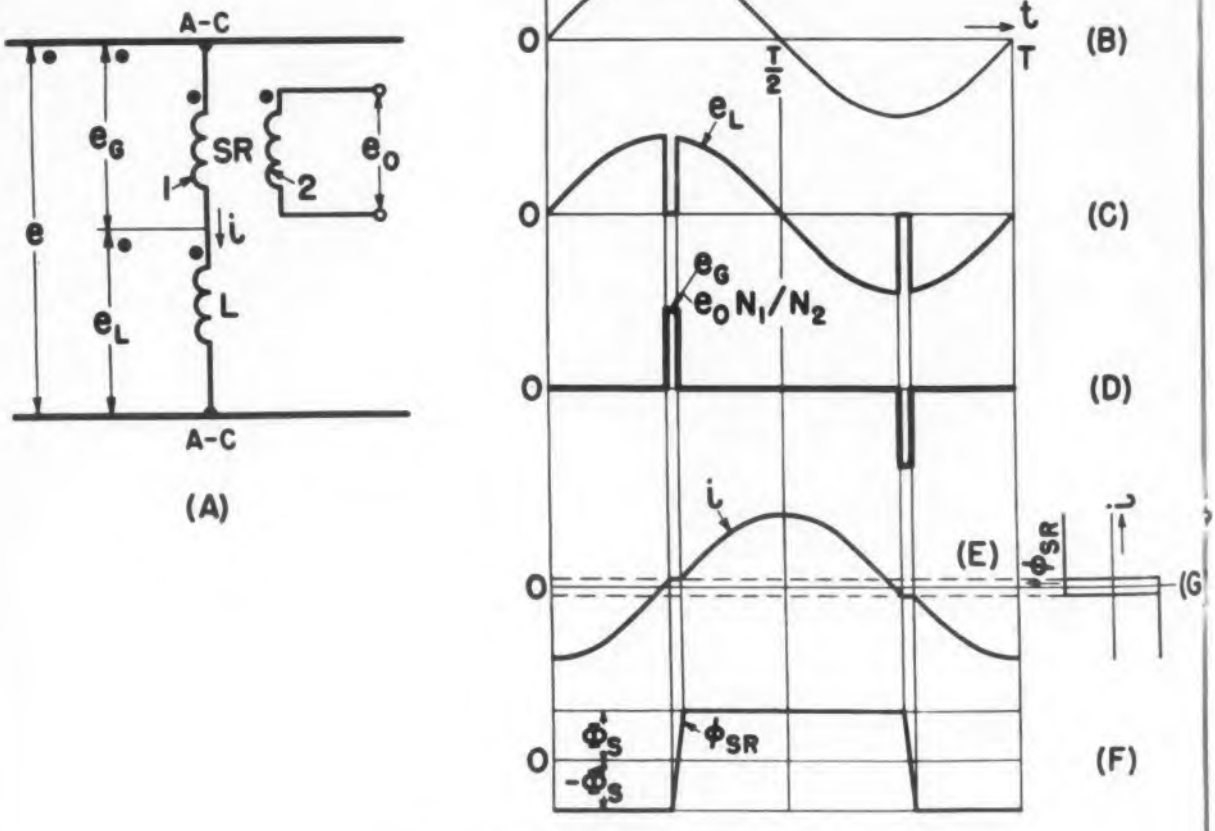

Fig. 4-1. Peaking Circuit. (A) Circuit diagram, (B) Supply voltage, (C) Voltage on inductor *L*, (D) Gate and output voltages, (E) Current in winding *1* of *SR*, (F) Flux in *SR*, (G) Flux-current loop for core of SR.

having the resonant frequency of the filter will flow in the load circuit. The filter is shock-excited so the high frequency voltage will be damped. This method of frequency multiplication was used in the early days of radio telegraphy where supply frequencies of 5 to 10 kc were available. These were stepped up by a factor of 15.

A linear capacitor in series with the inductor L of Fig. 4-1A increases the circuit efficiency to

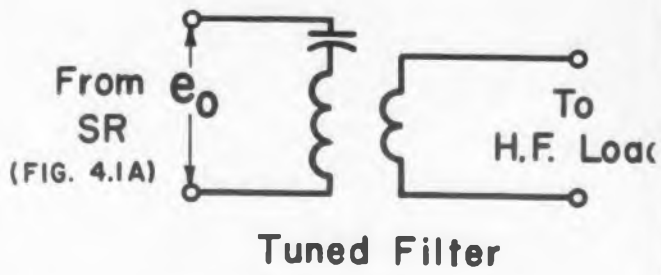

Fig. 4-2. Shows frequency multiplication through tuned filter.

50 per cent when multiplying the supply frequency by a factor of 47. (Ref 4-1).

References 4-2 to 4-8 discuss frequency multipliers which use multiple magnetic cores.

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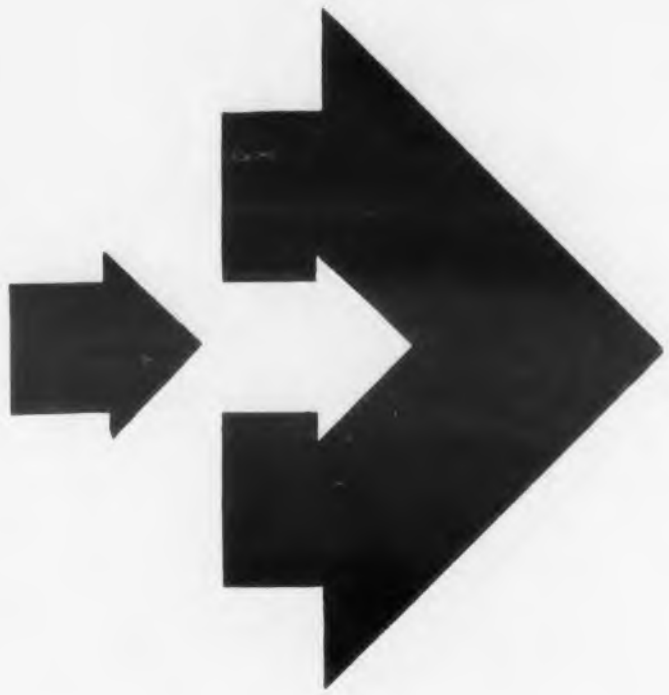


THE THYRISTOR

Loy E. Barton
RCA Laboratories
Princeton, N. J.

The Thyristor is a new transistor that behaves much like a thyratron. It can be triggered "on" and "off" with low power and has a collector voltage drop of only about 0.5 volts during conduction. It is almost a perfect switch having a collector current rise and fall time of less than 0.1 microsecond. Characteristics and circuit applications are described.

THE POINT contact transistor is well known for its greater than unity alpha and for its negative resistance characteristics—it sometimes made a better electronic switch than an amplifier. The junction transistor, however, except for specialized units, is stable and is normally used as a linear amplifier.

The Thyristor is stable at low collector currents and unstable for collector currents above a critical value. These characteristics between those of the point contact transistor and the junction transistor make the Thyristor a bistable unit and a most useful device for electronic switching and pulse applications.

The Thyristor, in part, is a modified version of the high frequency diffused base transistor as described by Lee.[1] The RCA Laboratories modified version has been found to have a new and novel characteristic, as discovered by the writer. As the collector current was increased to a critical value the alpha of the experimental transistor increased to a value greater than unity resulting in a high speed triggering action. Because of this thyratron-like characteristic this transistor was named the Thyristor. The small emitter, the close spacing of the emitter and collector, and the manner in which the collector is connected, give rise to a second alpha due to electrons passing thru the collector "P" type junction. This second alpha due to electrons is emitter-current sensitive and contributes to a total alpha, hole alpha plus electron alpha, greater than unity at critical collector currents.

This greater-than-unity alpha in conjunction with the base resistance is used to trigger the collector current. The low power applied to the base to trigger the collector current "off" or "on" is a very desirable feature of the Thyristor. Other features are that the collector-to-emitter resistance is very low for current "on" condition and no sustaining power is needed on the base to maintain the collector current "on" or "off." The above features, coupled with high-speed rise and fall of the collector current, permits the use of the Thyristor in high-speed electronic switches or relays.

It is the purpose of this paper to describe the Thyristor, and its characteristics, and to present several circuits that make use of these characteristics.

Construction of the Thyristor

The construction of an experimental model of the Thyristor is shown in Fig. 1. The germanium wafer consists of a thin base layer of "N" type germanium and a thicker layer of "P" type germanium. The "N" type base region is formed by diffusing an "N" type material into one surface of the "P" type wafer. A "P" type junction with respect to the "N" type layer is within the wafer. This junction is the Thyristor collector junction electrically connected to the collector terminal through the "P" type germanium and the alloyed connection to the "P" type germanium.

The small emitter is an alloyed "P" type junction on the outer face of the "N" type germanium layer. The base connection is soldered to the

[1]C. A. Lee, "A High-Frequency Diffused Base Germanium Transistor" Bell System Technical Journal, Vol. 35, pg. 23-34: 1957.

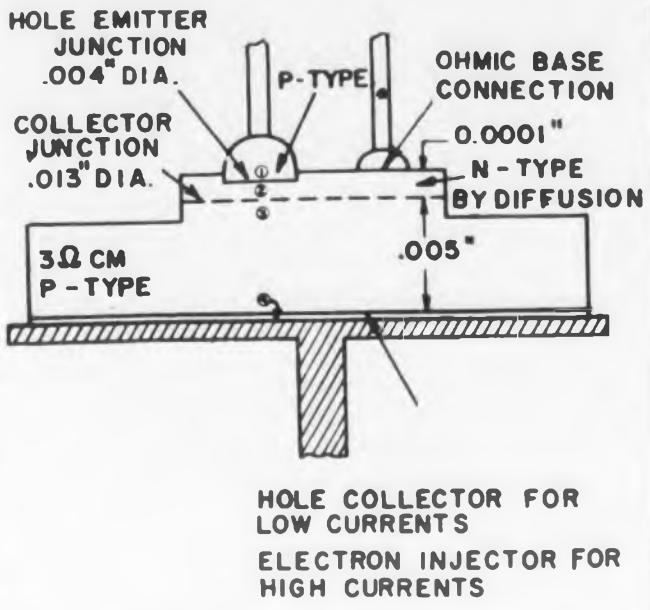


Fig. 1. Cross section showing construction.

outer face of the "N" type germanium at an appropriate distance from the emitter.

The sensitivity of the Thyristor as a triggering device depends upon several features of the transistor. Some of these features are, size of the emitter dot, thickness of the "N" type germanium layer, thickness of the "P" type germanium layer, and material, position, and size of the collector dot. The Thyristor used for the curves of Fig. 2 had an emitter junction about 0.004 inches in diameter. The "N" type layer was about 0.0001 inches thick. The "P" type germanium region was about 0.005 inches thick. A more complete and detailed description of the transistor may be found elsewhere.[2]

Characteristic Curves

A set of curves representing the characteristics of a typical Thyristor are shown in Fig. 2. It should be noted that the particular Thyristor selected for the above characteristic curves had a fair sensitivity, that is, the triggering of the collector current occurred at a relatively low collector current.

The curves were taken by varying the base bias and reading the appropriate voltages and currents. It is necessary that a collector current limiting resistor always be in the collector circuit. In the case of the curves in Fig. 2, the collector resistor was chosen to obtain the approximate desired collector current upon triggering.

[2]C. W. Mueller and J. Hilibrand, "The 'Thyristor,' A New High-Speed Switching Transistor," to be published in the Transactions of the IRE Professional Group on Electronic Devices.

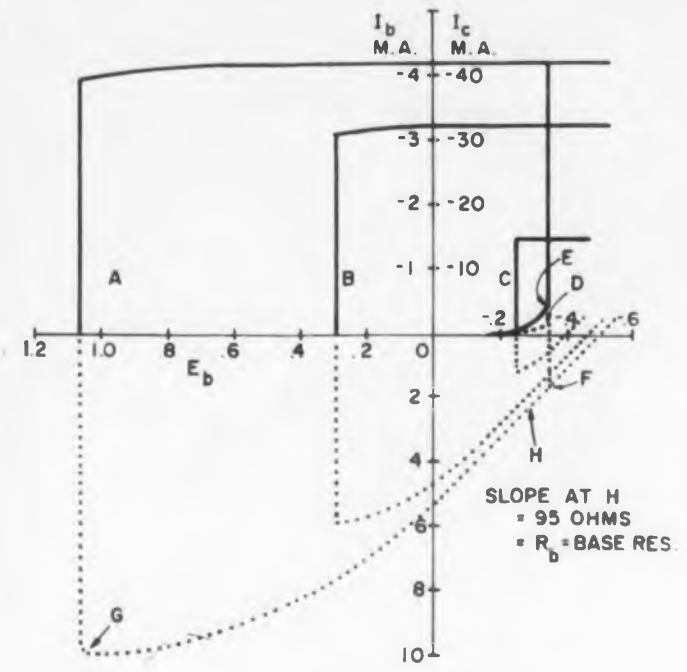


Fig. 2. Switching characteristics of the Thyristor.

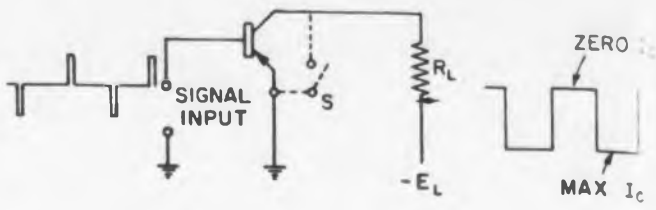


Fig. 3. The Thyristor as an electronic switch relay.

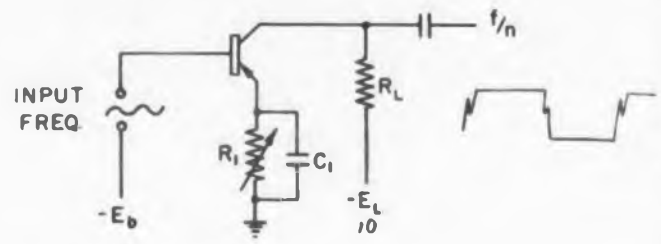


Fig. 4. The Thyristor as a frequency divider.

This resistor is the load resistance when the Thyristor is used as a switch or relay. The base current curves are mostly below the zero current horizontal line and are broken lines. The collector current curves are above the zero current line and are shown by solid lines.

Beginning with a zero base bias (E_b) an increase of forward bias to the right causes the collector current to start at about —0.2 volts. Further increase in base bias causes the collector current to rise to point E or about 4.5 ma. The base current has risen to about 0.2 ma at a corresponding point D. At this point triggering takes place.

The source resistance of the base bias supply was low so that the base supply voltage at point D remained constant. However, the base current reversed to a value at F. The base bias was then increased until the base current was zero. The voltage at this point corresponds to the floating potential that the base assumes when the transistor is in the triggered condition. At this zero-current point the base circuit may be opened without affecting the triggered collector current. A decrease of the base voltage causes a rise in base current as indicated by the curve at H. The slope of this curve is the approximate internal base resistance of the "Thyristor," and in this case was about 95 ohms.

To cut the collector current "off" for curve A the base bias is reduced to a reverse polarity of about one volt before the collector current triggers "off."

The curve B, for a lower collector current of 32 ma indicates a final internal base voltage of 0.27 volts. In this case the alpha due to holes is not zero so that the electron maximum alpha was less than unity. At the point of collector current cutoff the sum of the hole alpha and electron alpha was less than unity. This is necessary for collector current cutoff.

Note that the point at which the collector current is triggered "on" is the same for all triggered currents. This is true because the electron alpha when added to the hole alpha has increased to a total alpha greater than unity at a given emitter current and is independent of the final triggered current. The total alpha is also essentially independent of the collector voltage.

Thus, in all cases an input power of about 0.6 mw for one to two microseconds is needed to trigger the collector current "on." In the case of the 43 ma collector current, 15 milliwatts for one to two microseconds was needed to trigger the current "off." For a supply voltage of 10.5 volts the power switched was about 400 mw.

A corresponding figure for 32 ma was an input power of 4.8 mw to trigger the collector current "off" for a switched power of 300 mw. A corresponding figure for the 14 ma current was an input power of 0.28 mw for a switched power of 140 mw.

From the above it is obvious that transistors designed for lower sensitivity would be more suitable for switching large collector currents. Conversely, if low currents are to be switched, transistors with high trigger sensitivities are needed.

Circuit Applications

The use of the Thyristor as a switch requires a very simple circuit as shown in Fig. 3. The input power to the base for a control of the

transistor as a switch may be very small if a Thyristor is selected for the particular current desired. Results to date indicate that a Thyristor of the size and type described above, except less sensitive, may switch upwards of one ampere for low duty cycles. At one ampere the collector to emitter voltage drop may be as low as 1 volt. At a collector supply voltage of 50 volts the switched power would be 50 watts.

The speed of switching is limited by the Thyristor design and the input and output capacities. Since the high frequency response is good the rise and fall times below one tenth microseconds are easy to obtain.

The use of the Thyristor for frequency division is shown in Fig. 4. The circuit provides a self-excited switch or blocking oscillator having an output frequency near the divided frequency. The time constant of R_1C_1 in Fig. 4 largely determines the output frequency as a blocking oscillator. Assume the Thyristor is nonconducting and the charge on C_1 is zero. A base bias, E_b, of about —1 volt causes the collector current to trigger. The duration of the "on" current depends upon the time required to charge C_1 to a value to reduce or reverse the value of the base bias to collector current cutoff. The collector current will remain "off" until C_1 loses enough of its charge to permit the base bias to again trigger the collector current "on." Now, if a frequency f is applied to the base in series with the bias the collector current will be switched "on" at the nearest negative rf half cycle to the time that the collector current would normally trigger "on." The collector current would then trigger "off" at the nearest positive rf half cycle to the normal time for triggering "off." The output frequency then becomes a submultiple of the input frequency.

In general, R_1 is comparatively small (200 ohms or less) and the switched currents are of the order of 10 ma. The power output from such a divider is relatively high and may easily drive another similar divider without additional amplification.

Frequencies as high as 4 mc have been divided by a factor of 15 in a single stage without critical adjustments of R_1 or the signal input amplitude. It is obvious that division by numbers lower than 15 will require even less critical adjustments.

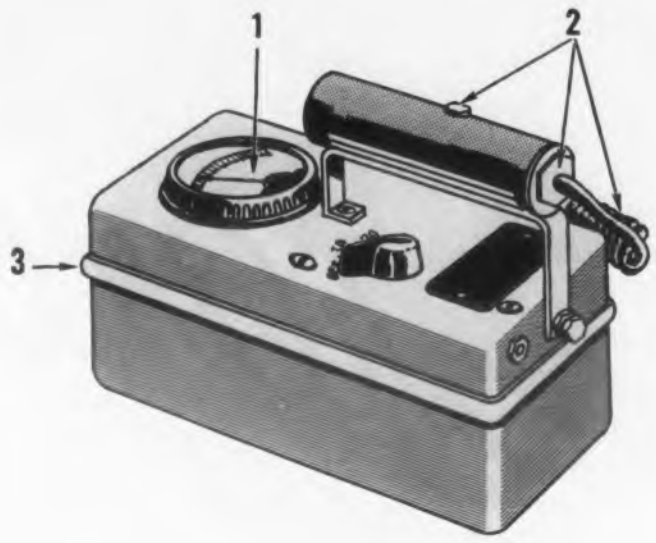
Ring counters, shift registers, and similar type devices may be made by using the Thyristor collector current triggering characteristics.

Acknowledgment

The writer wishes to acknowledge the cooperation of C. W. Mueller of the RCA Laboratories, and his associates, for providing experimental Thyristors which had the trigger collector current characteristics.

How to Minimize

Radar Effects on Electronic Circuits



Three sources of radar interference: (1) through meter window, (2) through external probes or connections, (3) difference in potential between sections of the case.

W. G. Egan

Ford Instrument Co.
Long Island City, N. Y.

High power radar transmitters have considerable effect on electronic circuits. Certain instruments, such as nuclear radiation survey equipment, are affected by pulse-type microwave radiation. When used near operating radar equipment they are subject to serious errors. Digital computers and nuclear scalers are also subject to triggering from radar pulses.

Many different types of circuits are affected:
a. Multivibrator Type (used with an extension probe containing a Geiger-Mueller tube, as well as another Geiger-Mueller tube contained within the body of the instrument). As would be expected, the multivibrator is triggered at the repetition rate of the radar transmitter. The triggering is caused by the flow of grid current on the triggered half of a two tube multivibrator circuit. This yields an upscale meter deflection but only in the highest field (at 20 feet). The radar pulses entered the radiac set (1) through the indicating meter window on the set, (2) by the external probe wire, and (3) by exciting the upper and lower halfs of the radiac set case (which were separated by a rubber gasket) to different electrical potentials. The size of the case and length of the mounting studs were such that a resonant cavity was created, and there was a sufficient electric field within the case near the sub-miniature multivibrator tube to cause triggering.
b. Dc amplifier (high impedance Wheatstone bridge-photomultiplier type with two tubes as arms). At a distance of 20 feet, there was half scale deflection of the meter. This unit had no external probe, and radiation (1) entered the meter window and (2) caused the two halfs of the case to be at different potentials. Rectification occurred when grid current flowed on the positive part of the microwave cycle. This voltage caused the bridge to unbalance. The phenomenon is complicated by the fact that the input leads to the tubes form, in some way, a distributed resonant circuit, or the tube elements actually form the resonant circuit.
c. Transistorized dc amplifier (ionization chamber type detector). Large upscale or downscale deflections of the meter occurred at 20 feet in the X and S bands where the electric field is 505 and 15700 volts/cm., respectively, depending upon orientation of radiac set with respect to radiation. This unit did not haxe an external probe. At 300 feet when the X and S band electric field were 34 and 1240 v/cm, only X-band radiation

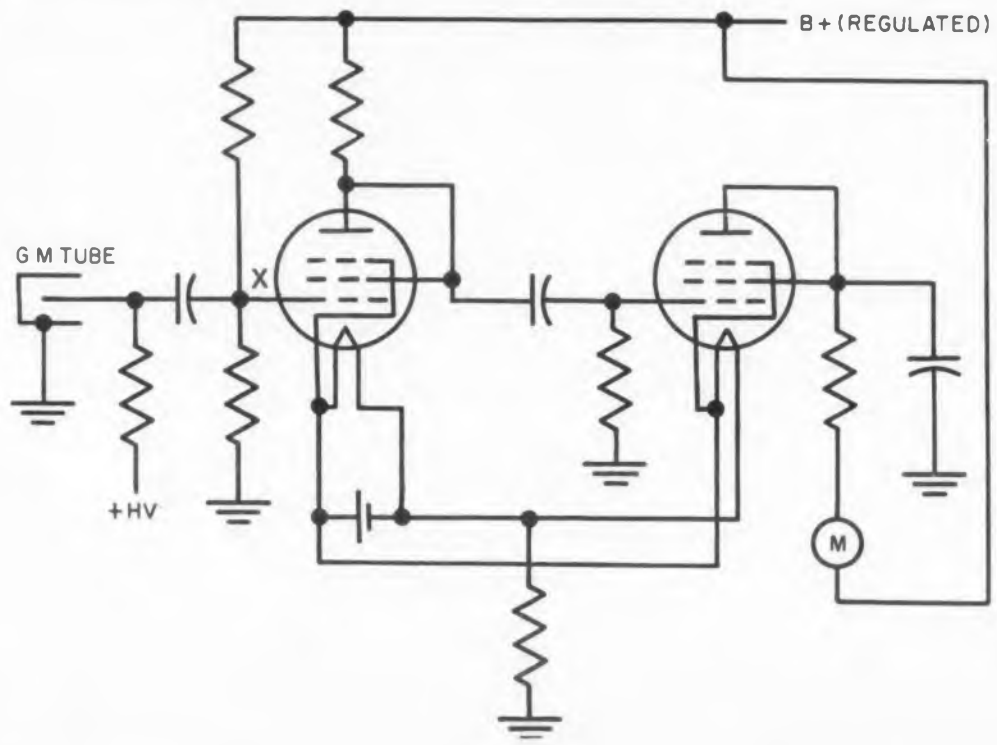


Fig. 1. Typical two-tube multivibrator circuit which may be triggered at the repetition rate of the radar transmitter. The triggering is caused by the flow of grid current at point x, due to rectification of the radar signal. This grid current flow causes a negative charge to accumulate on the grid (at point x) and trigger the circuit.

affected the instrument because it has a small case, and formed a resonant cavity only at this higher frequency. The radiation (1) entered this unit through the meter window and (2) caused the various sections of the four sectioned case to be at different potentials. The circuit effects are complicated by the relative effects of the rectification of the microwave fields within the unit by the emitter and collector circuits of the two transistors within.

d. Dc amplifier (very high impedance electrometer tube type connected to an ionization chamber). Large downscale deflections occurred (amounting to 65 per cent or full scale) at a distance of 20 feet, but only X-band radiation was effective at 300 feet, because of the small size of the unit as in c. The radiation (1) entered the set through the meter window and (2) caused the two sections of the set case to be at different potentials. Rectification occurred when grid current flowed on the positive part of the microwave cycle. This caused the downscale deflection, with the subminiature tube forming part of the distributed resonant circuit.

e. Pulsed Geiger-Mueller tube circuit. This circuit was unaffected by radar because it was active only for a short time (of the order of microseconds) a few hundred times a second, and since the circuit was not synchronized with the radar frequency, it was unaffected. In addition, the pulsing circuit within the set was low impedance, and not triggered by the radar.

Shielding the Meter Window

The effect of radar on circuits can be minimized by minimizing the radiations that enter the equipment. The amount of radiation that enters through the meter window may be decreased by the use of conducting glass for the meter window[2] or by using wire mesh across the meter window.[2, 3] A thin gold film is readily applied to the inside of the meter glass; however, it must form a good electrical contact with the case in order to be highly effective. For particular instrumental applications where visual acuity is less important, wire mesh or the Corning heating panel glass may be more suitable.

Good electrical conductivity is essential to microwave shielding, whereas this characteristic is not generally compatible with high light transmission. The microwave results are rather critically dependent on frequency and thickness of the material used. At the higher frequencies, the shielding effects of the film coatings are generally better. The greater the film thickness, the better the shielding because the film conductivity is greater. In general, thin films do not have the same volume resistivity as the bulk metal because of surface effects. It should be noted that the microwave attenuation is the result of both reflec-

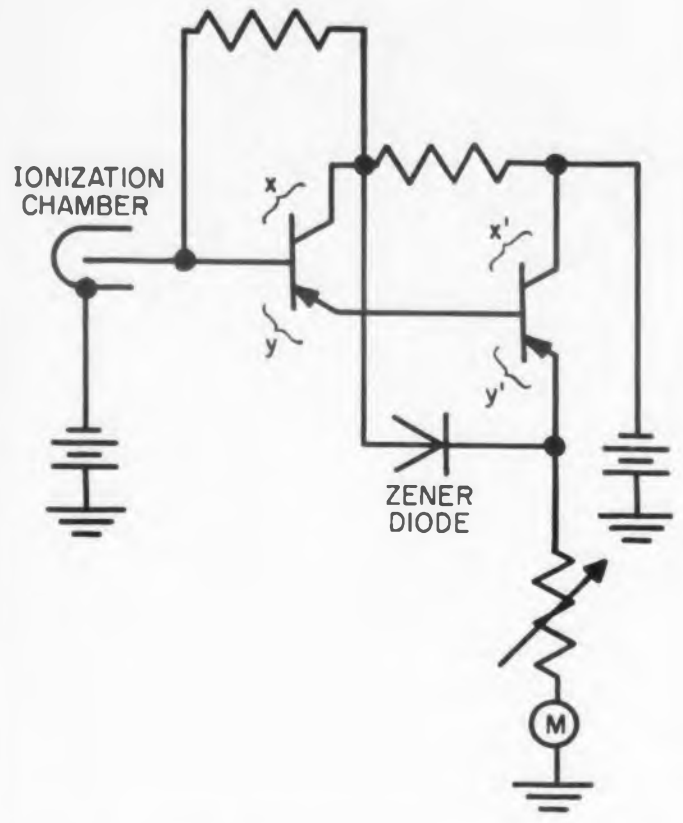


Fig. 2. Typical transistorized dc amplifier in which rectification of the microwave fields within the unit by the emitter (x,x′) and collector (y,y′) circuits of the transistors and diode circuit may occur. The rectification is similar to square law rectification.

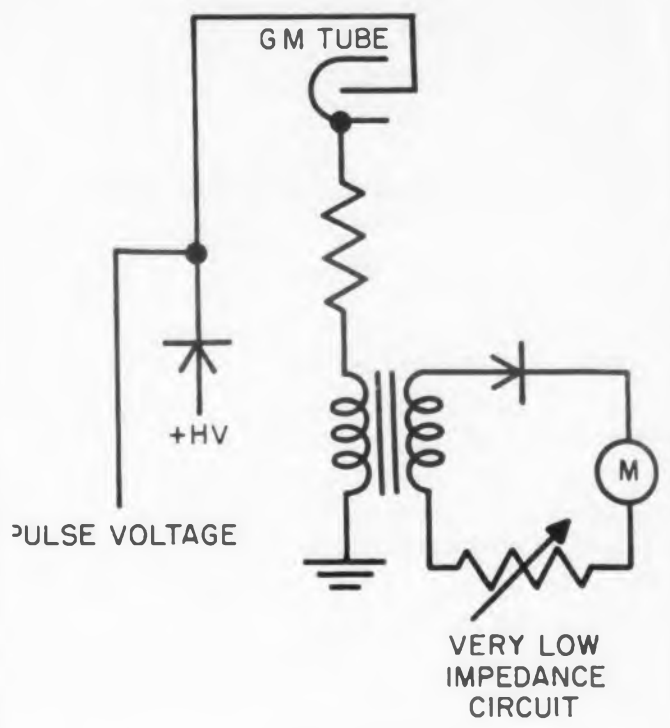


Fig. 3. Typical pulsed Geiger-Mueller tube circuit which is unaffected by radar because it is active for only a short time (of the order of microseconds). In addition, sensitive circuits are of low impedance, and comparatively insensitive to radar effects. The G-M tube was operated below threshold and responded to nuclear radiation only during the pulse voltage.

tion and absorption of microwave energy by various materials. The measurements were made by determining the insertion loss by inserting the material being investigated between the coupling flanges of the two wave guide sections. Thus, the attenuation measured is, in part, a function of the mis-match between the impedance of the conducting film. The dc values of the surface film resistivity are specified as a guide to judging the relation to reflection properties.

The effect of radiation causing potential differences between sections of the case can be minimized by using case materials of adequate thickness and conductivity and establishing a good connection between them with a conducting gasket.[4,5] Where watertightness is a consideration, a composite rubber and metallic gasket may be used. The gasket must have a very low resistance. Thus conductive rubber or plastic gaskets are unsatisfactory.

By-pass condensers are, in general, ineffective at microwave frequencies. A button type condenser checked at 10 kmc appeared as nearly a pure resistance of about 100 ohms. Where extensions or probes are used on equipment, careful grounding of the shield is necessary.

It is sometimes possible to enclose the entire unit in a wire mesh container to minimize radiation pickup sufficiently.

Reducing Radar Effects

Circuits which are active during only a small portion of the time are not subject to interference from radar; the probability of the radar pulse

cuit action is small. However, it is possible that the pulsing circuit in the instrument be triggered at the radar repetition rate. This, in itself, is not objectionable, but if this occurs, other circuit elements such as diodes, transistors or vacuum tubes may be affected by the radar fields existing within the case during the radar pulse, and result in erroneous readings. This assumes negligible recovery time from the circuit action caused by a radar pulse, and, in general, depends upon the circuit time constants for a particular circuit.

Multivibrator, electrometer, dc amplifier or transistor circuits can be shielded with a copper screen carrying case. This presents a problem if knobs are to be adjusted on the instrument, but the meters can be easily read through the wire.

Screen wire shielding is most effective at lower radar frequencies, whereas a metallic film type of shielding is considerably more effective at higher radar frequencies.

At higher radar frequencies, a Corning heating panel (or equivalent) material for the meter window may be used, as well as a conducting resilient gasket between case sections.

Where the microwave radiation is of the continuous wave type, with amplitude or frequency modulation, the present maximum radiated power is relatively less than the peak power of radar pulses, and the associated circuit effects are correspondingly less. However, a multivibrator type circuit will not necessarily be triggered, but the circuit bias values may be affected because of rectification effects. Similar bias changes could affect the operation of pulse-type circuits. These rectification effects can occur with the other nonlinear devices (transistors, diodes, electrometer and vacuum tubes). Nevertheless, the same shielding considerations outlined above apply. It may be remarked that the shielding properties of the various materials described for continuous radiation are nearly the same as those for pulse modulation. Exceptionally thin shielding films have nonlinear, semiconducting properties which depend on the method of preparation, and the shielding properties would be better for pulse-type, high-power radiation.

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NEW PRODUCTS

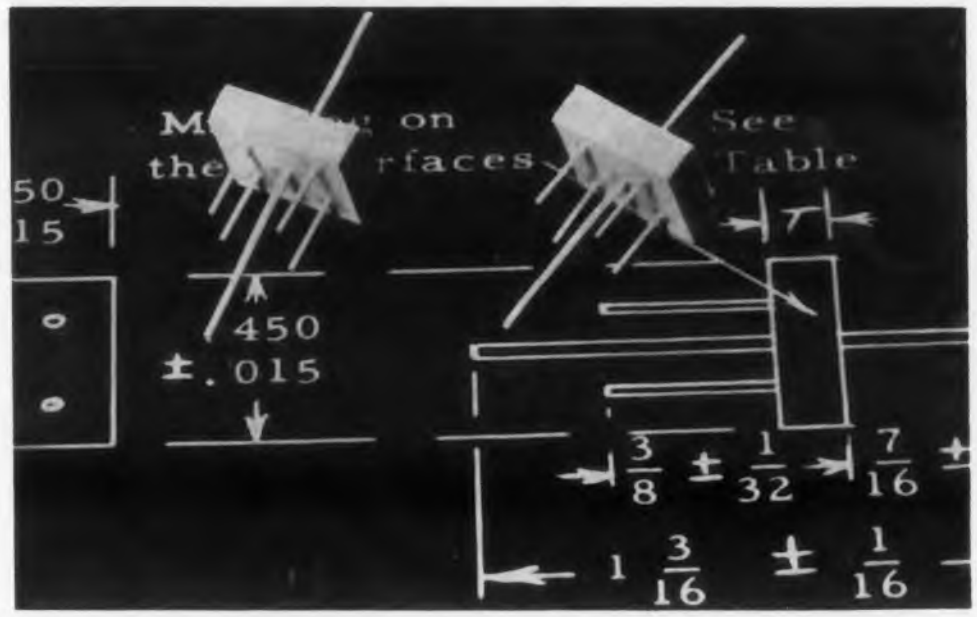
To provide a complete coverage of ALL new products generally specified when designing electronic original equipment, the New Product section has been extended. To include the largest number of items, products which are best suited to a brief description have been noted at the end of the section.

TRANSISTOR COLD PLATE

Used to dissipate heat generated in power resistors, the U-521330 cold plate provides good control of junction temperature. Heat generated by the power transistors is transferred across a pressure thermal contact to the cooling air ducted through the cold plate. The air flow is given as 7 lb per min, causing a pressure drop of 0.25 in. H_2O. The temperature drop is 1.5 C per watt. The aluminum cold plates are bonded by a dip braze method for light weight and maximum heat transfer. The cold plates can be used individually or assembled into manifolded banks.

United Aircraft Products, Inc., Dept. ED, 1116 Bolander Ave., Dayton, Ohio.

CIRCLE 56 ON READER-SERVICE CARD



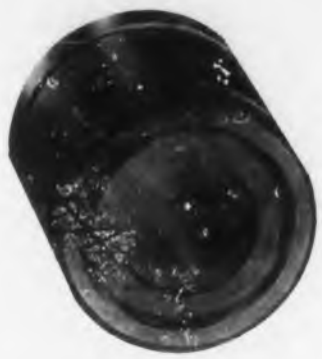
COAXIAL CAPACITOR

Axial design and use of rugged materials give this capacitor very stable, low inductance characteristics. The position of the four terminals, each attached to a separate electrode, allows a radial flow of current. This geometry results in a cancellation of magnetic fields and consequent low effective inductance.

The use of porcelain dielectrics and fine silver electrodes in a vitrified body enable a temperature coefficient rating of 115 ±25 ppm per deg C, through a temperature range of —55 to +125 C. Capacitance drift is 0.05 per cent and Q is greater than 2500.

Vitramon, Inc., Dept. ED, Box 544, Bridgeport 1, Conn.

CIRCLE 57 ON READER-SERVICE CARD

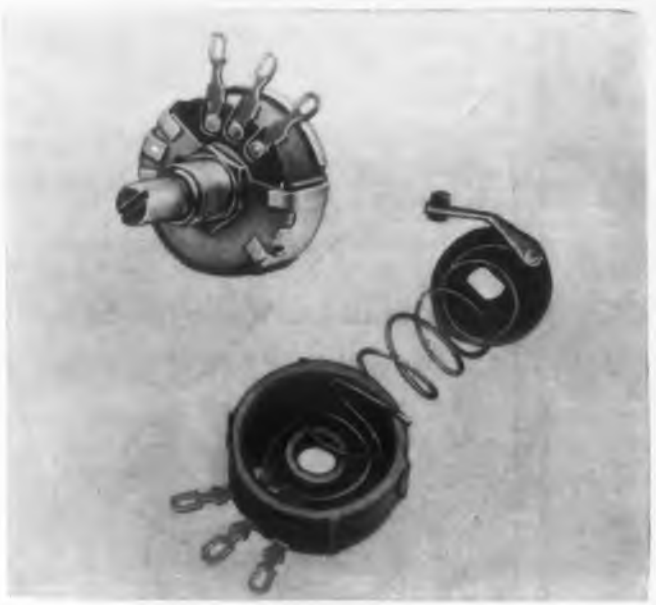


INSTRUMENT BEARING

The extremely low friction of this ball bushing is made possible by a re-circulating ball principle, providing unlimited linear travel. Threshold sensitivity is such that the bearing will roll down a shaft at an angle of one minute or less. Outside diameter of the INST-4812 ball bushing is 1/2 in. The unit weighs 0.02 lb and takes a rolling load of 13 lb.

Thomson Industries Inc., Dept. ED, Manhasset, N.Y.

CIRCLE 58 ON READER-SERVICE CARD



POTENTIOMETER

Only one moving point of contact serves to greatly reduce noise in this molded composition potentiometer. The conventional wiper arm collector has been replaced by a beryllium copper spring, directly connecting the contact arm to the center terminal. Rotational life is given to be over one million cycles, with an overall resistance change of 6.3 per cent. The potentiometer meets the Y specifications of MIL R-94B, and is available in all tapers with either standard or locking bushings.

Reon Resistor Corp., Dept. ED, 117 Stanley Ave., Yonkers, N.Y.

CIRCLE 59 ON READER-SERVICE CARD

(Left to Right) Frank Marshall, Assistant Engineer, Arthur H. Wulfsberg, an Assistant Director of Research & Development, and John Sprengeler, Project Engineer, discuss the use of a General Electric GL-6442 in a power amplifier assembly which is part of the AN/ARN-46 receiver-transmitter unit shown in center foreground.

Disassembled power amplifier from AN/ARN-46. A G-E GL-6442 is used in each of 3 such amplifiers within the TACAN receiver-transmitter unit.

Collins Airborne TACAN Uses General Electric GL-6442 For Reliable Performance

EXCEPTIONAL performance characteristics of General Electric tube type GL-6442 are contributing significantly to the accurate and reliable performance of Collins TACAN equipment, which is capable of operation at altitudes over 70,000 feet.

TACAN provides the military or civil pilot with continuous, precise distance and bearing information for navigation at ranges up to about 200 miles.

The pressurized receiver-transmitter unit of the equipment employs five G-E GL-6442's—ceramic, disc-seal triodes of planar construction—in the frequency multiplier and power amplifier systems. Three of the tubes are used in the pulse-modulated final amplifier. These tubes are mounted in coaxial resonators, tunable over a 1025-1150 mc. range. More than 1 KW peak power output is obtained.

Designed primarily for use in grounded-grid cavity circuits as a plate pulsed oscillator or amplifier up to 4000 mcs., the tube is also useful as a continuous-wave RF power amplifier, oscillator, or frequency multiplier up to 2500 mcs. Typical operation in plate-pulsed oscillator service at 3500 mcs. produces 2 KW peak power output with an average power input of 7.5 watts and a duty cycle of 0.001.

Ratings for other classes of service available on request. For full information on Type GL-6442, call your regional G-E power tube representative. *Power Tube Dept., General Electric Co., Schenectady 5, N. Y.*

Progress Is Our Most Important Product

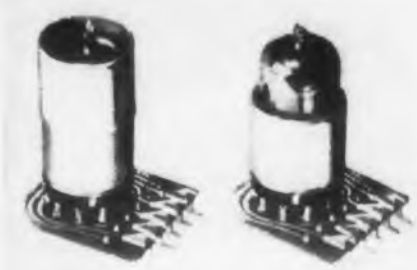
GENERAL ELECTRIC

9545-8481-6

NEW PRODUCTS

Shielded Right-Angle Sockets

Shield is integral part of assembly



Being an integral part of 9 right angle sockets, this tube shield cannot be lost or misplaced when servicing the socket or installing a new tube. The tube shield is telescopic with a bayonet locking feature to maintain it in the raised position. The upper half is disengaged and lowered to remove the tube. The right angle shielded sockets are designated as the 7 PC-IS and 9 PC-IS series. Base material of the sockets is 1/16-in. XXP phenolic with 0.00135 copper capable of carrying 6-1/2 amp.

Cleveland Metal Specialties Co., Dept. ED, 1783 E. 21st St., Cleveland 14, Ohio.

CIRCLE 62 ON READER-SERVICE CARD

Blocking Oscillator Series

Rise and Fall Time of 0.04 μSec

These transistorized blocking oscillators have minimum pulse widths of 0.2 μsec, with rise and fall times down to 0.04 μsec. These oscillators work with up to 30 v power input, designs being easily altered for varying input voltages. Pulse repetition rates are up to 800 kc per sec. Amplitudes are approximately 40 per cent of the applied voltages.

Epsco Components, Dept. ED, 588 Commonwealth Ave., Boston 15, Mass.

CIRCLE 63 ON READER-SERVICE CARD

◄ CIRCLE 61 ON READER-SERVICE CARD

Microsyn Signal Generators

Linearity of 0.5 Per Cent

Different models of temperature compensated generators are available with 1/2 per cent linearity and allowable angular rotation up to ±20 deg. Sensitivities are available up to 8 v per deg with a signal to noise ratio better than 0.01. They measure 1-3/8 in. od by 0.4 in. length, and are nominally supplied for 26 v input and a frequency range of 400 to 5000 cps.

Luther Mfg. Co., Dept. ED, 7312 Varna Ave., North Hollywood, Calif.

CIRCLE 64 ON READER-SERVICE CARD

Solenoid Ball Valve

Manual reset type with extreme temperature range

This 2-way, 2-position ball valve allows unrestricted straight-thru flow with an equivalent orifice of 1/4 in. diam and 3/8 in. tube size. It is available in pressures up to 4500 psi with a temperature range of −300 to +300 F. A momentary electrical surge of approximately 2-1/2 amp is required for actuation. A 24 v dc solenoid is furnished. Easy access to the manual reset lever arm is provided. The valve can be supplied either normally open or normally closed and may be used for most hydraulic or cryogenic applications.

Pneu-Hydro Valve Corp., Dept. ED, 364 Glenwood Ave., East Orange, N.J.

CIRCLE 65 ON READER-SERVICE CARD

CIRCLE 66 ON READER-SERVICE CARD ➤

redesigning?

1/3 the panel area, same scale length

* MODEL 1145

side indicators

* MODEL 1135

* MODEL 1120

Save space on crowded, complex panels *without* sacrificing readability or accuracy. Model 1145 provides accuracy and scale length of conventional 4½" meters with ⅓ the panel area and far less weight . . . Model 1135 compares with conventional 3½" meters. For horizontal or vertical mounting. Feature dust-proof cases with clear plastic covers. Center, top or bottom zero position and other variations so pointer movement will conform with "human engineering" principles. Side indicator panel meters are an original International Instruments development, and *only* International offers you a complete line with scale lengths of 2.7", 2.1" and 1.2"! Supplied in a wide variety of standard and special ranges.

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AT THE I.R.E. SHOW

WRITE NOW FOR ENGINEERING DATA SHEETS

. . . on Side Indicators and also on our 1½" Ruggedized Meters, 1" and 1½" Panel Meters, VU, DB and Illuminated Meters, and Miniature Multitesters. Sub-miniature Rotary and Lever Switches.
P.O. Box 2954, New Haven 15, Connecticut.
Cable: "INTERINST"

*PAT. PENDING

MINIATURIZATION HEADQUARTERS

international instruments inc.

CIRCLE 67 ON READER-SERVICE CARD

NEW PRODUCTS

Output Transformers

Secondary winding brought out as separate sections

Eight models of the P5000 series of transformers are available with ratings of 35 and 50 w. The secondary winding of these transformers brought out as four separate sections which may be connected in series or parallel to match impedances of 0.95, 3.8, 8.5 and 15 ohms, thus ensuring that the complete secondary is utilized. At the full power rating, these units have 1 per cent distortion at 50 cps.

Swedgal Electronics, Dept. ED, 258 Broadway, N.Y. 7, N.Y.

CIRCLE 68 ON READER-SERVICE CARD

Frequency Transducer

Voltage output proportional to frequency input with 0.5 per cent accuracy

The Megacycler, a precision frequency and pulse rate transducer, produces a dc output current or voltage which is directly proportional to the input frequency. With temperature variations from −60 to +100 C, the Megacycler will maintain an output accuracy and linearity of better than ±1/2 per cent of full scale.

Four standard models cover the audio range to 4000 cps. Model MC125-A, as an example, has a range of 0 to 30 cps up to 0 to 125 cps (Frequency range is varied by an attenuator.) Full output of 5 v dc can be obtained at any desired full scall frequency between 30 and 125 cps. All models are assembled in a drawn steel can measuring 1-3/4 x 1-5/16 x 1-5/16 in.

Pioneer Magnetics Inc., Dept. ED, 5858 Wilshire Blvd., Los Angeles 36, Calif.

CIRCLE 69 ON READER-SERVICE CARD

Cooling Unit

Integral part of equipment

Mounted on a lightweight, but structural 20 x 24 in. honeycomb base, this cooling unit is designed as part of a container that holds equipment sealed in a gaseous environment at a constant pressure of 20 psia. This particular unit provides a net cooling capacity of 1.5 kw at 50,000 ft. Two fans and a heat exchanger complete the cooling unit. One fan circulates nontoxic sulfur hexafluoride through the heat exchanger and over the electronic equipment within its pressurized container.

The Garrett Corp., Airesearch Mfg. Div., Dept. ED, 9851 Sepulveda Blvd., Los Angeles, Calif.

CIRCLE 71 ON READER-SERVICE CARD

Encapsulated Precision Resistors

In accuracies to 0.001 per cent

Previously available in a sealed oil-bath construction, these encapsulated resistors are available in resistance tolerances to 0.0025 per cent relative or 0.005 per cent absolute, with temperature coefficients of resistance of 2.5 ppm per deg C absolute or 0.7 ppm relative. Units can be furnished trimmed under specified ambient temperature and dissipation level and to track over MIL specification temperature ranges, such as to 0.01 per cent from −45 to +85 C.

Julie Research Labs., Inc., Dept. ED, 556 W. 168 St., New York 32, N.Y.

CIRCLE 72 ON READER-SERVICE CARD
CIRCLE 73 ON READER-SERVICE CARD ➤

What's under her hat?

It isn't an earring. It's an ACESET® . . a micro-miniature, precision, wire-wound potentiometer featuring small pot size with big pot performance! Only ½" in diameter and 5/16" in body length, the ACESET excels in a combination of all around top performance characteristics. Heat dissipation, for example, is 2 watts at 60° C. Other specification information is listed below.

Improved performance at lower cost has been achieved in these micro-miniature units by mass producing to standard specifications. You can select from nine different resistance values between 100 and 25,000 Ohms. Shipments are guaranteed within 24 hours of receipt of order. Call, wire or teletype Dept. G, at Ace Electronics Associates, Inc., 99 Dover Street, Somerville, Mass. SOmerset 6-5130. TWX SMVL 181

MECHANICAL SPECIFICATIONS	ELECTRICAL SPECIFICATIONS
One piece precision-machined metal case	Heat Dissipation: 2 watts at 60° C.
Passivated stainless steel shaft	Voltage breakdown: 1,000 VDC
Self-contained locking device	Electrical Angle: 325° nominal
Panel anti-rotation pin	Temp. coefficient of resistance wire: 20 ppm
Mechanical rotation: 330° nominal	Resistance tolerance: ± 10%
Size: ½" diameter x 5/16" body length	Linearity: ± 5%

ACEPOT®
ACETRIM®
ACESET®
ACEOHM®

ACE ELECTRONICS ASSOCIATES, INC.

CIRCLE 74 ON READER-SERVICE CARD

NEW PRODUCTS

200 C Capacitors

Insulation Resistance 10^{13} Ohms

The dielectric material used in the low voltage HT-4 capacitor offers high quality in a small unit. Insulation resistance of 10^{13} ohms at 25 C enables holding charge for long periods without derating. Operating temperature without derating is −55 to +200 C. Capacitance ratings are 0.001 to 0.1 μfd, voltage rating up to 50 v dc, and tolerance is as low as ±1 per cent.

Balco Research Labs, Inc., Capacitor Div., Dept. ED, 49 Edison Place, Newark, N.J.

CIRCLE 75 ON READER-SERVICE CARD

Accelerometer

Tests small component acceleration down to 0.01 g

Operating on the electrokinetic principle, type 4-242 accelerometer is designed to sense dynamic accelerations down to 0.01 g from 25 cps to 80 kc. The instrument produces flat response between 50 cps and 60 kc. It accurately senses vibratory acceleration and shock up to 1000 g, with reading not affected by 200 g steady acceleration. The pickup itself withstands overloads of 5000 g without damage. It will operate at temperatures from −10 to +140 F. Transverse response of the type 4-242 in the plane perpendicular to the sensitive axis is less than 1 per cent of response in the sensitive axis.

The unit operates by means of a polar fluid acting as a seismic mass, which is contained in a cylinder partitioned laterally by a porous-ceramic disc and closed at both ends by flexible diaphragms. As vibratory acceleration or shock occurs, a minute flow of the fluid is forced through the porous ceramic partition. This creates an electrical output equivalent to the instantaneous acceleration.

Consolidated Electrodynamics Corp., Dept. ED, 300 N. Sierra Madre Villa, Pasadena, Calif.

CIRCLE 76 ON READER-SERVICE CARD

Receiving System

Primarily for use in antenna pattern measurements, this receiver covers the range from 30 mc to 75 kmc. The system will be displayed at the coming IRE Show.

Designed for application in antenna pattern measurements, the series 402 receiver has a linear dynamic range exceeding 40 db and sensitivities greater than —90 dbm at 30 mc and —70 dbm at 75 kmc. A feature of the receiver system is that no waveguide connections from the antenna to the receiver are required. A receiving antenna may be located up to 75 ft from the receiver with negligible loss in sensitivity even at 75 kmc.

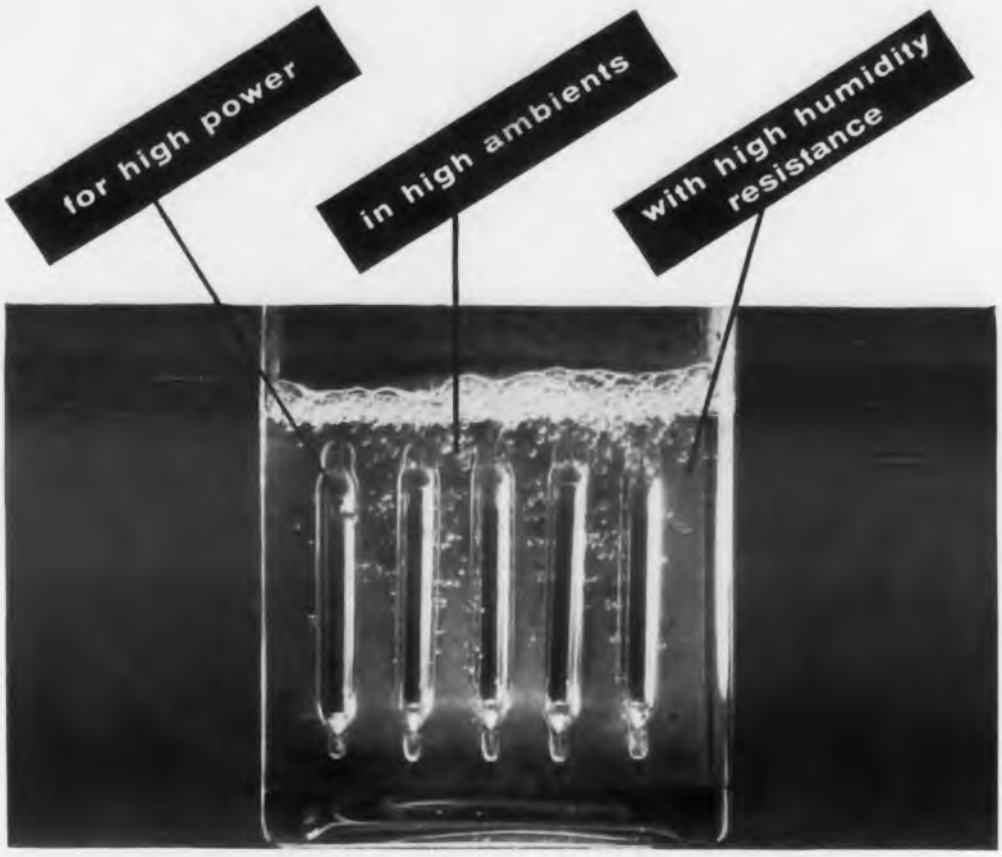
Operation is as follows: A Carcinotron oscillator, voltage-tunable over the frequency range of 2 to 4 kmc, serves as the local oscillator. For receiver operation between 2 and 75 kmc, the oscillator signal is fed through a coaxial cable to a simple crystal mixer at the terminals of the antenna under test. The local oscillator is tuned such that its frequency or one of its harmonics generated by the crystal heterodynes with the received signal to provide an intermediate frequency of 65 mc. This i-f signal, whose amplitude is proportional to that of the received signal, is returned through the same coaxial cable to the i-f amplifier.

The Carcinotron is swept in frequency at a 1000 cps rate over a range of several megacycles. The heterodyne mixer output is consequently swept through the pass-band of the i-f amplifier with a sweep width somewhat greater than the i-f bandwidth. The resulting audio modulation of the i-f signal is detected by a bolometer and the detected signal is fed to an antenna pattern recorder or other indicating device. A crystal detector is used a provide a signal for the cathode ray oscilloscope and the afc circuit.

Sweeping of the local oscillator makes the receiver insensitive to drifts of the transmitter and local oscillator frequencies so long as the received signal is included within the swept frequency interval. An afc system which operates over the full dynamic range of the receiver prevents detuning for larger frequency drifts.

Scientific-Atlanta Inc., Dept. ED, 2162 Piedmont Rd., N.E., Atlanta 9, Ga.

CIRCLE 79 ON READER-SERVICE CARD



VICTOREEN ULTRA-STABLE FILM TYPE RESISTORS

Who ever heard of boiling water with resistors? Though they're obviously not designed for this purpose, Victoreen ultra-stable film type resistors *can* do it. What's more they stand up under this abuse.

The "boiling water test" does prove *conclusively* the high power . . . high humidity resistance . . . stable operation in high ambients—of Victoreen resistors. And you get all these desirable qualities in Victoreen *precision* resistors—Victoreen models RX-4 and RX-5.

	MODEL RX-4	MODEL RX-5
Resistance	200 ohms to 50 megohms	200 ohms to 200 megohms
Tolerance	1, 2, 5, 10%	1, 2, 5, 10%
Size	.413 dia. x 2" long	.413 dia. x 3 1/16" long
Power	5W at 150°C 3W at 225°C	10W at 150°C 5W at 250°C

Stability—±4% for 1000 hours guaranteed life at rated power

If you have an application requiring precision resistors for operation at high power with high stability in severe ambients, it will pay you to check with Victoreen first. AA-7083

Victoreen's Ultra-Stable Film Type Resistors will be on display at the IRE SHOW BOOTH 2232

The Victoreen Instrument Company

Components Division

5806 Hough Avenue • Cleveland 3, Ohio

CIRCLE 81 ON READER-SERVICE CARD

Differential Meter Relay

Serves as Control Device

SIGNAL comparison and control are both provided simply and effectively by a new circuit using a differential contact meter relay. This relay has two moving coils instead of one. They are polarized so that the indicating pointer shows either the sum of, or the difference between the signals reaching the two coils. Two adjustable pointers are preset at high and low signal limits.

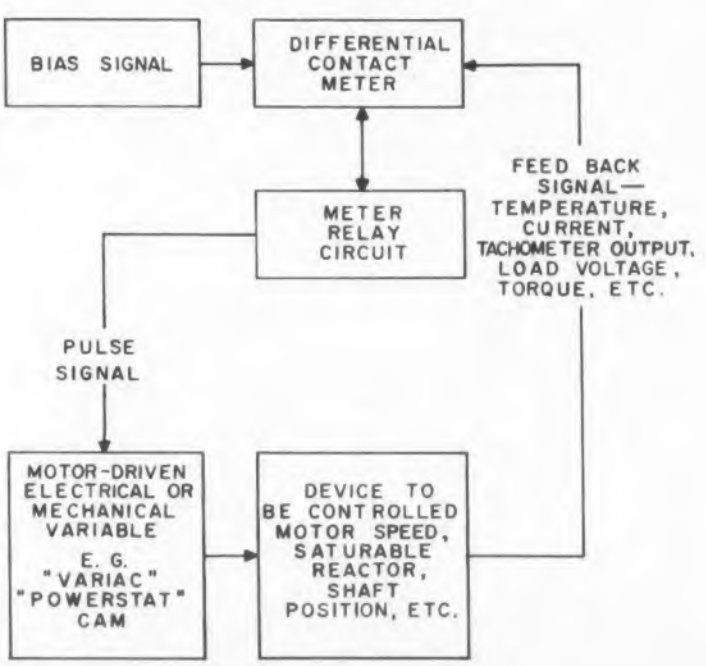
The circuit performs the same function as a closed loop pulse servo, but much more easily. Developed by Assembly Products Inc., of Chesterland, Ohio, it is probably the first control circuit to apply feedback directly to a meter relay to guide control action.

In the usual programming setup, the moving coils are wired so the indicating pointer shows the sum of their signals, and the low adjustable pointer is set at the level of a bias signal.

The bias and the feedback from the controlled device comprise the total signal to the indicating pointer. The feedback directly reflects the control being exercised. If the bias is reduced, the indicating pointer meets the low adjustable pointer and their contacts lock. As the bias decreases, the meter relay tries to make up the difference by increasing the signal to the other moving coil. Since this latter signal is fed back from the controlled device, it indicates that a change corresponding to the signal increase has occurred in the action of the device.

For more information, turn to the Reader's Service Card and Circle **82.**

IRE booths 3815-3817.



Block diagram of a typical programming circuit.

CIRCLE 310 ON READER-SERVICE CARD for Ohmite ➤

New Xenon-filled Westinghouse THYRATRON TUBES fit 90% of new equipment needs!

CHARACTERISTICS:

TUBE TYPE	FILAMENT Volts	FILAMENT Amps	VOLTS PEAK Inverse	VOLTS PEAK Forward	ANODE AMPS Peak	ANODE AMPS Avg.	HEIGHT	DIAMETER
WL5796	2.5	8.5	1500	1500	20	1.6	5½"	1 9/16"
WL5877	2.5	10.8	1500	1500.	40	3.2	5⅞"	1¾"
WL5878	2.5	21	1500	1500	80	6.4	6⅛"	2 3/16"

Compact new design saves space, gives superior performance and uniform quality!

For motor controls, firing ignitrons, inverter service or any other new industrial or military equipment need—you'll find new Westinghouse Thyratrons the most advanced you can use. They meet NEMA and EIA specifications for control applications and have the following characteristics:

- 12 to 1 peak to average anode current rating.
- 1,500 volt forward and inverse voltage rating.
- 15 second averaging time.
- Operate in broad ambient temperature limits (—55° to 70°C)
- Fast cathode heating time.
- Small compact construction.

YOU CAN BE SURE...IF IT'S

Westinghouse

Electronic Tube Division Elmira, N.Y.

To see how Westinghouse Thyratrons can fill your design requirements, write today for detailed data. Westinghouse engineers will be glad to consult with you, if you wish. Sample orders available for immediate shipment.

CLIP AND MAIL COUPON NOW

COMMERCIAL ENG. DEPT., ELECTRONIC TUBE DIV. WESTINGHOUSE ELECTRIC CORP. Elmira, N. Y.

Please send me full information on the following Thyratron Tube (s):

—WL5877 —WL5878 —WL5796

NAME_____

TITLE_____

COMPANY_____

ADDRESS_____

CIRCLE 312 ON READER-SERVICE CARD

VT Variable Transformers
Continuously adjustable auto-transformers. Unique Ohmite features for reliable service.

Relays
Compact relays in many types. For AC or DC. Power-handling and multiple circuit varieties.

The main ultramodern Ohmite plant contains 170,000 square feet and is one of the largest completely air conditioned plants in the Midwest. Manufacturing areas, laboratories, warehousing, and offices are housed in one efficiently integrated design, thus keeping all phases of production under direct control for service and quality.

Tap Switches
Ceramic insulated selector switches in many sizes for AC use up to 100 amperes. Single or tandem.

Resistors
Vitreous enameled power resistors in tremendous variety of types and sizes.

OHMITE®

Precision Resistors
Encapsulated and other wire-wound close tolerance resistors. Unique Ohmite Metal Film precision resistors.

R. F. Chokes
Radio-frequency chokes in many sizes for 3 to 520 megacycle applications. Single-layer wound.

Resistors

Rheostats

Tap Switches

Relays

Tantalum Capacitors

Variable Transformers

R. F. Chokes

NEW CATALOG
and Engineering Manual

Here it is . . . The new, complete Ohmite Catalog 58! Contains detailed information on Ohmite Resistors, Rheostats, Relays, Tap Switches, Tantalum Capacitors, Variable Transformers, and R. F. Chokes. There are 190 pages of useful tables of ratings, graphs, dimensional drawings, illustrations, and engineering data. Catalog 58 is more than twice as large as the previous catalog. The wealth of information it contains will make it an authoritative reference in the electrical and electronic industries, and a valuable addition to your technical files.

Write on company letterhead for *your personalized* copy.

OHMITE MANUFACTURING COMPANY
3637 Howard Street, Skokie, Illinois

Rheostats
Complete range of vitreous-enameled close control power rheostat-potentiometers. Single or tandem. Many additional features.

Tantalum Capacitors
Sub-miniature wire-type in several styles. Several sizes of foil-type. High performance in minimum space.

STATISTICAL COMMUNICATION TECHNIQUES and SPACE TECHNOLOGY

The transmission of information to the earth from a ballistic missile or a space vehicle presents unusual problems in communications. With severe limitations on equipment size and power, the communication system must operate in the presence of receiver noise and interference from the radio environment, including terrestrial sources and, for longer ranges, sources in space. Statistical communication techniques are valuable tools in achieving reliable communications under these difficult conditions. These techniques, by providing means for coding and decoding information and for determining the amount of information which can be sent, make possible the use of low-strength signals which otherwise could not be sorted out from the background of interference and noise.

The statistical approach is also important in the development of systems with a high degree of immunity to electronic countermeasures. The less regular or predictable the nature of transmitted waveforms, the less likelihood there is that interference will prove effective against the communication system. However, it is necessary to design the system to take maximum advantage of the near-random waveform characteristics.

Future space vehicles inherently will impose greater demands on communication systems. Systems for guidance, tracking, and data transmission through space to the moon or the nearer planets are now real goals in space technology. In the development of such systems, statistical communication techniques can be expected to play a significant role.

At Space Technology Laboratories, both experimental and analytical work are proceeding in the application of statistical techniques to the problems of space vehicle electronics. This work illustrates the advanced research and development activities in STL's Electronics Laboratory and the emphasis upon the application of new techniques to the requirements of space technology.

Both in support of its over-all systems engineering responsibility for the Air Force Ballistic Missile programs, and in anticipation of future system requirements, STL is engaged in a wide variety of research and experimental effort. Projects are in progress in aerodynamics, propulsion, structures, and electronics.

The scope of activity at Space Technology Laboratories requires a staff of unusual technical breadth and competence. Inquiries regarding the many opportunities on the Technical Staff are invited.

SPACE TECHNOLOGY LABORATORIES

A Division of The Ramo-Wooldridge Corporation

5730 ARBOR VITAE STREET • LOS ANGELES 45, CALIFORNIA

Couplings

Handle 5 deg misalignment

These couplings will accommodate angular misalignment of driving and driven shafts up to 5 deg, parallel offset to 0.01 in. and axial end play up to 0.09 in. They can transmit torques up to 150 oz-in., permit speeds to 10,000 rpm, and provide high torsional rigidity. Couplings are bored to receive 3/16, 1/4, 5/16, or 3/8 in. shafts or combinations of these shaft sizes. Overall diameter of the coupling is 1.078 in.

Metron Instrument Co., Dept. ED, 432 Lincoln St., Denver 3, Colo.

CIRCLE 83 ON READER-SERVICE CARD

Screen Room Filters

100 db attenuation from 14 kc to 10,000 mc

This series of r-f interference suppression screen room filters, provides attenuation characteristics of 100 db and above at frequencies from 14 kc to 10,000 mc. Designated the FSR-1200 series, they are designed for use in circuits carrying 25 to 200 amp, for voltages to 250 v ac or 600 v dc, and power line frequencies of 0-400 cps. Assembled filters are completely tested for voltage breakdown, characteristic insertion loss, voltage drop, insulation resistance and hermetic seal.

Filtron Co., Inc., Dept. ED, Flushing, N.Y.

CIRCLE 84 ON READER-SERVICE CARD

CIRCLE 85 ON READER-SERVICE CARD ➤

◄ For Ohmite CIRCLE 310 ON READER-SERVICE CARD

NEW PRODUCTS

Variable Inductors

Range of 0.1 to 10,000 μh

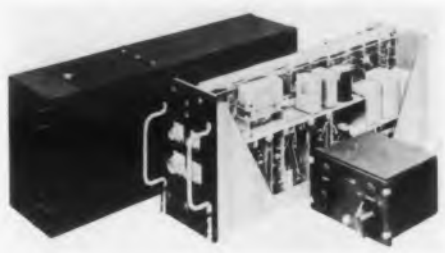
Three series of encapsulated variable inductors, built to meet MIL-C-15305A, Grade 1, Class B, cover the range of from 0.1 μh to 10,000 μh. Series 1, 01.-22 μh, measures 13/32 diam x 7/8 in. Series 2, 33-10,000 μh, measures 17/32 x 1 in. Series 3, 0.1-15 μh measures 11/32 x 5/8 in. Standard nominal inductance values are selected in steps of approximately 50 per cent. Inductance varies ±25 per cent or more from nominal. The variable inductors are encapsulated under vacuum and are tuned by means of powdered iron cores.

Vanguard Electronics Co., Dept. ED, 3384 Motor Ave., Los Angeles 34, Calif.

CIRCLE 87 ON READER-SERVICE CARD

Digital Timing Generators

For airborne application



Models 206A, 206B, and 206C have been specifically designed for environmental conditions encountered in airborne applications. Model 206A employs the company's standard timing code format and a binary coded decimal tone burst system whose bit rate and tone burst frequencies are a function of magnetic tape speed. Model 206B is designed for an output to conform with the 20 pps, binary coded Patrick timing format. Model 206C is designed for the Parset timing code format in the forward or reverse form. This format is a 100 pps, pulse width, binary coded signal which modulates a 1000 cps carrier. The units are built to MIL-E-5400 specifications, weigh 15 lb, and consume 15 w.

Hycon Eastern, Inc., Dept. ED, 75 Cambridge Parkway, Cambridge 42, Mass.

CIRCLE 88 ON READER-SERVICE CARD

Linear Differential Transformer

Directly Proportional Output

A linear variable differential transformer, type 3050XS-AT, has an output voltage which is a precise linear function of core displacement over a linear range of more than ±3 in. A plot of output versus displacement will not deviate from a straight line drawn through the origin by more than ±0.25 per cent of the output at 3 in. displacement. At this displacement, the output for a nominal 26 v 400 cps input into a 1/2 meg load is 6 v. When the core is at null position, residual voltage is less than 0.5 per cent of output at rated maximum displacement.

Schaevitz Engineering, Dept. ED, P. O. Box 505, Camden 1, N.J.

CIRCLE 90 ON READER-SERVICE CARD

Two-Speed Gearhead

Changes speed upon dc signal

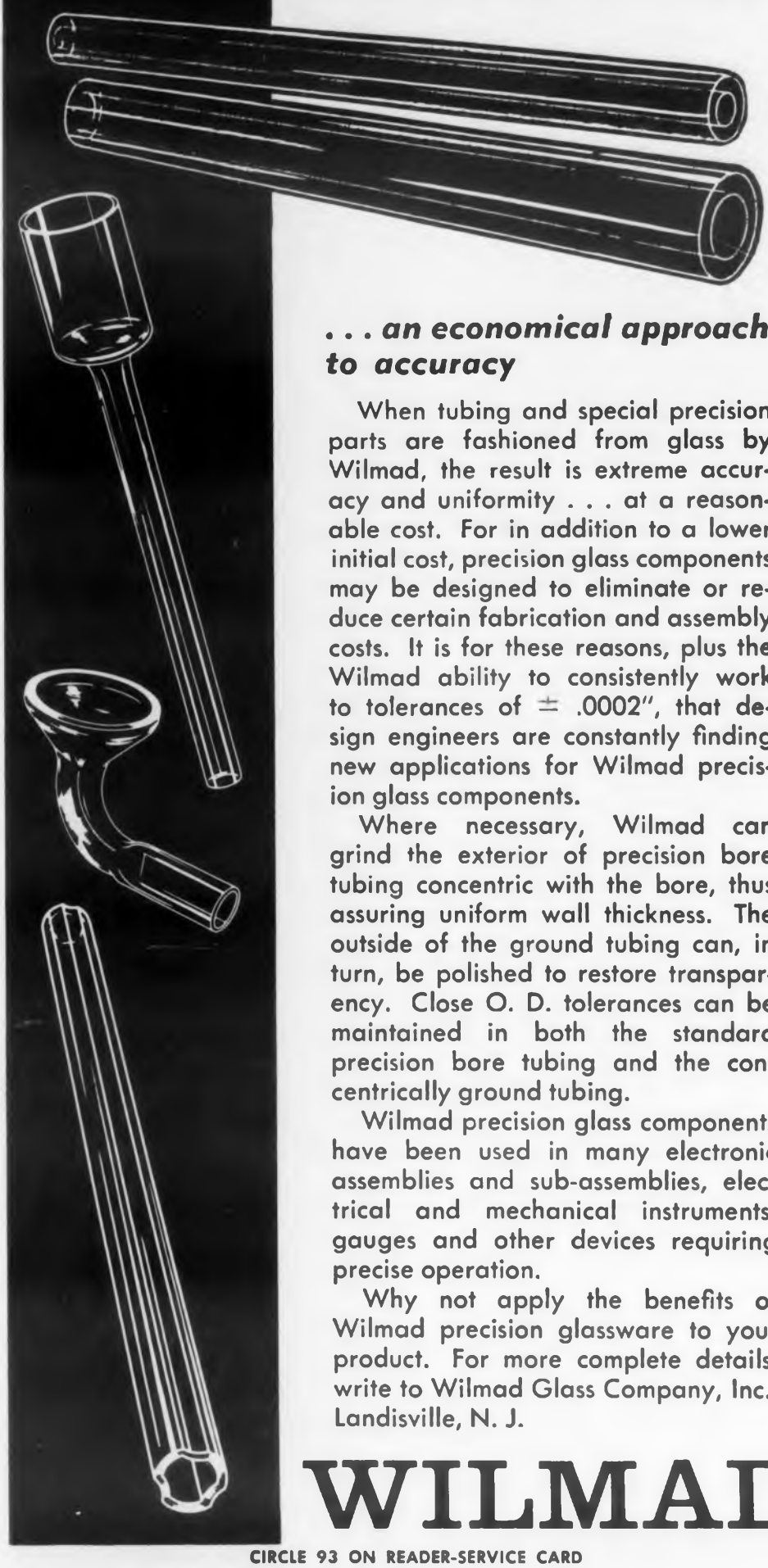
For use with servo motors, the X-544 changes ratios internally when dc voltage is applied to, or removed from, an actuating solenoid. Primary applications are in positioning computing mechanisms which require fast approaches but slower zeroing or synchronizing action. Ratios in the size 14 unit pictured are on the order of 1800:1 de-energized and 36,000:1 energized. Similar two speed units are available in all ratios or combinations of ratios required. Units are furnished with housings to mount to servo motors.

Designed for integration with sizes 11, 14, or 18 motors, the X-544 requires 0.008 in.-oz of starting torque, and will operate 12 in.-oz of load torque. Operating at the higher ratio the assembly features a backlash maximum of 1 deg with a 5 in.-oz reversing load, and it introduces not more than 5 min of position change when it shifts speed.

Bowmar Instrument Corp., Dept. ED, 8031 Bluffton Rd., Fort Wayne, Ind.

CIRCLE 91 ON READER-SERVICE CARD

WILMAD PRECISION GLASS COMPONENTS



. . . an economical approach to accuracy

When tubing and special precision parts are fashioned from glass by Wilmad, the result is extreme accuracy and uniformity . . . at a reasonable cost. For in addition to a lower initial cost, precision glass components may be designed to eliminate or reduce certain fabrication and assembly costs. It is for these reasons, plus the Wilmad ability to consistently work to tolerances of ± .0002", that design engineers are constantly finding new applications for Wilmad precision glass components.

Where necessary, Wilmad can grind the exterior of precision bore tubing concentric with the bore, thus assuring uniform wall thickness. The outside of the ground tubing can, in turn, be polished to restore transparency. Close O. D. tolerances can be maintained in both the standard precision bore tubing and the concentrically ground tubing.

Wilmad precision glass components have been used in many electronic assemblies and sub-assemblies, electrical and mechanical instruments, gauges and other devices requiring precise operation.

Why not apply the benefits of Wilmad precision glassware to your product. For more complete details, write to Wilmad Glass Company, Inc., Landisville, N. J.

WILMAD

CIRCLE 93 ON READER-SERVICE CARD

NEW PRODUCTS

Signal Simulator

Simulates PW signals for telemetering use

The MSS-3 is designed as a laboratory standard for simulating PW signals of 30 x 30, 45 x 20, 60 x 15, and 90 x 10 configurations for the checking and calibration of telemetering ground stations. The unit makes use of solid state devices throughout, with transistors operating in the switching mode exclusively. Both standard PW and a differentiated PW output to simulate PW/PM signals are provided. Pre-programming provisions permit the selection of simulated data inputs and channel assignments with complete flexibility.

Applied Science Corporation of Princeton, Dept. ED, P.O. Box 44, Princeton, N.J.

CIRCLE 94 ON READER-SERVICE CARD

Buffer Storage Unit

1000 bit capacity for high speed data

This magnetic core buffer storage unit, model CB-602/1000, has a total storage capacity of 1000 bits of information. The memory unit is particularly suitable for the storage of high-speed (above 20 kc) data. Since construction is modular, assemblies of lesser storage capacity are also available. The use of shift registers permits power to be consumed only during the times of read-in and read-out commands. Storage is retained indefinitely—even in the event of power failure. The shift registers may be connected to achieve combinations for special input and output capacities.

Epsco, Inc., Components Div., Dept. ED, 108 Commington St., Boston 15, Mass.

CIRCLE 95 ON READER-SERVICE CARD

Sweeping Oscillator

Latest model sweeps 100 kc to 150 mc range

The Ligna-Sweep model CP has been added to this Company's series (Vara-Sweep, Rada-Sweep, etc.) of precision sweeping oscillators. This instrument provides continuously variable center frequencies calibrated on a direct reading dial from 100 kc to 150 mc with continuously variable sweep widths. The output is held constant over each band and the entire frequency range. The crystal markers are available in five groups of three and are controlled by a separate rotary switch. By decreasing its sweep width to a minimum, the model CP may be used as a cw signal generator. The output is held flat within ±0.4 db over the widest sweep width. Sweep rate is variable around 60 cps and locks to line frequency.

Kay Electric Co., Dept. ED, Maple Ave., Pine Brook, N. J.

CIRCLE 97 ON READER-SERVICE CARD

Miniature Servo Motor

Measures 1/2 in. in diameter

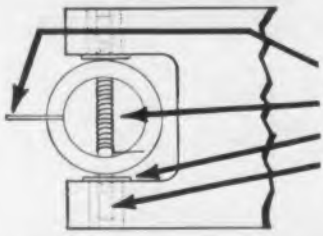
Measuring 1/2 in. diam by 1-19/64 in. long, this 400 cps servo motor consists of a squirrel-cage rotor on precision ball bearings, a two-phase stator and a stainless steel housing.

Characteristics include: size, number 5 frame; weight, 0.94 oz; fixed phase and control phase voltage, 26 v; current, 92 ma; impedance, 283∠ 19.2+j210 ohms at stall; power input, 3.3 w; stall torque, 0.11 oz-in.; no load speed, 9500 rpm; torque-to-inertial ratio, 35,000 rad/sec²; and operating temperature range, −55 to +70 C.

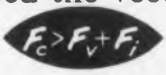
Bendix Aviation Corp., Eclipse-Pioneer Div., Dept. ED, Teterboro, N.J.

CIRCLE 98 ON READER-SERVICE CARD

5,000,000 CYCLE LIFE!



"another result of dynamic balance"* precision potentiometers

Long life is achieved by minimizing wear. Wear results from pressures or forces between contact assembly and winding. Total force consists of a dynamic force  due to vibration, acceleration and shock; an inertial force  acting on the contact assembly; and a static force resulting from contact pressure. For proper operation, contact force must exceed the vector sum of the dynamic forces 

The Kintronic contact assembly is *dynamically balanced* about a pivot  and therefore vibration, acceleration and shock forces cancel out. Inertial force on the contact assembly is minimized by making its mass and size small as possible. Reduction of these dynamic forces enable use of very low contact pressure.

Operational Results: total wear producing force is extremely small. 5,000,000 cycle life is achieved at maximum speeds of 3,425 r.p.m., under 2,000 cycle 30g vibration!

Incidentally, we know these are *hot* pots mechanically . . . but they're also hot for temperature, too. Power derates to zero at 165°C standard — 225°C special.

* Patent Pending

Get complete engineering data on Kintronic "Dynamic Balance" precision potentiometers. Write today.

kintronic Division of Chicago Aerial Industries, Inc.

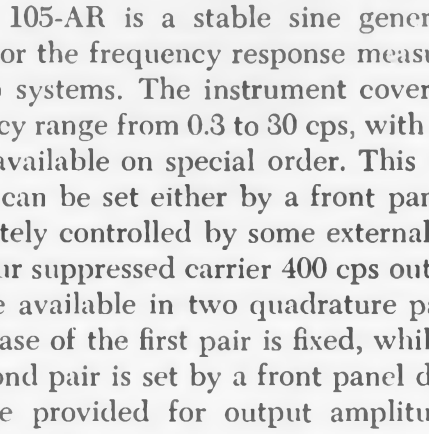
10265 Franklin Avenue • Franklin Park, Illinois

CIRCLE 100 ON READER-SERVICE CARD

NEW PRODUCTS

Servo Tester

Remote control of data frequency



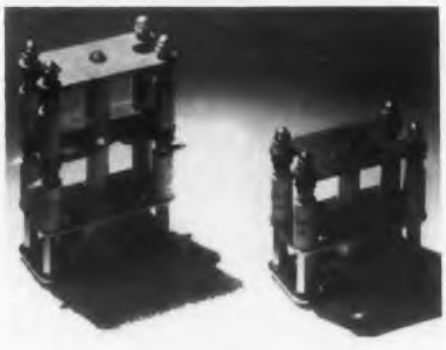
Type 105-AR is a stable sine generator designed for the frequency response measurements of servo systems. The instrument covers a data frequency range from 0.3 to 30 cps, with different ranges available on special order. This data frequency can be set either by a front panel knob, or remotely controlled by some external dc voltage. Four suppressed carrier 400 cps output voltages are available in two quadrature pairs. The data phase of the first pair is fixed, while that of the second pair is set by a front panel dial. Controls are provided for output amplitude, data phase, and frequency.

Industrial Control Co., Dept. ED, 805 Albin Ave., Lindenhurst, L.I., N.Y.

CIRCLE 101 ON READER-SERVICE CARD

Relays

Switch high voltage in severe environments



The basic model of this relay, designated RL-1007, and a double deck version RL-906, are both designed to withstand severe shock, vibration, temperature range of −55 to +95 C and a minimum of 500,000 operations. Specifications include: Contact capacity under load of 1 amp ac at 10,000 v peak, 100 ma (res.) at 200 v dc; contact arrangement of spdt double-break, and dpdt double-break; dielectric strength of 17,000 v dc between mutually insulated contacts, and vibration of 10 g acceleration from 5 to 55 cps.

Joseph Pollak Corp., Dept. ED, 81 Freeport St., Boston 22, Mass.

CIRCLE 102 ON READER-SERVICE CARD

Gain Measuring System

Measures up to 80 db of gain or loss

A complete system for making precise measurements of gain or loss of near-zero up to 80 db in. microwave components or systems has been announced. The system consists of four basic components: a preamplifier unit, an attenuator, an amplifier-detector, and a power supply. These components are placed on separate relay rack panels. When additional power supply and control facilities are required, a double klystron power supply may be added. All components are available either separately or as a complete system. The meter scale gives readings as small as 0.025 db.

Kay Electric Co., Dept. ED, Maple Ave., Pine Brook, N. J.

CIRCLE 104 ON READER-SERVICE CARD

Power Supply Regulation Analyzer

Measures applied dc, percentage change, and rms ripple on the applied dc

Model 901B power supply regulation analyzer is designed to measure applied dc voltage, the percentage change in applied dc voltage, and the rms ripple on the applied dc voltage of regulated and unregulated power sources. The unit measures characteristics of dc voltage in the test range 1 to 3000 v. The applied dc voltage can be measured to an accuracy of 0.1 per cent. The unit provides four ranges of sensitivity, measuring per cent regulation from 0.005 per cent each side of null position to 5 per cent each side of null position. Eleven ranges for measuring ripple voltage from 0 to 100 v are provided. This unit also provides for oscilloscope monitoring and external recording so that either a visual or permanent continuous record can be made.

Kepco Labs., Inc., Dept. ED, 131-38 Sanford Ave., Flushing 55, N.Y.

CIRCLE 105 ON READER-SERVICE CARD

If you need TEFLON* in any form R/M is the place to get it!

Raybestos-Manhattan pioneered in research and development in the use of "Teflon." R/M has had vast experience in fabricating this amazing substance . . . has accomplished things with it once thought impossible, such as molding highly complex valve diaphragms.

But R/M has more than the know-how—it has the facilities to produce "Teflon" in exactly the form you want it . . . can supply *all* your needs, from the usual types of tubes, tape, rods, sheets and flexible wire braid covered hose to complicated molded and machined parts.

That is why R/M should be your headquarters for all your needs in products made of "Teflon," from simple standardized parts to intricate components painstakingly customized to your specifications. Call on your nearest R/M district office for the cooperation you need. Or write for detailed information.

*A Du Pont trademark

R/M

RAYBESTOS-MANHATTAN, INC.

PLASTIC PRODUCTS DIVISION FACTORIES: MANHEIM, PA.; PARAMOUNT, CALIF.

Contact your nearest R/M district office listed below for more information or write to Plastic Products Division, Raybestos-Manhattan, Inc., Manheim, Pa.

BIRMINGHAM 1 • CHICAGO 31 • CLEVELAND 16 • DALLAS 26 • DENVER 16 • DETROIT 2 • HOUSTON 1
LOS ANGELES 58 • MINNEAPOLIS 16 • NEW ORLEANS 17 • PASSAIC • PHILADELPHIA 3
PITTSBURGH 22 • SAN FRANCISCO 5 • SEATTLE 4 • PETERBOROUGH, ONTARIO, CANADA

RAYBESTOS-MANHATTAN, INC., Engineered Plastics • Asbestos Textiles • Mechanical Packings • Industrial Rubber
Sintered Metal Products • Rubber Covered Equipment • Abrasive and Diamond Wheels • Brake Linings
Brake Blocks • Clutch Facings • Laundry Pads and Covers • Industrial Adhesives • Bowling Balls

CIRCLE 107 ON READER-SERVICE CARD

NEW PRODUCTS

Printed Circuit Connector

Dip Soldered or Wire Wrap

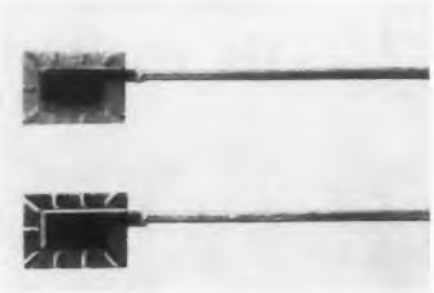
Printed circuit boards may be joined at right angles using type GPCW connectors with dip-solder terminals. The contacts are made of heat-treated beryllium copper in order to retain their contact force after repeated insertions and withdrawals. The same contacts are so designed that they may be also used for wire wrap techniques. The GPCW connector is available with 15 and 22 contacts, spaced 5/32 in. apart for 1/16-in. boards, molded in fiber glass filled plaskon alkyd, or in melamine, or dyall-phalate.

Gorn Electric Co., Inc., Electronics Div., Dept. ED, 845 Main Street, Stamford, Conn.

CIRCLE 108 ON READER-SERVICE CARD

Temperature Transducers

Cemented or welded to surface



Type 1375 and 1376 surface temperature transducers are platinum resistance units that can be installed on any surface, flat or curved, metallic or non-metallic. The protective cover of the resistive element is cemented or welded directly to the thermal surface and forms an isothermal system which gives true skin temperature reading.

Units are available in various ranges from −400 to +1550 F. The resistance change over the operating interval of the instrument is 100 ohms. Outputs are up to 5 v without amplification. A 5-point resistance vs temperature calibration certificate is supplied with each transducer. Specifications include an accuracy of calibration of ±1 per cent.

Trans-Sonics, Inc., Dept. ED, Burlington, Mass.

CIRCLE 109 ON READER-SERVICE CARD

Cooling Units

Centrifugal blowers provide up to 1200 cfm

This series panel mounted centrifugal blowers provide from 600 to 1200 cfm of filtered air. Blowers mount in rack or cabinet as standard 8-3/4 x 19 in. panels. They measure 15 in. front-to-back exclusive of extensions. Radio interference requirements of MIL-I-16910A are met. Eight different models provide air discharge (through top, side, or rear outlets) to suit various applications.

Western Devices, Inc., Dept. ED, 600 W. Florence Ave., Inglewood, Calif.

CIRCLE 110 ON READER-SERVICE CARD

Quadrature Rejection Unit

Good operation at low temperature

Type SB-9505-04 hermetically sealed quadrature rejection unit can achieve 90 per cent or more of full speed when turned on at −60 C. The 22 rpm minimum speed at rated voltage will not vary more than ±10 per cent over the entire operating range of −60 to +80 C. When properly excited the output will be an ascending saw tooth voltage. Motor voltage is 26 v, 400 cps, 2 phase. Motor input power is 3.2 w max per phase, potentiometer linearity, 1.5 per cent max.

John Oster Mfg. Co., Avionic Div., Dept. ED, 1 Main St., Racine, Wis.

CIRCLE 111 ON READER-SERVICE CARD

CIRCLE 112 ON READER-SERVICE CARD ➤

NEW PRODUCTS

Silicon Rectifier Stacks

25 Amp, 245 V

Designed for high power rectification in a limited amount of space, these stack assemblies of silicon rectifiers have been made available. Illustrated is a single phase gull wave bridge assembly, rated at 25 amp average rectified current at an rms input of 245 v with forced air cooling, utilizing 2 x 2 in. fins. Over-all dimensions are 5 x 3 x 2 in. The assemblies have been successfully operated at ambient temperatures ranging from −50 to +165 C.

General Instrument Corp., Automatic Manufacturing Div., Dept. ED, 65 Gouverneur St., Newark 4, N.J.

CIRCLE 113 ON READER-SERVICE CARD

Silicon Rectifiers

Current ratings to 750 ma

Featuring current ratings up to 750 ma, and voltage to 1000 v, the IN538, IN540, and IN547 are available as axial lead types. The forward conductance characteristics and low inverse current at high operating temperatures, make them useful for power supply, magnetic amplifier, and low frequency switching applications. The units are available for either 100 or 150 C operation.

Transitron Electronic Corp., Dept. ED, Wakefield, Mass.

CIRCLE 114 ON READER-SERVICE CARD

Recorder-Reproducer

14 Channel

Model TR-782 is a 14 channel two-speed data recorder-reproducer (7 track am and 7 track fm). The equipment is designed primarily for record-

ing and reproducing simultaneously dc to 100 kc information. One fm channel may be used for tape sync control and voice monitoring. The sync control unit, combined with the precision frequency controlled power supply permit the playback of recorded data to be reproduced at the exact rate of the recording.

Telectro Industries Corp., Dept. ED, 35-18 37th St., Long Island City 1, N.Y.

CIRCLE 116 ON READER-SERVICE CARD

Regenerative Repeater

High Reduction of Transient Noise

This regenerative telegraph repeater, model RTR-1, is a self-contained, one-way regenerative repeater designed for various teletypewriter speeds. Input circuits permit connection to telegraph lines grounded on either side of battery or floating. Transient noise spikes and signals distorted as much as 45 per cent are regenerated at the output with less than 5 per cent distortion. The unit occupies 3-1/2 in. of standard panel height. In conjunction with the telegraph repeater TR-2, the RTR-1, slightly modified, can be used in an electronic-hub system.

Stelma, Inc., Dept. ED, 190 Henry St., Stamford, Conn.

CIRCLE 117 ON READER-SERVICE CARD

Mag Amp Power Supply

Remote Regulation

This transistorized power supply provides a fast response time to load changes, a reduced overshoot and undershoot of regulated voltages, and remote regulation at long distances.

It delivers a 27 V to 42 V output at 0 to 300 amp, regulated at the load. Surge capacity is 400 per cent overload for 2 sec. Regulation across the load is 1 per cent or better. Recovery time is less than 50 msec from initial load change. Overshoot and undershoot less than 25 per cent, with 30 per cent change in load. Ripple is 1 per cent of output voltage from no load to full load.

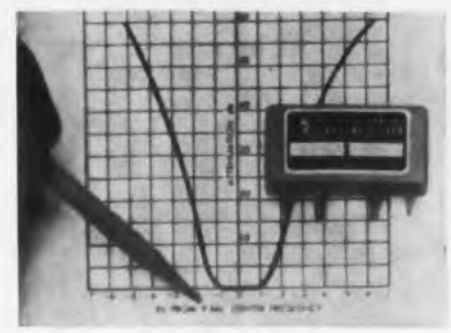
Packard-Bell Electronics, Dept. ED, 12333 West Olympic Blvd., Los Angeles 64, Calif.

CIRCLE 118 ON READER-SERVICE CARD

NEW PRODUCTS

Crystal Filters

For Single Conversion Receivers



The model 9MA symmetrical bandpass crystal filter is designed for single conversion receivers used in mobile services. Specifications include a center frequency of 9 mc; passband ripple of less than $\pm 1/2$ db; bandwidth at 6 db attenuation of 3 kc; bandwidth at 60 db attenuation of 12 kc; insertion loss of less than 3 db; and impedance of 1 K nominal.

Hycon Eastern, Inc., Dept. ED, 75 Cambridge Pkwy., Cambridge 42, Mass.

CIRCLE 120 ON READER-SERVICE CARD

Frequency Converter

Portable 60 to 400 cps lab supply

Type PPS-101 converter takes 105-125 v 50/60 cps, and produces 115 v, 400 ± 0.5 cps. Voltage regulation is ± 5 v for full load and 10 per cent for no load. Load ratings are 100 va 3-phase and 70 va single-phase.

Eicor, Dept. ED, 4235 W. North Ave., Chicago 39, Ill.

CIRCLE 121 ON READER-SERVICE CARD

Servomotor

Features fast response to small signals

The fast response to minimum control signals of model 15 SM 460 servomotor is the result of a combination of low rotor inertial of 1 gm-cm^2 and a high stall torque of 1.45 oz-in. The torque-speed curve is linear from stall through no-load speed, demonstrating ideal viscous damping characteristics, particularly for small error signals. Teflon wire and insulating materials

enable the unit to operate continuously at total unit temperatures up to 200 C. The servomotor weighs 8 oz. Motor housing, shaft and ball bearings are stainless steel and all windings are fully encapsulated for protection against temperature, humidity and vibration

Beckman/Helipot Corp., Dept. ED, Newport Beach, Calif.

CIRCLE 122 ON READER-SERVICE CARD

Spiral Harnessing

Wide overlap leaves no open joints

Although similar to the company's previously announced Spiral Wrap in many ways, Spiral Cover has the unique feature of overlapping itself 100 per cent forming a double cover over the wire and leaving no open joints. The insulating qualities are therefore almost equal to solid jacketing. Made only in non-inflammable Teflon, the wire harnessing has an 0.04-in. wall and is available in six different diameters from 1/4 in. to 1-1/2 in.

Illumitronic Engineering, Dept. ED, 680 E. Taylor, Sunnyvale, Calif.

CIRCLE 123 ON READER-SERVICE CARD

Terminal Blocks

Permit rapid, neat assembly

This terminal block is available for custom assembly or in factory assembled strips rated at 600 v ac or dc, 15, 25, and 50 amp ratings. Features include a snap in marking strip, and a snap on terminal block, both of which make modifications to a mounted terminal strip a fast operation. Standard 3/16 in. round cold rolled steel fits each molded piece and permits rapid assembly. All three current ratings can be assembled into one mounting strip.

Gemco Electric Co., Dept. ED, 25685 W. Eight Mile Rd., Detroit 40, Mich.

CIRCLE 124 ON READER-SERVICE CARD

NEW PRODUCTS

Environmental Test Chamber

Close humidity control over wide range

Model SU-40-8-HC environmental test machine is adjustable from −50 to +200 F and will maintain a relative humidity of 95 per cent, ±5 per cent between 80 and 160 F. The humidity element is supplied by a distilled water-air pressure reservoir, controlled by a solenoid valve. Clear working area is 24 in. high by 24 in. wide by 19 in. deep.

Cincinnati Sub-Zero Products, Dept. ED, 3932 Reading Rd., Cincinnati 29, Ohio.

CIRCLE 127 ON READER-SERVICE CARD

FHP Motors

Ratings up to 1/50 hp

A wide variety of fractional horsepower motors is available in ranges from 1 to 24 v and up to 1/50 hp. The motor shown is of the permanent magnet type; 1-6 v, 230-340 ma; 5000 rpm on 1-1/2 v.

Moen Trading Co., Dept. ED, 7 West 24th St., New York 10, N.Y.

CIRCLE 128 ON READER-SERVICE CARD

Power Supply

Silicon rectifier type supplies 32 v dc with 0.5 per cent ripple

Model KM93B silicon rectifier power supply with a continuous duty rating of 40 amp. Ripple is held to within 0.5 per cent throughout the range of the equipment. A safety factor allows for continuous operation at 125 per cent of rated current. Cooling is by convection. Voltage regulation from 1/10 load to full load does not exceed 12 percent at 32 v output.

Opad Electric Co., Dept. ED, 69 Murray St., New York 7, N.Y.

CIRCLE 129 ON READER-SERVICE CARD

DC Power Supplies

Two models offering 0.1 per cent regulation

Models RS-205 and RS-305 power supplies are of modular type mounting design, and are similar except for output voltage ranges. Outputs are 150-225 and 225-325 v dc, 50 ma for the respective models. Input is 105 to 125 v line with regulation is 0.1 per cent ripple and noise less than 7 mv peak to peak, and recovery time is less than 25 μsec. Internal impedance is less than 1 ohm for both models.

Trans Electronics, Inc., Dept. ED, 7349 Canoga Ave., Canoga Park, Calif.

CIRCLE 130 ON READER-SERVICE CARD

VHF Transmitter

Adjustable output from 10 to 50 w

Offering continuous operation in the 108 to 152 mc range, the 242F-5 transmitter features adjustable carrier output from 10 to 50 w. Linear power amplification is utilized to maintain low spurious output and to minimize intermodulation interference. Although a single channel transmitter, the unit offers additional service on up to four channels within a 500 kc spectrum as an optional feature. Over-all frequency stability is ±0.005 per cent where standard CR-23/U crystals are used.

Collins Radio Co., Dept. ED, 855 35th St., N.W., Cedar Rapids, Iowa.

CIRCLE 131 ON READER-SERVICE CARD

Digital Tape Handler

Has fast stop time of 1.5 msec

Model 906 digital magnetic tape handler has ranges of four speeds forward and reverse, up to 150 in. per sec. The machine is capable of continuous cycling at any frequency from 0 to 200 cps without flutter. Start time is 3 msec and stop time is 1.5 msec. A vacuum loop device is used in the tensioning system to provide proper tape tension.

Potter Instrument Co., Inc., Dept. ED, Sunnyside Blvd., Plainview, Long Island, N.Y.

CIRCLE 132 ON READER-SERVICE CARD

NEW PRODUCTS

Color Image Orthicon

Increased sensitivity permits reduced light levels

Type 7037 image orthicon for use in color TV cameras is stated to have more than twice the average sensitivity of previous tubes. Features include a higher effective sensitivity to red, green, and blue which permits reduction in lighting level or lens aperture, and a stabilized target which prevents picture sticking.

Radio Corporation of America, Tube Div., Dept. ED, Harrison, N.J.

CIRCLE 471 ON READER-SERVICE CARD

Pulse Generator

Provides high power pulses from 28 v dc

Model 591-P pulse generator converts low-voltage dc to high-voltage dc or ac pulses. Operating from a 28 v dc line, the unit delivers a peak pulse power of 150 w at a 20 per cent duty cycle. Peak output voltage can be any value between 20 and 2000 v, with a rate of from 500 to 3000 pps. Rise and fall times are each approximately 100 μsec. Amplitude and frequency of pulses are held within 2 per cent for variations in line input voltages from 24 to 30 v, and for load variations from half to full load.

Arnold Magnetics Corp., Dept. ED, 4613 W. Jefferson Blvd., Los Angeles 16, Calif.

CIRCLE 134 ON READER-SERVICE CARD

Pre-Set Counter

Designed for high speed counting and control

Model 4159 counter features high counting and recycling rates and has been designed for control of automatic operations. A panel switch-

WARRIOR WITH HIS F

ing arrangement permits use either as a totalizing counter at rates up to 5000 counter per sec or as a pre-set counter adjustable from one to 9999 counts at rates up to 1000 counts per sec without error. An optional batch counter also totalizes batches at rates up to 600 per min. A rear panel test switch permits use of the instrument as a preset time interval generator adjustable to 1/60 sec increments for accurate cycle timing.

I-L-S Instrument Corp., Dept. ED, 4527 W. 160th St., Cleveland 11, Ohio.

CIRCLE 135 ON READER-SERVICE CARD

Microwave Regulator

Constant power source provides faster measurements

Model 301 microwave regulator is designed primarily for use with a traveling wave tube or in traveling wave tube manufacture. The unit serves as the connecting link for a 1 kc square wave modulated constant power source. The device itself operates at an audio frequency, and hence is completely independent of microwave power and frequency.

D. C. Broker Labs., Dept. ED, P. O. Box 967, Sunnyvale, Calif.

CIRCLE 136 ON READER-SERVICE CARD

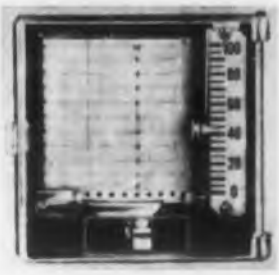
Flight Simulator

Tests flight control system in three axes

Model 1806 flight simulator is capable of unlimited motion about any axis. Each gimbal is driven by a hydraulic servo system in response to signals from an analog computer. Synchros are used for error sensing in the closed servo loop, and a high gain amplifier drives a spool-type servo valve for hydraulic motor control. A maximum load can be accelerated up to 5 radians/sec^2 and a maximum velocity of 30 rpm may be attained with a velocity error of one per cent.

Aircraft Armaments, Inc., Dept. ED, Cockeysville, Md.

CIRCLE 137 ON READER-SERVICE CARD



Pressure Gage

Records on 3-in. strip chart

Using a 3-in. strip chart for recording, these gages are offered in ranges from 0-3 psi up to 0-60 psi. Elements in various ranges are offered in Ni-Span C, berryllium copper, and phosphor bronze. The recording chassis is interchangeable. Several versions of the instrument are available for differing recording and indicating uses.

Bristol Co., Dept. ED, Waterbury 20, Conn.

CIRCLE 138 ON READER-SERVICE CARD

Solenoid Valves

Plug-in units are ready-wired

This complete line of Speed King plug-in 1/4-in. 4-way control valves features fast, automatic connection of electrical circuits. Permanent wiring connections, made in the manifold or subbase at the time of original machine assembly, need not be disturbed during in-service maintenance. The valves are designed for control of smaller devices, and are available in both single and double solenoid types.

Valvair Corp., Dept. ED, 454 Morgan Ave., Akron, Ohio.

CIRCLE 139 ON READER-SERVICE CARD

Printed Circuit Connectors

Available in one-piece construction

Printed circuit board receptacles in one-piece body construction are now available in either type GR and MFE mineral filled phenolic, MDG

A CONCEPT OF SCIENCE

Five years ago, The Martin Company conceived a unique undertaking in the field of pure science which grew out of a belief that our own and our country's resources in creative scientific research must be greatly enlarged and cultivated.

We believed that the country—and the Company—that concentrates on short-range material achievements, without a deep concern for the creative source of tomorrow's even greater achievements, will have no tomorrow.

It is now three years since that belief motivated management's action with the foundation of a program in pure research. Known as the Research Institute of Advanced Study, RIAS is now a substantial organization staffed by scientists who are working in many fields, including theoretical physics, biochemistry, metallurgy and mathematics, without short-range applied research requirements.

Today, the increasing appeals to industry and the nation for accelerated activities in basic research give the RIAS story a special significance. For creative research in pure science is the true life source of our technological security—the "seed bed" from which our national strength shall continue to grow.

MARTIN

BALTIMORE · DENVER ORLANDO

diallyl phthalate or CFG general purpose phenolic. This board receptacle series has a new contact design to prevent board-to-contact damage. Standard terminations are solder eye, taper tab (AMP), solder dip and wire wrap, for either single- or double-sided board circuits. Minimum creep is 3/32 in., working volts are 550 ac, 770 dc; and test voltage is 1650 rms.

H. H. Buggie, Inc., Dept. ED, Box 817, Toledo 1, Ohio.

CIRCLE 140 ON READER-SERVICE CARD

Power Supply

Provides total receiver high voltage in mobile radio systems

A high-efficiency 25-w unit particularly suitable for existing two-way radio equipment has been developed with over 80 per cent efficiency. The supply can furnish total standby receiver high voltage, thereby decreasing the standby drain of a mobile unit's receiver section. Input voltage is 13.8 v dc nominal with a ±20 per cent variation. Output voltage is 250 v dc ±10 v at a 90 ma load.

Other specifications include a five per cent half to full load voltage regulation and a peak-to-peak ripple that does not exceed 0.1 per cent.

Allen B. DuMont Labs., Inc., Dept. ED, 760 Bloomfield Ave., Clifton, N.J.

CIRCLE 141 ON READER-SERVICE CARD

Megohmmeter

Single range, easy-to-use meter

Model 500 self-calibrating megohmmeter measures from 10-10,000,000 megohms, and model 501 measures from 0.10-10,000 megohms. Basic features include six decades of resistance, logarithmic presentation with no scale compression. Accuracy is within 20 per cent of any reading. Test potentials of 8 v (model 500) and 1.5 v (model 501) are used.

Keithley Instruments, Inc., Dept. ED, 12415 Euclid Ave., Cleveland 6, Ohio.

CIRCLE 142 ON READER-SERVICE CARD

Delay Line

Has efficient use at 125 mc

Model V-215 has a practical operating frequency of 125 mc, a total delay of 50 mμsec, and impedance of 50 ohms. Designed for a continuous motor driven application, the unit is constructed with a printed circuit commutator-type switch having rhodium plated segments and a silver alloy wiper arm. Resolution is 1 part in 120. The delay line is also supplied as a manually operated unit and in other delays and impedances.

Control Electronics Co., Inc., Dept. ED, 1925 New York Ave., Huntington Station, N.Y.

CIRCLE 144 ON READER-SERVICE CARD

Mag-Amp Power Supplies

Provide from 50 to 5000 amp

Known as Selenifiers, these magnetic amplifier controlled rectifiers provide regulation of 0.5 per cent with less than 1 per cent ripple factor in output. Output ratings are 22 to 32 v or higher; or 28 v constant with optional manual control. Units from 50 to 5000 amp can be furnished.

American Rectifier Corp., Dept. ED, 95 Lafayette St., New York, N.Y.

CIRCLE 145 ON READER-SERVICE CARD

Testing Bridge

Tests up to 99 circuits sequentially

The CML 1020 Rotorbridge is an automatic, self-stepping comparison type bridge which will sequentially test up to a total of 99 circuits for continuity and resistance tolerance. It is designed

for the production testing of errors in wiring, defective components and improper installation of components. The unit permits rapid change-over from the testing of one device to another. The bridge range is from 200 ohms to 2 meg with an accuracy of 10 per cent of the selected tolerance figure (ie: 10 per cent of 5, 10 or 20 per cent for instance) or from 47 ohms to 5 meg if an error of 12 per cent of the selected tolerance figure is acceptable.

Communication Measurements Lab., Inc., Dept. ED, 350 Leland Ave., Plainfield, N.J.

CIRCLE 147 ON READER-SERVICE CARD

Standard Cell Oven

Provides 0.05 C regulation

The SCO-106 standard cell oven provides short-turn regulation of 0.01 C and long-term regulation of 0.05 C. The thermal resistance bridge permits measurement of enclosure temperature to 0.005 C. The enclosure provides space for 3 cells of the type used by the National Bureau of Standards. Enclosure volume measures 6-1/2 x 3 in. Heater supply is 24 to 28 v dc.

Julie Research Labs., Inc., Dept. ED, 556 W. 168 St., New York 32, N.Y.

CIRCLE 148 ON READER-SERVICE CARD

Ammeters

A thermocouple type withstanding large overloads

This line of thermocouple type rf ammeters is described as having thermocouple characteristics of unusual sensitivity. A double wire construction makes possible greater overload and less power consumption. Meters are ruggedized and conforming to specification MIL-M-10304. They are available for panel mounting in 1-1/2, 2-1/2, 3-1/2 and 4-1/2 in. diam in ranges up to 0 to 15 amp rf.

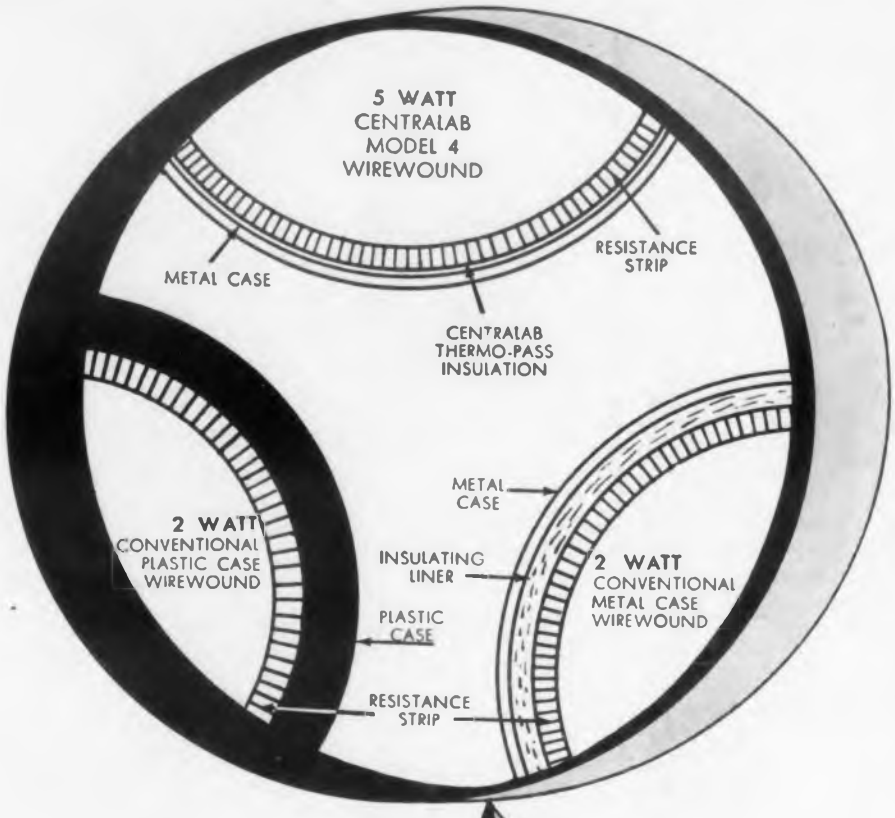
Sun Electric Corp., Meter Div., Dept. ED, Harlem and Avondale, Chicago 31, Ill.

CIRCLE 149 ON READER-SERVICE CARD

5 watt capacity – 2 watt size

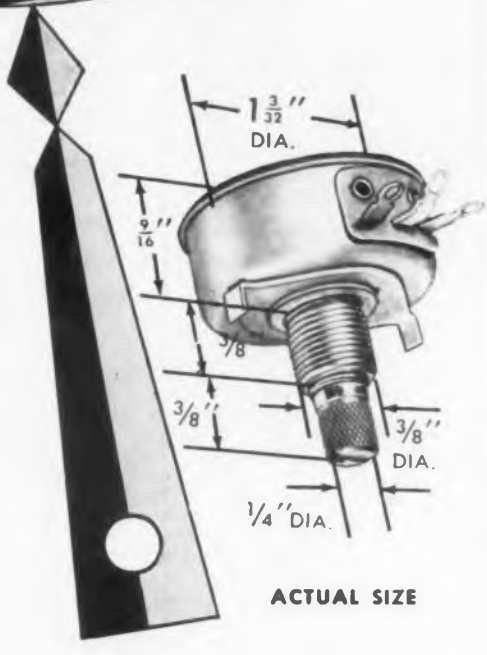
Centralab MODEL 4

Miniature Wirewound Radiohms®



As you know, the rating and size of a variable resistor depends upon the speed with which heat can be transferred from the resistance element to the atmosphere. Centralab "thermo-pass" insulation combines exceptional heat transfer with a dielectric strength of 4500 volts per mil at 25° C Result: Model 4 Radiohm, a conservatively rated 5 watt wirewound variable resistor smaller than a conventional 2 watt unit.

- Only $1\frac{3}{32}$" diameter by $\frac{9}{16}$" deep.
- Resistance range, 1 ohm to 15K ohms; linear taper.
- 295° rotation, stop strength 15 inch pounds
- Minimum life, 25,000 complete cycles.
- Totally enclosed elements.



ACTUAL SIZE

For detailed information write for Centralab Engineering Bulletin EP-493 or contact your Centralab sales representative. Ask your local distributor about the many values he carries in stock in the WW and WN series (listed in Catalog 30).

Centralab
B-5810

A DIVISION OF GLOBE-UNION, INC
960C E. KEEFE AVE. • MILWAUKEE 1, WIS.
In Canada: 804 Mt. Pleasant Rd. • Toronto, Ontario

VARIABLE RESISTORS • PACKAGED ELECTRONIC CIRCUITS • ELECTRONIC SWITCHES
CERAMIC CAPACITORS • ENGINEERED CERAMICS • SEMI-CONDUCTOR PRODUCTS

CIRCLE 150 ON READER-SERVICE CARD

NEW PRODUCTS

Dielectric Test Set

Supplies potentials called for in MIL-C-13294A

Type no. 50 breakdown tester is designed to furnish the potentials required for dielectric tests conducted under MIL-C-13294A. Output is 5 kw at 1000 v or 5000 v rms, and is continuously adjustable from zero to max by panel mounted control driving a variable auto-transformer, within the console. The test set operates from 220 v rms, 60 cps single phase. Voltage and current are simultaneously metered. The test set measures 22 in. deep, 24 in. wide, and 42 in. high and weighs approximately 400 lb.

Industrial Transformer Corp., Dept. ED, Gouldsboro, Pa.

CIRCLE 151 ON READER-SERVICE CARD

Limit Stop

20 lb-in. capacity

The NM-217 multi-turn limit stop is designed for direct mounting on an instrument gearbox in the manner of a Mark 8 servomotor. It is continuously adjustable from 0 to 50 turns, and has a torque capacity of 20 lb-in. The device is constructed to conform to applicable sections of MIL-E-5400.

Normac Tools and Engineering, Dept. ED, 7120 Canby, Reseda, Calif.

CIRCLE 152 ON READER-SERVICE CARD

Scaler-Ratemeter

Features plug-in units

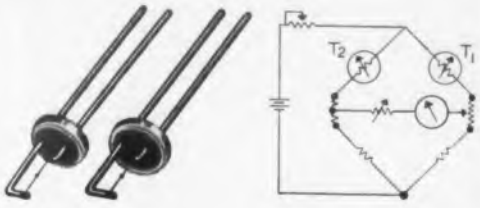
Pulse amplifier or linear amplifier and single channel analyzer are available as plug-in units for the input section of the model PFA-100 scaler-

Using Thermistors

Edited by
FENWAL ELECTRONICS

MATCHED THERMISTORS FOR GAS ANALYSIS

Now Fenwal Electronics offers resistance and voltage-current matched thermistor assemblies which are particularly useful for gas chromatography and other gas analyses.



The matched thermistor assemblies above are used in a balanced bridge circuit. One assembly is in each arm of the bridge and equal current is applied to each. The thermistors, self-heated by the passage of current, will dissipate heat at equal rates if the medium surrounding each thermistor is identical. The meter will show an equilibrium reading.

If the thermal conductivity of the gas surrounding either one of the thermistors should change, the rate of heat dissipation will also change, altering the resistance of the thermistor and unbalancing the bridge, thus causing a reading on the meter. The meter can, therefore, be calibrated to give an accurate indication of the percentage of a foreign element in the gas being analyzed, as related to a known reference gas.

It's all based on the unique characteristic of thermistors — when temperature rises, resistance falls. This relationship occurs whether the thermistor is self-heated, as in the example above, or externally heated through a liquid, gas or solid.

Write FENWAL ELECTRONICS, INC., 38 Mellen Street, Framingham, Mass., for complete information on matched thermistors (Bulletin EM-14), and for many other thermistor applications (Catalog EMC-1).

Fenwal Electronics

Design — Engineering — Production
of Precision Thermistors

CIRCLE 154 ON READER-SERVICE CARD

ratemeter. The counting unit can be either a high-speed decade scaler (either 100 kc or 1 mc) or a ratemeter with aural monitor. The instrument includes built-in timer, continuously variable voltage for probe with 1/2 per cent regulation, calibrator, and connection for 1 ma pen recorder.

Nuclear Electronics Corp., Dept. ED, 2632 W. Cumberland St., Philadelphia 32, Pa.

CIRCLE 155 ON READER-SERVICE CARD

Care Testers

Provides complete display of magnetic toroid characteristics

Model 123 core tester provides a display of coercive force, saturation flux density, B_r:B_m ratio, differential permeability and shows the shape of the hysteresis loop. The display is made on an oscilloscope. This display permits a quick evaluation of basic core characteristics in relation to a specific circuit application. The test probe is a single solid rod which permits manual testing rate up to 400 cores per hr.

Mack Trucks, Electronics Div., Dept. ED, 40 Leon St., Boston 15, Mass.

CIRCLE 156 ON READER-SERVICE CARD

Pulsed Oscillator

A flexible source of high power in the uhf range

Model 105 Series of high-power tunable pulsed oscillators provides high peak powers for the laboratory testing of components and systems in the uhf range. The units provide peak power outputs of at least 75 kw for duty cycles up to 0.03. Model 105A tunes from 17 to 52 mc. Other basically similar models provide complete coverage from 10 to 120 mc. A 10 kv plate supply and grid pulser unit provides pulse rates variable from 100 to 400 pps with pulse widths from 10 to 100 μsec.

Granger Associates, Dept. ED, 966 Commercial St., Palo Alto, Calif.

CIRCLE 157 ON READER-SERVICE CARD

rule out the bottleneck

You'll have time to pause and refresh if, unlike friend Sherman here, you've specified our Vibrotron Transducers for your flight testing. In case you're wondering, that's an F-106 Sherm is so ably piloting. We use it to illustrate that the people at Convair have found a way to simplify monitoring of *their* flight tests.

They mount two of our Vibrotron Absolute Pressure Transducers and matched amplifiers aft of the nose boom. One set measures total pressure, the other static pressure (altitude). As pressure variations occur, wire tension changes are fed into an FM/FM telemetering system. At the monitor, total pressure minus static pressure is *digitally* read out as airspeed. By this unquestionably advanced means, analog to digital conversion is bypassed, photo panel instrument hystersis overcome, intelligence transmitted a good long way without accuracy drop.

Whatever your remote sensing application, if direct digital data, miniaturization, accuracy and dependability are considerations, talk to us about Vibroton® Transducers. Available in combinations of a wide range of pressures from 10 to 2000 psi, RDB Channels 8-14, temperature environment ranges from —65° to 350°F. General purpose, corrosion resistant and temperature controlled models are laboriously explained in current technical bulletins. Please write for yours.

BJ ELECTRONICS
B-W
BORG-WARNER

BJ ELECTRONICS

BORG-WARNER CORPORATION

Reliability you can count upon

3300 NEWPORT BOULEVARD, P. O BOX 1679, SANTA ANA, CALIFORNIA
EXPORT SALES· BORG-WARNER INTERNATIONAL CORP., CHICAGO, ILLINOIS

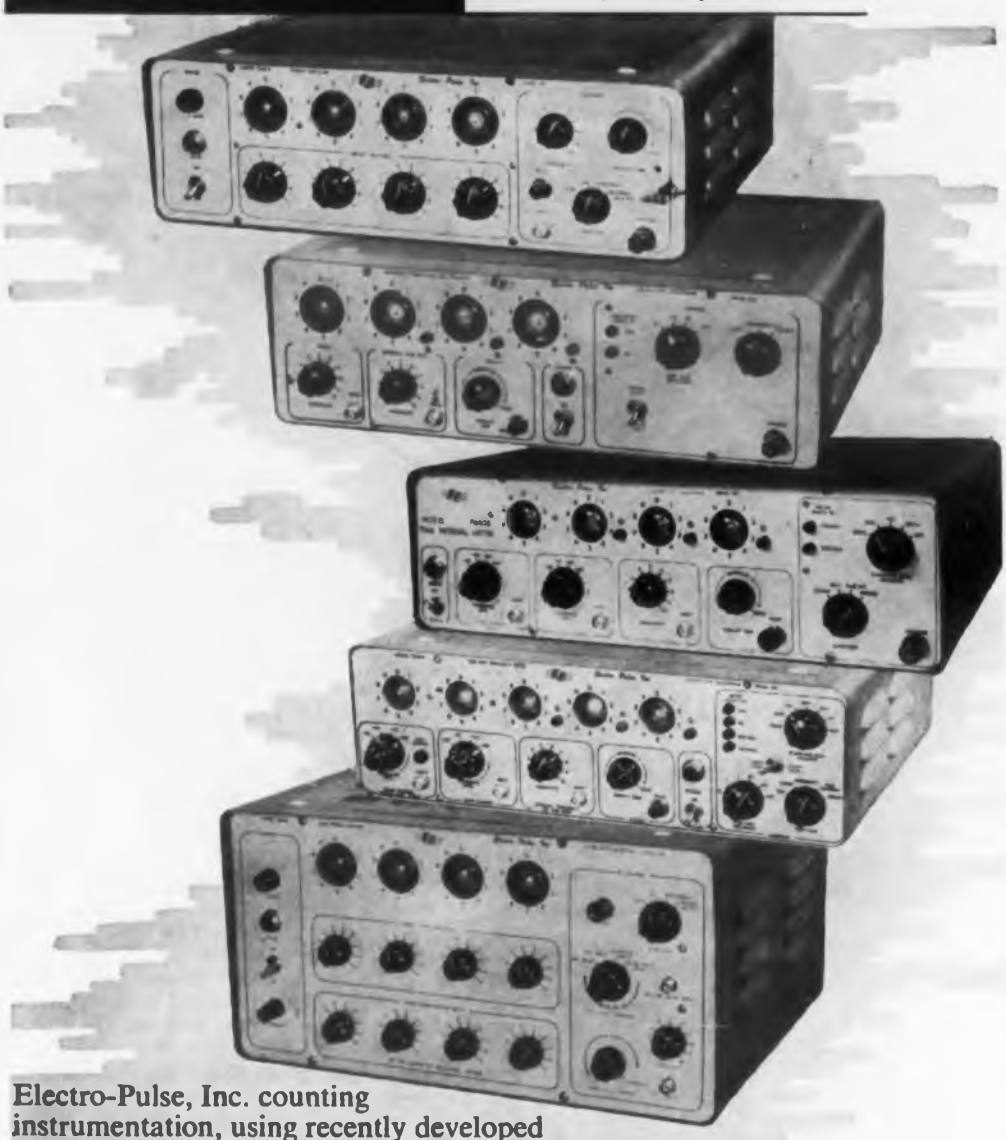
CIRCLE 158 ON READER-SERVICE CARD

a New Concept in

See our complete instrumentation Display—IRE Show—BOOTH 3611-13

ELECTRONIC COUNTING EQUIPMENT

- **Printed Wiring & Modular Construction**
- **Simplified Circuitry, Low Maintenance**
- **Self-testing, Self-indication**
- **Low Power Requirement**
- **Counter Tube Life: 10,000 hours**
- **Competitively Priced**



Electro-Pulse, Inc. counting instrumentation, using recently developed self-indicating glow transfer tube counters, offers significant advantages in a wide range of measurement and control applications. Simplified circuitry and advanced design provide laboratory accuracy and industrial reliability.

Packaging features include snap-off top and bottom cabinet plates—for easy maintenance access and conversion to bench or relay rack mounting. Standard printed circuit modules utilized in this equipment may also readily be combined for OEM and other special test and control requirements.

Instruments available include single and dual preset counters, frequency indicators with and without print-out, time interval meters, totalizers, combination frequency and time interval indicators.

Contact local Representative for further information—or . . .

Write for Complete Data: Catalog IC-58/ED

Electro-Pulse, Inc. also offers a broad line of **precision pulse instrumentation:**

Pulse Generators, Time Delay Generators, Magnetic Core Testing Equipment, Pulse Code Generators, etc.

Write for Catalog 1P-58/ED

Electro-Pulse, Inc.

11861 TEALE ST., CULVER CITY, CALIF. • Phone: EXmont 8-6764 or TExas 0-8006

CIRCLE 159 ON READER-SERVICE CARD

NEW PRODUCTS

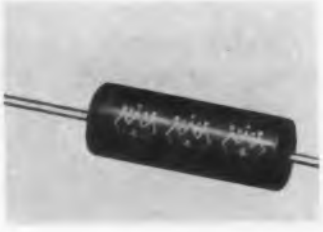
Variable Autoformers

Explosion-proof types

Designed for controlling power line voltage in hazardous areas, these autoformers feature lightweight cast aluminum housings and compact construction. Model 6240 illustrated has a power input of 120 w, 60 cps and output of 0-140 v, 7.5 amps, 1 kva max. Weight is 29 lb. Other models with smaller capacities are also available.

I-L-S Instrument Corp., Dept. ED, 4543 160th St., Cleveland 11, Ohio.

CIRCLE 160 ON READER-SERVICE CARD



Film Resistors

Costs little more than carbon types

The primary feature of these film type resistors is given as low cost. Characteristics are stated, to be comparable to wirewound properties. Seven types are available: 1/2 w, 350 v; 1 w, 500 v; 2 w, 750 v. The 3, 4, 5, and 7 w units can be used at their full wattage ratings at 40 C ambient temperature.

Union Resistor Corp., Dept. ED, 1001 W Weed St., Chicago 22, Ill.

CIRCLE 161 ON READER-SERVICE CARD

Caution Switch

Lighted bar gives warning

A caution switch assembly with a lighted bar containing any desired warning nomenclature is available. The unit is lighted by three AN3140-

327 lamps in parallel. Nomenclature is never visible unless the lamps are energized. Pressing the lighted strip actuates a switch inside the unit which can be used for re-setting in an annunciator system, or for any other desired control. The assembly has been qualified for extremes of vibration, shock, and temperature, and life of 50,000 operations.

Radar Relay, Inc., Dept. ED, 2120 Pontius St., Los Angeles 25, Calif.

CIRCLE 164 ON READER-SERVICE CARD

Microwave System Slide Rule

Simplifies communication calculations

Designed to simplify calculations used in planning a microwave communications system, this slide rule contains 28 scales and is used on both sides. One side is used to rapidly calculate propagation characteristics from 1000 mc to 30,000 mc. Included are Fresnel zone clearance, path loss, antenna and reflector gain, beam width and other path perameter needed for system design. On the reverse side are scales for multiplex calculations including signal-to-noise ratio, carrier loading and all other related factors for both fm and single sideband multiplex system performance calculation.

Motorola Communications and Electronics, Inc., Microwave & Industrial Control Dept., Dept. ED, 1400 N. Cicero Ave., Chicago 51, Ill.

CIRCLE 165 ON READER-SERVICE CARD

Reset Counter

Count is independent of input direction

Designed for speeds up to 1000 rpm or 1000 strokes per minute, these counters have capacities of 4 and 5 figures. A ratchet action is available which will record oscillations of the driveshaft through an arc as small as 45 deg.

The counter registers in one direction, regardless of the direction of driveshaft input. It may be obtained to add but not subtract or to subtract but not add.

Technicraft, Dept. ED, 6222 Ridge Ave., Philadelphia 28, Pa.

CIRCLE 166 ON READER-SERVICE CARD

THE ELEMENT OF GROWTH

and the Circuit Design Engineer

Technical growth thrives when two basic conditions are combined: (1) a complex program that explores new areas of science and engineering and (2) engineers and scientists whose personalities demand that their work extend them to the utmost.

Both conditions exist at System Development Corporation. Now, with significant expansion in progress, several new positions for Circuit Design Engineers have been created.

To qualify, at least three years' experience in general circuitry design in both tubes and transistors is required. Experience should encompass areas such as video and pulse circuits, cathode ray tube displays and analog and/or digital computer techniques.

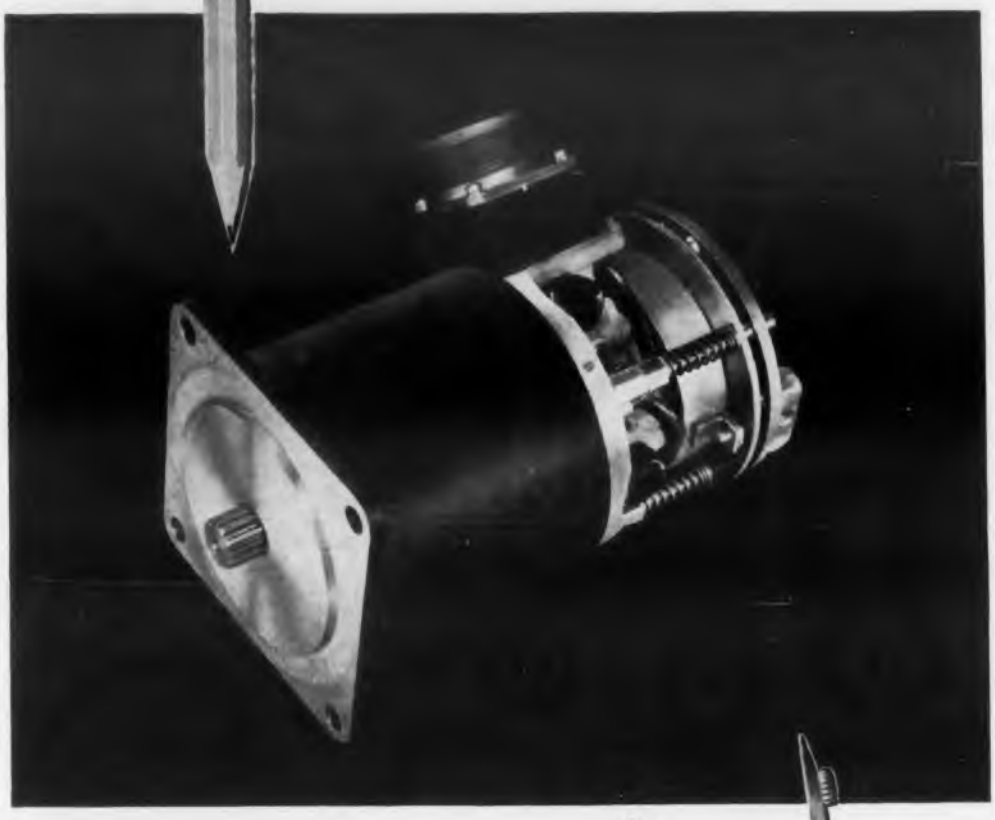
You are invited to write for more information or phone collect. Address R. W. Frost, System Development Corporation, 2432 Colorado Avenue, Santa Monica, Calif.; phone EXbrook 3-9411.

SYSTEM DEVELOPMENT CORPORATION

An independent nonprofit organization, formerly a division of the Rand Corporation

CIRCLE 553 ON READER-SERVICE CARD

DC MOTORS



Eicor rotary electric

and electronic components

precisely engineered to rigid government specifications

produced in the widest range of output ratings in the most compact sizes and weights

also manufactured for many commercial requirements

Inverters · Converters · Power Supplies · Generators
DC Motors · Dynamotors · Transistorized Power Supplies

EICOR

4233 WEST NORTH AVE., CHICAGO 39

Another F. L. Jacobs Division

CIRCLE 168 ON READER-SERVICE CARD

NEW PRODUCTS

Exciter-Demodulator

Supplies ac excitation and dc output in transducer circuits

Model 200 exciter-demodulator supplies current regulated ac excitation to a transducer, demodulates and filters the resulting signal and supplies a linear dc output signal proportional to transducer input. Direct operation is provided with standard strip chart recorders X-Y plotters and digitizing equipment. A magnetically regulated, tubeless circuit allows reliability for critical applications and freedom from drift. Model 200 is designed for operation with instruments having input impedances of 3000 ohms or greater. Model 200L is designed for 400 to 3000 ohm instruments.

Daytronic Corp., Dept. ED, 216 S. Main St., Dayton 2, Ohio.

CIRCLE 169 ON READER-SERVICE CARD

Magnetic Head Stacks

All-metal construction protects tape

Offered in a number of standard and special sizes, these magnetic head stacks present an all-metal surface to the magnetic tape, thus eliminating oxide and dirt deposits. Exceptional stability of all dimensions and track alignment has been achieved by eliminating plastics and resins as binding agents for aligning individual heads within the stack. Precision lapping, possible because of the all-metal design, provides long-time conformity of tape to heads. Head gaps are aligned to ± 50 μin and the line of gaps in each stack is perpendicular to the stack base plane within 0.02 deg. Heads for magnetic-drum applications are also available on special order.

Consolidated Electrodynamics Corp., Dept. ED, 300 N. Sierra Madre Villa, Pasadena, Calif.

CIRCLE 170 ON READER-SERVICE CARD

DENSITY PROBE.—The P-625 measures the density of liquids wherever liquir processing of any kind is involved. The unit will indicate liquid density change of 0.01 gram per cc in about one second.

General Communication Co., Dept. ED, 681 Beacon St., Boston 15, Mass.
IRE Booth No. 3063

CIRCLE 173 ON READER-SERVICE CARD

R-F CONNECTORS.—Added to the Company's line of Subminax components, these connectors have a nominal impedance of 50 ohms, and are for use with miniature RG-196/U Teflon coaxial cable.

Amphenol Electronics Corp., Dept. ED, 1830 S. 54 Ave., Chicago 50, Ill.

CIRCLE 174 ON READER-SERVICE CARD

MICROMETER HEADS.—Micrometer heads for wave-meters and other electronic equipment requiring micrometric adjustment are available to meet exact specifications as to length, head diameter, range, graduation, finish, or material.

L. S. Starrett Co., Dept. ED, Athol, Mass.

CIRCLE 175 ON READER-SERVICE CARD

ALARM-CONTROL UNIT.—Additional alarm sequences are being offered with the Electro-Pane annunciator. Mercury switches combined with mechanical tripping latch action allow alarm units to be used directly for control.

Electro Devices, Inc., Dept. ED, 116 S. Michigan Ave., Chicago 3, Ill.

CIRCLE 176 ON READER-SERVICE CARD

POWER TRANSISTORS.—Germanium types electrically matched to provide low distortion in audio and servo applications requiring push-pull amplification. Designated 2N399 and 2N401, and rated 8 w undistorted Class B push-pull output, each unit can dissipate to 25 w.

Bendix Aviation Corp., Dept. ED, Long Branch, N.J.

CIRCLE 177 ON READER-SERVICE CARD

SOCKET SCREWS.—A complete range of self-locking screws in all diameters from microsize no. 0 to 1-1/2 in. fasteners supplement the self-locking hexagon head screws introduced by the company last year. The socket screws are made self-locking by a nylon pellet inserted in the threaded section of the screws.

The Cleveland Cap Screw Co., Dept. ED, 4444 Lee Rd., Cleveland 28, Ohio.

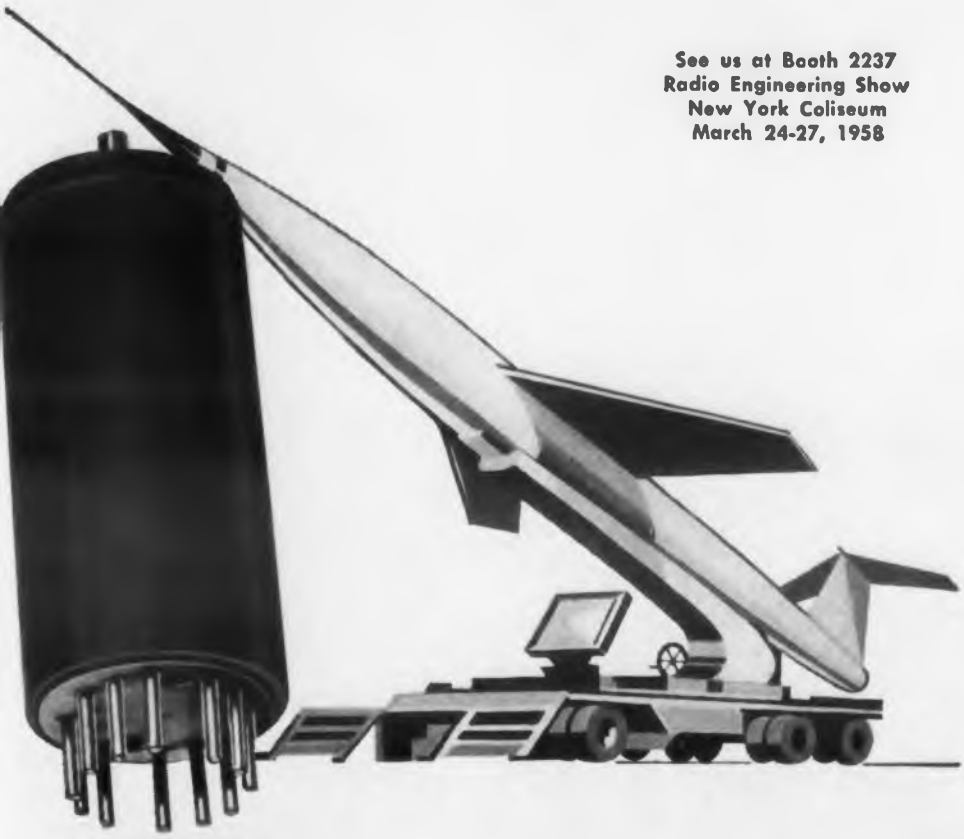
CIRCLE 178 ON READER-SERVICE CARD

SEARCH RADAR SIMULATOR.—May be used in place of an operational radar to supply inputs to tracking devices and other data processors. Effects of antenna radiation pattern, target scintillation, and receiver thermal noise may be simulated with validity.

Federal Scientific Corp., Dept. ED, 615 W. 131st Street, New York 27, N.Y.

CIRCLE 179 ON READER-SERVICE CARD

See us at Booth 2237
Radio Engineering Show
New York Coliseum
March 24-27, 1958



DIEHL*

SIZE 11 RESOLVER REACHES NEW STANDARD OF ACCURACY

0.03% TOTAL FUNCTIONAL ERROR

Missile guidance today requires more accurate Function Generators, Data Transmitters and Phase Shifters.

The DIEHL Size 11 Resolver is an answer to these problems.

DIEHL engineering and exceptional manufacturing methods insure a *uniformity* of product with a great percentage of the total production well within the 0.03% Total Functional Error. DIEHL defines percentage of Total Functional Error (T.F.E.) as: theoretical sine minus Actual Reading divided by sine 90° multiplied by 100.

A recent statistical check of one standard DIEHL resolver shows:

74% with T.F.E. less than 0.020%
22% with T.F.E. from ..... 0.020% to 0.025%
4% with T.F.E. from ..... 0.025% to 0.03%

This kind of quality eliminates the risk of culling special units from regular production.

All DIEHL standard units are available within 10 days. We invite your inquiries.

DIEHL MANUFACTURING COMPANY*
Electrical Division of THE SINGER MANUFACTURING COMPANY
Finderne Plant, SOMERVILLE, N. J.

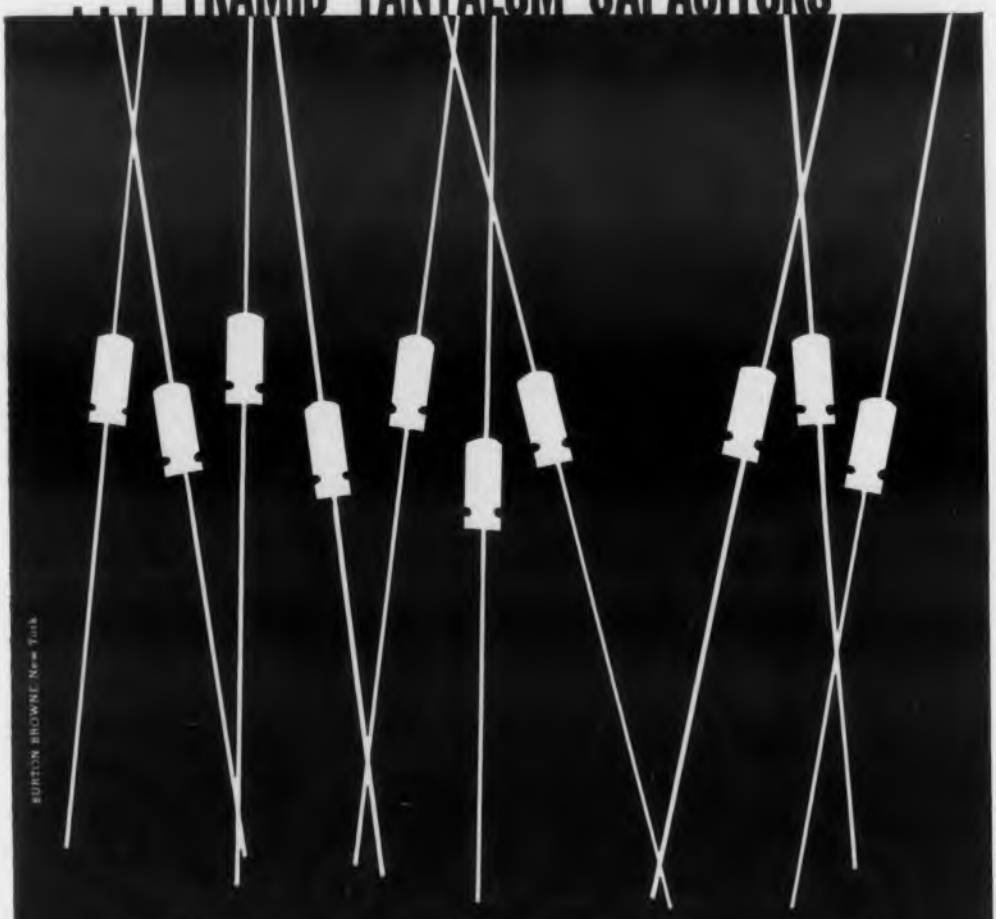
Other available components:
A.C. SERVOMOTORS • A.C. SERVOMOTORS WITH A.C. TACHOMETERS
A.C. SERVOMOTORS WITH D.C. TACHOMETERS • A.C. AND D.C. TACHOMETERS
D.C. SERVO SETS • RESOLVERS

*A Trademark of DIEHL MANUFACTURING COMPANY

CIRCLE 180 ON READER-SERVICE CARD

UP TO 1000 MFD-VOLTS IN LESS THAN 2/100 OF A CUBIC INCH

...PYRAMID TANTALUM CAPACITORS



Pyramid Tantalum slug capacitors are miniaturized to provide maximum space economy.

New Pyramid Tantalum slug capacitors have cylindrical cases and contain a non-corrosive electrolyte. Due to the special construction of materials used in the manufacture of Pyramid Tantalum slug capacitors, these units are both seep and vibration proof. In addition, this type of capacitor assures long service life and corrosion resistance — made to meet MIL-C-3965 Specifications.

Commercially available immediately, these new Pyramid Tantalum capacitor units have an operating range between —55° C to 100° C for most units without any de-rating at the higher temperature.

To obtain complete engineering data and prices for Pyramid Tantalum slug capacitors, write to: Pyramid Research and Development Dept., Pyramid Electric Company, 1445 Hudson Boulevard, North Bergen, New Jersey.

. CAPACITORS — RECTIFIERS
FOR ORIGINAL EQUIPMENT —
FOR REPLACEMENT

PYRAMID
ELECTRIC COMPANY
NORTH BERGEN, N. J.

CIRCLE 181 ON READER-SERVICE CARD

NEW PRODUCTS

CONNECTORS.—Four no. 12 size contacts, each carrying 40 amp have been arranged in a 19-pin shell. Designation is DM9700-194 and DM9601-194.

The Deutsch Co., Dept. ED, 7000 Avalon Blvd., Los Angeles, Calif.

CIRCLE 182 ON READER-SERVICE CARD

SWEEP GENERATORS.—The line of Transitron signal and sweep generators is now available for mounting on standard size racks. Included are the SG-161 (900-2100 mc), SG-132 (15-400 mc), SG-109 (400-1000 mc), and the SG-153 (1800-4000 mc) types.

Van Norman Industries, Inc., Electronic Div., Dept. ED, 186 Granite St., Manchester, N.H.

CIRCLE 183 ON READER-SERVICE CARD

WATER LOAD.—Rated to dissipate 75 kw, type 517 load is available for 50, 75 or 230 ohms impedance on any specified frequency within the range of 300 kc to 3000 kc.

Continental Electronics Mfg. Co., Dept. ED, 4212 S. Buckner Blvd., Dallas 27, Texas.

CIRCLE 184 ON READER-SERVICE CARD

PACKAGING.—Sus-Rap is a preformed fibre board wrap-around material designed to block, space, and cushion fragile products. The manufacturer also offers design facilities to provide custom packaging.

Vanant Co., Inc., Dept. ED, 952 S. Water St., Milwakee 4, Wis.

CIRCLE 185 ON READER-SERVICE CARD

3-WAY VALVE.—Second in a series produced by Eckel, type BF42C weighs three ounces and provides inherent minimum internal leakage. Power consumption is 9 w at 28 v dc.

Eckel Valve Co., Dept. ED, 1425 First St., San Fernando, Calif.

CIRCLE 186 ON READER-SERVICE CARD

POWER SUPPLY.—A low-voltage type has been added to the Nelson line for purposes such as production testing of semi-conductor products. Output is 1.5 to 15 v, 0 to 1 amp with 0.5 per cent ripple and regulation.

Nelson Instrument Co., Dept. ED, 607 Howard St., Evanston, Ill.

CIRCLE 187 ON READER-SERVICE CARD

SOLENOIDS.—Type C-8 measures 5/8 x 3/4 x 1-1/4 in. and is available for ac-dc service. Type C-8 is a miniature version for lower force requirements.

Anderson Controls, Inc., Dept. ED, 2777 Mannheim Rd., Des Plaines, Ill.

CIRCLE 188 ON READER-SERVICE CARD

INSTRUMENT CABINETS.—Counter-height equipment cabinets have been designed for instrumentation purposes where operators are required to be on the move or standing. The enclosures can be mounted on casters for mobility.

Elgin Metalformers Corp., Dept. ED, 630 Congdon Ave., Elgin, Ill.

CIRCLE 189 ON READER-SERVICE CARD

CAPACITANCE PROBE TESTER.—The MD-2A measures electrostatic capacitance and electrical insulation resistance directly. Capacitance range is from 0 to 5000 μμf. Accuracy of the unit is 0.25 per cent of full scale.

Consolidated Airborne Systems, Inc., Dept. ED, 321 Willis Ave., Mineola, N.Y.

CIRCLE 192 ON READER-SERVICE CARD

GLASS-ENCLOSED CRYSTALS.—Similar to type RH-8DP released last year, the RHG-DP has an increased frequency range from 1 to 15 kc. Components are hermetically sealed in glass bulbs (T5 1/2 with noval base). Temperature range is −55 to 100 C with a stability of ±0.02 per cent.

Dynamics Corp. of America, Reeves-Hoffman Div., Dept. ED, Carlisle, Pa.

CIRCLE 193 ON READER-SERVICE CARD

TRANSISTORS.—Three types added to the Philco line include type 2N534, a 50-v version of the basic low level audio transistor; type 2N535 for 85 C operation with 20-v collector voltage rating; and type 2N536 for switching applications.

Philco Corp., Dept. ED, 4700 Wissahickon Ave., Philadelphia 44, Pa.

CIRCLE 194 ON READER-SERVICE CARD

DOUBLE-ENDED CRYSTAL DIODES.—Eliminating the need to specify reverse diodes, these units are designated 1N416B, C, D, and E for 1N21 types, and 1N415B, C, D, and E for the 1N23 series.

Sylvania Electric Products, Inc., Dept. ED, Woburn, Mass.

CIRCLE 195 ON READER-SERVICE CARD

CAPPED CLINCH NUTS.—Self-locking type LHC-FKM has an integral metal cap to prevent potting compound from flowing inside the nut threads when used inside miniature transformers.

Elastic Stop Nut Corporation of America, Dept. ED, 2330 Vaux Hill Rd., Union, N.J.

CIRCLE 196 ON READER-SERVICE CARD

THERMOSTAT.—For use in ranges up to 700 F, this unit has three separate heating phases, one of which is on continuously when desired. Two other phases are controlled thermostatically.

Robertshaw-Fulton Controls Co., Thermostat Div., Dept. ED, Youngwood, Pa.

CIRCLE 197 ON READER-SERVICE CARD

MIXER CRYSTAL.—The MA-423A, for C and X bands requires no dc bias. It is mechanically interchangeable with the 1N23 series but provides improved receiver noise figures of 7 db or better when used with a 1.5 db r-f strip at 30 mc.

Microwave Associates, Inc., Dept. ED, Burlington, Mass.

CIRCLE 198 ON READER-SERVICE CARD

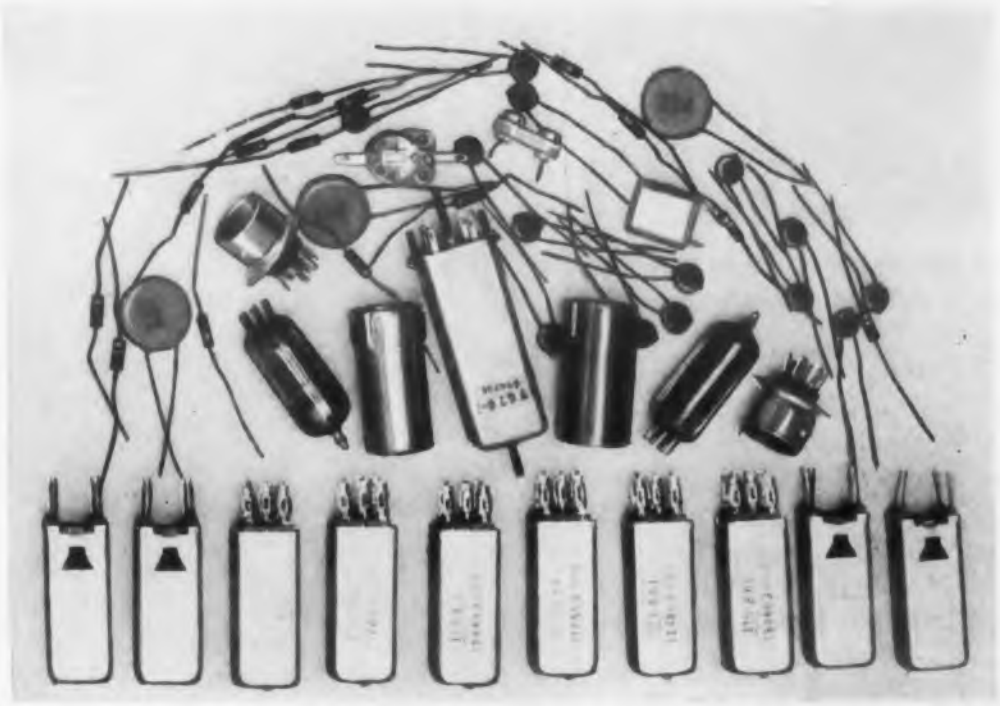
PUMP AND MOTOR.—Model 1203-152D is a pump and motor combination designed to supply oil under pressure to hydraulic actuators on the ground-based radar antennae. The equipment features three-phase thermal protection with automatic reset.

Eastern Industries, Inc., Dept. ED, Hamden, Conn.

CIRCLE 199 ON READER-SERVICE CARD

CRYSTAL FILTERS

NOW YOU CAN REPLACE ALL OF THESE COMPONENTS



Shown approx. ⅓ size

WITH A SINGLE HYCON EASTERN CRYSTAL FILTER

Shown approx. ⅓ size

IRE SHOW
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HYCON EASTERN, INC.

75 Cambridge Parkway Dept. B, Cambridge 42, Mass.

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NEW MATERIALS

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For applying potting compounds

The Helix disposable syringe, made of molded polyethylene, can be used for applying bonding agents and potting compounds easily and quickly. Each syringe has a tapered tip so that orifice diameters may be enlarged by cutting back the tip. Also available with steel hollow needle tips.

Carl H. Biggs Co., Inc., Dept. ED, 2255 Barry Ave., Los Angeles 64, Calif.

CIRCLE 201 ON READER-SERVICE CARD

Copper Clad Laminate

Has highly resistant bond

This material, Textolite 11558, is characterized by a copper to laminate bond which is as resistant to cyanide plating solutions, solvents and thermal aging as the base laminate itself. It will easily pass dip solder specifications. Illustrated is a solder pot test at 500 F.

General Electric Co., Dept. ED, Coshocton, Ohio.

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CIRCLE 203 ON READER-SERVICE CARD ➤

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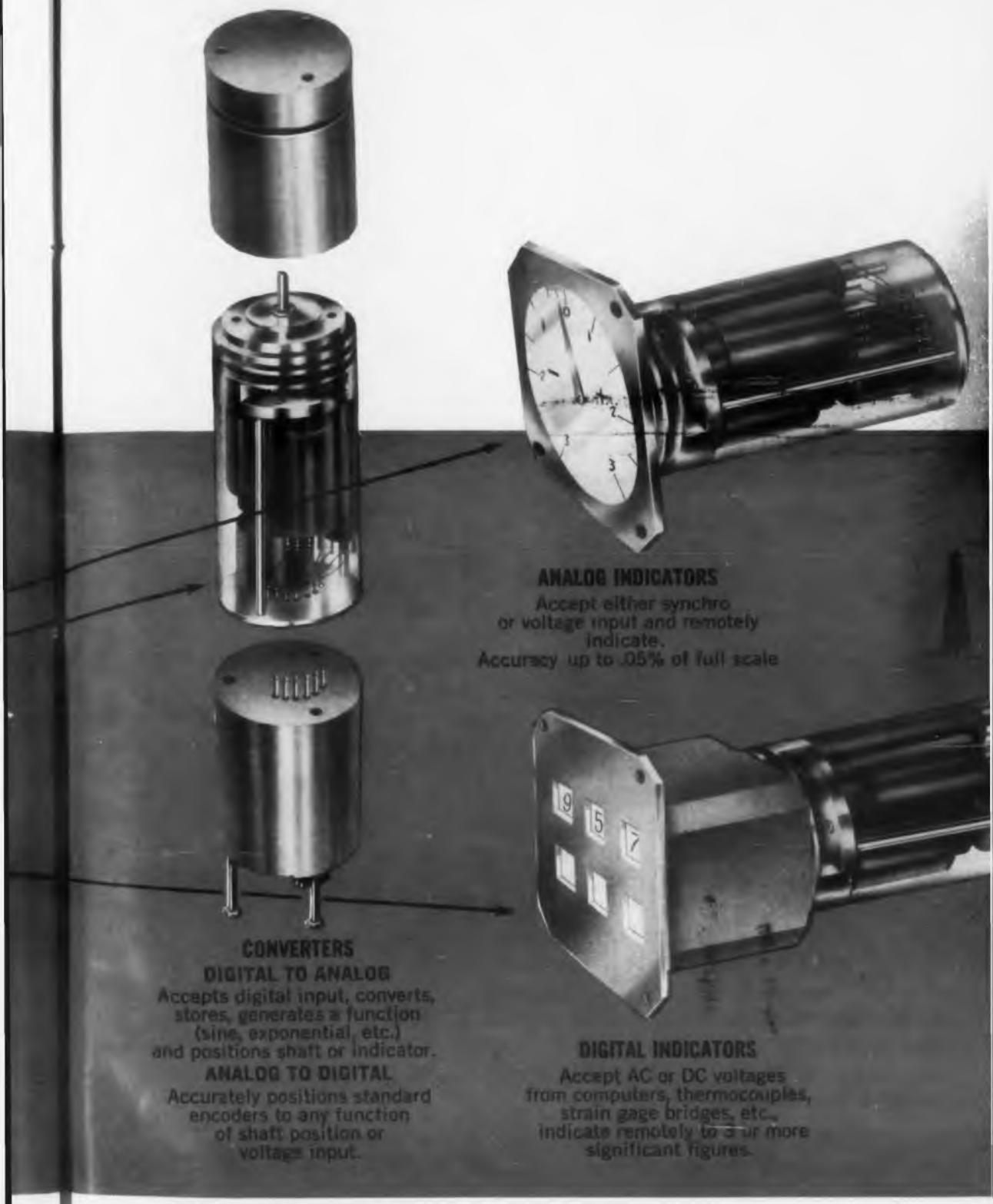

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Colored Insulator Stock

Color-coded Teflon rod

This colored Teflon rod stock is intended for use in the machining of such parts as feed-through and stand-off insulators. Available in eleven colors, it meets the requirements of specification MIL-STD-104. Supplied in diameters from 1/32 to 2 in.

Chemplast, Inc., Dept. ED, 3 Central Ave., E. Newark, N.J.

CIRCLE 204 ON READER-SERVICE CARD

Conductive Adhesive

For use where solder is impractical

These conductive adhesives are epoxide based materials which are supplied in paste form and can be cured rapidly at moderate temperatures to produce rigid, low electrical resistance solids. They are of use where soldering is impractical due to heat or because solder will not wet and adhere to conductive plastics or nichrome wire. Adhesion is excellent to metals, plastics, glass and ceramics. Bond strength is about 2000 psi. Conductivity of resultant compositions compares with that of metals. No solvent is present. Once cured, they can be used from −65 to +500 F.

The adhesives, trademarked Eccobond, are as follows: Type 56 C is two component paste cured at 120 F with a volume resistivity of 0.1 ohm-cm. Type 58 C is one component, cured at 300 F, with same resistance. Type 60 L is a two component paste, cured at room temperature, with resistance of about 300 ohm-cm.

Emerson & Cuming, Inc., Dept. ED, 869 Washington St., Canton, Mass.

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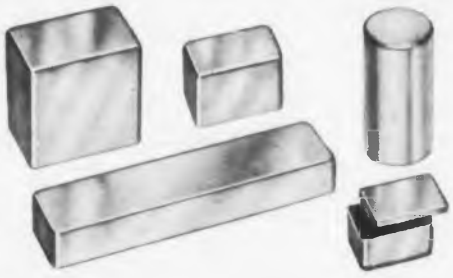

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CIRCLE 207 ON READER-SERVICE CARD

NEW MATERIALS

Flattened Aluminum Wire

Has rounded edges

Round edge flattened wire in thickness ranging from 0.02 to 0.187 in., and in widths from 0.063 to 1 in. is available in E. C. grade and in alloys 1100, 3003, 5052, and 5056. Numerous other flattened wire sizes and alloys are also available upon special request by customers. Round edge flattened aluminum wire is being used for primary and secondary transformers, dc generator commutator windings, armor for electrical cable, and for electro magnets.

Kaiser Aluminum & Chemical Sales, Inc., Dept. ED, 919 No. Michigan Ave., Chicago 11, Ill.

CIRCLE 208 ON READER-SERVICE CARD

Glass Domes

For Transmitting Infrared Radiation

Called Servofrax, this arsenic trisulphide glass may be molded, ground and polished to produce one-piece domes. Used in transmitting infrared radiation to infrared detection equipment, this shape is available in sizes from 4 to 12 in. diam and may be ordered in any spherical section up to 180 deg. The dome has a slight negative lens effect which sometimes can be used effectively as a Maksutov corrector for concentric optical systems.

Servo Corp. of America, Dept. ED, 20-20 Jericho Turnpike, New Hyde Park, N.Y.

CIRCLE 209 ON READER-SERVICE CARD

Encapsulating Compound

High flow properties

The flow properties of this compound called Chem-o-sol permit it to conform to complex-mold cavities. It may also be employed in dipping operations, such as in coating capacitors, wire ends, and complex wire constructions. Chem-o-sol is also applicable to spaghetti tubing and to other types of vinyl constructions.

The conversion of Chem-o-sol from a liquid to a solid is accomplished by exposing it to heat in the order of 375 F. No pressures are required in the conversion process. Electrical resistance is 800 v per mil when deposited in thicknesses of 10 mils, and short-term heat resistance is 450 F.

Chemical Products Corp., Dept. ED, King Philip Rd., East Providence, R.I.

CIRCLE 211 ON READER-SERVICE CARD

Ceramoplastics

Molding techniques make thinner sections possible

Sections as thin as 0.018 in. to tolerances of ±0.001 in. have been precision-molded of Supramica 555 ceramoplastic offering added possibilities for designers of miniature components for high-temperature applications. Illustrated is a field coil bobbin in which the flanges are 0.018 in. thick, with the entire piece measuring 3/8 x 7/16 in. overall. The molding technique used makes possible the use of Supramica for parts which have previously been moldable only by injection molding of organic plastics materials. Supramica ceramoplastic is a standard product of the company made from synthetic mica.

Mycalex Corp. of America, Dept. ED, 125 Clifton Blvd, Clifton, N.J.

CIRCLE 212 ON READER-SERVICE CARD

Precision Pins

Tapered and other shapes

Small precision pins and shaft are being offered in diameters from 0.03 to 0.1875 in. and lengths from 0.125 to 2 in. Precision taper pins are also available with tolerances of 0.0001 in. through length of pin. Shapes include dowel, straight, countersunk, or angle ends.

Commercial Centerless Grinding Co., Dept. ED, 6609 Cedar Ave., Cleveland 3, Ohio.

CIRCLE 213 ON READER-SERVICE CARD

NEW MATERIALS

Silicon Glass Tubing

Precision Coil Form

Precision bore 96 per cent silica glass tubing has been made available with inside diam tolerance of up to ±0.0005 in. The Vycor brand tubing can be manufactured with diameters from 1/8 to 3 in., with special slots or indentations made to precision tolerances. Having a very low coefficient of expansion, the tubing has uses as a precision coil form, or as an enclosure for high frequency, high temperature transmitters, and precision resistors.

Corning Glass Works, Dept. ED, Corning, N.Y.

CIRCLE 218 ON READER-SERVICE CARD

Ultrathin Precious Metal

Clad to Inexpensive Base

Precious metals permanently clad to inexpensive base metals are available in precision-rolled strip. Precious metals include silver, gold, platinum and palladium. Cladding is accomplished by direct bonding by means of heat and pressure. As an example, gold clad nickel can be manufactured with a layer of gold 0.00006 in. thick.

American Silver Co. Inc., Dept. ED, 36-07 Prince St., Flushing 54, N.Y.

CIRCLE 224 ON READER-SERVICE CARD

High Temperature Cement

Capable of sealing glass to metal at temperatures as high as 450 C

Presently being used to seal the face panel to the funnel of color TV tubes, this cement has a service temperature as high as its sealing range, from 400 to 450 C. The new cement can be used to seal most glasses, including lead, lime and barium-flint types, ceramics to glass, ceramics and metal to glass and metal to metal. A short heat treatment transforms the cement into an extremely strong glass-ceramic. In most glass-to-glass seals, this bond is stronger and harder than the parts, even at elevated temperatures.

Corning Glass Works, Dept. ED, Corning, N.Y.

CIRCLE 225 ON READER-SERVICE CARD

Class F Insulating Varnish

Cured at 125 C

Designed to meet temperature requirements of 155 C, this insulating varnish may be cured at temperatures as low as 125 C. The polyester-type varnish cures to a tough, flexible film with good adhesive and electrical properties and resistance to oil, moisture and acid. Typical applications include treating of transformers, magnet coils, stators, fields, and low-speed armatures.

General Electric, Dept. ED, Schenectady 5, N.Y.

CIRCLE 226 ON READER-SERVICE CARD

NEW LITERATURE

Instrument Catalog 229

This 4-color, 132 page catalog contains the manufacturer's entire line of 200 items, ranging from Geiger Mueller detectors to transistorized multi-channel analyzers. For reading ease, the catalog is divided into four sections, with a special section of applications. Each section has its own table of contents. The applications section shows how the detectors, instruments and accessories can be combined to form various detecting, counting and analyzing systems. The catalog contains colored charts, graphs, and other illustrations. Radiation Counter Labs., Inc., 5121 W. Grove St., Skokie, Ill.

Centrifugal Fans 230

Catalog 1121 presents a line of centrifugal fans with airfoil blading. It depicts and describes a number of fan arrangements, bearings, wheels, and accessories. The 10-page booklet also contains selection charts and dimensional drawings. Westinghouse Electric Corp., Sturtevant Div., 200 Readville St., Hyde Park, Boston 36, Mass.

Motor Generator Sets 231

Bulletin MG957 covers 400 cps motor generator sets. The 4-page folder presents specifications and pictures for synchronous and induction type units from 500 w to 250 kw. Kato Engineering Co., 1415 First Ave., Mankato, Minn.

Insulating Materials 232

Electrical insulating materials are featured in catalog 23. Containing photos, prices, and ordering data, the 32-page catalog describes over 36 different insulating materials. Several pages are devoted to Mylar and Rag paper combination and dispenser packaged cuffed paper and Mylar combination insulations. Insulation Manufacturers Corp., 565 W. Washington Blvd., Chicago 6, Ill.

Motor Generators 233

An illustrated catalog describes a recent addition to a line of motor generators. The dc unit has removable inspection covers and is fan cooled. Carter Motor Co., 2711A W. George St., Chicago, Ill.

Safety Cleaning Solvent 235

Specifications of a safe cleaning solvent are given in a 1-page sheet. The cleaner is compared with carbon tetrachloride and other chlorinated solvents which it can replace. Harco Chemical Co., Cranford, N. J.

Ultrasonic Welding 236

Ultrasonic welding and equipment to effect it are discussed in Bulletin SW-87. The 4-page illustrated brochure points out advantages of the system and the strength of spot-type welds in various materials. Sonobound Corp., Subsidiary of Aeroprojects, Inc., West Chester, Pa.

Overheat Detection 237

"Continuous Fire and Overheat Detection for Aircraft Safety" is the title of this 8-page brochure. The brochure, illustrated with graphs, charts and photographs, contains a description of the operating principal behind the detector and gives general specifications. Uses in general industry as well as aircraft are also included. Fenwal, Inc., Pleasant Street, Ashland, Mass.

Wire Processing Film

"Modern Wire Processing," a 15-minute 16mm color motion picture on an automatic wire cutter and stripper is available on a loan basis. The color film shows in detail the action and operation of the machine, which will cut and strip 12 ga. to 32 ga. insulated wire in lengths from 1 in. to 300 ft at speeds up to 8,000 pieces an hour. *It may be obtained from Eubanks Engineering Co., 260 N. Allen Ave., Pasadena, Calif.*

Pulse Transformers 238

Specifications on a full line of pulse transformers are listed in Catalog TR-57. Twenty-five new items have been added to this latest edition. Triad Transformer Corp., 4055 Redwood Ave., Venice, Calif.

Time Interval Meter 239

A 1-page catalog sheet presents illustrations and complete specifications for a time interval meter. The unit measures periods and period ratio as well as intervals. Electro-Pulse, Inc., 11861 Teale St., Culver City, Calif.

CIRCLE 241 ON READER-SERVICE CARD

NEW LITERATURE

Axial Flow Fans 243

Attractively illustrated, the 4-page bulletin, No. 5703, includes a detailed enumeration of aircraft, electronic, commercial and marine applications for a line of axial flow fans. Illustrations show the self-contained "package" design. Specifications in table form are also given. The fans described have a range or rating from 16 to 5000 cfm. Borg-Warner Corp., Pesco Products Div., 24700 N. Miles Rd., Bedford, Ohio.

Carbon Pile Elements 244

Bulletin 6 AE discusses carbon discs, plates, and pile assemblies for all types of carbon pile rheostats and similar control units. Its 5 illustrated pages point out carbon properties, size ranges, and methods for determining the resistance of a specific pile. Two graphs plot resistance and elongation versus force for a typical large and small carbon rheostat element. Speer Carbon Co., St., Marys, Pa.

Electronic Parts Catalog 245

A 200-page electronic parts catalog has been announced. It lists, with details, components and equipment for service, industrial, communications, public address, and amateur applications. Electronic Publishing Co., Inc., 180 N. Wacker Dr., Chicago 6, Ill.

Stainless Fasteners 246

A 12-page catalog of stainless steel AN fasteners is offered. With pictures, it describes government specification aircraft bolts, slotted and Phillips machine screws, flat and round rivets, and washers. Stock sizes and dimensions are given. Allmetal Screw Products Co., Inc., 821 Stewart Ave., Garden City, N. Y.

Crystal Filters 247

A 4-page catalog outlines the major characteristics of some standard crystal filters. Specifications, outline drawings, a typical characteristic curve, and a circuit diagram are shown. Hycon Eastern, Inc., 75 Cambridge Pkwy., Cambridge 42, Mass.

Wide Range Pulse Generator 249

A wide range pulse generator, Type 1006, is illustrated and described in a technical bulletin just released. The unit produces a stable source of pulses in eight overlapping frequency ranges up to 4.5 mc. Its output may be a continuous train of pulses controlled by selecting one of the eight frequency ranges or a single pulse controlled by pressing a pushbutton on the front panel. The output pulse is either a positive or negative half sine-wave of 0.1 μsec duration. Amplitude is variable from 8 to 30 v. Burroughs Corp., 1209 Vine St., Philadelphia 7, Pa.

Pulse-Height X-Ray Technique 250

In a 4-page article David C. Miller discusses problems related to pulse height analyzers used in X-ray work. The article outlines the construction, application, and limitations of pulse-height analyzers and devotes separate sections to window and base line settings, detector operation, and interference. Illustrated with graphs and tables, the text explains how to operate pulse-height units with scintillation, proportional, and flow counters to obtain best results. It also tells how to handle two energies which are quite well resolved and two overlapping distributions where one is much stronger than the other. Reprinted from Norelco News, "Some Considerations in the Use of Pulse Height Analysis with X-Rays" is free to those who request it. Philips Electronics, Inc., Instruments Div., 750 S. Fulton Ave., Mt. Vernon, N.Y.

Precision Fasteners 251

A broad range of precision industrial fasteners—for a wide variety of production assembly and maintenance applications—is reviewed in a bulletin now available. The four-page bulletin covers the complete line of standard industrial fasteners including socket screw products, self-locking nuts, spring pins and steel collars.

The illustrated literature gives range of sizes, materials, finish, and other specifications for socket, head, cap, and set screws, shoulder screws, both regular height and thin self-locking nuts, clinch nuts, dowel pins and collars. Standard Pressed Steel Co., Box 202, Jenkintown, Pa.

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IDEAS FOR DESIGN

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Rapid Design of Transistorized Regulated Power Supplies

A RAPID, simplified design of practical transistorized regulated power supplies can be accomplished using the following procedure. A set of basic rules is a prerequisite. They are:

1. The power source for the reference should be taken from the regulated output of the supply in order to maintain the reference current independent of power supply input variation;

2. The maximum current drawn from the reference should be as small as possible in order to reduce the reference voltage variation and drift, due to heating;

3. Automatic compensation must be provided to further reduce output variations. (The alternative method of increasing regulator gain by cascading several transistors increases cost, complexity, and transistor leakage problems);

4. The design must be based upon transistor types in plentiful supply. This dictates pnp types, if germanium transistors of reasonable voltage and power ratings are desired.

Circuit And Operation

The simple one-transistor schematic in Fig. 1 fulfills the above requirements. It is capable of reducing input voltage variation by a factor which can exceed 1000.

The transistor is in shunt with load resistor R_L. Rising output voltage causes the zener reference to pass more current into the transistor base. The transistor then passes beta times the base current, giving rise to an increased voltage drop across R_s. This tends to maintain the output constant. R_c, if properly chosen, will greatly reduce any remaining variations in output voltage.

The action of R_c is as follows: Since the transistor collector current flows thru R_c, an increase in collector current causes an increased voltage drop across R_c. This voltage drop is additive with the drop across R_s as far as the output voltage is concerned, but does not affect the zener reference element. Hence, it compensates for input voltage variation. Increasing R_c will give the supply a negative resistance characteristic, i.e, an increase in input voltage will result in a decrease in output voltage.

Design Example

Assume a required regulator delivering 10 ma at 7 v, from an input of 24 to 28 v. R_L is therefore 700 ohms.

Step 1. *Determining* R_s.

$$R_s \cong \left(\frac{minimum\ E_{in} - E_{out}}{E_{out}}\right) R_L$$

$$= \frac{24-7}{7}\ (700) = 1700\ ohms.$$

This approximation is not quite correct, due to the fact that at the lowest input voltage the zener reference must remain in conduction. The transistor is thus caused to pass a small current, to which must be added the transistor leakage. This necessitates decreasing the value of R_s somewhat; however, the above formula furnishes a quick guide to the selection of R_s. (Transistor leakage and minimum zener currents vary with type and quality of units, and are not predictable).

Step 2. *Choosing the transistor.*

$$I_{collector\ max} = \left(\frac{maximum\ E_{in} - E_{out}}{R_s}\right) - \frac{E_{out}}{R_L}$$

$$= \frac{28-7}{1500} - \frac{7}{700} = 0.004\ ampere$$

(R_s is assumed to be 1500 ohms here, instead of 1700, in accordance with the notes in Step 1. The next lowest stock value of resistance was 1500 ohms).

Since $E_{collector} = -7$ v, maximum dissipation

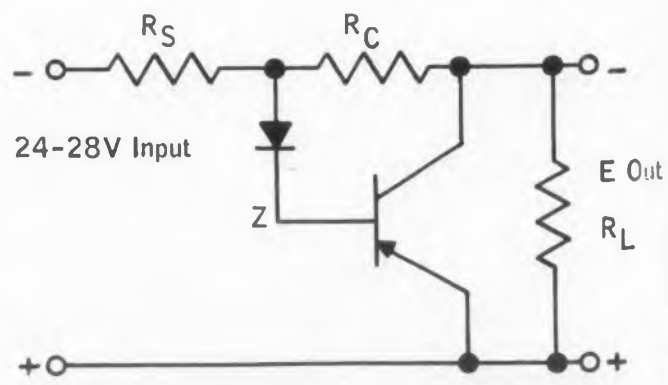


Fig. 1. Basic transistorized shunt regulator.

is 28 mw. Suitable is any low base-resistance, pnp medium beta transistor, with collector voltage rating above 7 v, and dissipation exceeding 28 mw at the desired ambient temperature. A typical choice might be a Tung Sol 2N382 which has a wide margin of safety factor, and beta of ≅ 50.

Step 3. *Choice of a zener.*

$$Maximum\ I_{zener} \cong \frac{I_{collector\ maximum}}{Beta}$$

$$= \frac{0.004}{50} = 80\ microamperes$$

The zener must have a voltage rating equal to the maximum desired output voltage of the regulator—7.0 v.

Dissipation = 7.0 v (80 x 10^{-6}) = 0.56 mw. Any 7 v zener will meet this requirement powerwise; however, zeners are available with various temperature coefficients and dynamic impedances. This zener should be selected for the desired temperature coefficient and low dynamic impedance at the working current of 80 μa.

Step 4. *Selection of compensating resistor R_c).*

$$R_c \cong \frac{\Delta\ E_{out}}{I_{collector\ maximum}}$$

With R_c shorted out and load connected, vary the input voltage from minimum to maximum and note change in output setting. R_c can then be calculated as above. Sure R_c compensates for variations of both zener and transistor, it cannot be calculated accurately till $\triangle E_{out}$ is known. It is practical to substitute a rheostat for R_c where extremely close compensation is required.

Filter Considerations

A regulated supply, designed as above, gave a variation of ±2 mv from nominal with an input variation of 4 v, or ±0.05 per cent. The ripple reduction factor inherent in this supply, reduces the necessity for elaborate input filtering, hence a simple resistance capacitance filter suffices for many applications. This was achieved economi-

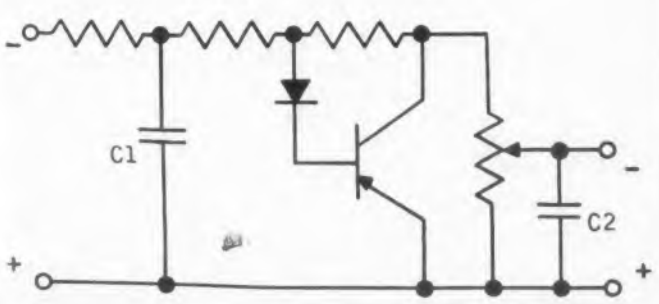


Fig. 2. Shunt regulator with filter and variable output control. Note simplicity.

IDEAS FOR DESIGN

cally by splitting R_x into two 750 ohm resistors in series, and adding a filter capacitor, *C1*, as in Fig. 2. This resulted in 500 μv of output ripple.

An output capacitor *C2* was also added to maintain low output impedance at frequencies above the transistor cut off frequency, and eliminate any noise generated by the zener diode. In this design, the 10 ma current drain of the load resistor chosen was much greater than the small ouput current delivered to another circuit by the reference supply. A potentiometer was therefore substituted for R_L, delivering any required voltage from 0 to 7 v, with exceptional freedom from line and load variations. The total power consumed by this basic supply was less than 1/3 w. The reduction in circuit complexity enabled packaging in 10 cu in. without crowding, using conventional components and techniques.

Bernard B. Daien, Chief Engineer, Transistor Devices Inc., Kenilworth, N.J.

New Ground Strip for Electron Tubes

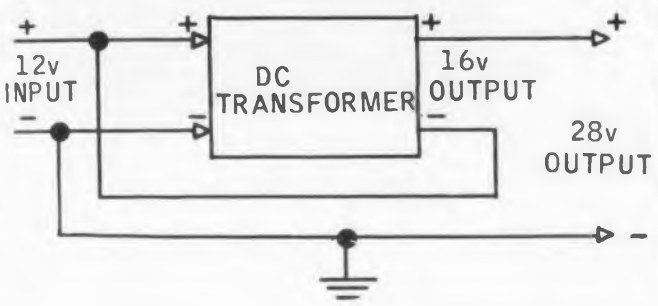
Left, the old ground strip; possibility of poor ground connections prompted new design. **Right,** the new ground strip; contact pressure provides good ground connections, and tubes are easily inserted.

The new ground strip, shown at right, eliminates poor ground connections often experienced with the design shown at left. This ground strip is made of two identical semicircular, tin-plated phosphor-bronze pieces curved to fit around the base of the tube socket. When assembled as shown, the pieces form a four-section ground strip mounted in the same manner as, and interchangeable with, the older one. The sections are designed to minimize the possibility of tube pins

catching on the top or in the openings, unless there is a misdirection to the extent that one or more tube pins are outside the ground strip. The tubes and shields cannot be put in at an angle because the four sections act as guides, and the sections also allow the tube and shields to be rotated to locate the pins in their contact holes without snagging. Such features are particularly advantageous when a person must reach to insert a tube in a location where he cannot see the socket. Because the individual sections are rugged and are not easily damaged, they insure a reliable ground connection.

From Bell Laboratories Record, Volume XXXVI, No. 1, January, 1958.

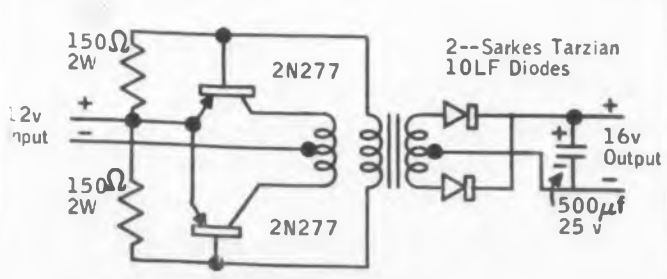
Transistorized Audio Amplifiers From 12-volt Supply



It was desired to design a transistorized audio amplifier to operate from a 12 v supply and deliver 50 w output. This problem is made difficult by the fact that there are no transistors currently available that will deliver this amount of power without a higher voltage supply. A supply voltage of 28 v would be ideal for this application.

A dc transformer (sometimes called a dc power converter, dc-to-dc transformer and dc voltage changer) which delivers 16 v output with a 12 v input can be connected as shown in Fig. 1 to provide about 100 w at 28 v from a 12 v line. The overall efficiency of the device when used in this manner is about 82 per cent. Ground continuity is maintained. A schematic of the dc transformer is shown in Fig. 2.

Thomas P. Prouty, Engineering Section Chief, Hallamore Electronics Co., 8352 Brookhurst Ave., Anaheim, Calif.



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YOUR HEART IS *YOUR* BUSINESS. Whatever your way of life, your future depends on your heart. Heart disease causes personal suffering and undermines the happiness and economic welfare of the family. No one—no child or adult—is immune.

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REPORT BRIEFS

Metallurgy, Ceramics Studies

Thirteen studies for the Atomic Energy Commission in metallurgy and ceramics were released. The reports are:

ANL-5635 *A shielded metallograph for remote metallography*, Oct. 1957, 32 pp, $1.00.

ANL-5678 *Manufacture of the ThO_2UO_2 ceramic fuel pellets for borax–IV*, Aug. 1957, 20 pp, $.75.

ANL-5752 *A study of mechanical-electrolytic polishing on uranium metallographic specimens*, Jan. 1957, 19 pp, $.75.

BMI-1048 *The characteristics of the bond interface formed between zircaloy 2 and uranium-12 w/o molybdenum*, Oct. 1955, 44 pp, $1.25.

BMI-1184 *Fabrication of dispersed uranium fuel elements using powder-metallurgy techniques*, May 1957, 46 pp, $1.25.

BMI-1224 *High-strength materials for pressurized-water-in-pile tubes*, Sept. 1957, 56 pp, $1.75.

BMI-T-16 *Control of particle size in aluminum-uranium alloys*, Nov. 1949, 19 pp, $.50.

HW-51998 *Fabrication of a titanium tube heat exchanger*, Aug. 1957, 31 pp, $.75.

ISC-906 *Tabulation, bibliography, and structure of binary intermetallic compounds, III—Compounds of copper, silver and gold*, Sept. 1957, 48 pp, $1.25.

LA-1846 *Casting of magnesium oxide in aqueous slips*, Mar. 1957, 47 pp, $1.25.

WAPD-127 *Development and properties of uranium-base alloys corrosion resistant in high temperature water, Part II—Alloys with protective cladding*, Sept. 1955, 152 pp, $4.00.

WAPD-184 *Properties of UO_2*, Sept. 1957, 140 pp, $3.75.

WAPD-TM-86 *Weigh-shape conversion tables for zircaloy-2*, May 1956, 12 pp, $.50.

Order from OTS, U. S. Department of Commerce, Washington, D. C.

Fault Protections Device

Fault diverters, or "crowbars," have proven very effective in protecting against transient-induced power arcs in oscillator tubes used at the University of California's Radiation Laboratory. The protective device short circuits the oscillator-plate power supply in the event of an over-current, thus removing the power flow from the fault within a few microseconds. Ignitrons, thyratrons, and triggered spark gaps are used for short circuiting. The power supply is pro-

tected from the short circuit either by a current-limiting device or a high-speed contactor which removes the system from the power lines. *Fault Diverter—A Protective Device for High-Power Electron Tubes, B. H. Smith, Radiation Laboratory, University of California for U. S. Atomic Energy Commission, Aug. 1957, 21 pp, $.75. Order UCRL-3701 from OTS, U. S. Department of Commerce, Washington 25, D. C.*

Radiated Energy Power Supply

This report describes the principle and circuitry for powering electronic devices entirely from electromagnetic energy radiated from distant sources. The energy sources may be transmitters operated specifically for powering the devices, or ordinary commercial radio or television stations in urban areas. In most applications of the system, dc power derived from received rf energy is used to power transistors in various circuits. The report emphasizes the use of a transistor amplifier in the system to provide remote switching of power to a load. Complete instructions are given for construction of a standard broadcast radio receiver operating on this principle. Circuit arrangements are described for storing dc power, withdrawing the stored power at selected rates and amplitudes, changing dc power to ac power, and applying the required power to various devices. *Powering Transistorized Electronic Devices with Radiated Energy, by Lloyd R. Crump, U.S. Ordnance Corp, Diamond Ordnance Fuze Labs., Washington 25, D.C. Feb., 1956, 13 pp, $.50. Order PB 131264 from OTS, U.S. Department of Commerce, Washington 25, D.C.*

Communication Theory, Antenna Design

Contents: Introduction, by Roy C. Gunter; Mathematical Introduction I, by Charles Bumer; Mathematical Introduction II, by F. Sheppard Holt; Application to Electronics I, by Arthur Kohlenberg; Application to Electronics II, by Peter Elias; Application to Optics I, by Edward O'Neill; Application to Optics II, by George B. Parrent, Jr.; Electro-Optical Systems in Cascade, by Otto Schade; Antennas I, by John Rize; Antennas II, by W. H. Steel; Antennas III, by Charles Drane; Summary Comments, by Francis J. Zucker; Bibliography; Attendance List. *Proceedings of Symposium on Commuication Theory and Antenna Design., U.S. Air Force, Air Research and Development Command. Nov., 1957. 229 pp, microfilm $9.90, photocopy $34.80. Order PB 128075 from Library of Congress, Washington 25, D.C.*

PATENTS

Transistor-Magnetic Amplifier Bistable Devices

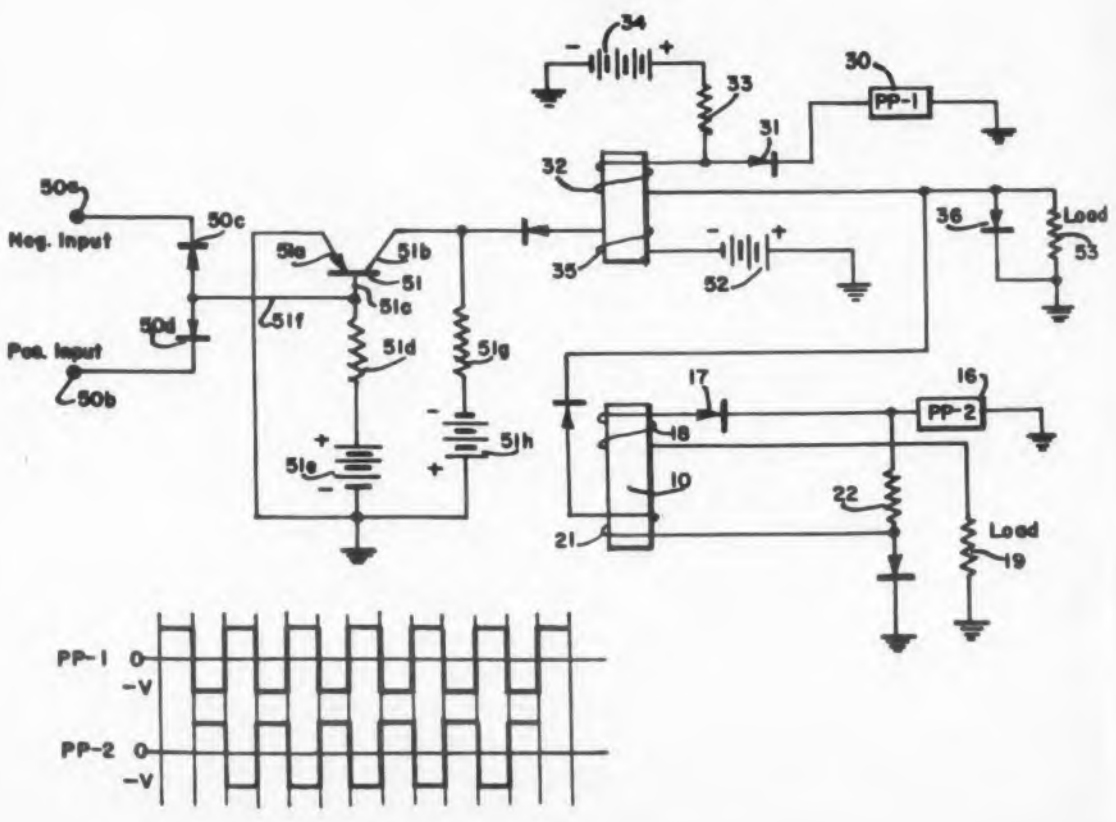
Patent No. 2,798,169. J. P. Eckert, Jr. (Assigned to Sperry Rand Corporation)

By combining a transistor and a magnetic amplifier into a bistable device, both high current and voltage gains are achieved. Both of these devices also have the virtue that the components will not burn out.

The circuit illustrated in the figure, has a transistor 51 to the base electrode of which are applied negative and positive control signals from the input source or terminals 50a and 50b. The collector 51b of the transistor is connected with the control winding 35 of a magnetic amplifier. Power pulses are applied through the winding 32 from source 30 to the load 53 as long as there is no current flowing through the control winding 35. When there is no current in this winding, the battery 34 resets the core between power pulses by current flow through resistor 33, winding 32, and diode 36. If, however, negative input pulses are applied at input terminal 50a of the transistor, the current flow through the collector and winding 35 sets up a magnetizing force which equalizes that set up by the battery 34 and the core of the magnetic amplifier is not reset. The power pulses are now fed to a low impedance winding 32 and these pulses, therefore, pass through to the load. Upon application of positive pulses at the input terminal 50b of the transistor, current will not flow in the collector circuit and winding 35 and hence the core is reset. The impedance of the winding 32 becomes high and the power pulses from the source 30 are not applied to the load.

The basic combination covered by the patent includes a transistor and a single magnetic amplifier. In the figure, a more complex circuit is illustrated in which a second magnetic amplifier is used in conjunction with the first with power pulses fed to the second magnetic amplifier from the source 16. However, when power pulses of the first amplifier are being applied to the load 53, current flows through control winding 21 of the second amplifier and biases the second amplifier to cut off. Power pulses are fed to the load 19 of the second amplifier only when the first amplifier is not transmitting power pulses to its load.

The patent also discloses numerous other modifications of the circuit for accomplishing more complex results.



Magnetic Transformer Apparatus

Patent No. 2,811,689. Anthony T. Balint.

The voltage regulator uses a pair of magnetic cores of dissimilar core material so that their hysteresis loops are substantially different for low levels of magnetization and more similar hysteresis loops for high levels of magnetization. An input circuit receives alternating signals from a signal source having magnetic intensity application means which magnetizes the cores in accordance with the signal. An output circuit applies energy to a load the circuit of which is responsive to the magnetic and hysteresis response of the cores.

Superheterodyne Receiver

Patent No. 2,812,429. Johan van Baarda. (Assigned to North American Philips Company, Inc.)

The receiver is designed particularly for use in frequency-shift telegraphy and includes a local oscillator having a frequency control circuit. A detector circuit detects the received telegraphy signals and produces a signal having given amplitudes representing respectively the work-frequency and the rest-frequency of the received signals when the oscillator is correctly tuned. The detected signal has differing amplitudes when the oscillator is detuned in the direction of a frequency higher or lower than the correct tuning frequency. A first and a second threshold tube are provided which are normally biased to cutoff. The detected signal is coupled to the control electrode of both tubes so that the given amplitude representing the work-frequency of the received signal adjoins the threshold level of the first tube when the oscillator is correctly tuned and exceeds this threshold level, to render the first tube conductive, when the oscillator is detuned in one of the directions. Hence the given amplitude representing the rest-frequency of the received signal adjoins the threshold level of the second tube when the oscillator is correctly tuned and exceeds the last-mentioned threshold level to render the second tube conductive when the oscillator is detuned in the other direction. The output electrodes of the tubes are in push-pull relation to the frequency control circuit.

Transistor Oscillator Circuit

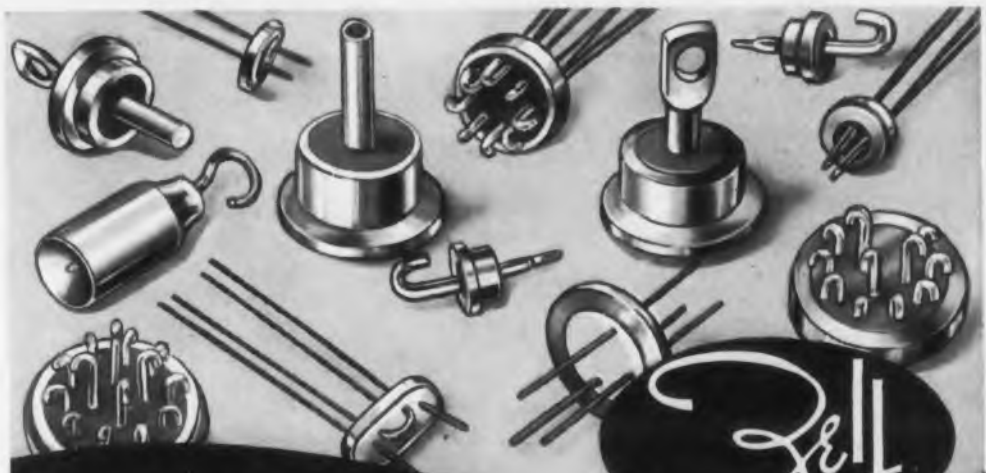
Patent No. 2,811,646. Huo-Bing Yin. (Assigned to Radio Corporation of America)

The circuit produces a very high frequency oscillation using a semiconductor having a normal base electrode and an auxiliary base electrode. The semiconductor has predetermined interelectrode capacitance. Energizing potentials are applied to the collector, emitter, and auxiliary base electrode. An oscillator signal is generated by a first frequency-determining circuit connected with the normal base electrode and this circuit is tuned to a fundamental oscillator frequency. The interelectrode capacitance of the semiconductor provides regenerative internal feedback between the normal base and the emitter. A second frequency-determining circuit is connected with the collector and is tuned to a harmonic frequency of the fundamental oscillator frequency. An output circuit derives from this second circuit a sinusoidal output wave at a frequency determined by the resonant frequency of the second circuit.

Time Discriminator

Patent No. 2,814,725. Jerome E. Jacobs and Ercell E. St. John. (Assigned to Hughes Aircraft Company)

The time discriminator circuit includes first and second thermionic tubes with an impedance element providing a dc path between the anode of the first tube and the cathode of the second tube. Control signals are impressed upon the control grids of the tubes through suitable circuitry. An input circuit which receives signal pulses is connected between the anode of the second tube and the cathode of the first tube and is operable to apply the received pulses to the tubes with proper polarity so as to establish anode-cathode supply voltages for the tubes. The tubes are conductive only when the signal pulses are coincident with the control signals. An output circuit is coupled to the impedance element so as to develop an error signal at the impedance element which represents the difference in the conductive periods of the tubes.



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Cat. No.	430-A	440-A	450-A	431-A	441-A	451-A	432-B	442-B	452-B
Z_{in} Z_{out}	50 ohms nom.	70 ohms nom.	90 ohms nom.	50 ohms nom.	70 ohms nom.	90 ohms nom.	50 ohms nom.	70 ohms nom.	90 ohms nom.
Max. Power	½ watt								
Insertion Loss	10 db			zero db at low freq. approx. 0.3 db at 200 mc			zero db at low freq approx. 0.5 db at 200 mc		
DB Switched	41 db in 6 steps						101 db in 9 steps		
Steps	20 db, 10 db, 5 db, 3 db, 2 db, 1 db						20 db, 20 db, 20 db, 20 db, 10 db, 5 db, 3 db, 2 db, 1 db		
Frequency Range	DC to 500 mc								
Accuracy of Attenuation	Within 0.1 db db to 500 mc Better accuracy at lower frequencies								
Connectors	BNC type UG-185/U								
Dimensions	2¼" x 8¼" x 2⅛"						2¼" x 11½" x 2⅛"		
Weight	2½ lbs.						4 lbs.		
Price	$65			$60			$95		

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Books

Glossary of Terms in Nuclear Science and Technology

American Society of Mechanical Engineers, 29 W. 39th St., New York 18, N.Y. 188 Pages, $5.00.

This glossary was approved by the American Standards Association as the American standard.

It was prepared to include terms:

1. peculiar to the field of nuclear energy;

2. used in this field in a different sense or with different emphasis from what is commonly understood in other connections;

3. used elsewhere in the same way, but so infrequently as to be unfamiliar.

It is well organized and complete.

Elements of Tape Recorder Circuits

Herman Burstein and Henry C. Pollak, Gernsback Library, Inc., 154 West 14th St., New York 11, N.Y. 223 Pages, $2.90 soft cover, $5.00 hard cover.

The latest in the Gernsback Library series, this book is an excellent compilation of information on tape recorders and their circuitry. With a minimum of mathematics, basic design principles are presented for the audio enthusiast and the technician.

Engineering readers can derive a great deal of useful information on circuits which can find application outside of tape recorders. Of the book's ten chapters, the last three, on oscillators, record-level indicators, and on minimizing

noise and hum, can be most useful to those with only a secondary interest in tape recorders.

Elsevier's Dictionary of Electronics and Waveguides

Van Nostrand Co., Inc., 120 Alexander St., Princeton, N.J., 628 pp, $17.50.

This six-language volume, the third in a planned series of polyglot technical dictionaries relating to special fields in science and industry, contains over 2000 words in its basic list. The words are arranged on an English alphabetical base and clear distinction is made between American and British usages. Corresponding terms in French, Spanish, Italian, Dutch, and German then appear. A thumb-indexing system has also been incorporated which permits one to find words in any of the languages at once with numerical keys to the basic English list. Certain principles proposed by UNESCO have been utilized in planning the dictionary so that it may fit into a pattern which will cover all interrelated fields and all necessary languages.

Electrical Discharges in Gases

F. M. Penning, Macmillan Co., 60 Fifth Ave., New York 11, N.Y., 75 pp, $3.00.

This collection of essays, published posthumously, is a masterly synopsis of the field reflecting much of the investigations which were begun by the author in 1924 at the Phillips Company Research Laboratories, in Eindhoven, Holland. The simplicity of description and the completeness of treatment indicate the reason that the volume, which was published originally in Holland in 1955, requires a wider circulation than would be found in Dutch-speaking countries alone. Particularly lucid discussions are offered with regard to Townsend discharge and breakdown, the positive column, and non-self sustaining and self-sustaining arc discharges.

Wrong Book Price

Price of the book, Handbook of Tri-Plate Microwave Components (*ED*, Feb. 5, p 100) is $3.50—not $3.00 as originally reported. Tri-plate is a registered trademark of Sanders Associates, Inc.

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In response to many reader requests, we have rearranged our abstracts of Russian articles according to subject matter. In addition, we are expanding our coverage to include some of the newest Russian technical journals.

What the Russians Are Writing

SPUTNIK

UHF Receiver by O. Rzhiga and A. Shakhovskoy. R 7/57, pp 17-20, 4 figs.

A receiver was developed primarily for observation of the artificial earth satellite. It has high selectivity, high sensitivity, good stability of heterodyne frequency and minimum internal noise level. The fact that the signal at the receiving antenna will at best not exceed several microvolts per meter, and the Doppler effect involved in the reception of the signal from a satellite traveling at 8 km/sec, is taken into account. A detailed circuit diagram and instructions for the construction, alignment, and placement of parts are contained in the article.

Observation Procedure by O. Rzhiga and A. Shakhovskoy. R 8/57, pp 17-19, 6 figs.

This is a continuation of the article by the same authors in the July issue of *Radio*, discussing antennas used for the reception of signals from the earth satellite, preparation for observations, recording of the signal on magnetic tape, determination of the instant of passage of the satellite, and various ionospheric observations to be made simultaneously.

Direction Finder Attachment by V. Dubrovin. R 7/57, pp 21-23, 9 figs.

The attachment is intended to enable the radio amateurs to detect the signals from the artificial earth satellite and to determine the instant of

KEY

The sources of the Russian articles and their dates of issue follow the authors' names. Here is the key to the names of the journals in which the articles originally appeared.

AT	Automation and Telemechanics *(Avtomatika i Telemekhanika)*
CJ	Communications Journal *(Vestnik Svyazi)*
EC	Electrical Communications *(Elektrosvyaz')*
IET	Instruments and Experimental Techniques *(Pribori i Tekhnika Eksperimenta)*
R	Radio
RE	Radio Engineering *(Radiotekhnika)*
REE	Radio Engineering and Electronics *(Radiotekhnika i Elektronika)*

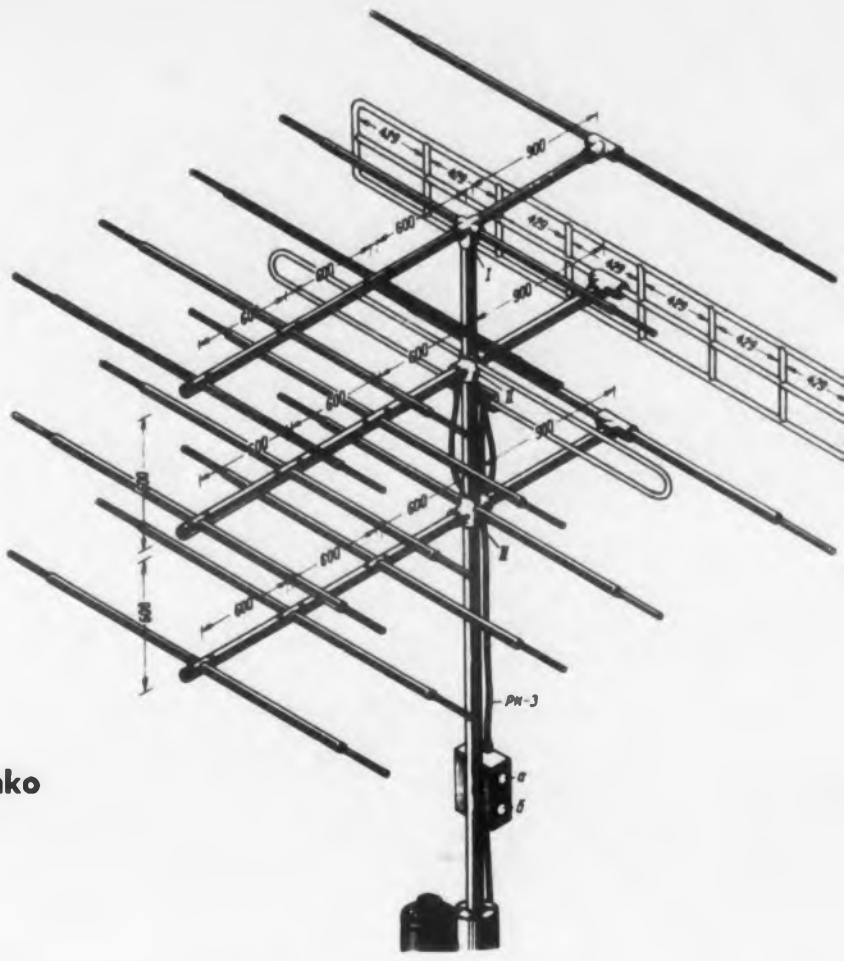
TRANSLATIONS AVAILABLE

ELECTRONIC DESIGN is gratified to learn of the growing availability of full translations of important Russian electronics journals.

Consultants Bureau, Inc. of 227 W. 17th St., New York 11, N.Y. translates *Automatic and Telemechanics* regularly.

Pergamon Press of 122 E. 55th St., New York 22, N.Y. is preparing translations of *Radio Engineering, Radio Engineering and Electronics, and Electrical Communications.*

Readers interested in specific Russian journals can obtain more information by writing directly to one of these publishers.



J. George Adashko

time when the satellite passes over the reception point. The system is based on the use of the so-called "equal signal zone" in which two antennas are used. The location for which the signal from the two antennas is the same is determined with a fair degree of accuracy.

Operation with Direction Finding Attachment by V. Dubrovin. R 8/57, pp 19-20, 3 figs.

Continuation of an article in the July issue of *Radio*. It describes the mounting of the two receiving antennas and of the auxiliary equipment involved in the determination of the passage of the satellite over a certain locality.

RECEPTION

Methods of Combating Pulse Noise in Television Reception by M. Tovbin. R 7/57, pp 40-43, 9 figs.

Description of various schemes employed to reduce the noise level in television sets, including the addition of a RC network in the control grid circuit of the selector tube, various limiting circuits, various methods based on the blocking of the synchronization channel for the duration of the noise pulse, methods based on the compensation of the noise pulses, and a few others.

Sound Channel Receiver for Long Distance Television Reception by S. Sotnikov. R 7/57, pp 44-47, 3 figs.

Long-distance reception of television signals occupies the efforts of many workers in the Soviet Union. In such reception, it is necessary to

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P1020	10	200	141	<5
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P1505	15	50	35	<5
P1510	15	100	70	<5
P1515	15	150	105	<5
P1520	15	200	141	<5
P1540	15	400	283	<5
P2005	20	50	35	<5
P2010	20	100	70	<5
P2015	20	150	105	<5
P2020	20	200	141	<5
P2040	20	400	283	<5
P2505	25	50	35	<5
P2510	25	100	70	<5
P2515	25	150	105	<5
P2520	25	200	141	<5
P2540	25	400	283	<5
P3005	30	50	35	<5
P3010	30	100	70	<5
P3015	30	150	105	<5
P3020	30	200	141	<5
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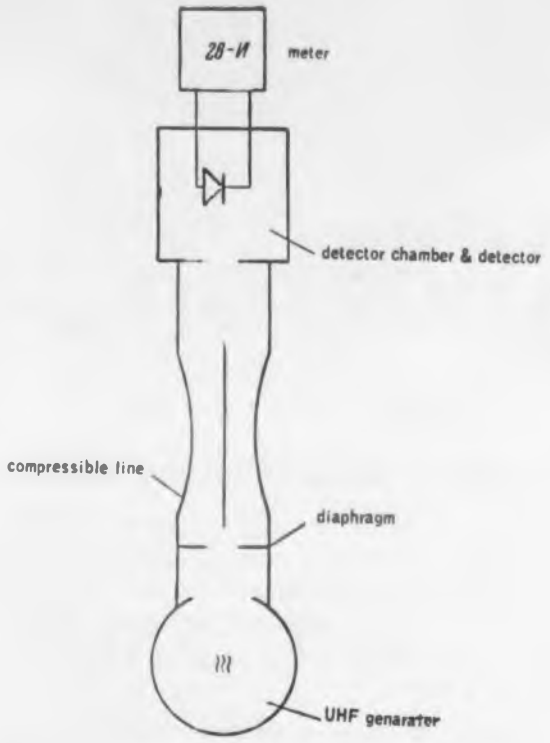


Fig. 1. This scheme uses the video detector to measure its own vswr.

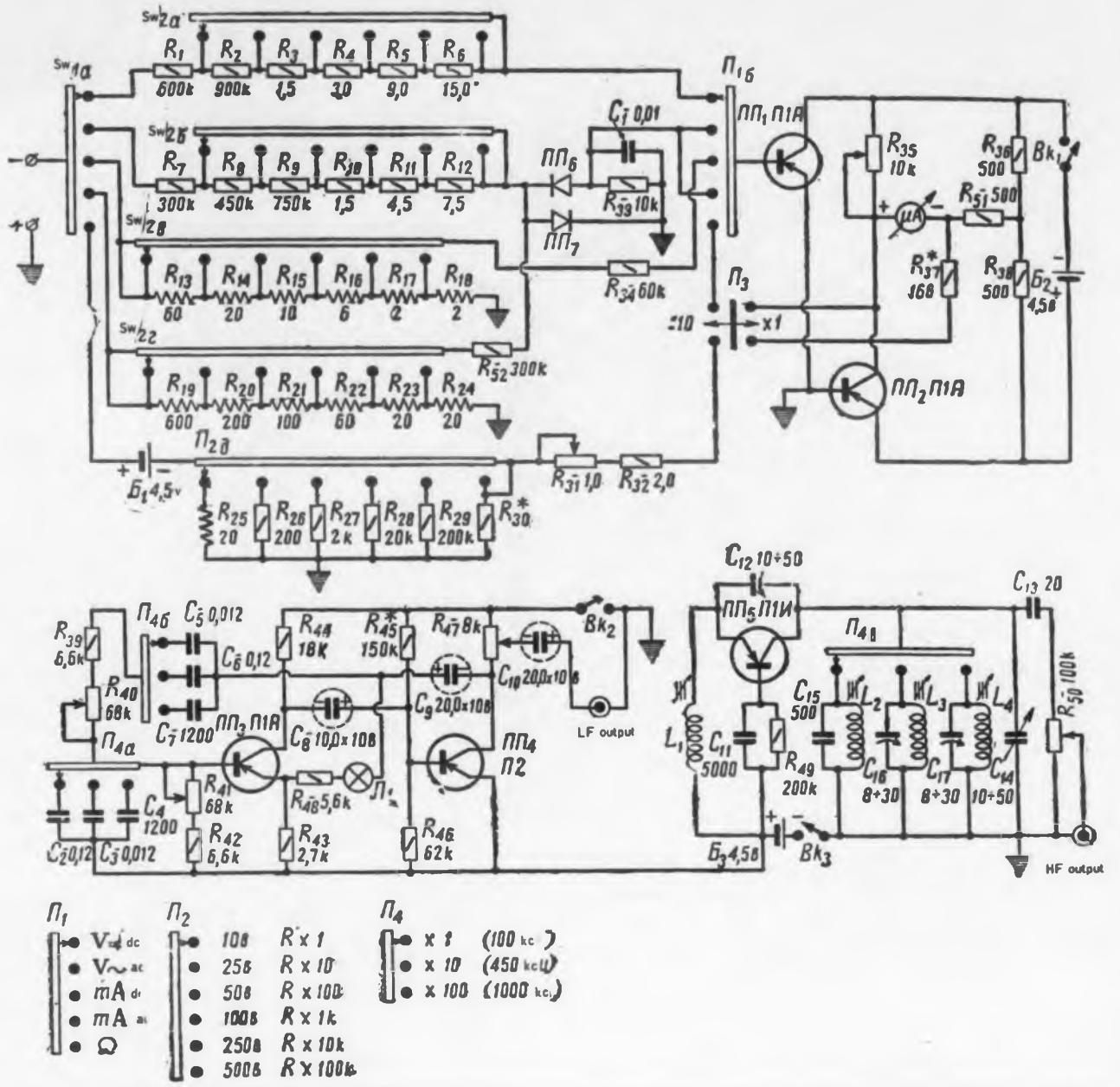


Fig. 2. Completely transistorized, this portable test instrument measures voltage, current, and resistance; and includes a lf and hf signal generator.

have a separate receiver for the sound channel. The article describes a superregenerative and a superheterodyne receiver for the purpose.

Antennas for Long Distance Reception of Television by S. Sotnikov. R 8/57, pp 34-37, 9 figs.

Detailed description of several antennas used to receive television signals reflected by the ionosphere. Construction data and directivity patterns are also given.

Long Distance Reception of Television Broadcasts. R 8/57, pp 37-40, 5 figs.

Report by various amateurs, accompanied by photographs of television reception, mostly from Germany and Italy, at frequencies of 55.25, 48.25, and 62.25 mc.

Setup for Superhigh Distance Television Reception by V. Vasilenko. R 9/57, pp 33-34, 2 figs.

The author in Voroshilov, was able to receive broadcasts regularly from Japan, a distance of about 500 miles. The article describes the equipment employed. The figure shows a drawing of the antenna.

AUTOMATIC CONTROL

Conditionally Stable Regulated Systems (Concerning One Class of Optimum Regulated Systems) by A. M. Letov. AT 7/57, pp 601-604, 6 figs.

A highly theoretical paper, in which it is shown that for a strictly linear system, constructed to satisfy any arbitrarily adopted optimum criterion, it is possible to obtain damping of the transient during the first swing, thus converting the system into a conditionally stable system. The time for conditional damping will be considerably less in such a system than in the initial system. This result can be accomplished without substantially modifying the existing systems, but by merely adding a simple computing device.

Approximate Determination of the Self-Oscillation Transients in Certain Automatic Control Nonlinear Systems by A. A. Voronov. AT 7/57, pp 631-639, 8 figs.

This article shows how to approximate the higher-order equation with two nonlinear systems of first order, similar to the equations used for second-order systems. It is also shown that by piecewise-linear approximation of a certain function obtained during the process of solving these problems, it becomes possible to obtain a relatively simple approximate solution to the problem. The method frequently yields satisfactory accuracy even in cases when the oscillations attenuate within 1-3 cycles. Refers to "A Frequency Response Method for Analyzing and Synthesizing Contactor Servomechanisms" by R. J. Kochenburger, Transactions AIEE, Vol. 69, Part I, 1950.

GROWING INTEREST

Consultants Bureau reports that the volume of 1957 subscriptions to *Automation and Telemechanics* increased 46 per cent over the 1956 figure. This is one of the many indications of the growing interest in Russian technical literature.

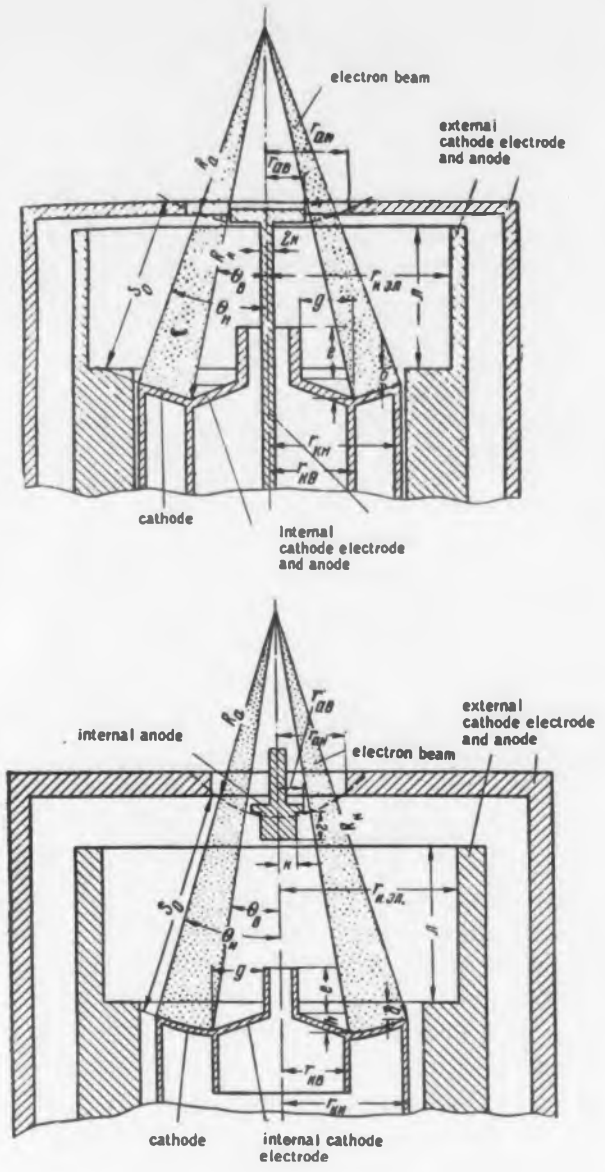


Fig. 3. Two types of guns for forming hollow electron beams.

Automatic Control of Liquid Level by Means of Detection of the Phase of UHF Waves by V. B. Brodskiy. AT 7/57, pp 640-652, 3 figs.

A theory is developed and it is shown that the use of transition transformers and dielectric filling in the measuring line makes it possible to measure a liquid level over a range that may be considerably larger (or smaller) than the range over which the minimum of the standing wave is shifted. The errors of the method are analyzed and the limits of its applicability are estimated.

MEASUREMENTS

Method of Measuring the VSWR of Video Detectors by L. S. Liberman. REE 7/57, pp 941-942, 1 fig.

Since the power level must be quite low in such a measurement (not more than 10 microwatts), the ordinary slotted line introduces considerable errors. The author develops a method in which the detector itself serves as an indicator. Fig. 1 shows the instrumentation.

Universal Measuring Instrument by R. Svoren' and V. Bol'shov. R 5/57, pp 46-50, 5 figs.

Here is a detailed description of a universal measuring instrument, transistorized and miniaturized, for the measurements of a wide range of voltages, currents, and resistances. In addition, the instrument contains a low-frequency and high-frequency signal generator. The instrument shown schematically in Fig. 2, is intended particularly for use in expeditions.

Modulation of Active Radiation for Automatic Control Devices by D. I. Ageykin, L. V. Mel'tser, and N. N. Shumilovskiy. AT 7/57, pp 686-688, 1 fig.

The use of modulated nuclear radiation uncovers new possibilities for automatic control of manufacturing processes, making it possible to obtain more reliable and accurate instruments without dc amplifiers or special converters. The article describes both mechanical and electromagnetic modulation schemes.

ELECTRON PHYSICS

Electron Guns for the Formation of Solid and Hollow Conical Beams with High Current Density by S. N. Treneva. REE 7/57, pp 925-934, 19 figs.

A description of electron guns with electrodes of simple configuration, developed for the production of solid and hollow conical beams with high current density (see Fig. 3). A method is given for the design of such guns and several graphs are provided for determination of the dimensions of the gun electrodes to meet specified parameters of the electron beam. The guns operate at zero potential on the cathode. 98-100 per cent of the total beam current passes through the aperture of such a gun. Such guns can be used in traveling wave tubes, klystrons, and other devices where high intensity solid or hollow electron beams are required. Leans heavily on the work by Pierce (Theory and Design of Electron Beams, 1949, New York) and refers to work by Langmuir & Blodgett, Physical Review, 1924, vol. 24, pp 49-59.

Nonlinear Theory of A Traveling Wave Tube. Part I. Equations and Conservation Laws by L. A. Vaynshteyn. REE 7/57, pp 883-894, 2 figs.

This paper was delivered at the First International Congress on UHF Electronics held in Paris in 1956. This part of the paper contains the equations of nonlinear theory of the traveling wave tube, taking into account the overtaking of one group of electrons by the other. It is shown that it is possible to derive from these equations two laws of conservation and conversion of energy, one in a stationary system of coordinates, and the other in a system of coordinates that moves uniformly with the initial velocity of the electrons. Various methods are given for account-

ing for the repulsion between the electrons in the electron beam. Reference is made to work by A. Nordsieck (Proceedings IRE, 1953, vol. 41, p 630) and Tien, Walker & Wolontis (Proceedings IRE, 1955, vol. 43, p 260).

Integral Energy Distribution of Electrons Behind the Output Cavity of a Transit Time Klystron by I. R. Gekker. REE 7/57, pp 895-900, 9 figs.

The integral energy distribution is obtained in this article in the kinematic approximation. A procedure for determining experimentally the above distribution using a two-cavity klystron as a model, has been attempted. When the electron beam was modulated in the output cavity, the agreement with the elementary theory was quite good. Reference is made to work by Warnecke, Chodorov, Guenard, and Ginzton "Velocity Modulated Tubes," in Advances in Electronics III, 1951, pp 41-83.

Effect of Dielectric on the Phase Constants of Spatial Harmonics of a Helix by V. P. Kryushin. REE 7/57, pp 901-911, 5 figs.

A dispersion equation is derived for a helix surrounded by a dielectric cylinder of finite thickness, using certain approximations. Good agreement is obtained in the comparison of the calculated values of the effect of the dielectric for the first backward harmonic with the measurements made of a double-wound helix made of round wire, secured by means of quartz tubes. Refers to "Traveling Wave Tube Helix Impedance" by P. K. Tien (Proceedings IRE, 1953, vol. 41, p 11, 1617-1623), "Electromagnetic Wave Propagation on Helical Structures" by S. Sensiper (Proceedings IRE, 1955, vol. 43, no. 2, p 149-161), and "The Helix as a Backward Wave Circuit Structure" by Watkins and Ash (Journal of Applied Physics, 1954, vol. 25, no. 6, pp 782-790).

Electron Conductivity of Space Charge Clouds in Magnetrons by V. P. Tychinskiy. REE 7/57, pp 912-924, 6 figs.

This is a paper delivered at the Conference of the Scientific Technical Society for Radio and Electronics in the name of A. S. Popov in May 1957. ELECTRONIC DESIGN reported on this conference in its issue of January 22, February 5, and February 19. The article represents an attempt to calculate the electron conductivity of the magnetron for the case of small amplitudes, using the mathematical theory developed by Buneman and MacFarlane (Wave Propagation in a Slipping Stream of Electrons: Small Amplitude Theory" (Proceedings of the Physical Society, 1954, VLXIII, 6-D, 409). Differential equations are derived for the distribution of the tangential component of the field and a formula is obtained for the electron conductivity introduced into the resonator system. The results of the calculations of the conductivity, of the field, and of the energy flux are given. References are made to numerous other American and British papers.

ABSTRACT

Electrical Characteristics of Printed Circuit Panels

THE NATIONAL Bureau of Standards has been investigating the electrical characteristics of several types of copper-clad laminates for printed circuit applications. The results of these studies concerning temperature rise, surface resistivity, dissipation factor and dielectric constant are qualitatively discussed here. In addition, a design chart to aid in estimating temperature rise above ambient vs current for various cross sectional areas of etched copper conductors is included. A conversion chart has also been developed showing resistance per linear inch vs cross section.

[A report contained in ELECTRONIC DESIGN of January 22, 1958 discussed the tests conducted at Bell Telephone Co. to determine the "Current-Carrying Capacity of Printed Wiring." Design procedures were noted utilizing data obtained from these tests.]

Temperature Rise Measurement

A large number of measurements were made under different conditions of use on various lengths and widths of conductors bonded to a variety of materials. The curves derived indicated that cross-sectional area is a dominant factor in the ability of a conductor to carry a given current for a particular temperature rise, especially for the usual copper thickness of 0.00135 in. for 1 oz and 0.0027 in. for 2 oz. As might be expected, heavier coppers (0.004 in.) appear capable of carrying less current, and thinner

coppers (0.00067 in.) higher current, for a given cross-sectional area.

Thickness of the laminate core material also affects the temperature-current relationship. Core materials about 1/32 in. thick exhibited some reduction in current-carrying capacity compared with heavier cores. When a solid copper backing was used, the same type of material showed a higher-current-carrying capacity.

For the usual 1/16 in. core thickness, only small differences could be noticed between single-clad and double-clad laminate panels. Samples coated with a protective plastic material produced a reduction in current-carrying capacity of about 15 to 20 per cent for a given temperature rise.

Surface Resistivity

Seven groups of XXXP-composition phenolic laminates and one of the epoxy glass-mat type were subjected to a temperature of 70 C and 95 per cent relative humidity for a period of 2000 hr to determine the effects of various protective coatings on the surface electrical resistivity of the core materials. The coatings included various epoxy resins, microwax, varnish and silicone compounds.

The variation in surface resistivity for the coated samples was generally much higher than for uncoated control samples. Little variation was found between dip-soldered and nondip-soldered samples.

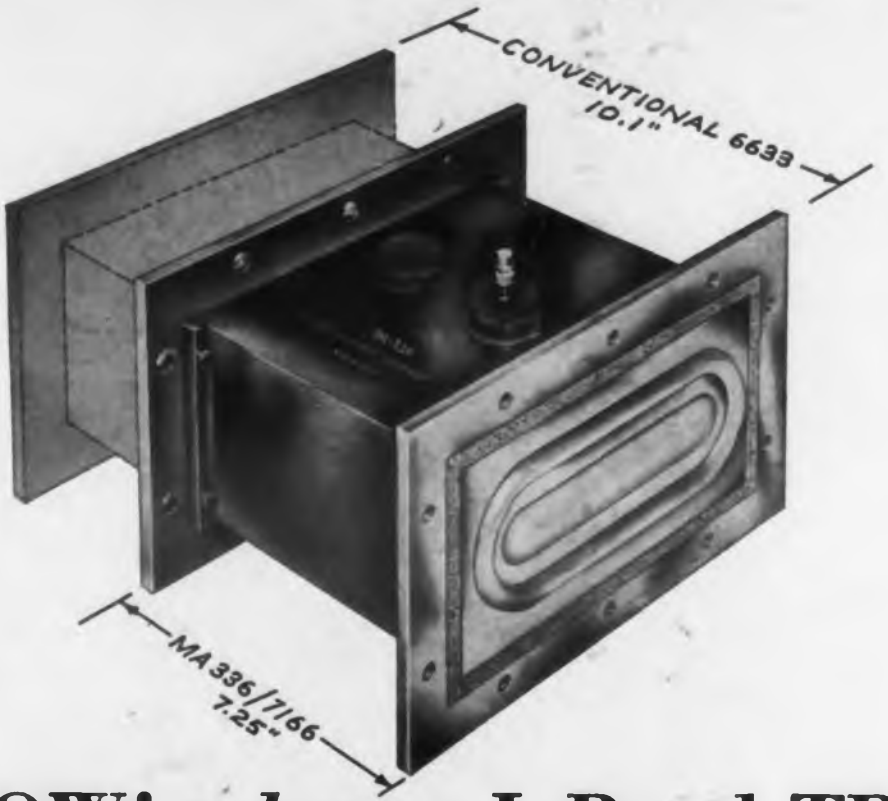
Dissipation Factor

Measurements were made over a frequency range of 10^2 to 10^7 cps on the dielectric properties of a group of 16 metal-clad laminates. Individual families of curves for each laminate were developed for dissipation factor and dielectric constant at −30 C, +23 C, and +100 C. Additional measurements were made at 150 C and 200 C on materials that might be expected to be useful at these higher temperatures.

With the exception of one sample, all of the phenolic-base materials showed a general reduction in dissipation factor with an increase in temperature at a frequency of 10^6 cycles. Considerable variation in dissipation factor was observed for the entire phenolic group at the lower frequencies, particularly at the 100 C temperature level.

Two samples of the epoxy-glass mat type laminates also showed a variation in characteristics similar to the phenolics. At temperatures of 100 C or less, both samples showed less change in dissipation factor than those of the phenolic group over the entire frequency range.

For one sample of silicone G-7 material, the dissipation factor at 10^6 cycles was 0.02 or



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Recovery time	Short . . . less than 25μ seconds	Long 45μ seconds
Low level characteristics	VSWR 1.3 max. over full band. Insertion loss: 0.5 db (.7 db at end of life.)	VSWR 1.4 max. Insertion loss: 0.7 db (1.0 db at end of life.)
Size	7.25" long	10.1" long

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less at temperatures up to 100 C but was influenced to a marked degree at lower frequencies.

The polytetrafluoroethylene-glass mat sample had the lowest dissipation factor of any of those tested in the group. At —30 C, the dissipation factor was nearly constant over the entire frequency range.

The nylon-base phenolic N-1 material showed good stability at the lower temperatures. At the higher temperature of 100 C, the dissipation factor increased as the frequency increased.

Dielectric Constant

The dielectric constant of the various core materials increased generally at higher temperatures. The polytetrafluoroethylene-glass mat material showed the opposite trend.

In the phenolic group the dielectric constant was lower for the XXXP materials than for the XXP and XXX materials. At 10^6 cycles, the approximate average of the dielectric constant was 4 for the XXXP materials tested and 5 for

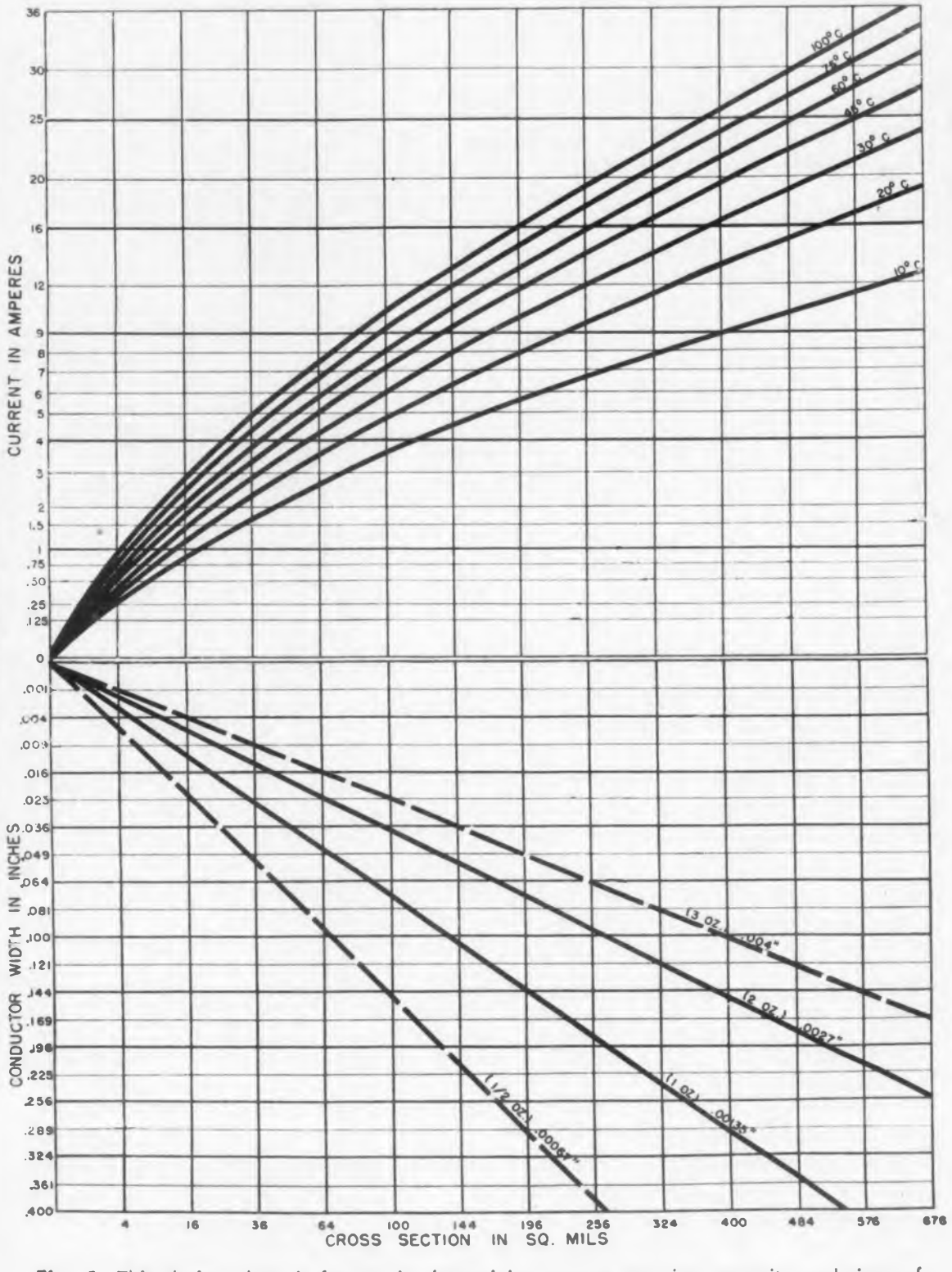

Fig. 1. This design chart is for use in determining current carrying capacity and sizes of etched copper conductors for various temperature rises above ambient.

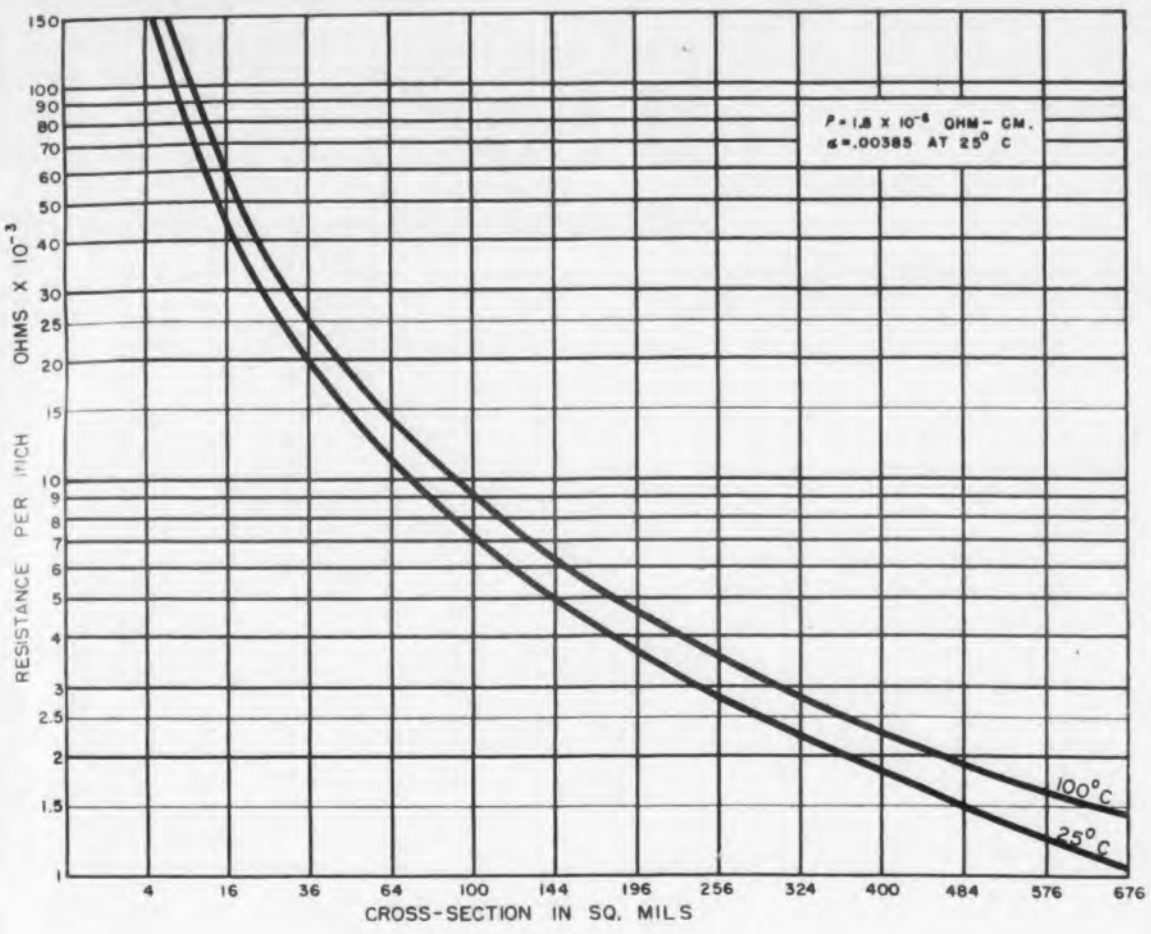

Fig. 2. Conversion chart for etched conductors.

the XXX and XXP materials. Constants for both epoxy-base samples at 10^6 cycles ranged between 5 and 6 at temperatures below 100 C. Above this temperature both samples showed increases to a value above 6.

Design Charts

A tentative design chart to aid in estimating temperature rise above ambient vs current for various cross-sectional areas of etched copper conductors is shown in Fig. 1. It is intended for use primarily with XXXP and epoxy-glass materials of 1/16 in. to 1/8 in. thickness and copper thickness of 0.00135 in. (1 oz), and 0.0027 in. (2 oz). Conductor surface area is assumed to be relatively small compared to the adjacent free panel area. The curves as presented include a nominal 10 per cent current derating to allow for variations in etching technique and conductor width estimates under optimum conditions of use. An additional current derating of up to 50 per cent should be allowed in order to compensate for different panel and copper thicknesses, the use of dip-soldering techniques, and coatings.

For single conductor applications the chart can be used directly for determining conductor widths, conductor thickness, cross-sectional area, and current-carrying capacity for various temperature rises.

For groups of similar parallel conductors, if closely spaced the temperature rise may be found by using an equivalent cross-section and an equivalent current. The equivalent cross-section is equal to the sum of the cross-sections of the parallel conductors, and the equivalent current is equal to the sum of the currents in the conductors.

Where etched coils are to be used, the maximum temperature rise can be obtained by using an equivalent cross-section equal to $2n$ times the cross-section area of the conductor, and an equivalent current equal to $2n$ times the current in the coil, n being equal to the number of turns.

The conversion chart, Fig. 2, shows resistance per linear inch vs cross-section for etched conductors. It is applicable where the IR voltage drop in a conductor may be the primary consideration instead of temperature rise.

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Batteries

MIL-B-11814A, Battery, Storage, Zinc-Silver Oxide, Alkaline, Portable, 20 November 1957
One type of portable, alkaline, zinc-silver oxide, storage battery is covered in this spec. This 6-volt, 80-ampere-hour battery is designed for use in electronic and communication equipment. It is specifically intended for use where high rates of discharge for comparatively short periods, or high energy outputs with minimum weight and volume, are desirable. Applications in guided missiles and portable communications equipment are examples of use. This spec supersedes MIL-B-11814(SigC) and MIL-B-17425(Ships).

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Insulation Tape

MIL-I-3825, Insulation Tape, Electrical (Polyethylene-Base, Self-Fusing; for Use in Electronic, Communications and Allied Equipment), Amendment 3, 6 November 1957
Dielectric strength requirement has been increased to 800 volts per mil and tests are now performed in the air on single thicknesses of tape. Volume sensitivity tests are now conducted on three thicknesses of fused tape. Marking will now be placed on the edge of the core.

Manuals

MIL-M-9830(USAF), Printing of Pocket Size Technical Manuals, Amendment 1, 4 September 1957
This new format for Air Force publications provides for the publishing of 8 by 4 inch books. The dimensions for the location of the drilled binding holes have been changed by Amendment No. 1.

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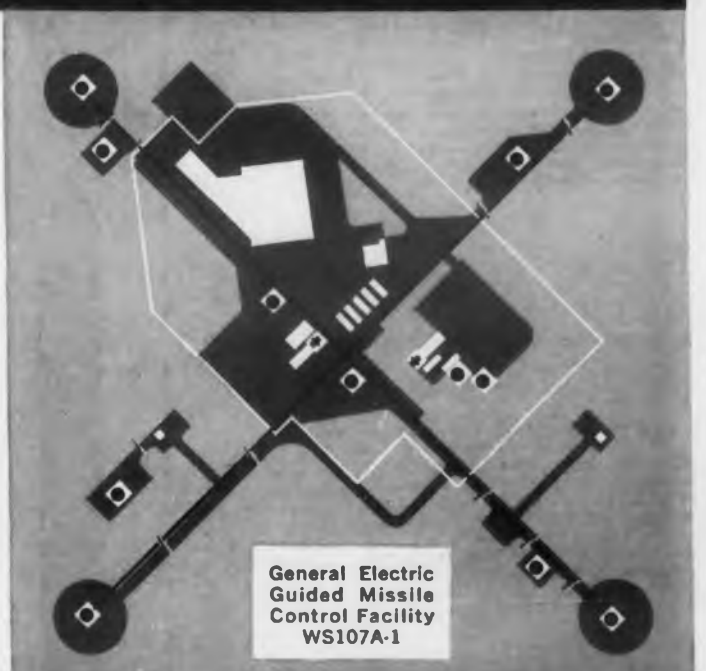

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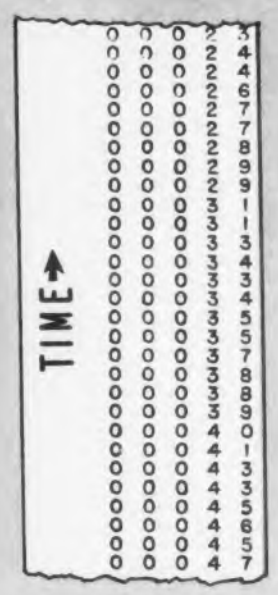

Figure 1. -*hp*- digital recorders, counters and dual trace oscilloscope assembled for satellite tracking.

Figure 2. Printed tape from -*hp*- 560A similar to that used during satellite measurements. Note Doppler frequency shift in cps.

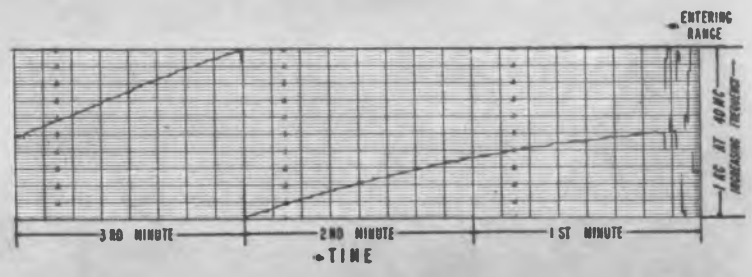

Figure 3. Strip-chart recording of 40 MC transmission from Soviet satellite. Note Doppler shift during 3-minute period when satellite transmitter was continuously keyed.

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NEW 2N358*	9	30 at +300	+500
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2N404*	12	40 at −20	−100
NEW 2N582*	18	60 at −20	−100
NEW 2N583	8	30 at −20	−100
2N269	12	40 at −20	−100
NEW 2N584	18	60 at −20	−100
p-n-p Types for High-Current Switching Applications			
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NEW 2N579*	8	30 at −400	−400
NEW 2N580*	15	45 at −400	−400
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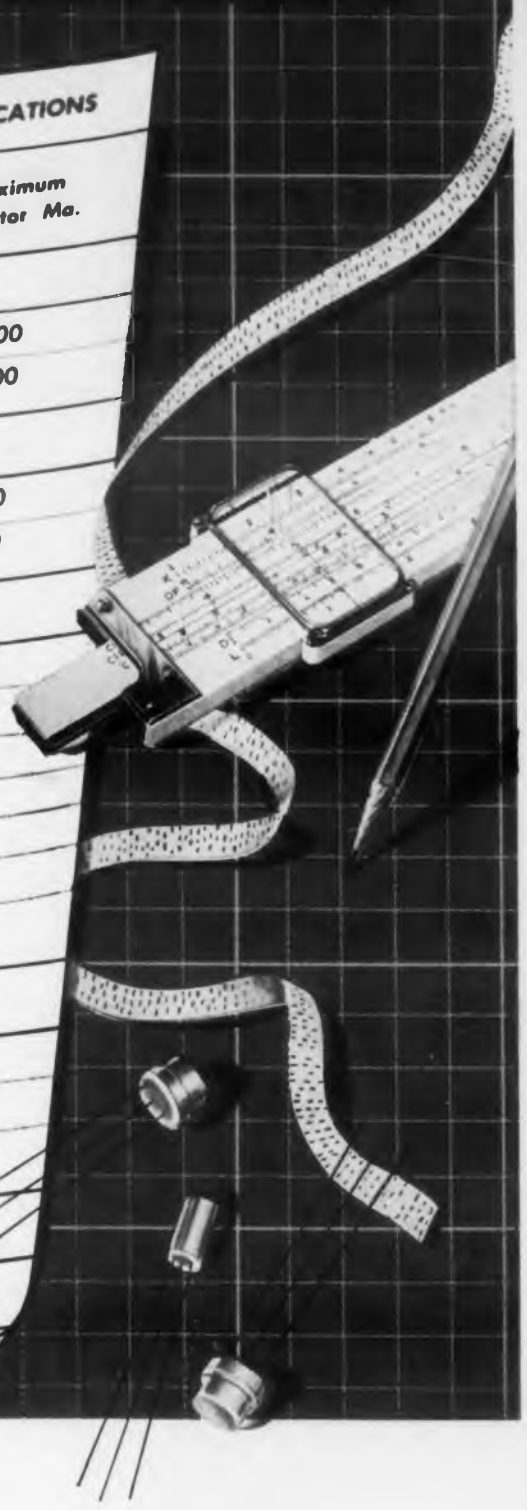

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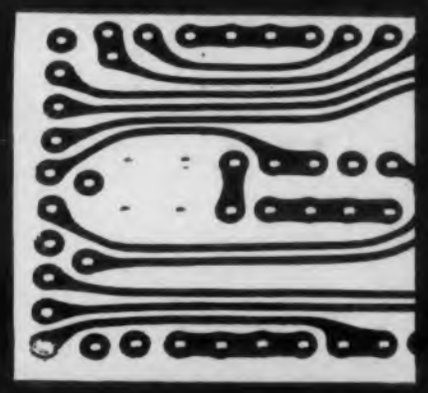

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The Resisting Transistor for Servo Design 14

By using a transistor as a "resisting device in a servo amplifier you get twice the output expected from Class B output stages. The efficiency is as high as 95 per cent. In the resisting transistor output stage, voltage across the load is in phase with that across the conducting resistor. The transistor acts as a variable resistor between the power supply and the load. Power delivered to the load is greater than maximum dissipation.

How to Correct Phase Distortion with an L-C Lattice 20

Since real electrical circuits do not always provide desirable phase characteristics, special networks are often required to control phase distortion. Mr. Fogarty shows how to use a universal phase curve to design lattices to do the job.

3 issues this month. Watch for April 16, and special Thermistor report April 30.

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ELECTRONIC DESIGN

DATA REQUEST PROCESS CARD
Use Before May 14th, 1958

Name | Title

Company

Company Address | City | Zone | State

For Change of Address:
Old Company Name | Old Company Address

	10	20	30	40	100	110	120	130	140	200	210	220	230	240	300	310	320	330	340	400	410	420	430	440	500	510	520	530	540
1	11	21	31	41	101	111	121	131	141	201	211	221	231	241	301	311	321	331	341	401	411	421	431	441	501	511	521	531	541
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April 2, 1958 Vol. 6
Number 7

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Hayden Publishing Co., Inc., 830 Third Avenue, New York 22, N.Y.

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ELECTRONIC DESIGN is published bi-weekly by Hayden Publishing Company, Inc., 830 Third Avenue, New York 22, N. Y., T. Richard Gascoigne, President; James S. Mulholland Jr., Vice-President & Treasurer; and David B. Landis, Secretary. Printed at Hildreth Press, Bristol, Conn. Accepted under section 34.6. P. L. & R. authorized. 30,000 copies this issue.

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ENGINEERING REVIEW

For more information on developments described in "Engineering Review," write directly to the address given in the individual item.

Processing Pictorial Information on Digital Computers

Exploratory experiments involving the use of general purpose digital computers to help understand the nature of pictorial information are being conducted by National Bureau of Standards.

To feed pictorial information to the Bureau's Electronic Computer (SEAC), a simple mechanical drum scanning device digitalizes the information as illustrated in Fig. 1. Through associated scanner circuitry, a dark square on the picture is converted into a binary 1. A sufficiently white square produces a binary 0.

To display a picture that has been fed into the computer from the scanner, a program was prepared to derive a pair of coordinate numbers for the position of each binary 1 in the picture stored in the memory. When decoded, the numbers produce a pair of analog voltages that are

(Continued on following page)

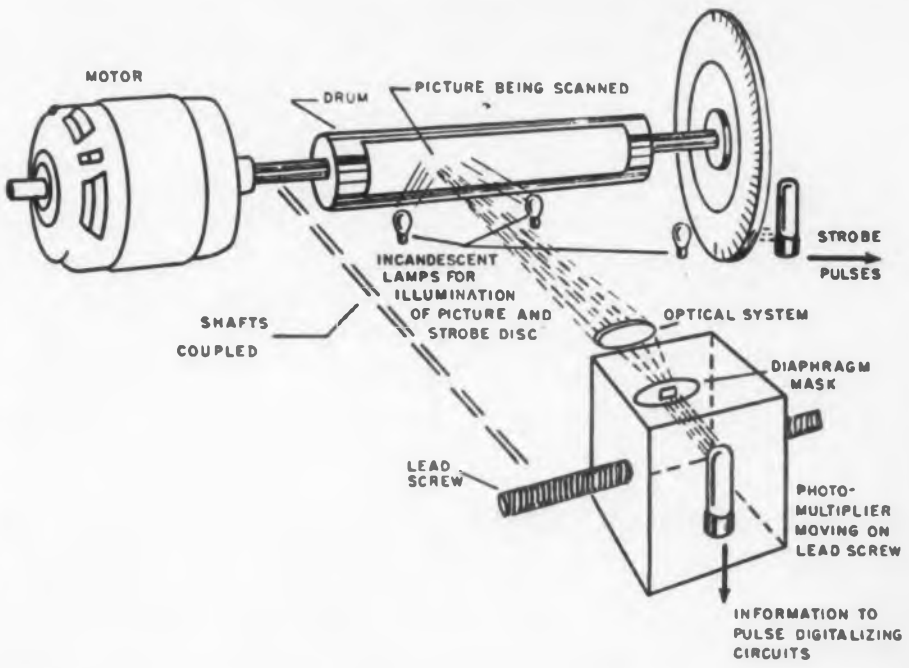


Fig. 1. Photograph to be scanned is mounted on a drum 2/3 in. in diam. As the drum rotates a photomultiplier and a source of illumination mounted on a lead screw move parallel to the axis of the drum. A mask in the optical system illuminates a 0.25 mm square and a strobe disc produces optical pulses for each 0.25 mm of drum rotation. The photo-multiplier can examine the relative reflectance of each 0.25 mm square.

applied to the vertical and horizontal inputs of an oscilloscope, thus generating the visual display.

In these experiments, the approach was to develop a library of computational processes for simplifying patterns in order to obtain their most significant features. Preliminary experiments were concerned with determining those manipulations which would prove to be the most informative. The compilation of discrete routines for the performance of these elementary manipulations would provide the basis of a flexible system for simulating many widely diversified pattern-identification logics. After determining the intended course of his pattern analysis, the programmer needs only to refer to this file and to select those routines which in combination will best serve his purpose.

One routine counts the total black area in a pattern. Advantage is taken of the fact that in many patterns there will be numerous words that are all black or all white. By comparing whole words against constants of all zeros or all ones, much time is saved.

Another routine was designed to count the number of "objects" in a picture. An object is a black area which is completely surrounded by white areas.

Nor was the routine for counting limited to solid, simply connected objects. The SEAC, could handle objects containing re-entrant profiles (spirals), multiply-connected objects (a letter B), or objects interspersed among other objects. Another type of question that SEAC was programmed to answer involved evaluating the area of each of the objects counted. The area of an object was defined as the total black part of the object and did not include, for example, the white circle enclosed by a black annular area.

A study of various logical schemes that have been proposed for recognizing printed characters was undertaken. A routine was written based upon the identifica-

◀ CIRCLE 4 ON READER-SERVICE CARD

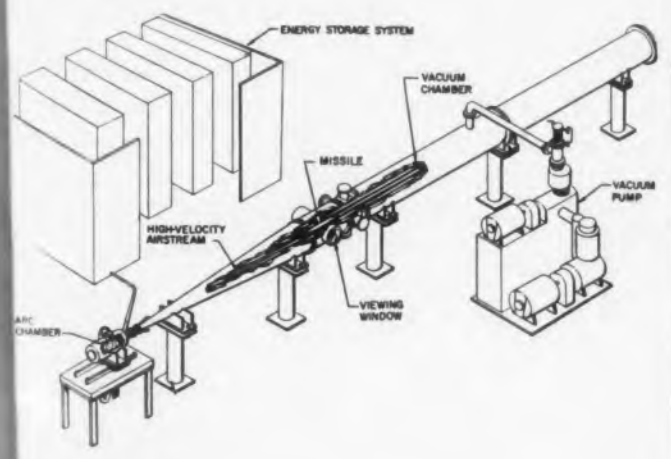
tion of unique areas for each character in an alphabet. Several photographs of different characters were compared to determine which parts of the viewing matrix were: (1) black for all letters concerned; (2) white for all letters concerned; or (3) sometimes black and sometimes white. This last area is the only part of the whole viewing frame that can be used to identify characters. Studies can now be made of characters in different fonts to determine the percentage of useful recognition areas that characterize each font.

Programs were coded to perform simple operations on each of the spots in a 30,000 spot picture.

One operation that produces unusual results is a kind of spatial differentiation. In this operation the computer investigates every black spot. If completely surrounded by eight other black spots, it is converted to a white spot. In any other case, a black spot is written. The effect of such an operation is to preserve the boundaries of an image while erasing all the internal area. After performing this operation the computer inverts all the digits of the picture, converting black to white and vice versa. One such operation constitutes a "custer." Even after custering 50 times, some traces of the image still remain.

Routines have also been written to superimpose pictures, to smear pictures by translating and superimposing them, to magnify and to record in permanent form on tapes and wire.

Additional information is contained in the NBS Technical Report No. 2194.



Hotshot Tunnel

Speeds up to 15,000 mph and temperatures of 18,000 deg will be reproduced in this 44 ft wind tunnel. Designed by Lockheed at Palo Alto, California, it will be, reportedly, the fastest and hottest wind tunnel in use by private industry. Compressed gas in the arc chamber, will be fired by a 20-million kw jolt of electricity from 320 condenser units-energy system-stacked in an adjoining room. Gas will be heated instantly causing it to erupt through a diaphragm. Superheated air will explode through the tunnel, which is evacuated by a vacuum pump, and blast against the nose of a test missile.

ENGINEERING REVIEW

Counting System Totals Newspaper Output

An electronic counting system, which can total simultaneously the output of forty different operations will be used to program the press output of the Detroit News, daily and Sunday editions. The multiple-source counting system, reportedly first of its kind, is completely transistorized and can count up to 120,000 units a minute.

The counter is a twelve-channel system which will record newspapers being carried from the press room on eleven different conveyors. One or more of the eleven newspaper conveyors can be totaled simultaneously. The twelfth channel serves as a spare.

The installation will also provide detection devices at the input section of each of the eleven conveyors, which sense the folded edge of each paper as it moves along the conveyor, and a master totalizer, remotely located, which provides the centralized accounting of newspaper production. The totalizer houses eleven input devices, one for each newspaper conveyor, together with memory and dividing systems, an electro-mechanical counter and visible recording dial, and pre-setting controls to enable the production staff to dial the required quantity of each edition.

Each input device relays the incoming signals to its own memory system. The memory stores them for a split-second and then releases them in rapid sequence to a dividing system. The latter automatically divides the signals and sends a triggering count-signal to the electro-mechanical counter for each 100 signals received. Each numeral added on the counting dial represents 100 newspapers.

When the pre-set number of copies of an edition has been recorded, a signal is sent automatically to the press room superintendent to shut down the presses.

◀ CIRCLE 6 ON READER-SERVICE CARD

Russian Taught on TV

Russian is now being taught on television. Broadcast over WRGB-TV, Schenectady, N.Y., the course is being sponsored jointly by General Electric, the Mohawk-Hudson Council on Educational Television, and the Northeastern branch of the American Chemical Society. It was conceived by the latter group who saw opportunity in the heavy concentration of scientific personnel in this area.

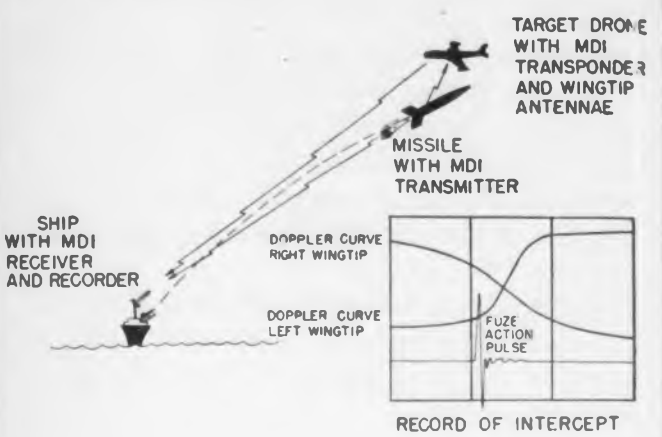
The course, conducted by Dr. Irving S. Bengelsdorf, organic chemist at the GE Research Laboratory, is designed to help in the rapid dissemination of Russian technical literature to scientists and engineers.

Occupying a 6:30 to 7 a.m. spot, the Tuesday-Thursday programs reach a potential audience of more than one million upstate New Yorkers.

A special series of six television programs on Russia's historical and cultural background featuring recent visitors to Russia, preceded the language course.

Moon Bounce Tracking.—This 50-ft. dish antenna, in combination with a new radio transmitter, the Space Sentry, located at the U. S. Army Signal Corps Labs, Fort Monmouth, N. J., is being used to bounce signals from the moon for close tracking of the earth satellites. Transmitter power is equal to a million and a half watts. Before the new transmitter was installed, Diana was used to establish the feasibility of the method for aligning the satellite receiving and computing equipment.

ENGINEERING REVIEW



Miss-Distance Indicator

Anti-aircraft gunners can now tell how close their missiles come to a target with vhf miss-distance indicator perfected at the Naval Ordnance Laboratory, Silver Spring, Md. Based on the Doppler effect the system consists of a transmitter in the missile, a shipboard receiver-recorder, and an aircraft transponder, which receives a radio signal from the missile transmitter on one frequency and retransmits it to the shipboard receiver on another. The distance by which the missile missed the target is noted by taking the frequency difference between the two signals. Analysis reveals the distance in feet and the relative speed between missile and target aircraft. Insert on lower right is an enlarged facsimile of a graph made by an electronic recording device at the shipboard receiving station. The indicator is intended expressly for crew training and missile development, not for combat use.

Capacitance Pickup Detects Heart Defects

A heart sound pickup that detects chest wall movements as small as one-half billionth of an inch is being used for detection of defects in the heart valves at an earlier stage than was possible.

Developed cooperatively by Dale Groom, M.D., assistant professor of medicine at the Medical College of South Carolina, and Yro T. Sihvonen of General Motors Research Staff's Physics & Instrumentation Dept., GM Technical Center, the capacitance device is contained in a small bell-shaped housing similar to the bell of a physician's stethoscope and transduces chest wall vibrations directly into electrical signals.

These faint signals are amplified and reproduced on an oscilloscope or recorded on tape. Utilizing the capacitance principle, the skin on the patient's chest may serve as one electrode, or a suitable diaphragm may be used, applied directly to the skin. The other electrode is suspended above the skin surface, inside the pickup, and is connected by cable to electronic accessories that amplify and record heart murmurs.

Copper Plating On Aluminum

A process for electroplating copper on aluminum strip and aluminum wire has been developed at Sylvania Electric Products, Inc., Warren, Pa. The new technique is reported to permit plating of aluminum strip in widths up to 10-in. and in thicknesses from 0.008 to 0.050 in. Thickness of the copper plating ranges from a flash coating to 0.002 in. per side. Aluminum plated by the new process can be tinned, soldered or formed without breaking the copper plating.

5 Billion Dollars For 1959 Missiles

Orders for missiles in fiscal year 1959 will amount to $5,729,000,000, a four-fold increase since 1955. In a report by "Planes" official publication of the Aircraft Industries Association, it was also indicated that funds scheduled for ICBM's and IRBM's, compared with total missile obligations, jumped from less than 1 per cent in 1951 to 41 per cent in 1958. However, orders for ICBM's and IRBM's in fiscal 1959 reveal for the first time that obligations for these two types of missiles will decline, both in actual amount of money and in percentage comparison to total programmed obligations. In fiscal 1959 only 34 per cent of the total ($1,941,000,000) is scheduled, compared with 41 per cent of the total ($2,070,000,000), in fiscal 1958.

Know Thyself

A strong radio signal interfered with a railroad communication system in the San Francisco area. Unable to locate the trouble, the company requested aid from the local FCC engineering office. The latter traced the signal to a yard locomotive with a transmitter in continuous operation because of a defective control relay. The company expressed appreciation with an apology since the trouble was in its own switchyard.

MEETINGS

Apr. 8-10: Sixth National Conference on Electromagnetic Relays

Oklahoma State University, Student Union Building, Stillwater, Okla. Sponsored by the National Association of Relay Manufacturers. Papers will include the results of individual investigation by the authors. More information may be obtained from Charles F. Cameron, Dept. of Electrical Engineering, Oklahoma State University, Stillwater, Okla.

Apr. 8-10: Symposium on Electronic Waveguides

Auditorium of Engineering Societies Bldg., 33 W. 39th St., New York. Sponsored by IRE, PGED and PGMTT, and the Department of Defense Research Agencies. The symposium will deal with the interaction of electromagnetic fields and electron or plasma beams in general waveguide regions. The symposium covers the fields of electron beams, plasma, and electromagnetics to compare the rather widely disparate theories and techniques employed to describe the wave phenomena encountered in the interaction of such fields. For further information contact the Polytechnic Institute of Brooklyn, 55 Johnson St., Brooklyn 1, New York.

Apr. 10-12: IRE South West Regional Conference and Electronics Show

San Antonio Hotel and Municipal Auditorium, San Antonio, Tex. Write for details to J. O. Parr, Jr., 202 Janis Ave., San Antonio, Tex.

Apr. 14: Symposium on "Chemical Aspects of Printed Wiring"

San Francisco, Calif. Sponsored by the American Chemical Society. Speakers will discuss new developments in printed wiring technology. For further details write Louis H. Sharpe, Bell Telephone Labs., Inc., Murray Hill Lab., Murray Hill, N.J.

Apr. 17-18: Second Annual Technical Meeting of the Institute of Environmental Engineers

Hotel New Yorker, New York. A display of the earth satellite model and an address by Kurt R. Stehling, Propulsion Head of the Vanguard Missile Project, Naval Research Laboratory, will highlight the meeting. Write Institute of Environmental Engineers, 9 Spring St., Princeton, N.J., for further information.

EDITORIAL

The Engineer with a Job Knows No Recession

We've yet to run across the employed engineer with time on his hands. Just about everyone is on a crash program. Not so the shopkeepers and car dealers we meet. They have much time to talk recession. But as we see it, and as most of the engineers we talk to see it, there is no recession in electronics.

Our subjective view is born out by business reports. According to an ELECTRONIC WEEK article March 3, the worst in slow-downs in defense is over and companies are reporting expansion. It is not accurate to claim consumer electronics is booming. Radio and TV are off for this time of year. But in defense electronics prosperity is just around the corner, and the anticipated big pickup should be taking place now. Third quarter government contract money will begin to be paid out in the form of salaries. There will be more money for more jobs.

Right now the electronic engineer out of a job has better prospects than his professional brothers in chemistry, aeronautics, and mechanical engineering. In fact the only electronics people who haven't been on a payroll for some time are those with the least to sell. Employment agencies report that engineers with strong backgrounds are snatched up quickly. It's the junior engineers (many of whom are upgraded technicians), industrial engineers, and junior administrators who are not getting jobs.

One effect of the cutbacks last fall and the current national dip in the economy is to make engineers security-conscious. It appears that good engineers are more cautious than they need be. For fear of being the last man hired and the first man off, many are passing up good opportunities. Companies are always on the lookout for qualified good men and will hire a good man any day even though they don't have widely publicized recruitment programs going on. Wise companies do not drop good men.

Without asking a single question, without picking up a phone, an editor can see business activity. The signs are: business is good. For one thing, our advertising in March was 313 pages—over eight per cent over 1957. Judging from the new product announcements that pour in daily, there's no retraction of plans, no fear of the market. For example, new products shown at the IRE Show are greater in number in 1958 than they were in 1956, and only slightly below the record-breaking 1957.

We see no reason for preoccupying oneself with thoughts of pessimism. Electronics is still in its infancy and there are needs to be filled by bold, level-headed engineering.

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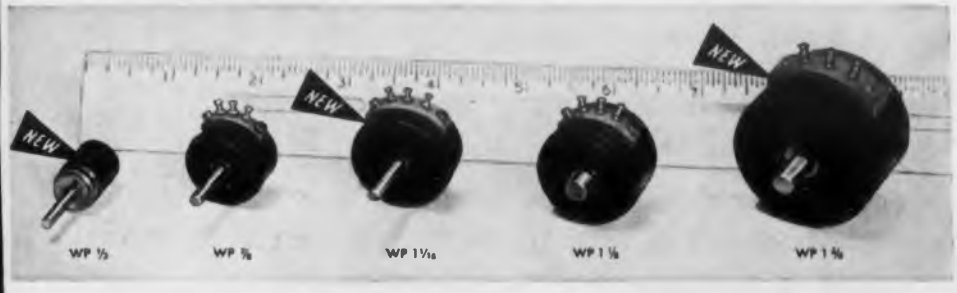

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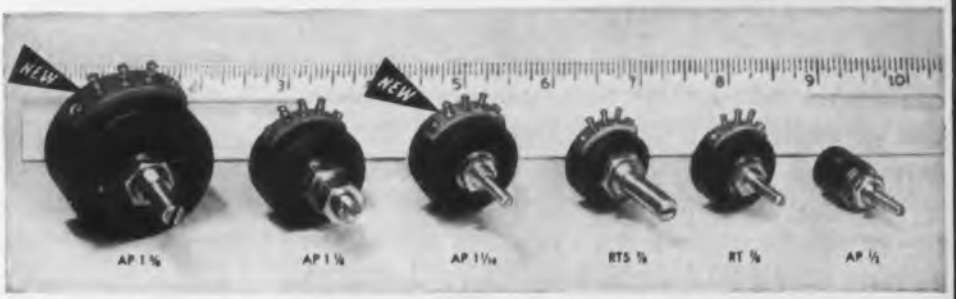

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CIRCLE 11 ON READER-SERVICE CARD

The "*Resisting*" *Transistor* for Servo Design

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Also Scientific Co., Inc.
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Developed by the author during the design of a servo-amplifier to be manufactured by the Alto Scientific Company, the *resisting transistor* technique provided 94 per cent efficiency from a pair of Sylvania 2N307's in a prototype model. This technique, which was named by the author, effectively uses the transistor as a variable resistor between the power supply and the load. The technique is useful only in amplifiers where the ac input signal is of fixed frequency and phase angle with respect to the ac power source. But in the case of servo amplifiers, such as the one described in the text, the substantial increase in efficiency and operating temperature over previous designs should make the technique of particular interest in aircraft and missile electronics.

COMPARISON with the conventional class B output stage shows that using the *resisting transistor* technique in the design of a servo amplifier, more than twice as much output can be delivered with an efficiency of the order of 95 per cent. Smoothing components are eliminated, and the transistor pair is so arranged that the transistor acts as a variable resistor. If the comparison between class B and the new technique includes a rectified ac power supply in each case, there are further advantages in weight, size and temperature of the operation.

The type of amplifier to which this technique can be applied is limited to that which uses an ac input of variable amplitude but of fixed frequency and phase angle with respect to the ac power source as in servo amplifiers where the ac error signal varies either side of a null. The output from the resisting transistor is a faithful replica of the amplitude and phase of the input. Negative feedback can be used to improve linearity if required.

A conventional Class B output stage and a resisting output stage are shown in Fig. 1. The principal circuit difference is the omission of smoothing components in the latter. The theory of operation is quite different in the two cases.

In the conventional output stage, the voltage across the load is 180 deg out of phase with the voltage across the conducting transistor. At maximum output the transistor current and dissipation are greatest. An output of about 3-1/2 times single transistor dissipation can be obtained—the theoretical maximum of 78 per cent efficiency being reduced to about 64 per cent in practice.

In the resisting transistor output stage, the voltage across the load is *in phase* with that across the conducting transistor. The transistor is, in effect, acting as a variable resistor between the power supply and the load. When the transistor and load resistances are equal, maximum transistor dissipation takes place (Fig. 2). If the transistor were shorted out, the power delivered to the load would be four times the maximum transistor dissipation. This fact offers a quick check on the possible output from a pair of resisting transistors—eight times the dissipation rating of a single transistor.

From Fig. 3 it can be seen that with each transistor conducting on alternate half-cycles, the action of the rectifier is complemented. At full output the ac power source is connected directly through the 1:2 step-up transformer to the load. It can also be seen that the voltage applied between collector and emitter rises to a peak which is twice that of the supply voltage.

Absence of electrolytic capacitors in the resisting transistor circuit means an easing of the problems associated with design for high temperature operation. Transistor dissipation being comparatively low, higher ambient temperatures of operation are possible.

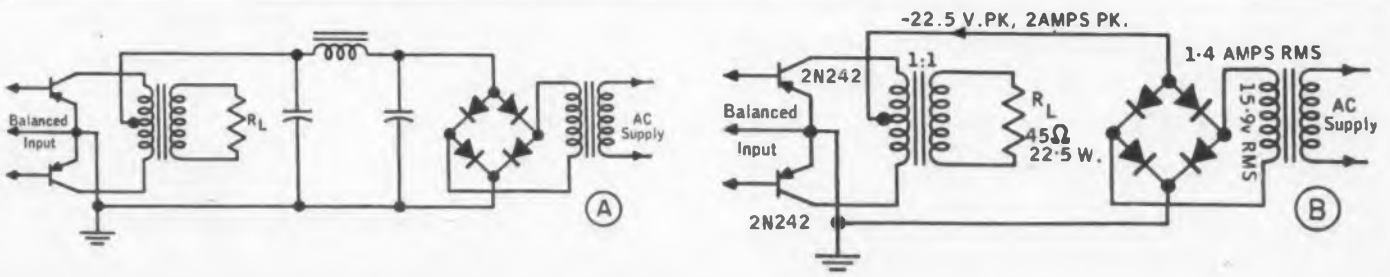

Fig. 1. *(a)* Simplified circuit of a conventional class B output stage. *(b)* Resisting transistor basic circuit. Values shown are impractical: losses were ignored in the calculations.

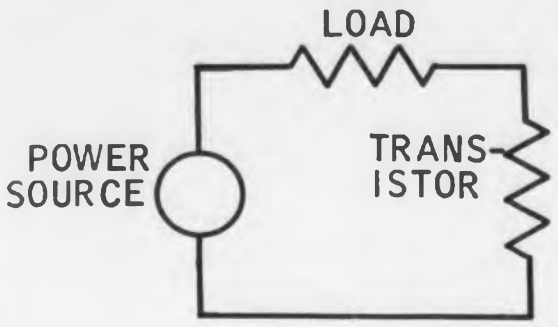

Fig. 2. Maximum dissipation occurs when load and transistor resistances are equal. The transistor can control the power in the load from zero to four times its maximum dissipation.

The efficiency of the resisting transistor circuit varies with the ratio of actual output to maximum output, reaching 50 per cent at the 6 db point, when maximum transistor dissipation occurs. Efficiency vs output is shown in Fig. 4, with the equivalent for a conventional Class B amplifier.

Load Line

As in the case of the conventional amplifier, a load line can be drawn across the transistor characteristics for the resisting configuration. This is the *peak load line*, representing the locus of peak voltages and currents at different signal amplitudes. For a given amplitude, the operational load line is a straight line from the origin to a point on the peak load line, as shown in Fig. 5. This operational load line rotates about the origin for different signal amplitudes: the one shown in Fig. 6 represents the condition of maximum transistor dissipation, when the power output is 6 db below the maximum power output. In practice, this operational load line may not be centered quite at the origin, and it may be slightly elliptical or irregular due to the series impedance in the power circuit and nonlinearity of the transistor characteristics. The use of negative feedback will cause the base current to adjust itself towards the value which is necessary to preserve the similarity between input and output waveforms.

Design

Where a choice exists, the load impedance should be as low as possible. This rule of thumb arises from consideration of the nature of the maximum voltage and current ratings, and it suggests the use of the maximum current rating as the starting point in the design.

Clearly there are three limits which must not be exceeded—voltage, current and dissipation. In some transistors, such as the 2N242, 2N256 or the silicon 2N289, the permissible dissipation cannot be taken advantage of, except by increas-

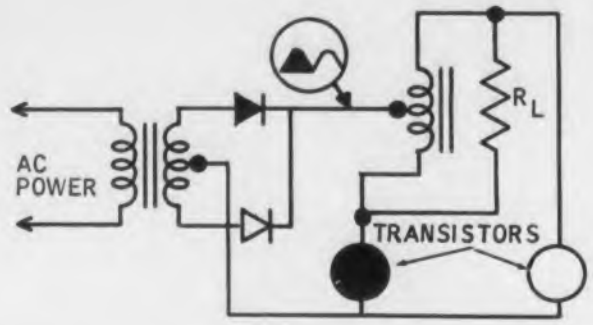

Fig. 3. Shading indicates conduction in this schematic. Transistor action complements that of rectifier; 180 deg phase shift in transistor input will result in 180 deg shift in output. Intermediate phase angles cannot be handled.

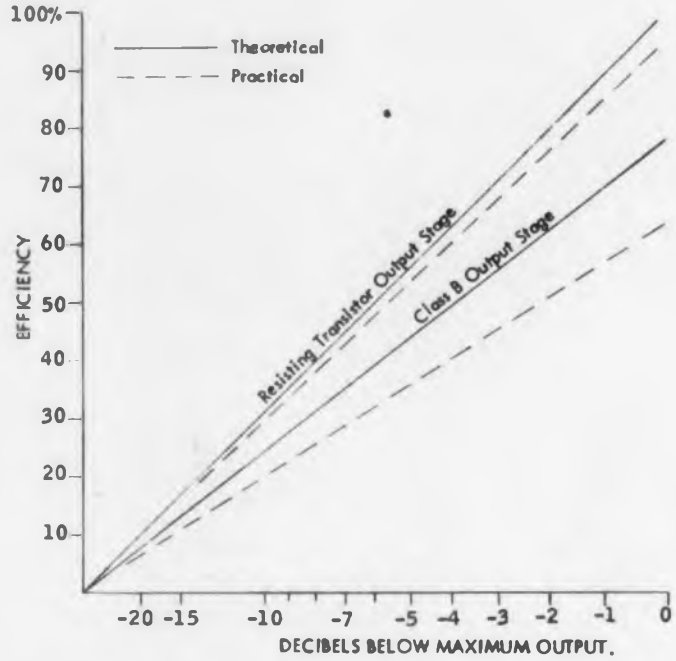

Fig. 4. In the resisting circuit efficiency rises toward 100 per cent as dissipation decreases, after passing the 6 db point. In the class B amplifier dissipation continues to increase up to full volume of output.

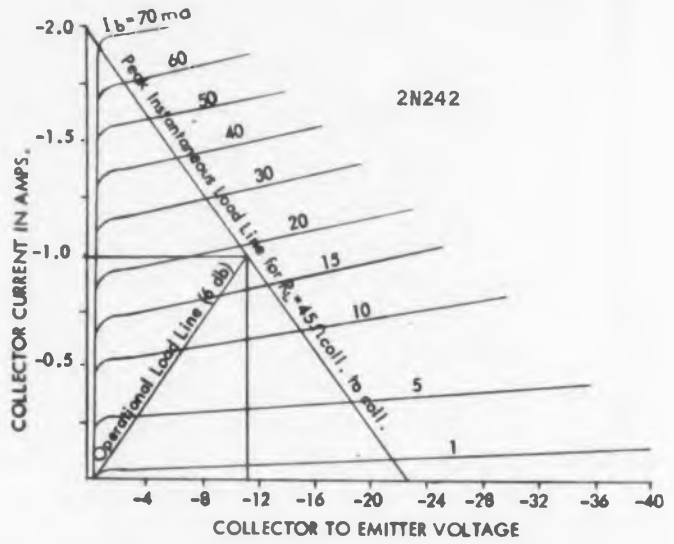

Fig. 5. Operational load line rotates about origin from zero output to maximum output, extending as far as the peak load line in each case. In practice, the vertical (maximum) will never quite be obtained.

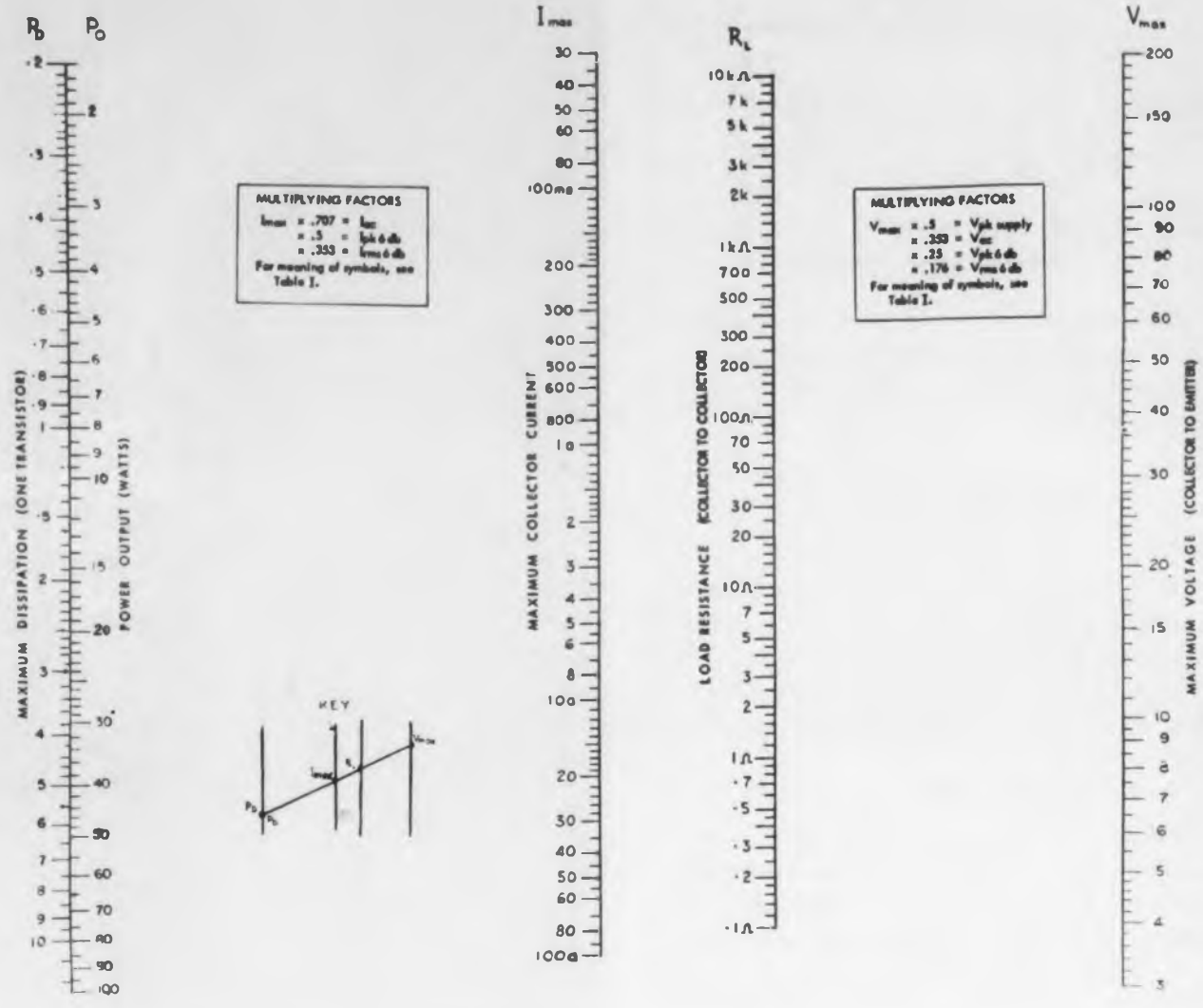

Fig. 6. Resisting transistor design nomogram. From the maximum voltages and currents used in the nomogram, the other relevant values can be found by using the multiplying factor shown. For meaning of symbols, see Table 1.

Table 1. Resisting transistor design procedure.

Symbol	Description	Derivation	2N242	2N174	2N156	2N389	2N352	Units
I_{max}	Absolute maximum collector current	Mfr's rating	2	13	3	2	2	amp
$I_{pk\ 6db}$	Peak collector current at half volume	1/2 (I_{max})	1	6.5	1.5	1	1	amp
$I_{rms\ 6db}$	Rms collector current during half-cycle at half volume	.707 $I_{pk\ 6db}$	.7	4.6	1.1	.7	.7	amp
P'_D	Maximum permissible collector dissipation	Mfr's rating	5	7.7	5	15	7	watts
P_D	Actual dissipation (one transistor, full cycle)	1/2 ($I_{rms\ 6db}$ $V_{rms\ 6db}$	2.8	7.7	2.1	3.7	1.2	watts
$V_{rms\ 6db}$	Rms voltage across transistor during conducting half-cycle at half volume	$P_D/I_{rms\ 6db}$	7.9	3.3	4	11.3	3.5	volts
$V_{pk\ 6db}$	Peak collector-to-emitter voltage during conducting half-cycle at half volume	1.414 $V_{rms\ 6db}$	11.2	4.7	5.6	15	5	volts
$V_{pk\ supply}$	Peak supply voltage	2 $V_{pk\ 6db}$	22.5	9.5	11.2	30	10	volts
V_{max}	Maximum collector-to-emitter voltage	2 $V_{pk\ supply}$	45	19	22.5	60	20	volts
V'_{max}	Maximum permissible collector-to-emitter voltage	Mfr's rating	45	60♦	22.5♦	60	20	volts
R_L	Collector-to-collector load resistance	4 $V_{rms\ 6db}/I_{rms\ 6db}$	45	2.9	15	60	20	ohms
P_o	Power Output (two transistors)	1/2 (I_{max} $V_{pk\ supply}$) = 8 P_D	22.5	62	16.8	30	20	watts
—	Typical Class B output (two transistors)	Mfr's example	2.5●	—	9	15	10	watts

Other symbols used in nomogram: V_{ac} = rms supply voltage, I_{ac} = rms supply current.
●One transistor, Class A.
♦Assumed to be 75 per cent of maximum collector-to-base voltage

ing the upper temperature limit of operation. In others, such as the 2N174 and 2N177, the current or voltage must be less than the maximum permissible. In such cases it is preferable to keep the current high and the voltage low.

If the maximum current rating is used, half of it represents the peak current when the output is 6db below maximum, and its rms value during the conducting half-cycle can be found. This current causes maximum dissipation during the half-cycle. If it flowed during a full cycle, it would cause twice the permissible maximum transistor dissipation. With this as a basis, the equivalent rms voltage can be determined, and from it the peak voltage across the conducting transistor at the 6 db output level can be calculated. Twice this peak gives the peak supply voltage, and twice the peak supply voltage is the peak which the transistor must be able to withstand. If the transistor cannot withstand it, then the maximum voltage which it *can* withstand is taken and the sequence of the calculation changed to provide information as to the maximum transistor dissipation which will occur.

Table 1 shows the design procedure, with results for various transistor types. The nomogram, Fig. 6, is useful for designs to meet specifications other than maximum output from a given type of transistor.

Maximum Ratings

No really accurate method is available for stating what peak voltage may safely be permitted in a resisting—or any other—circuit, since one of the factors upon which it is dependent is the base-to-emitter circuit resistance. This must be kept as low as possible.

The dangers involved in exceeding the maximum voltage, on the other hand, can be quite simply stated. Saturation current I_{co} is driven by a peak voltage twice that of the supply: it is temperature sensitive, and its tendency to produce avalanche effect increases with the applied collector-to-emitter voltage. When it occurs, avalanche effect can be completely destructive, since it prevents the center-tapped transformer from reflecting the load into the power circuit.

If the maximum permissible collector-to-emitter voltage is not specified by the manufacturer, a fairly safe rule-of-thumb is to take a figure of two thirds to three quarters of the maximum permissible collector-to-base voltage, or twice the dc supply voltage specified for a typical Class B amplifier.

Still better, the difficulty should be avoided altogether—and in many cases this can be done, since the limit imposed by the maximum collector dissipation may leave an unused margin of voltage or current. The maximum permissible voltage then need not always be used.

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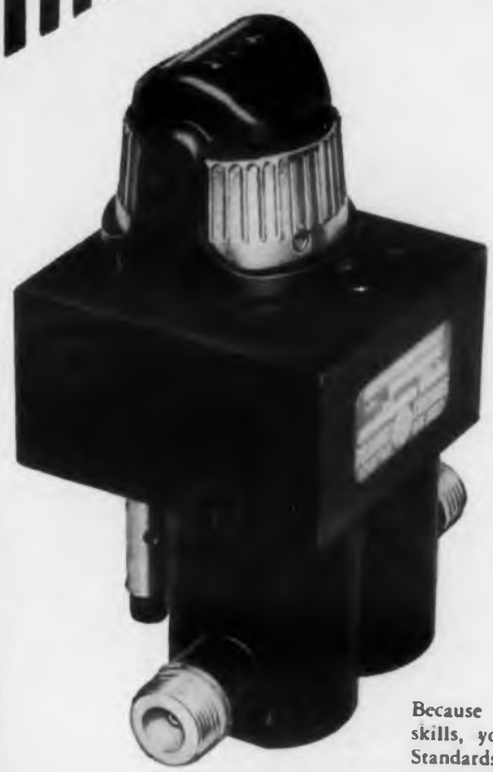

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CIRCLE 13 ON READER-SERVICE CARD

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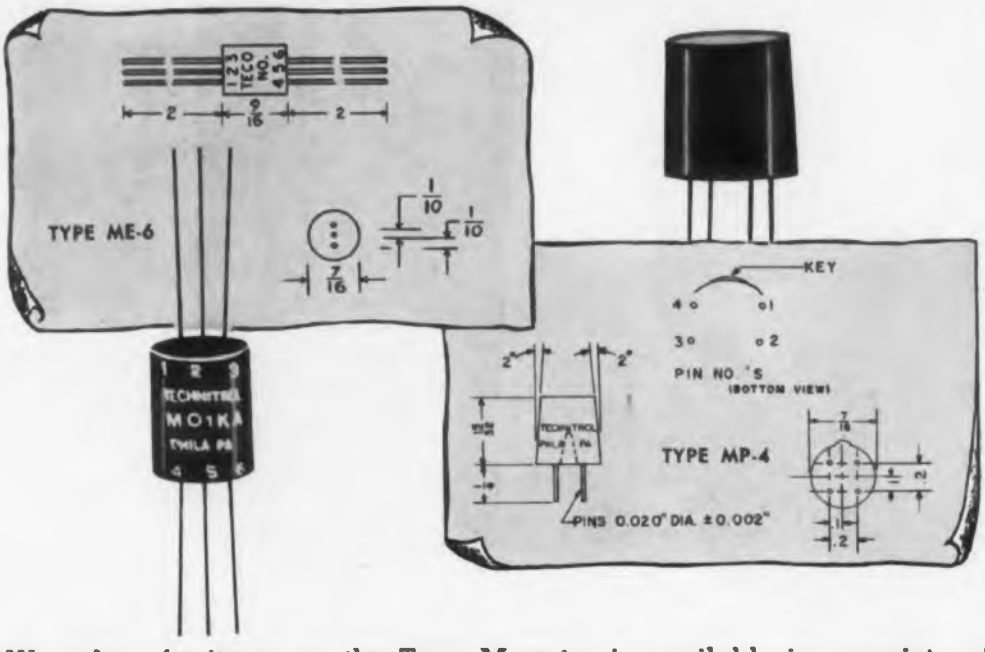

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CIRCLE 14 ON READER-SERVICE CARD

Copper-Metallized P-C Boards

have high bond strength and withstand 250C

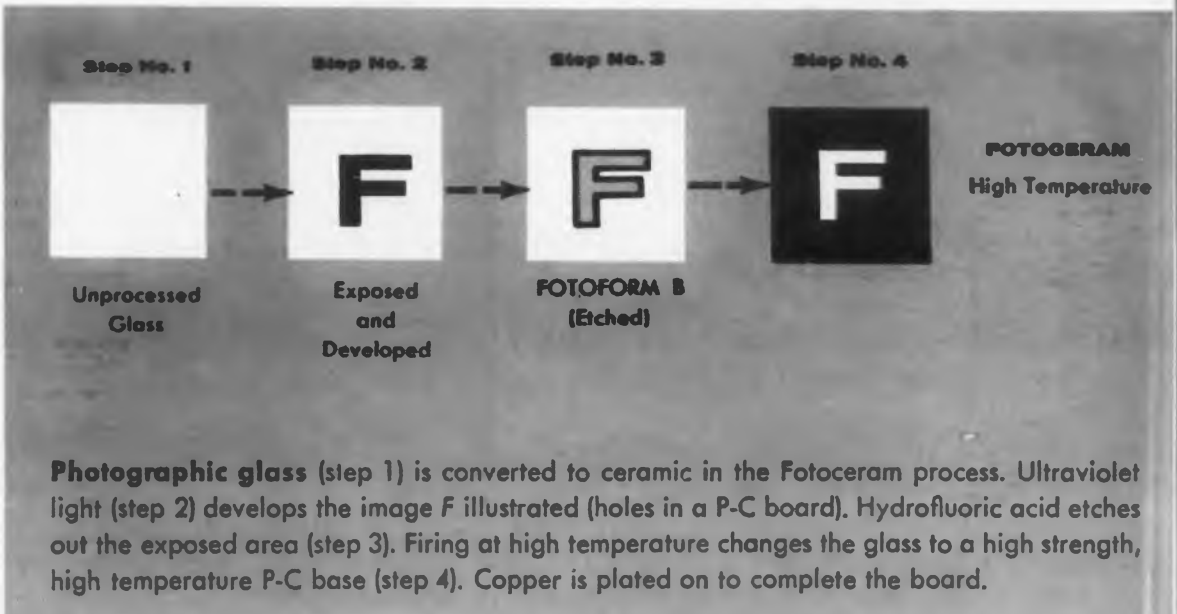
REMOVING and resoldering components 50 times to the same circuit run of a printed wiring board without blistering or lifting sounds improbable. You can do it with Corning Glass Works' Fotoceram—plated copper on a high-strength, high-temperature ceramic-type glass substrate. The company literature conservatively states "components have been resoldered to the same circuit run more than 20 times without indication of failure." Applications engineer Tom O'Leary said he resoldered 25 components 50 times with no evidence of trouble, so he quit. Other claims of the "believe-it-or-not" variety are these: additional heat actually increases the bond between the copper and the base; you can immerse the board in a 500 F solder-pot for five minutes without damage (a prospective customer left a board in for three days and it was reported better than new).

Fotoceram is intended for missiles, communication systems, control and measuring instruments, radar, and other high reliability units. It is competitive in price with high quality epoxy base boards.

Fotoceram is a Different Process

There are a number of steps involving unusual materials necessary to produce Fotoceram. Photographic glass is used at the start; holes are chemically machined and the glass is converted to a ceramic with zero water absorption, no sag, and no warp. In detail:

1. Customer provides drawing of board and Stabiline film (or equal) of circuit;
2. Corning makes photographic negative for holes only;
3. Using this negative and an ultraviolet light source, a contact print is made on Fotoceram glass;
4. Heat treatment converts the exposed area to an etchable glass;



Photographic glass (step 1) is converted to ceramic in the Fotoceram process. Ultraviolet light (step 2) develops the image *F* illustrated (holes in a P-C board). Hydrofluoric acid etches out the exposed area (step 3). Firing at high temperature changes the glass to a high strength, high temperature P-C base (step 4). Copper is plated on to complete the board.

5. Application of hydrofluoric acid etches out the image to form holes and shape of board;

6. The transparent glass is heat-treated at 800 C to produce Fotoceram, a brownish ceramic with a resistivity of 6×10^{15} ohm-cm (at 25 C) and flexural strength of 25,000 psi. Crystalization takes place making it different from other glass;

7. The entire board is then coated with a layer of nickel. Holes and edges are covered with nickel;

8. A resist for protecting the insulated areas is silk-screened on the board;

9. Copper is electroplated on the nickel base and through the holes;

10. A finish plate of gold or tin-lead, etc., to customer specifications is added;

11. Plating resist is dissolved and nickel plate chemically stripped. Board is ready for use.

Most of the steps can be performed automatically by batch or continuous flow processing. The process cannot compete pricewise with lower quality boards used by radio and TV manufacturers. It may be cheaper than epoxy boards depending on the quantity and number of holes. Any number of holes are etched out simultaneously. Because the board is reliable and soldering techniques are no problem, the final cost of incorporating printed wiring into equipment may be lower than present methods.

The fact that the photographic glass can be etched precisely opens up new fields for packages in three dimensions.

Seemingly Disadvantages

The material is glass-like. Although the flexural strength is 25,000 psi, the base is brittle. Mounting precautions should be followed. Usually all that is necessary is to use a fiber washer between the board and mounting bracket or support. Mounting is no problem in the Falcon missile where Fotoceram has been used two years.

You cannot add holes easily once the board has been completely processed. Cavitron or other glass-drilling techniques would have to be used. However, it is not too difficult to make an engineering change while an order is in process because no tools and dies are involved.

The company is accepting sample orders for quick delivery. For more detailed specifications, turn to the Reader-Service card and circle 15.

How To Correct Phase Distortion with an L-C Lattice

J. D. Fogarty

Remington Rand Univac
Division of Sperry Rand Corp.
Philadelphia, Pa.

Network phase distortion can often be corrected, or at least improved by means of a simple L-C lattice. Here, Mr. Fogarty analyzes the problem and presents a useful design aid for phase correction.

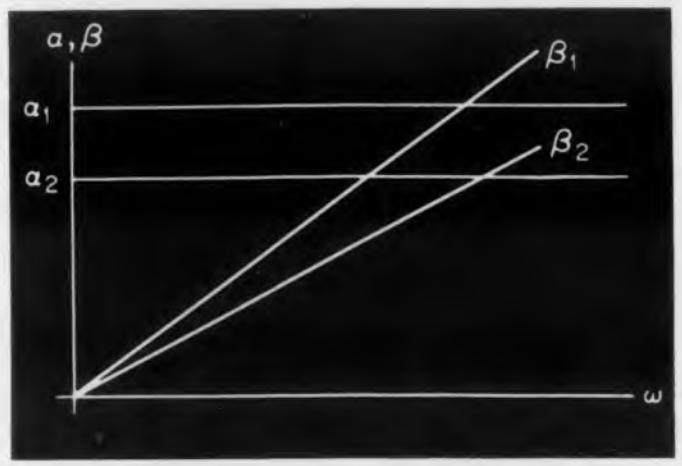


Fig. 1. Ideal distortionless transfer functions.

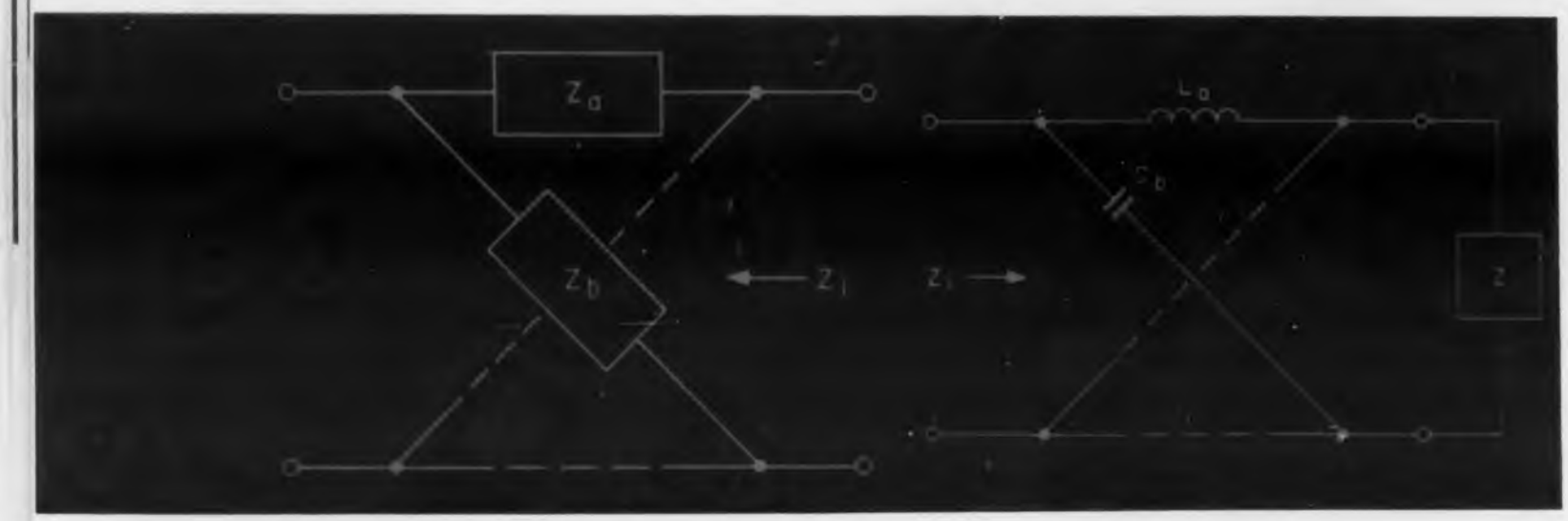
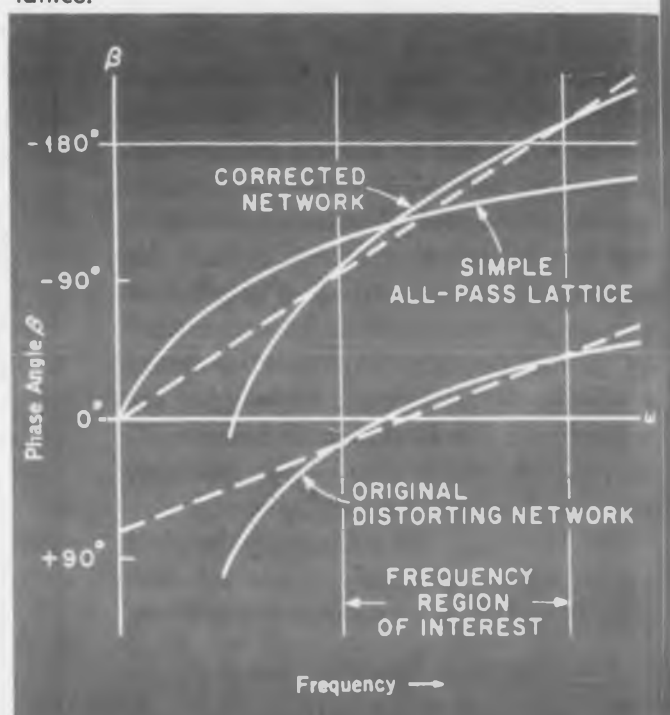


Fig. 2. General symmetrical lattice structure.

Fig. 3. The symmetrical L-C lattice.

Fig. 4. An example of phase correction using an L-C lattice.



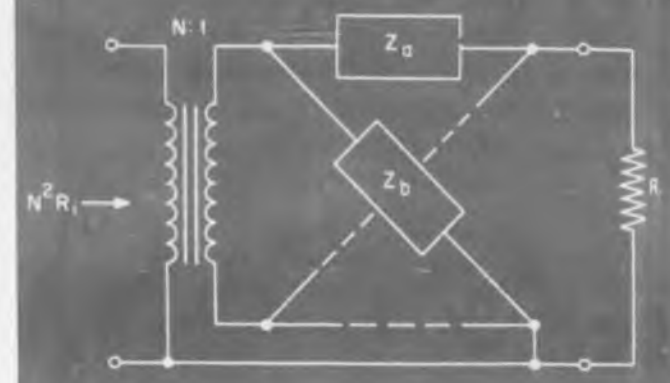


Fig. 5. A lattice network with a transformer to achieve a common ground.

ELECTRICAL networks can provide constant time delay with no phase distortion if two conditions exist.

- The network phase shift must be linear in the frequency region of interest, and
- The phase characteristic, if extended, should pass through zero phase shift at zero frequency.

Thus, the networks whose phase characteristics are sketched as a linear function of frequency in Fig. 1 provide different time delays with no phase distortion.

Since real electrical circuits do not always provide desirable phase characteristics, a special network is often added to control phase distortion. The symmetrical lattice of Fig. 2 is sometimes used as such a phase equalizer. If the branches are reciprocal reactances, it will have zero attenuation for all frequencies from dc to infinity when the lattice is terminated in its image impedance. This image impedance is

$$Z_i = \sqrt{Z_a Z_b}$$

and the phase characteristic is such that

$$\tan \frac{\beta}{2}$$

$$\tan \beta/2 = \pm\sqrt{Z_a/Z_b}$$

This phase characteristic can be controlled by the branch impedances, but its slope will always be such as to give increasing phase with increasing frequency.

The Symmetrical L-C Lattice

Fig. 3 shows a symmetrical L-C lattice with single inductors or capacitors in each branch. The L and C branches can be interchanged. This reverses the polarity of the output but does not affect the phase characteristic. The attenuation remains at substantially zero at all frequencies where the component Q's exceed 10. The image impedance is a pure resistance and is

$$R = \sqrt{L/C}$$

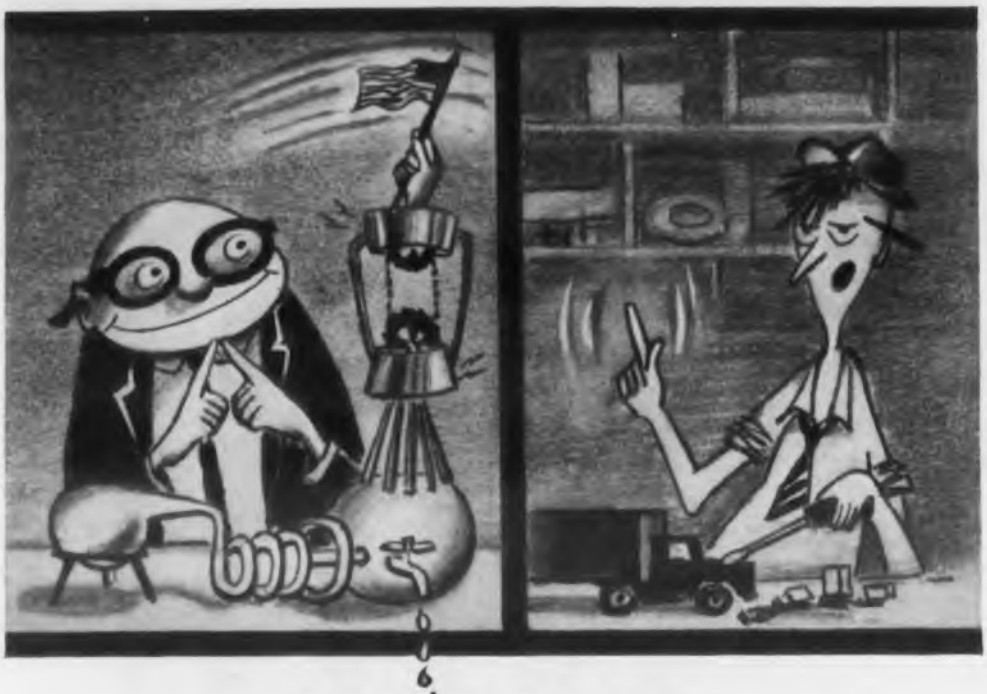
The phase characteristic can be represented by

$$\tan \beta/2 = -2\pi fT$$

where $T = RC = L/R = \sqrt{LC} = 1/2\pi f$

Phase Correction

Fig. 4 illustrates the use of this L-C lattice as a phase equalizer. The original network has a phase characteristic, in the frequency region of interest, which gives phase distortion. (Its extension does not pass through zero phase at zero frequency. By adding the phase response of the L-C lattice to the original network, a new phase characteristic is achieved which minimizes phase distortion. The equalizer increases the total signal delay, but in many applications, this is not important.

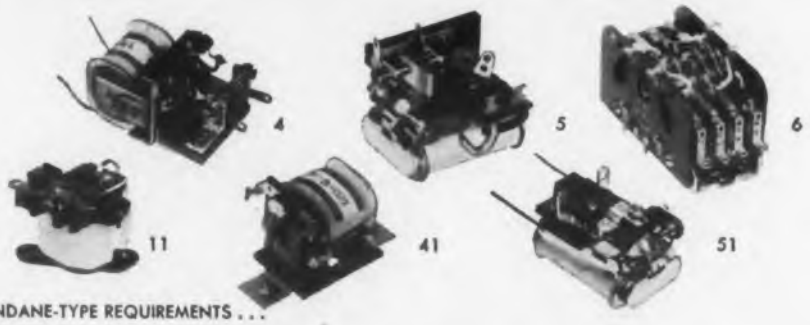


SIGMA TYPES AT YOUR SERVICE

On the left, Hardwicke J. von Cumulus exemplifies scientific inquiry in the best tradition, pondering problems of the highest order concerning interrelation of theoretical factors in sensitive relay design. His is an 0.6^{-13} world, beyond the ken of most, deaf to the Cry of the Coliseum. He's the gentleman to see if you're just wondering about the characteristics of a relay for use somewhere out of this world.

At right is Sigma's General Purpose Application Man of the Year, Mackinaw L. Mundane. Although Mackinaw will never quite understand what all the Hardwickes are muttering about, he doesn't care; he's closing in fast on some good unsophisticated jobs for Sigma relays. He's heard all about Progress, Improvement and Doing the Difficult Jobs Well, but he knows *his* bread is buttered by the guy who wants a relay that will work well, on the ground, under everyday circumstances. He will enthusiastically tell you, point blank, which Sigma type to pick for speed, quietness, price, life or some combination thereof. His customers make toys, burglar alarms, electric blanket controls, machinery controls, UL-approved items and such, and some of his favorite relays are shown below.

Actually, there's a whole crew of Mundanes here ready to jump when you speak — not at you, but up with answers. Or from a distance you can get some useful data on which to judge and select, in the form of specific relay Bulletins, or assembled within elegant covers as the NEW Sigma Catalog. Communication with H. J. von C. and other Scientists, however, is restricted to 8:30-5:00, Monday through Friday.



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CIRCLE 18 ON READER-SERVICE CARD

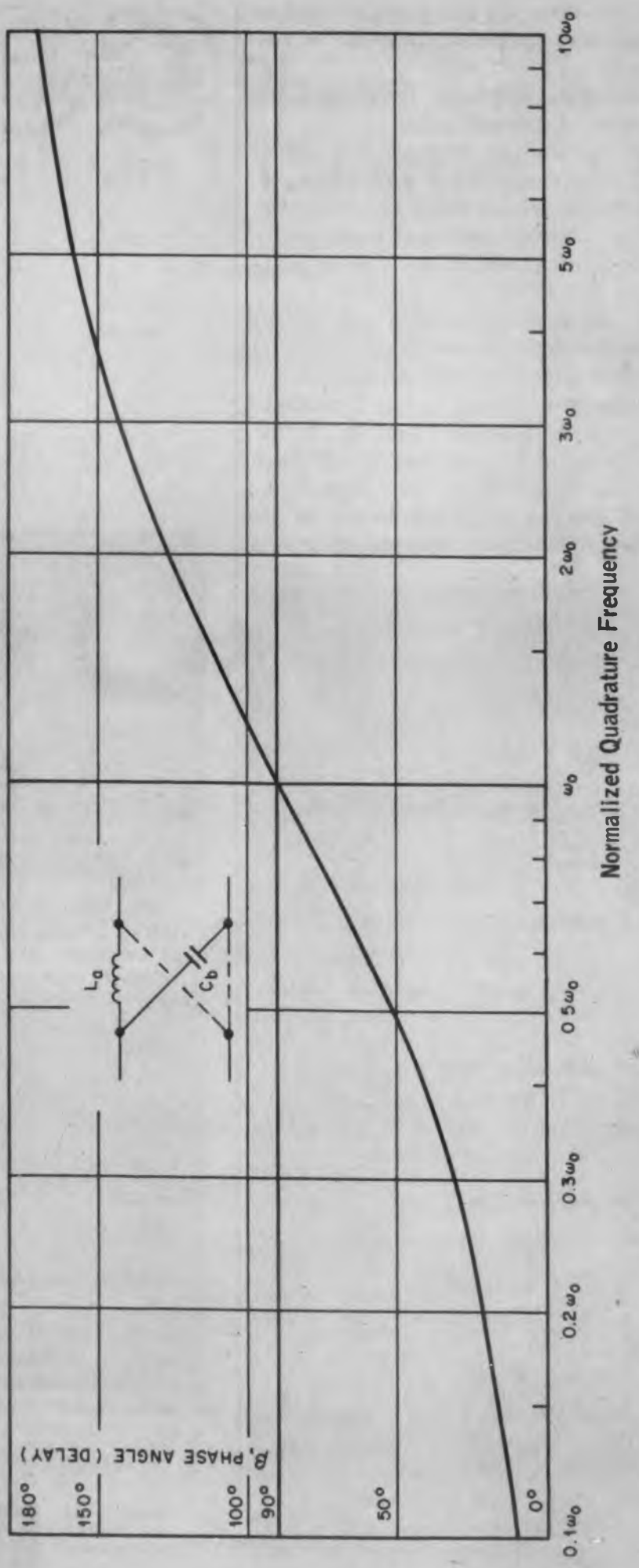


Fig. 6. Universal Design Curve for the all-pass L-C lattice network. (Two cycle semi-log paper, such as Dietzgen #340-L210, may be used as an overlay).

Since the phase vs frequency function of the simple L-C lattice is uniquely defined for this network configuration, the frequency chosen for one phase point on the curve determines the frequency of all other points. This frequency placement and the image resistance are the two independent variables at the disposal of the lattice designer. Thus, the simple L-C lattice cannot guarantee perfect phase equalization for all networks.

A Universal Phase Curve

Fig. 6 is a universal phase curve which can aid in the judicious choice of an L-C lattice for optimum phase correction. The lattice designer picks the two extremes of the frequency range over which the phase is to be optimized. Knowing the phase response of the network to be corrected, he goes to Fig. 6 and tries to locate two points on the quadrature frequency scale having the same ratio as his extreme frequencies, and having phase delays which, when added to the phase angles of the original network at the extreme frequencies, will most closely define a linear phase characteristic passing through zero at zero frequency. The designer should plot the original phase response on a linear scale as in Fig. 4. The designer should mark the ratio of the extreme frequencies on the edge of a card held along a logarithmic frequency scale such as the one in Fig. 6.

Knowing the ratio will be constant, he can move the card along the scale and attempt to find two phase delays at this ratio which will add to his original response to produce a linear phase characteristic. Once a "fit" is achieved, one of the known extreme frequencies is divided by the reading corresponding to it on the frequency scale to obtain the quadrature frequency, f_o, of the desired lattice. Finally a desirable image resistance is chosen to match the circuit impedance at the point of insertion.

The desired lattice elements will be

$$C = \frac{1}{2\pi f_o R}$$

and

$$L = \frac{R}{2\pi f_o}$$

The fact that a symmetrical lattice structure does not have a ground common to both input and output terminals limits its use in practical circuits. One terminal may be grounded and a transformer used at the opposite end to overcome this difficulty. This transformer may be used to transform the image resistance to a value leading to more easily realized components. Fig. 5 shows such a circuit.

Two-Gyro M

INFORMATION on this two-gyro stable platform has recently been made more public. Under development for the military during the past few years, the system proves to be truly worthy of its title of master reference. The instrument serves as a source of directional and vertical gyroscope intelligence for all systems aboard the aircraft, and thus eliminates the traditional necessity for individual gyros in each system. Moreover, the system is of relatively simple design, and is enclosed within a single package measuring a little over one foot in length.

The two-gyro master reference, developed by Lear, Inc., 110 Ionia Ave., N. W., Grand Rapids, Mich., is a completely non-tumbling type. In operation, the reference combines accuracies of newly designed gyros with the stabilized asimuth feature of the conventional Abbott-type stable platform. Both gyros are constructed on a common no-gimbal-lock type suspension. The directional gyro is a two-axis element stabilized by servo techniques in pitch and roll to eliminate gimballing errors, which often occur in conventional directional gyros during routine jet aircraft maneuvers. Random drift is extremely low. Drift rates are less than one degree per hour when magnetic heading control is removed.

The vertical gyro has a dual function, providing both non-tumbling roll and pitch signals for control systems. The no-gimbal-lock design of the vertical gyro allows full freedom of that element throughout 360 degrees in either pitch or roll. Because of this, the system can provide accurate stabilization information during such aircraft maneuvers as the planned Immelman and the one-half Cuban Eight, both used in loft bombing, and during sustained near-vertical flight of

ro Master Reference

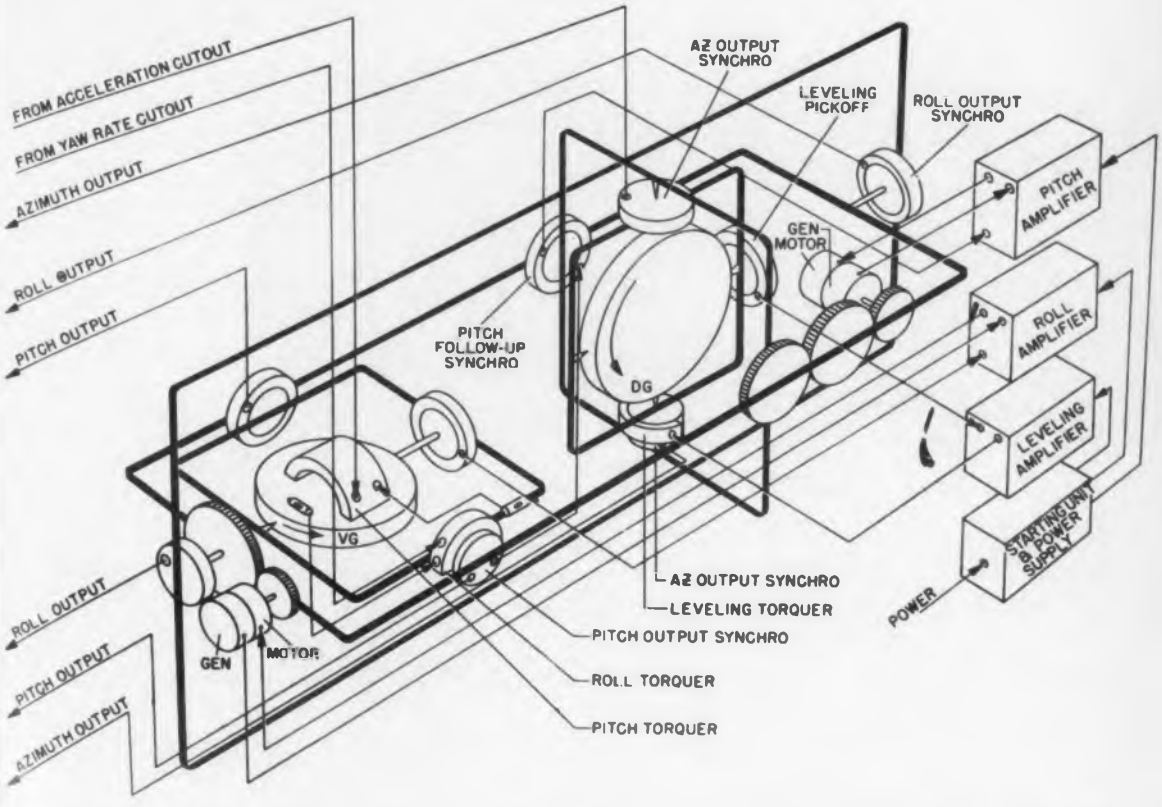


Diagram of the gyro reference system, showing its general construction. Note that both gyros are mounted on a common no-gimbal-lock type suspension. Gimballing errors in the directional gyro are eliminated by standard servo techniques. The vertical gyro is non-tumbling, permitting reference information during unusual aircraft maneuvers.

advanced aircraft. The master reference has been subjected to random noise type vibration through the range from 10 to 2000 cps at an average force of 10 g, and has also demonstrated good resistance to shock of this same magnitude. Other environmental characteristics meet those specifications typical for military jets.

For more information on this gyro system, turn to the Reader-Service Card and circle 21.

Instrument Calibration

MODEL 829

a modern method of maintaining ACCURACY

MODEL 261B

Superior and sustained quality control, through frequent calibration of test instruments, can be achieved by semi-skilled personnel using these self-contained standards.

Portable Model 829 calibrates both AC and DC meters over ranges from 0.25 millivolt to 2000 volts and 2 microamperes to 20 amperes. Direct reading accuracy of 1% (0.5% using charts supplied). Output frequency from 50 to 400 cps depending on line frequency used.

Net price $2,650.

Console Model 261B calibrates all types of AC meters to direct reading accuracies of 0.5% (0.25% using calibration charts) over frequency range of 50 to 1600 cps. Current range from 1.5 milliamperes to 200 amperes; voltage range from 75 millivolts to 1500 volts. Output of electronic power oscillator has less than 5% total harmonic content at 60 cycles.

Net price $9,250.

MODEL 262B

Model 262B Dual Potentiometer Standard calibrates DC electrical measuring instruments to direct reading accuracies of 0.1% (0.05% using calibration charts) through voltages ranging from 1 millivolt to 1500 volts and currents ranging from 1 microampere to 150 amperes. Employs Weston instruments and standard cells.

Net price $15,600.

Prices are f.o.b. Boonton, N.J. & subject to change without notice.

WE CAN HELP YOU

Technical and application data for our six basic models are fully described in a new 24-page catalog. Send for it today.

RFL

Radio Frequency LABORATORIES, INC.

Boonton, New Jersey, U. S. A.

CIRCLE 22 ON READER-SERVICE CARD

NEW PRODUCTS

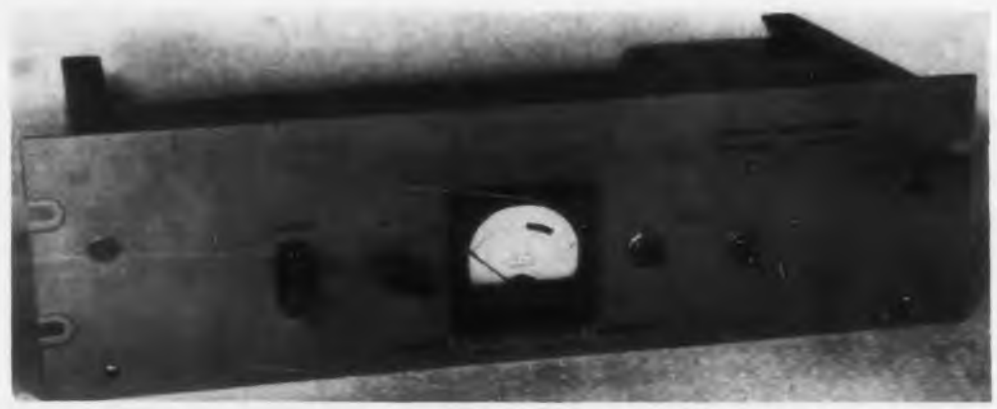
To provide a complete coverage of ALL new products generally specified when designing electronic original equipment, the New Product section has been extended. To include the larger number of items, products which are best suited to a brief description have been noted at the end of the section.

TRIGGER DIODE

A cold cathode gas trigger diode tube series has been designed for isolation purposes, switching, RC timing circuits, and other applications. The miniature tube has an extremely high input resistance before a critical voltage is reached, at which time the diode breaks down and becomes a very low resistance. A typical model of the series, Model TAA-113, has these characteristics: nominal firing voltage of 113 v; leakage resistance at 95 v of 5×10^{10} ohm; and energy transfer of 3000 ergs.

The Victoreen Instrument Co., Dept. ED, 5806 Hough Ave., Cleveland 3, Ohio.

CIRCLE 23 ON READER-SERVICE CARD



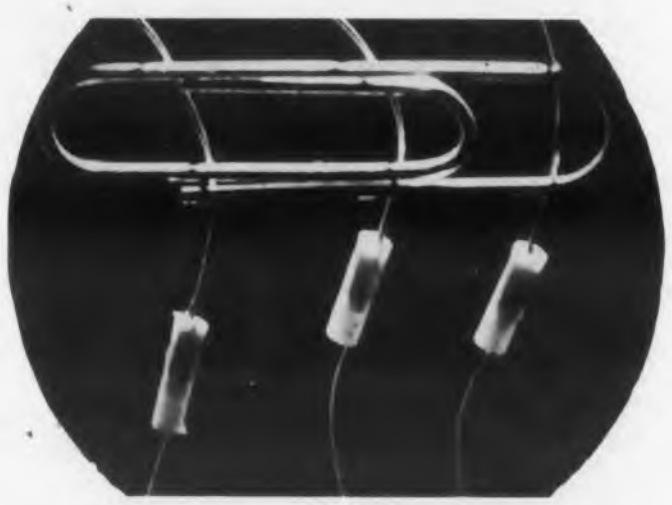
NOISE SOURCE

Thermal agitation of the electrons in an ordinary carbon resistor acts as the noise source in model 300B. The resulting voltage, about 13 μv, is then amplified by a stabilized feedback amplifier with 100 db of gain. Stability is such that it takes a change of about 54 F before the noise output varies 0.5 db.

Other specifications include an output of about 1 v for a frequency band up to 20,000 cps, output impedance of 20 ohm, and internal noise at least 10 db below thermal spectrum. The noise source furnishes constant energy per cycle, that is, rising 3 db per octave.

Western Electro-Acoustic Lab., Inc., Dept. ED, 11789 San Vicente Blvd., Los Angeles 49, Calif.

CIRCLE 24 ON READER-SERVICE CARD



TANTALUM CAPACITORS

These miniature polar electrolytics are slug-types recently added to the Tantalytic line. Designed for low voltage transistor applications, such as hearing aids, the units are rated from 1 to 20 v dc at values ranging from 0.1 to 16 μf. A typical unit measures 0.25 in. long with a diameter of 0.075 in. with the Mylar sleeve. Without the sleeve, the diameter is 0.067 in.

General Electric Co., Dept. ED, Schenectady, N.Y.

CIRCLE 25 ON READER-SERVICE CARD

DC AMPLIFIER

Multi-channel analog-digital conversion of strain-gage signals is greatly facilitated by the Model 1350 dc amplifier. An adjustable passband control can be set to suit the sampling rate while an output limiting circuit prevents a broken gage or other malfunction on one channel from saturating the rest of the commutation system. Signal compression, low noise, voltage gains to 1000, 2-μv zero stability, and 100 k input impedance are also featured.

Dynamics Instrumentation Co., Dept. ED, 1118 Mission St., So. Pasadena, Calif.

CIRCLE 26 ON READER-SERVICE CARD

DRIFT TRANSISTOR

A low collector-to-base capacitance of 1.65 μμf is made possible by the design of type 2N544 drift transistor. The unit can provide a power gain of 30.4 db at 1500 kc in circuits utilizing a neutralizing network and somewhat lower gains in circuits without a neutralizing network. The frequency range of the transistor is 535 kc to 1620 kc.

Radio Corporation of America, Dept. ED, 30 Rockefeller Plaza, New York 20, N.Y.

CIRCLE 471 ON READER-SERVICE CARD

NEW PRODUCTS

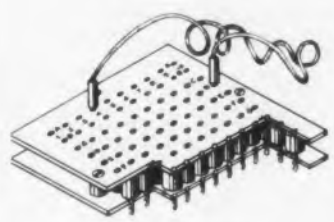
Choppers

Very low residual noise levels

Having nine pin bases with top coil connections, these choppers are available in both 20-120 cps and 350-500 cps models. The top coil connections in both hermetic seal and dust seal types assure residual noise of levels in one megohm circuits of less than 10 μv at 60 cps and 20 μv at 400 cps. These choppers have dpdt switching with both break-before-make and make-before-break contact closures. Like previous models, these choppers have center pivot construction and applicable to military environmental conditions.

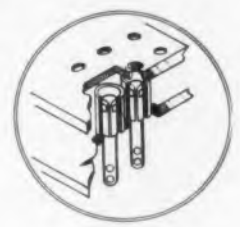
The James Vibrapowr Co., Dept. ED, 4050 N. Rockwell St., Chicago 18, Ill.

CIRCLE 30 ON READER-SERVICE CARD



Patchboard

Inexpensive assembly



These programming patchboards consist of a sandwich of two sheets of phenolic punchboard assembled with metallic terminals and spacers as shown. The panels have 0.095 in. diam holes. When the outer panel is removed the receptacles are exposed and can be easily changed or adjusted for optimum contact pressure. Since the outer panels are inexpensive, extra ones may be printed for different set-ups and are easily placed in position when needed. Standard units are made up in blocks of 100 receptacles on 0.265 in. centers, ten rows of ten receptacles each. Various color finishes are available.

Vector Electronic Co., Dept. ED, 1100 Flower St., Glendale 1, Calif.

CIRCLE 31 ON READER-SERVICE CARD

Power Supply

Delivers up to 1600 v dc at 300 ma

Model 6030 power supply is a laboratory type supplying 0-600 v dc at currents to 300 ma at any voltage setting. The circuitry insures rapid transient response with recovery times less than 50 μsec. Regulation for full load change is 100 mv. Ripple is 3 mv maximum. In addition to the main voltage range there is a bias supply delivering 0-150 v dc at currents to 5 ma.

Deltron, Inc., Dept. ED, P. O. Box 192, Glenside, Pa.

CIRCLE 32 ON READER-SERVICE CARD

Variable Delay Line

Delay is function of control voltage

Series EV-600 electrically variable delay lines provide a time delay which is a function of the applied voltage. Infinite resolution over a 50 per cent range of the nominal delay value is available. Since delay is proportional to control voltage, an amplitude function can be converted into time modulation of a pulse or phase modulation of a frequency. Delay range is 0.5 μsec to 50 μsec. Impedance range is 50 ohms to 2000 ohms. Delay to rise time ratio is 5 to 50.

ESC Corp., Dept. ED, 534 Bergen Blvd., Palisades Pk., N.J.

CIRCLE 33 ON READER-SERVICE CARD

CIRCLE 34 ON READER-SERVICE CARD ➤

Nickelonic News

VOL. 1 — DEVELOPMENTS IN NICKEL AND NICKEL ALLOYS AND THEIR APPLICATIONS — No 2

New ultrasonic welder solves heat problem in thin gauge welding

Magnetostrictive "A" Nickel transducer provides the vibratory energy

A new welding process has caught the ear of the electronics industry: "Sonoweld", developed by Aeroprojects, Inc., West Chester, Pa. By means of high-frequency mechanical vibrations, it produces a metallurgically sound weld – and *without the application of heat.*

Thin gauge forms of metals like copper and aluminum are now being welded ultrasonically without melting and with little deformation. Photo shows "Sonoweld" unit being used to weld aluminum and copper foil conductors in American Machine & Foundry Co.'s wafer transformer project.

To maintain its high power levels, "Sonoweld" relies on a laminated stack transducer made from Electronic Grade "A" Nickel, a rugged magnetostrictive material. In a periodic electro-magnetic field, nickel undergoes alternating length-changes to vibrate at the field's frequency.

This magnetostrictive effect of "A" Nickel is relatively large, and is useful over a wide frequency range. "A" Nickel also has high resistance to fatigue, heat and corrosion, and is easily fabricated.

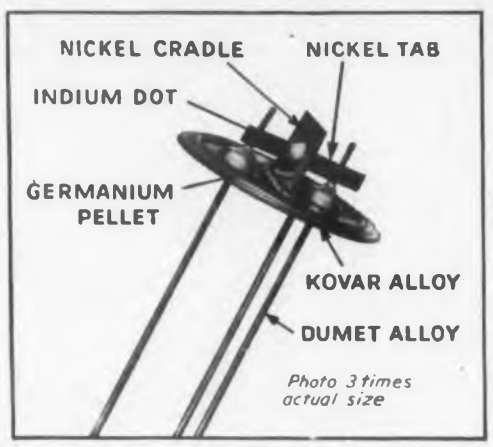
Purity of Inco Nickel helps Raytheon stabilize emission characteristics in magnetron

The vitality of a radar set is centered in its magnetron oscillator. This is why Raytheon chose their RK2J42 fixed-frequency magnetron to pulse their Mariners Pathfinder Radar Model 1500. This tube is designed for long-life operation at 7kw and 1500 pps.

One reason for the tube's top performance is the use of Electronic Grade "A" Nickel in the cathode. This commercially pure, wrought nickel is non-contaminating, and thus helps maintain optimum emission characteristics.

Raytheon engineers also report that it stands up against high ambient temperatures, and has good machinability.

G. E. builds rugged PNP triode for computer use



Even the testing treatment (being shot out of mortars) doesn't harm the 2N123 transistor. G. E. (Syracuse) engineers build it with rugged, 99%+ pure nickel.

Non-contaminating, corrosion resistant Electronic Grade "A" Nickel has the strength to withstand shock and vibration. It also holds its shape at processing temperatures, and forms, welds and solders easily.

For sure glass-to-metal seals, G. E. uses the special purpose alloys Kovar® (29% Ni) and Dumet (42% Ni).

®Trademark, Westinghouse Electric Corp.

Reprints of useful booklet on "Inco Nickel Alloys for Electronic Uses" now available

This booklet describes the compositions and special properties of the various grades and alloys of nickel which are widely used in the industry. It also lists many important electronic applications of the Inco Nickel Alloys. For your copy, fill out the Reader Service Card, or write to The International Nickel Company, Inc., 67 Wall St., New York 5, N.Y.

INCO TRADE MARK — THE INTERNATIONAL NICKEL COMPANY, INC. • 67 Wall Street • New York 5, N. Y. — INCO TRADE MARK

For more information on nickel alloys for electronic uses, send reader service card or write.

CIRCLE 35 ON READER-SERVICE CARD

NEW PRODUCTS

DC Insulation Tester

Has high sensitivity at speeds of 4000 fpm

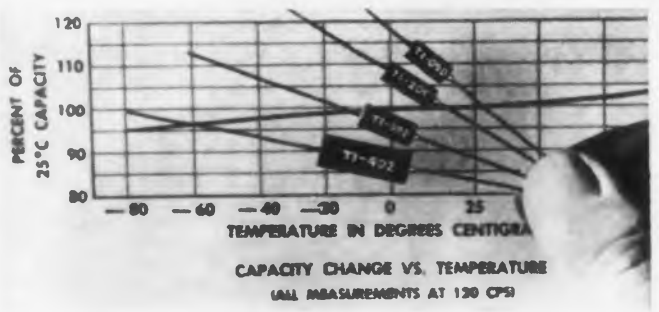
The CVX line of high voltage dc sparkers permits non-destructive fault detection at wire speeds of 4000 fpm. Absence of electrode length saves the floor space in a wire line usually needed for a 36 in. long electrode. The test unit is stated to greatly exceed the limitations of comparable ac testers in respect to speed and sensitivity.

Peschel Electronics, Inc., Dept. ED, Towners, RFD 1, Patterson, N.Y.

CIRCLE 36 ON READER-SERVICE CARD

Electrolytic Capacitors

Solid tantalum types up to 200 μf



These solid tantalum electrolytic capacitors, called Tan-ti-caps, are now available in 18 ratings. Five models are 6 v units ranging from 22 to 200 μf, five are 15 v devices from 10 to 100 μf, five are 15 v capacitors from 5 to 55 μf, and four are 35 v units from 4 to 25 μf. These units are stable within 10 per cent of rating from —80 to +85 C, and ±20 per cent capacity tolerances at 25 C. The case, which is cylindrical and without a protruding lip, measures 0.358 by 0.173 in. for the smallest device and 0.7 by 0.264 in. for the largest.

The capacitors are constructed of a solid pellet of pressed and sintered tantalum powder with an integral wire lead. The dielectric is formed by a tantalum-derived coating deposited electrochemically on the pellet, resulting in a semiconductor-type junction with the solid electrolytic. The pellet is solidly embedded within the case to withstand high and low frequency vibrations and high impact.

Texas Instruments, Inc., Dept. ED, P.O. Box 312, Dallas, Texas.

CIRCLE 37 ON READER-SERVICE CARD

Frequency Converter

Supplies precise frequencies of 45 to 2000 cps

Model FCR100 frequency changer is for use in testing equipment drawing up to 100 va over a range of frequencies between 45 and 2000 cps. Because of its low output distortion, the FCR100 is a good servo supply. An auxiliary input allows an external signal to be applied to its oscillator circuit, permitting the frequency to be set with a precision frequency standard.

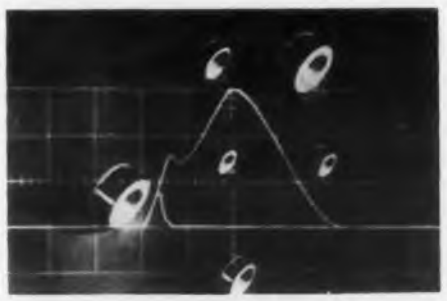
Features include input voltage range of 105-125 v at 45-65 cps; output voltage range of 0-130 v with ±1 per cent regulation for line or load; output frequency regulation of ±1 per cent normally, ±0.01 per cent with a built-in frequency standard or any accuracy obtainable with an external frequency standard. Frequency drift is less than 1 per cent in 24 hours; power factor is unity to 0.7 lagging at 100 va, unity to 0.5 lagging at 50 va, and fully inductive at 25 va; output distortion is 1 per cent for 75-125 v output. The unit has a 0 to 40 C ambient temperature range.

Sorensen & Co., Dept. ED, Richards Ave., South Norwalk, Conn.

CIRCLE 38 ON READER-SERVICE CARD

Bobbin Cores

Feature consistent uniformity



These magnetic bobbin cores are available in either of two materials: 4-79 molybdenum permalloy—a rectangular hysteresis loop material characterized by minimum switching time and medium saturation flux density. The bobbins feature consistent uniformity and are made of high quality ceramic or stainless steel. The cores are supplied protected by Mylar tape or by Nylon caps when it is desirable.

G-L Electronics, Dept. ED, 2921 Admiral Wilson Blvd., Camden 5, N.J.

CIRCLE 39 ON READER-SERVICE CARD

NEW PRODUCTS

Ferrite Isolators

Complete test equipment series

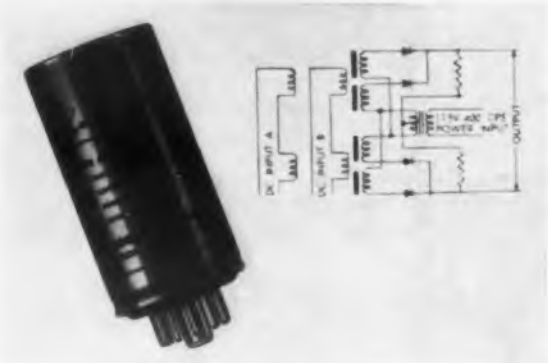
Designed to meet the requirements for test equipment applications, this series of broad band ferrite isolators are available in WR-28, WR-42, WR-62, WR-90, WR-112, WR-137, WR-187, WR-284 waveguide sizes. Frequency ranges extend from 2.6-3.95 to 26.5-40 kmc. Minimum isolation for most models is 30 dc, and average power rating ranges from 5 to 25 w. The isolators provide optimum frequency stability of test equipment and measurements during test, and extend the life of the rf source due to their high isolation.

Airtron, Inc., Dept. ED, 1096 W. Elizabeth Ave., Linden, N.J.

CIRCLE 43 ON READER-SERVICE CARD

Integrating Mag Amp

Takes less than 3 w



Model 430 is a plug-in, hermetically sealed, integrating magnetic amplifier which requires less than 3 w and operates from standard 115 v, 400 cps. Control winding A has a nominal gain of one volt dc output for 100 μa dc input current. Control winding B has a nominal gain of 10 v dc output for 100 μa dc input current. Signal frequency response extends from dc to 25 cps, depending on circuitry. Accuracy of integrators employing the model 430 is better than 2 per cent.

Acromag, Inc., Dept. ED, 22519 Telegraph Rd., Detroit 41, Mich.

CIRCLE 44 ON READER-SERVICE CARD

Solenoid Valve

Very high flow in small unit

Series AG, valves utilize the company's co-axial principle and provide a full ported flow rate that has previously been possible only with valves of twice the dimensions. Pilot operated, the valve functions under pressures in excess of 3000 psi, and requires no pressure differential to operate or remain open. The design inherently provides minimum internal leakage.

Eckel Valve Co., Dept. ED, 1325 First St., San Fernando, Calif.

CIRCLE 46 ON READER-SERVICE CARD

Video Oscillator

Thermistor bridge stabilized

Type 0-22C is a thermistor bridge stabilized LC oscillator covering the frequency band of 10 kc to 10 mc in six ranges. The accuracy of calibration is 1 per cent and the frequency is independent of load impedance. Total harmonic content of the output wave-form is less than 1 per cent. The amplitude remains constant to within $\pm 1/2$ db throughout the frequency range and is independent of variations in supply voltage and range setting. This feature not only avoids the necessity of resetting the reference level, but also provides a means of measuring the load impedance by the reading on the output voltmeter.

The reference level of the oscillator is 1 v peak to peak and a constant resistance attenuator provides a control of output between —50 db and +10 db in steps of 1/2 db. The output impedance is 75 ohm. An additional high level output socket is provided so that the oscillator may be used as a variable frequency source for bridge measurement.

Wayne Kerr Instruments, Dept. ED, P.O. Box 801, Philadelphia 5, Pa.

CIRCLE 47 ON READER-SERVICE CARD

Accelerometer

Plastic deformation of a metal sphere provides peak readings

Series G101 peak reading accelerometer and velocity transducers are inexpensive units, intended to be utilized for the determination of high G peak acceleration and velocities in such applications as drop impact equipment, gun systems, and explosive devices.

The principle of operation involves the degree of plastic deformation of a metal sphere caused by means of a movable piston, acting as a mass in acceleration. The units are small, lightweight, and made with corrosion resistant materials. The available top ranges are 2000 to 50,000 g. Accuracy is ±5 per cent over most of the range.

Avionic Products Eng. Corp., Dept. ED, Route 46, Dover, N.J.

CIRCLE 49 ON READER-SERVICE CARD

Video Translator

Accessory unit with 20 kc to 20 mc range

The VT-132 video translator is an accessory unit which extends the range of the company's uhf-vhf signal generator, SG-132, into the 20 kc to 20 mc region. It can also be used in conjunction with any other sweep generator having outputs in the 50-70 mc band. The instrument provides a 50 ohm output signal which sweeps from 20 kc to 20 mc, or produces narrower sweep width over any portion of this spectrum.

Completely quantitative results are obtainable, since the instrument is so designed as to permit use of the attenuator dial calibration and the crystal frequency markers of the SG-132 while maintaining their calibration accuracy. It is possible to vary the output of the video sweep from —3 db to below —100 db without affecting the output impedance. Flatness of the VT-132 output is better than ±0.15 db total variation, and second harmonics are better than 35 db below the fundamental output.

Van Norman Industries, Inc., Electronics Div., Dept. ED, Manchester, N.H.

CIRCLE 50 ON READER-SERVICE CARD

Use these precision -*hp*- instruments with -*hp*- 430C for greater coverage, convenience

-*hp*- 752 Multi-Hole Couplers—For measuring average power 1 watt to 1 kw (with attenuator) in waveguide systems. Models cover all frequencies 2.6 to 40 KMC. Coupling factors of 3, 10 and 20 db available most bands. Directivity better than 40 db full range; accuracy within ±.7 db full range. Primary guide SWR less than 1.10. $375.00 to $75.00.

-*hp*- 764-767D Dual Directional Couplers—For wide band coax reflectometer and power measurements. Four models cover frequencies 216 to 4000 MC. 20 db attenuation, coupling accuracy 0.5 db, max. primary SWR 1.1 to 1.25; max. secondary SWR 1.2 to 1.5. Minimum directivity (216 to 940 MC) 30 db; 26 db at higher frequencies. 50 watts CW capacity, 10 kw peak. Low insertion loss. $125.00 (any frequency).

-*hp*- 382A Precision Attenuators—For measurements up to 5, 10 and 15 watts, this revolutionary new broad band instrument may be employed. -*hp*- 382A attenuates from 0 to 50 db, full range, independent of frequency. Phase shift constant with attenuation. Accuracy within ±2% of db reading. Models cover frequencies 3.95 to 40.0 KMC, maximum dissipation 5 to 15 watts. SWR less than 1.15. $500.00 to $250.00.

-*hp*- 370 Waveguide Attenuators — Waveguide sections providing fixed amounts of attenuation. Used to extend power range of -*hp*- 430C. Models for frequencies 2.6 to 18.0 KMC, power dissipation 1.0 watts (1 kw peak), SWR 1.15; 3, 6, 10 or 20 db attenuation. $75.00 to $55.00.

-*hp*- 487B Thermistor Mounts—Simplify setups, save time and insure maximum accuracy in waveguide power measurements. Models cover frequencies 3.95 to 26.5 KMC with full range SWR of less than 1.5 (except K487B, 2.5). Permanently installed negative temperature coefficient thermistors. No tuning, large overload factor makes burnout virtually impossible. $95.00 to $75.00.

-*hp*- 485 Detector Mounts

-*hp*- 382A Precision Attenuators

-*hp*- 476A Bolometer Mount

-*hp*- 752 Multi-Hole Couplers

-*hp*- 487B Thermistor Mounts

-*hp*- 477B Coaxial Mount

-*hp*- 477B Coaxial Mount — Thermistor mount providing full frequency coverage 10 MC to 10 KMC with SWR less than 1.5. Requires no tuning, uses long time constant elements for accuracy even on low duty cycle pulses. For use with 430C or other bolometer bridges providing negative temperature coefficient operation at 200 ohms. Requires 13 ma bias. Power range 0.02 to 10 mw. Uses Type N rf connector. $75.00.

-*hp*- 485 Detector Mounts — Single tuning control accurately matches waveguide section to bolometer element; instrument also detects rf energy with crystal substituted for bolometer element. Models for frequencies 2.6 to 18.0 KMC, SWR 1.25 to 1.5. All models employ crystal or barretter except P485 (thermistor only) and S485 (crystal only). $125.00 to $75.00.

-*hp*- 476A Bolometer Mount—Universal bolometer mount requiring no tuning, no adjustment. Frequencies 10 to 1,000 MC, instantaneous, automatic power readings 0.02 to 10 mw. SWR less than 1.15, 20 to 500 MC; less than 1.25, 10 to 1,000 MC. Uses four 1/100 amp fuses. Uses Type N rf connectors. $85.00.

-*hp*- 764/7D Dual Directional Couplers

Prices f.o.b. factory. Data subject to change without notice.

HEWLETT-PACKARD COMPANY

4651K PAGE MILL ROAD • PALO ALTO, CALIFORNIA, U. S. A.

Cable "HEWPACK" • DAvenport 5-4451

FIELD REPRESENTATIVES IN ALL PRINCIPAL AREAS

COMPLETE COVERAGE, HIGHEST QUALITY

CIRCLE 51 ON READER-SERVICE CARD

Permanent Magnet Motors

Increased torque ratings in 1-in. diam

Series B permanent-magnet motors feature increased torque ratings although they measure only slightly over 1-in. diam. Stock models are available in voltages up to 115 vdc. The field structure consists of Alnico V1 cast in the form of a circular ring which completely surrounds the armature. A flat wafer-type commutator is used to reduce overall length. No-load speeds are available in the 3000 to 20,000 rpm range. A speed of 7200 rpm under load is recommended for most applications.

Servo-Tek Products Co., Dept. ED, 1086 Goffle Rd., Hawthorne, N.J.

CIRCLE 52 ON READER-SERVICE CARD

Power Transistor

Covers entire audio range

Since the CTP-1133 power transistor has a cutoff frequency of 20 kc for a 3 db drop in power gain, it has immediate application as a replacement for audio tubes, as well as use in high speed switching devices. The transistor has a total harmonic distortion at 8 w of 3.5 per cent. Other ratings are as follows: collector to base voltage of 40 v max; collector to emitter voltage of 40 v max; emitter to base voltage of 6 v max; and junction temperature of 90 C. The power dissipation at 70 C mounting base temperature is 10 w.

Clevite Corp., Clevite Transistor Products Div., Dept. ED, Waltham 54, Mass.

CIRCLE 53 ON READER-SERVICE CARD

"Is seat of pants Amerikan spacemen is flying by. Is not knowing of Reeves-Hoffman's . . .

NEW HIGH PRECISION CRYSTAL FOR FREQUENCY MEASUREMENT

WRITE FOR BULLETIN RH-5MC.

REEVES-HOFFMAN

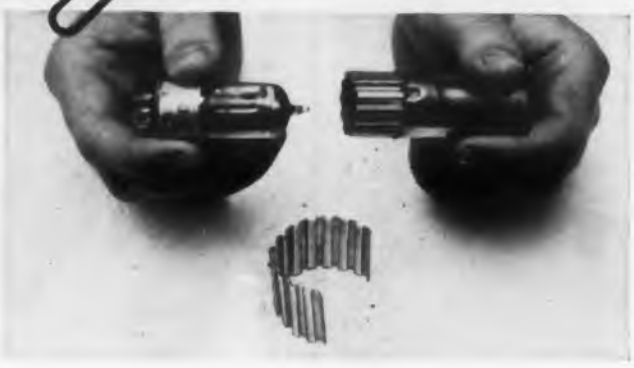
Designed for use as frequency standards, Reeves-Hoffman's new 5mc, high precision crystals offer exceptionally long term frequency stability, ±.0001%, with aging of less than one part per 10^8 a week! These units are available in hermetically sealed glass T5 1/2 enclosures with pigtail leads or 9-pin Bakelite bases. They are manufactured to meet the most exacting military and commercial standards for frequency measurement.

DIVISION OF **DYNAMICS CORPORATION OF AMERICA**
CARLISLE, PENNSYLVANIA

CIRCLE 54 ON READER-SERVICE CARD

for maximum reliability

reduce tube temperatures in **JAN** *shields* **BELOW** *bare bulb temperatures with*



BIRTCHER N.E.L. CORRUGATED INSERTS

MATERIAL
.003 spring brass

FINISH
Matte black to N.E.L. specification

SIZES
6 sizes available to fit all T-5½ (7-pin) and T-6½ (9-pin) miniature tubes.

Write for catalog

N.E.L. reports that 85% of all electronic equipment failures are caused by tube failures and the major cause of tube failure is excessive heat. The use of a Birtcher corrugated insert between miniature tube and JAN shield reduces tube temperatures well below bare bulb temperatures.

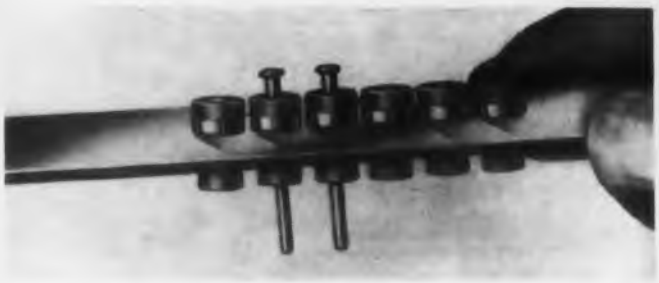
THE BIRTCHER CORPORATION	
INDUSTRIAL DIVISION	4371 Valley Blvd., Los Angeles 32, Calif.

CIRCLE 55 ON READER-SERVICE CARD

NEW PRODUCTS

Capacitors

Hip-mounted feed thru type



Type CFT ceramic feed thru capacitors are useful where compactness is desired. The units are 3/8 in. long, and protrusion from the chassis plane is only 9/64 in. for the larger-diameter end, and less than 15/64 in. for the shank end, depending on chassis thickness. Diameters of the head and shank ends are 7/32 in. and 0.187 in. respectively. A hip ridge holds insertion of the capacitor in the chassis hole to a fixed uniform distance. Type CFT capacitors have a dc working voltage of 600 v, and are available in capacitance values from 4.7 μμf to 1000 μμf. Operating temperature range is −55 to +85 C.

Cornell-Dubilier Electric Corp., Dept. ED, South Plainfield, N.J.

CIRCLE 56 ON READER-SERVICE CARD

Differential Transformer

Miniature sensitive unit

The ceramic bobbin of this 3/8 in. diam coil is wound with Teflon insulated wire and encased in a stainless steel shell. The coil is vacuum impregnated with a silicon varnish. Armature dimensions are 2-9/32 in. long by 0.105 in. od by 0.062 in. id. Range is ±0.25 in. Sensitivity features 0.25 mv output per 0.001 in. displacement per volt input at 60 cps. Null voltage is 0.1 mv. Input is 1.5 v, 60 cps; the output, which doubles for 3 v input, is 77 mv at 0.2 in. armature displacement and 93 mv at 0.25 in. armature displacement.

Automatic Timing & Controls, Inc., Dept. ED, King of Prussia, Pa.

CIRCLE 57 ON READER-SERVICE CARD

STRAITS TIN REPORT

New developments in the production, marketing and uses of tin

MALAYAN TIN BUREAU

A new engine bearing alloy of tin (about 20%) and aluminum was recently perfected after more than 3 years of testing. Of meshed tin-aluminum, in which the tin forms a lacework within the aluminum, the alloy gives a better balance between high fatigue resistance and low rate of wear than any other standard bearing known. It is also cheaper to manufacture than ordinary copper-lead plated types.

★ ★ ★

In his address to the Legislative Council in December, His Majesty the Yang di-Pertuan Agong again stated that the policy of his government will be to assist the tin and rubber industries, upon which the economy of the Federation of Malaya largely depends. "My government realizes it cannot maintain or increase the prosperity of the country unless it renders every assistance possible to both these industries," he said.

A new alloy of tin (13%), aluminum and titanium shows very good high-temperature characteristics. It is now being used in Europe for turbine parts in aircraft engines.

All modern dredges used in Malayan tin mining are now powered by electricity. The equipment for a single dredge may cost close to $170,000.

Ask us to send you TIN NEWS, a monthly letter. It will keep you posted on tin supply, prices, new uses and applications.

The Malayan Tin Bureau
Dept. 13D, 1028 Connecticut Ave., Washington 6, D.C.

CIRCLE 59 ON READER-SERVICE CARD

Water Load

Provides 100 kw continuous μhf dissipation

A 6-1/8 in. diameter 50 ohm coaxial load, rated at 100 kw maximum continuous power dissipation has been developed for μhf application. The vswr is 1.3 or less from 380 to 570 mc and 1.2 or less in the 390 to 525 mc range. Called the 518-A Mega-Sorber, the unit can be supplied to cover other uhf frequency ranges or a particular uhf frequency with optimum vswr. It is designed to handle peak power of two megawatts.

Continental Electronics Mfg. Co., Dept. ED, 4212 S. Buckner Blvd., Dallas 27, Texas.

CIRCLE 60 ON READER-SERVICE CARD

Filters

Minimum of 50 db attenuation

Three models of Twin-T filters are available for any fixed frequency from 15 to 1500 cps. The CO series, shown, have octal plug basing. The C series have banana plugs and jacks, and the CU series are uncased units designed for incorporation into circuit wiring. The filters are offered in two frequency tolerance ranges of 2 per cent and 0.3 per cent. Units of both ranges have a minimum attenuation of 50 db at the specified frequency. The units are constructed from low negative temperature coefficient deposited carbon resistors and low positive coefficient silver mica capacitors.

Custom Electronic Services, Dept. ED, P.O. Box 7504, San Diego 7, Calif.

CIRCLE 61 ON READER-SERVICE CARD

BLADE ANTENNAS by CANOGA

A new series of high performance blade antennas has been developed for high speed aircraft and missile applications which provide the following features:

All metal leading edge for maximum strength and erosion resistance

High aspect ratio with straight or swept back leading edge

Simple installation, no space required inside airframe

Circular radiation pattern, small ground plane

High temperature resistance

Broad band design

APPLICATIONS

- COMMUNICATION
- NAVIGATION
- TELEMETERING
- BEACON
- DATA LINK
- COMMAND CONTROL

TECHNICAL SPECIFICATIONS

Model No.	Center Freq. Mc.	Band width Percent	VSWR Max.	Dimensions	
				Length inches	Height inches
9928	5600	20	1.5	0.76	0.375
9933	3400	35	1.5	1.30	0.75
9927	3000	25	1.5	1.30	0.75
9934	2200	20	1.5	1.75	1.00
9926	1100	27	2.0	3.55	1.70
9925	310	55	2.0	15.00	7.00

Other blade antennas are also available for special applications.

FOR ADDITIONAL INFORMATION COMPLETE THE COUPON BELOW AND RETURN TO CANOGA.

CANOGA
CORPORATION
OF CALIFORNIA
5955 SEPULVEDA BLVD
VAN NUYS, CALIFORNIA

☐ *ANTENNAS*
☐ *RECEIVERS*
☐ *RADAR SYSTEMS*
☐ *TEST EQUIPMENT*
☐ *MICROWAVE COMPONENTS*

NAME AND TITLE _____
COMPANY _____
ADDRESS _____
CITY _____ STATE _____

DESIGN, DEVELOPMENT AND MANUFACTURE TO YOUR SPECIFICATIONS

CIRCLE 64 ON READER-SERVICE CARD

NEW PRODUCTS

Signal Generator

Tests video transmission facilities

This video transmission test signal generator is designed to produce precise signals for the testing of all long lines transmission facilities. Multiburst, stairstep and window waveforms are generated, along with standard Retma synchronizing waveform. Model 1006-A consists of three Model 1005-A-1 video transmission test signal units, and one Model 1005-A-2 Retma Synchronizing waveform unit.

Telechrome Mfg. Corp., Dept. ED, 28 Ranick Dr., Amityville, N.Y.

CIRCLE 65 ON READER-SERVICE CARD

Microwave Sweep Oscillator

Provides convenient microwave power

Model 2701 sweep power supply is a voltage tuned oscillator that allows evaluation of microwave devices with convenience and speed. Sweep is adjustable from a fixed frequency to the full tuning range of the backward wave oscillator tube, which is housed in a detachable r-f head. The oscillator now available, model 2701X, covers the frequency range 8.2 to 12.4 kmc.

Features include good isolation from load variations, high signal-to-noise ratio, and operation with amplitude or pulse modulation. Triggering is recurrent and may be external or manual. Sweep rates are from 30 v per sec to 30 v per msec. The time for a full band sweep is 0.01 to 30 sec with a sweep output of 20 v. A 1-kc square wave internal modulation is supplied together with provision for external modulation.

Maxson Instruments Corp., Sub. of the W. L. Maxson Corp., Dept. ED, 47-37 Austell Pl., Long Island City 1, N.Y.

CIRCLE 66 ON READER-SERVICE CARD

Power Supply

32-v unit offers regulation of 0.03 per cent

Model SC-32-0.5 transistorized power supply delivers 0.32 v at 0.-0.5 amp. Regulation for line or load is less than 0.03 per cent or 0.003 v, whichever is greater. Ripple is less than 3 mv rms. Recovery time is less than 50 μsec. Stability for eight hours is less than 0.03 per cent or 0.003 v, whichever is greater. Output impedance is less than 0.02 ohms. Additional features include a 0.005 per cent resolution with 10 turn voltage control.

Kepco Labs., Inc., Dept. ED, 131-38 Sanford Ave., Flushing 55, N.Y.

CIRCLE 69 ON READER-SERVICE CARD

Parabolic Antenna Calculator

Conversion rule for microwave systems

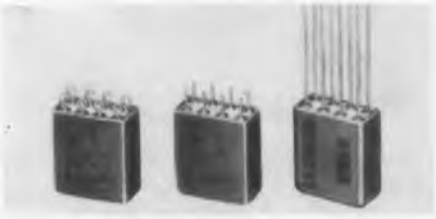
A slide-rule type of calculator is available for rapid computation of parabolic antenna radiation characteristics, passive repeater performance, free space and scatter propagation attenuation, and thermal and equivalent noise input of receiver. The reverse side of the calculator is a transmission line and waveguide selector showing attenuation and power ratings as well as other characteristics.

Andrew Corp., Dept. ED, 363 E. 75th St., Chicago 19, Ill.

CIRCLE 70 ON READER-SERVICE CARD

Relay

Miniature type with fast response



Type F relay is rated for ambient temperatures from −65 to +125 C, shock of 50 g, and vibration of 75-2000 cps at 20 g acceleration. Pickup time is 3.5 msec nominal; drop-out time is 1.5 msec nominal. Contact rating is 3 amp resistive at 28 v dc or 115 v ac. Terminal arrangements are suited to 1/10 in. grid spacing.

C. P. Calre & Co., Dept. ED, 4101 Pratt Blvd., Chicago 45, Ill.

CIRCLE 71 ON READER-SERVICE CARD

Pencil-thin slides increase valuable chassis space

CHASSIS-TRAK slides, with a new design improvement which increases the bearing area, are stronger and more rigid . . . yet as thin as a pencil (.250")!

This ultra-thin design allows up to 3" more in important chassis space and makes your electronic equipment more accessible with smoother sliding action—even on heavy-duty chassis.

Because of the thin design, you can fit a standard 17" chassis into a standard 19" panel rack. Thus you can cut engineering costs in half by using standard stock racks and chassis.

Slides are available in eight different lengths on both the "Detent," which locks in 7 positions (45°, 90° and 105° up, down, and horizontal), and the "Basic," which tilts upward but has no tilt-lock assembly.

Before making a slide selection, consider the advantages of the CHASSIS-TRAK *ultra-thin* design.

"Detent" model, locked in one of seven positions.

chassis Trak inc.

Write today for complete specifications and prices.

525 South Webster, Indianapolis 19, Indiana

CIRCLE 72 ON READER-SERVICE CARD

NEW PRODUCTS

Compression Seals

Glass extends beyond metal

These Hi-Dome compression seals permit the fused glass to extend beyond the metallic configuration without cracking or shearing. The dielectric properties of the increased glass mass in these seals provide higher electrical surface resistance and higher arc-over values. The glass-to-metal compression seals are expected to permit further miniaturization of components through closer terminal connections.

Hermetic Seal Corp., Dept. ED, 29 S. 6 St., Newark 7, N.J.

CIRCLE 75 ON READER-SERVICE CARD

Potentiometers

Provide long load life

All 8 standard resistance values (100 to 25,000 ohms) of these potentiometers are manufactured with 20 ppm resistance wire. The units can dissipate more than 1/2 w at 125 C for more than 2000 hr. Two basic 7/8 in. diam models, types 118F (bronze bearings) and 118H (ball bearings) are available as stock items. Both models feature linearities to ± 0.25 per cent for all resistance values, up to 9 taps to ± 0.5 deg, and precision machined metal housings.

Carter Mfg. Corp., Dept. ED, 23 Washington St., Hudson, Mass.

CIRCLE 76 ON READER-SERVICE CARD

COIL FORMS.—Ceramic types in five sizes available with or without terminal collars, and up to four terminals per collar. An internal, preset torque spring positions and locks the adjusting cores.

National Company, Inc., Dept. ED, Malden 48, Mass.

CIRCLE 79 ON READER-SERVICE CARD

TRANSFORMERS.—Used with transistor power supplies, types 685-745 operate on 12-14 v dc input with output from 250-600 v dc. The units provide 80 to 85 per cent efficiency in the 2000 cps region.

Triad Transformer Corp., Dept. ED, 4055 Redwood Ave., Venice, Calif.

CIRCLE 80 ON READER-SERVICE CARD

DOOR PANELS.—Side-hinged blank types, all 19 in. wide in different heights from 3½ to 21 in. The panels are constructed of no. 12 gage steel, and are hinged on either side.

Premier Metal Products Co, Dept. ED, 337 Manida St., New York 59, N. Y.

CIRCLE 81 ON READER-SERVICE CARD

HIGH VOLTAGE REGULATORS.—For voltages from 3500 to 6000 v, series GV6C corona type regulators are designed to supplement the GV5C series previously announced.

The Victoreen Instrument Co., Components Div., Dept. ED, 5806 Hough Ave., Cleveland 3, Ohio.

CIRCLE 82 ON READER-SERVICE CARD

TUBES.—Two tubes have been announced. The 7029 multiplier phototube is a small, dormer-window type for detection of low-level light signals in the presence of relatively high background illumination. Spectral response is from 2900 to 6200 A. The 7094 high-perveance beam power tube is designed for use at r-f power amplifier, oscillator, a-f power amplifier, modulator. The 7094 can be operated with 500 w input in cw applications at frequencies to 60 mc.

Radio Corp. of America, Tube Div., Dept. ED, Harrison, N. J.

CIRCLE 472 ON READER-SERVICE CARD

FLASHER UNIT.—A hermetically sealed unit operating at a nominal frequency of 100 cps with a 1 to 1 ratio of on to off time. Normal contact capacity is 1.5 amp inductive.

Radar Relay, Inc., Dept. ED, 2120 Pontius St., Los Angeles 25, Calif.

CIRCLE 83 ON READER-SERVICE CARD

GEARS AND SERVO COUPLING.—Two products have been announced: the first is a line of precision 2c gears in stock quantities, and the second is a zero adjustable bellows coupling allowing precision adjustment on the shafts of servo motors, resolvers and synchros.

PIC Design Corp., Dept. ED, 477 Atlantic Ave., E. Rockaway, N.Y.

CIRCLE 84 ON READER-SERVICE CARD

CERTIFIED TO LATEST MIL-R-94B 19A SPECS

Newly Developed CTS Military Variable Resistors

Complete line composition and wirewound military variable resistors now in production. Dependable, exceptionally good delivery cycle. Tested and certified to meet latest specs of MIL-R-94B characteristics X and Y, and MIL-R-19A.

Composition controls Styles RV2 (1 watt), RV4 (2 watts) and RV5 (1/2 watt miniaturized) meet latest MIL-R-94B specs. Wirewound controls Styles RA20 (2 watts) and RA30 (4 watts) meet latest MIL-R-19A specs. All are available in a variety of shafts, bushings and resistances. All except Type 65 are available in 2 or 3 section concentric shaft and straight shaft tandem constructions.

Founded 1896

CHICAGO TELEPHONE SUPPLY Corporation

ELKHART INDIANA

Specialists in Precision Mass Production of Variable & Fixed Resistors

CIRCLE 129 ON READER-SERVICE CARD

What is the TOTAL COST of a *plastic part?*

First costs often are only part of the total cost of plastic components. Poorly designed or inaccurately produced plastic parts can mean excessive inspection and assembly costs in your plant and a high failure rate, as well. American's *precision production* saves you money by eliminating these hidden cost factors and thus keeping your *total cost* per part to the barest minimum. That is why so many exacting buyers say, "We turn to American *first* for our plastic parts—because they are precision made."

American Plastics is equipped to give you full line service—injection, compression, extrusion, multiple-shot injection, and low pressure vacuum assisted forming.

Next time you need plastic parts, try American *first*. Others have for over 50 years! Write or wire Dept. ED.

AMERICAN PLASTICS CORPORATION

Subsidiary of Hayden Chemical Corporation
Executive Offices at 342 Madison Avenue
New York N. Y.

CIRCLE 85 ON READER-SERVICE CARD

REGULATED DC POWER SUPPLIES

HI-VOLTAGE SERIES

Designed for powering airborne electronics equipment under the most adverse environmental conditions, Arnoux High Voltage DC Power Supplies assure the utmost in reliability. These magnetic-amplifier regulated supplies are available in the range of 108 to 450 volts DC, with current ratings from 50 ma to 800 ma. Other ratings are also available on special order.

Model 250 S 025

ARNOUX

Input Power: 115 volts, 400 cps

Regulation:	Input (Variation)	Output (% Rated)
Line Voltage:	± 10%	± 0.25
Line Frequency:	± 20 cps	± 0.1
Load Current:	20-100%	± 0.1
	0-100%	± 0.2

Ripple: Less than 0.05% rms at full load

Output Adjustment: 5% adjustment available on request at slightly higher price.

Environmental: Meets specification MIL-E 5272A for acceleration, vibration, altitude, humidity and temperature operating at 20% to 100% rated load.
Also meets MIL-I 6181 B

Connector: AN-type connector

Mounting: Stud-mounted

(Write for Bulletin 200)

LO-VOLTAGE SERIES

Intended for use in precision airborne instrumentation systems, Arnoux Low-Voltage DC Power Supplies are available in both single and dual output. Ranging from 5 to 50 volts at currents up to 10 amperes, these rugged units are hermetically sealed.

Model 5 S 10

ARNOUX

Input Power: 115 volts, 400 cps

Regulation:	Input (Variation)	Output (% Rated)
Line Voltage:	± 15 volts	± 0.10
Line Frequency:	± 20 cps	± 0.15
Output Load:	20-100%	± 0.05
	0-100%	± 0.10

Temperature Stability: 0.5% per 100°F. (— 60°F. to + 160°F.)

Ripple: Less than 0.1% rms at full load.

Output Adjustment: Screwdriver adjustment provides ± 0.5 volt change. Wider range of adjustment available on request

Connector: Standard AN-type connector, or hermetically sealed header on request

Mounting: Stud-mounted.

Environmental: Meets specification MIL-E 5272A for acceleration, vibration, altitude, temperature and humidity.

(Write for Bulletin 100)

Designers and Manufacturers of

PRECISION INSTRUMENTATION

ARNOUX

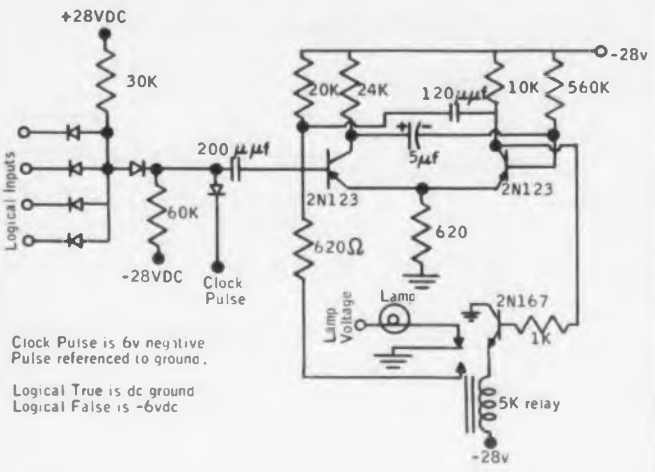
ARNOUX CORPORATION

11924 WEST WASHINGTON BLVD. • LOS ANGELES 66, CALIFORNIA

CIRCLE 86 ON READER-SERVICE CARD

IDEAS FOR DESIGN

Digital Signal Checker



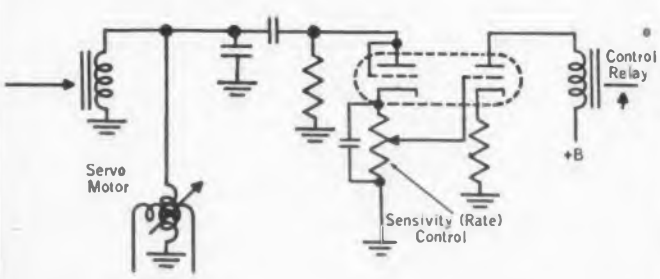
In designing digital computer logical circuits, transient type signals are difficult to check with conventional oscilloscope methods. A special indicator to detect a transient signal should save time in checking new computer circuits.

A special gated transistorized one-shot multivibrator was designed which would light an incandescent bulb for about 2 seconds whenever the logical inputs are true. Four inputs to the gate are shown in the schematic although more could be added by adding more diodes. When all the inputs are true, the clock pulse is impressed across the input condenser which triggers the left transistor into conduction. The right transistor is then cut off and the light goes on. With the components shown, the light will stay on for about 2 seconds before the one-shot multivibrator is reset.

Louis Kurkijian, Sub-Group Head, Hughes Aircraft Co., Los Angeles, Calif.

Servo Null Detector

The circuit shown here was developed in order to provide a means for indicating a null or balance condition in a servo system, and to provide automatic data print commands and tape punch when this balance occurs, or when a prescribed rate of change is exceeded. This arrangement is applicable in analog computers, data processing machines, and servo-type chart recorders for con-

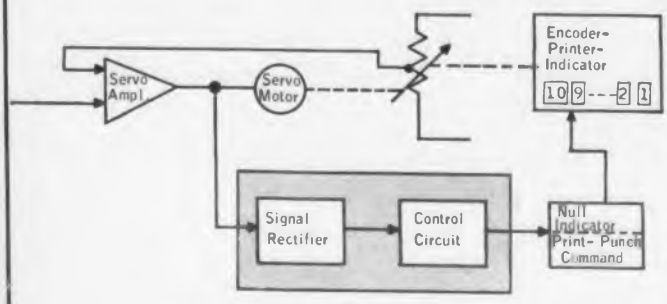


Null Detector and "Print-Punch Command" Control Circuit.

trolling various functions and operations.

A part of the servo output voltage, which energizes the servo drive motor, is rectified and applied as a grid control voltage to a stage which activates a relay, light, alarm or auxiliary control circuits. A single duo-triode performs both the rectifying and relay control functions shown.

Joseph A. Siderman, U.S. Army Signal Engineering Labs., Ft. Monmouth, N.J.



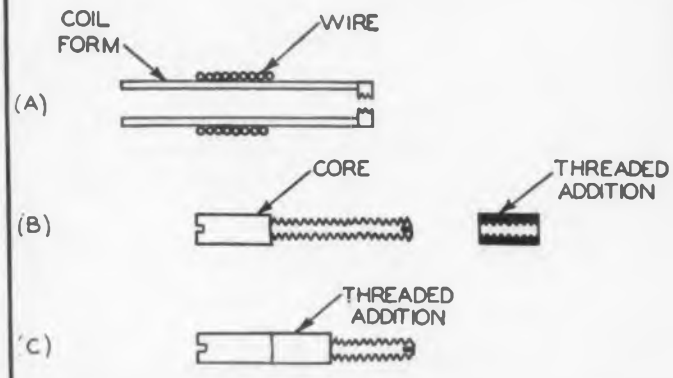
Servo System block diagram showing introduction of Null Detector and Control Circuit.

A Variable Inductor

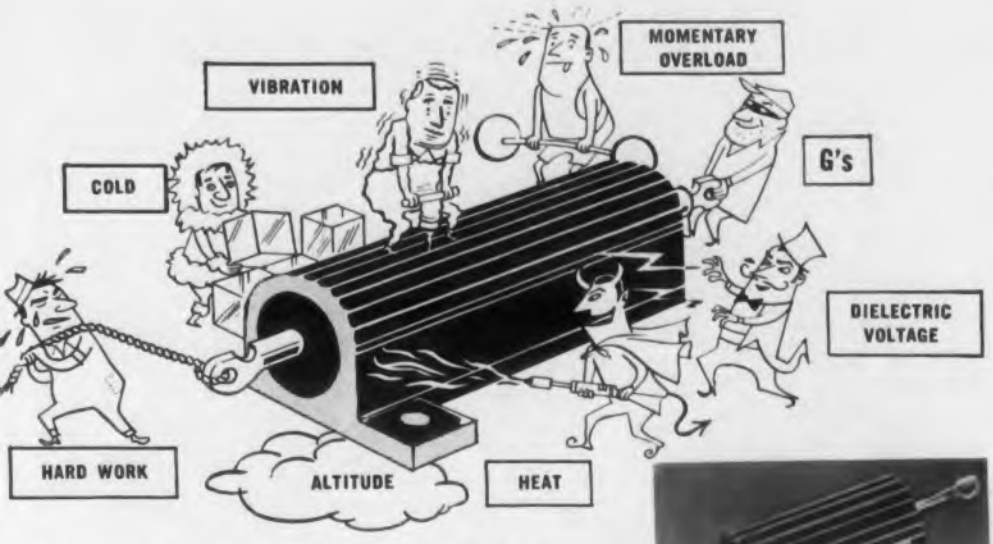
The range of a variable inductor is increased by adding a threaded piece (see fig.) to the existing core of the coil form. If the existing form has a powdered iron or ferrite slug (whose presence increases the inductance of an air core coil) then the threaded additional piece should be made of a good conducting material such as copper, brass, or aluminum. The addition of the extra piece would extend the low inductance end of the variable coil. If, however, the core is made of a good conducting material then the additional piece should be made of a ferrite type material. In this case, the additional piece will extend the high inductance end of the inductor.

This piece is attached by merely removing the original core from the coil form and screwing the threaded piece onto the core as shown at *C*. If the additional piece is given an extra half turn after it is threaded on, it will not come loose.

H. Roberts, New York University, N.Y., N.Y.



Mechanical Construction required to extend the range of a variable inductor. The coil form with tuning slug removed is shown at *A*. At *B* is the core with threaded "addition." At *C* is the modified core.



SAGE pioneered the metal-clad, chassis-mounted resistor. Truly miniature for the job it does, the Type "M" is establishing a reputation for dependable, trouble-free performance—a tribute to SAGE engineering skill and manufacturing "know-how."

We invite your inquiry regarding heat-sink applications . . . Write for complete specifications.

NEW SAGE "Silicohm"
TYPE "M", METAL-CLAD
RESISTORS
Available in 25 and 50 watts up to 60,000 ohms. Meet MIL-R-18546 requirements.

SAGE ELECTRONICS CORPORATION
309 North Goodman St., Rochester 7, N. Y.

CIRCL 89 ON READER-SERVICE CARD

Victoreen Company has ordered over 100,000 New Phaostron **PRESTIGE** *Panel Meters to be used in their equipment in 1958.*

NEW PHAOSTRON
PRESTIGE
PANEL METERS

MODERN DESIGN
NEW RINGCOR MOVEMENT
SHALLOW MOUNT
HIGH VISIBILITY
PROVEN PRODUCTS CONSTRUCTION

Available in:
2½" Round · 3½" Round · 2½" Rectangular
3½" Rectangular · 4½" Rectangular

The new Phaostron Prestige Panel Meters provide shielding from magnetic fields. Simplified Ringcor Movement and structural improvement insures consistent accuracy, long life. Precision cast elements for increased mechanical stability. Prestige meters have shock mounted jewels, ground and polished pivots. Meters can be mounted on magnetic or non-magnetic panels without recalibration. Colors are available in your choice of combinations for scale and case.

FEATURES:
Colors: Metallic or pastel. **Permanent Accuracy:** Within 2% D.C. or 3% rectified A.C. Insulated Zero Adjustment. **Large Clear Scales:** For easy reading. **Longer Scales:** For close tolerance reading. **Jewels:** Shock mounted. **Pivots:** Ground and polished. **Movement:** Ringcor self-shielded.

PHAOSTRON Instrument & Electronic Co.
151 Pasadena Avenue, South Pasadena, California

PHAOSTRON

CIRCLE 90 ON READER-SERVICE CARD

CIRCLE 91 ON READER-SERVICE CARD

...new insulator plastics hold strength at 500°F

High heat resistance and high insulation resistance are now added to the superior electrical and structural properties of Diallyl Phthalate materials.

DIALL FS-4 and FS-5 behave like Silicones at 500°F, showing excellent compressive, tensile and flexural strength. DIALL can be molded like conventional general-purpose materials.

Two types of compounds are available: FS-4, long-fiber, glass-filled; and FS-5, short-fiber, glass-filled. Both are meeting applicable Mil. Specs. Proof of military approval furnished on request.

Write for complete data in Bulletin FS.

MESA PLASTICS COMPANY
11751 Mississippi Ave., Los Angeles 25, Calif.

DIALL

CIRCLE 92 ON READER-SERVICE CARD

NEW LITERATURE

Precision Potentiometer 93

Complete mechanical and electrical specifications, three-view drawings of servo and bushing mount models, power input chart, and environmental characteristics, are included in Data Sheet 54-99. Outstanding features of the miniature pot include −55 to +150 C temperature range, resistance range of 500 to 70,000 ohms, with a linearity tolerance of ±0.5 per cent, and best practical linearity of ±0.25 per cent. Beckman-Helipot Corp., Newport Beach, Calif.

PC Laminates 94

The six most widely used grades of metal-clad laminates for printed circuitry used are described in a 6-page folder. Fully illustrated, it contains detailed tables giving strengths, properties, and dimensions of the various metal-clad laminates. Synthane Corp., Oaks, Pa.

Dials, Panels, Nameplates 95

This 6-page folder lists data for guidance in specification of dials, panels, and nameplates. The opening section gives information on various marking techniques available, including screening, photo marking, lithography, engraving, and etching. United States Radium Corp., Morristown, N.J.

Millisecond Operations Recorder 96

Catalog 30A1400 describes a millisecond operations recorder (MOR) for continuous automatic logging of power station operations at a cost 1/3 less than previous methods. Fischer & Porter Co., 488 Jacksonville Rd., Hatboro, Pa.

Nuclear Amplifiers 97

A 4-page bulletin available covers the N-300 series of nuclear amplifiers manufactured for use in the fields of radiation monitoring, scintillation spectroscopy, and proportional counter analysis. Discussing the units in the amplifier line, the bulletin lists specifications for the various models. Hamner Electronics Co., Inc., P.O. Box 531, Princeton, N. J.

Data Logger 98

Series 1200 data logger features "building-block" construction and flexible pinboard programming. Complete information is included in the catalog. Fischer & Porter, 464 Jacksonville Rd., Hatboro, Pa.

Electronic Equipment 101

A 2-page sheet shows a phase meter, a null meter, impedance comparators, precision power oscillators, an automatic hi-pot tester, a frequency standard, a multiplier, a phase shifter, and a null detector. Each unit is described with specifications and a picture. Industrial Test Equipment Co., 55 E. 11th St., New York 3, N. Y.

Electric Impulse Counters 102

Two 4-page folders tell how to use electric impulse counters in electronic circuits. Bulletin E-13 explains their use with transistors, and Bulletin E-28 their use with electronic tubes. In both folders wiring diagrams help describe several set-ups. Landis & Gyr, Inc., 45 W. 45th St., New York 36, N. Y.

Coil Winding Machines 103

A 2-page catalog sheet illustrating and giving condensed descriptions of coil winding machines has been announced. The machines include three bobbin winders, a 12 in. precision space winder, a multiple fly-back winder, a hand winder, and an automatic variable pitch progressive universal winder. Geo. Stevens Mfg. Co., Inc., Pulaski Road at Peterson, Chicago 30, Ill.

Shielded Measurements 104

Data Sheet 131 describes a portable shielded measuring chamber for testing delicate instruments under simulated pressure, vacuum, altitude, or nonpressurized conditions. The two pages include a drawing and a table of specifications. Perfection Mica Co., Magnetic Div., 1322 N. Elston Ave., Chicago 22, Ill.

Connectors 105

Manual C4 contains 44 illustrated pages on procedures for assembling AN, miniature AN, power, audio microphone, and RF connectors. Wire preparation and soldering techniques are illustrated and discussed. Amphenol Electronics Corp., 1830 S. 54th Ave., Chicago 50, Ill.

Programmed Centrifuge 106

A 14-page brochure describes a programmed centrifuge, both as a whole and unit by unit. Electrical, physical, and performance characteristics are among the detailed specifications presented. The booklet also gives typical test run data on the device, which was originally designed to simulate rocket flights. Dimensional diagrams, graphs, and photographs illustrate the booklet. The Magnavox Co., Ft. Wayne 4, Ind.

Resistor, Pot Data File

Engineers are offered a detailed technical data file on precision potentiometers and resistors. The file combines general information with sheets on individual products. The capabilities of each product are outlined along with electrical and mechanical specifications and other data. The complete set comes in a file-type folder. *Qualified engineers who want the file should write on company letterhead to Clarostat Mfg. Co., Inc., Dept. ED, Dover, N. H.*

Electronic Hardware 107

Catalog 600 fully describes a line of electrical and electronic components. The 75-page booklet presents detailed specifications and actual size illustrations. Products listed include solder terminals, terminal boards, hardware, insulated terminals, coil forms, shielded coil forms, coils, and capacitors. Cambridge Thermionic Corp., 445 Concord Ave., Cambridge 38, Mass.

Electronic Connector 108

A periodical has been initiated to announce recent product developments and designs in electronic connectors and components. Called "Electronic Connector", the bulletin will be issued quarterly. The first issue discusses coaxial, triaxial, and printed circuit connectors. H. H. Buggie, Inc., Box 817, Toledo 1, Ohio.

Small Lamp Sockets 109

Catalog S-557 contains 28 pages on sockets for small lamps used in electrical and electronic products. It gives technical descriptions and actual-size illustrations for each group of sockets. Solderless terminals, specialty items, and military specification equivalents are also covered. Leecraft Mfg. Co., Inc., 58-60 Greene St., New York 12, N. Y.

NEW LITERATURE

Speed Control Drives 112

Packaged drives for equipment requiring adjustable speed or speed synchronization are described in an 8-page bulletin No. 20,000. The bulletin explains the basic circuit, and the many modifications available including speed regulation, constant-potential dc supply, dynamic braking, and acceleration control. Major components are pictured and described. G. M. Basford Co., 422 Leader Bldg., Cleveland 14, Ohio.

Power Resistor Decade 113

Details of a power resistor decade box, providing a power resistor of any value from 1 ohm to 999,999 ohms, are presented in this four-page bulletin. Clarostat Mfg. Co., Inc., Dover, N.H.

High Torque Actuator Motor 114

A new high torque motor featuring split-second starting and stopping with starting torque equal to running torque is described in a detailed engineering Bulletin. The motor operates at temperatures up to 500 deg F at 60 or 400 cycles ac as well as pulsating dc. Viking Tool & Machine Corp., 20 Main St., Belleville 9, N. J.

Connectors 120

How to select a connector is concisely described in a 40-page Plug Guide. A check-list for selecting the proper connector includes important consideration such as size, number and style of contacts, and mounting space. It also shows photographs of representative connectors, and gives basic information on application. Cannon Electric Co., 3208 Humboldt St., Los Angeles 31, Calif.

Electronic Chemicals

A 28-page technical bulletin covers the use of electronic chemicals. The booklet takes up such chemicals as oxide cleaners, cements, resin sprays, varnishes, and others. A brief description of each product in the line is given, then the technical specifications and other information is presented. The booklet entitled "Electronic Chemicals", is available at a list price of $1.00. *For further information write directly to General Cement Mfg. Co., Div. Textron Inc., Dept. ED, 400 S. Wyman St., Rockford, Ill.*

Ceramic Parts 121

A booklet, "Precision Ceramic Parts for Industry," stresses the increasing demands of the electronics industry for precision parts capable of withstanding extreme heat and vibration. The 4-page booklet describes various factors involved in the fabrication of precision ceramic parts and vacuum-tight ceramic-to-metal composites. Sylvania Electric Products Inc., Parts Div., Warren, Pa.

Thermostat Wells 122

Complete specifications on wells for thermostat applications in fluids, gases, or high pressure environments are included in this catalog. The 2-page, 2-color catalog describes copper and stainless steel designs suitable both for immersion and surface mounting. Each of the seven designs listed has complete dimensions, and operating specifications. Fenwal Inc., Pleasant St., Ashland, Mass.

Nuclear Instruments 123

A 23-page catalog, No. 58, describes over 40 different instruments including such items as single and multi-channel pulse height analyzers, scalers, pulse generators, and timers. Technical descriptions, complete specifications, and photos of the instruments are included. Tullamore Electronics Lab., 6055 S. Ashland Ave., Chicago 36, Ill.

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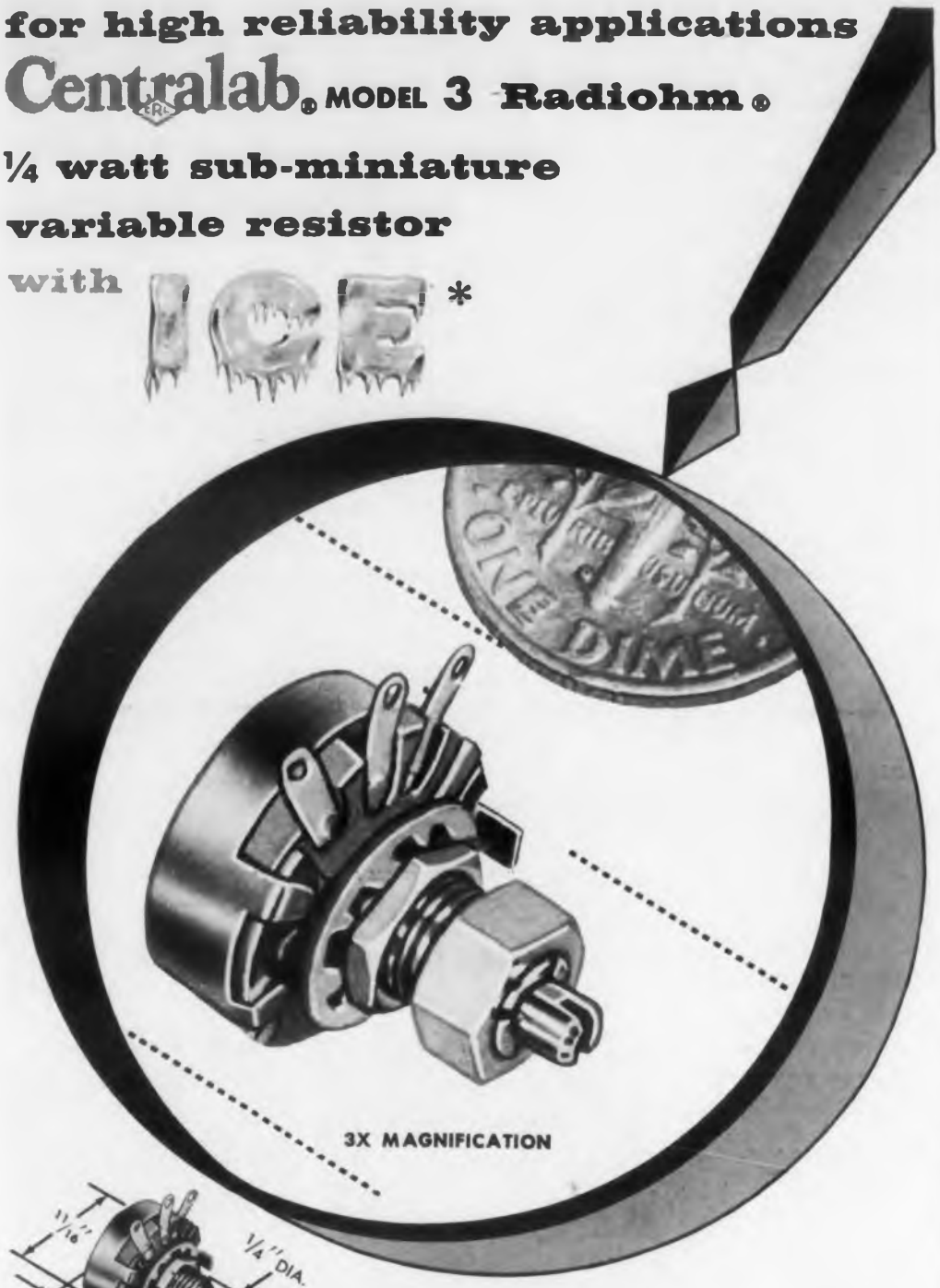
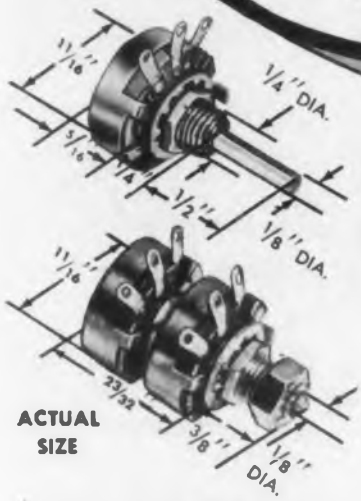
Centralab® MODEL 3 Radiohm®

¼ watt sub-miniature variable resistor

with ICE*





ACTUAL SIZE

Your local Centralab distributor carries a wide variety of these units in stock. Ask him for Model JP and JL controls—as listed in Catalog 30.

The Model 3 utilizes Centralab's ICE* (Interfused Composition Element) to provide exceptional heat dissipation and electrical stability under the most severe operating conditions. It is recommended for high temperature operation in both military and commercial equipment.

- Will meet MIL-R-94B resistance change requirements under *twice* its rated load.
- Meets or exceeds MIL-R-94B requirements for moisture resistance, insulation resistance, thermal cycling, etc.
- Completely enclosed case can be sealed or potted.
- Resistance range: 200 ohms to 2.5 megohms, linear taper and 5000 ohms to 2.5 megohms 10% log audio taper.

Write for Technical Bulletin EP-63 containing detailed specifications or contact your Centralab representative.

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VARIABLE RESISTORS • PACKAGED ELECTRONIC CIRCUITS • ELECTRONIC SWITCHES
CERAMIC CAPACITORS • ENGINEERED CERAMICS • SEMI-CONDUCTOR PRODUCTS

CIRCLE 127 ON READER-SERVICE CARD

ABSTRACT

The X-band pill box feed for the Radio Telescope at Pulkovo.

Electronics in the USSR

Impressions of Four Touring U.S. Engineers

Four U.S. engineers were invited to the USSR to attend a radio engineers' convention last year. They were permitted to visit a number of electronic plants and laboratories in Moscow and Leningrad. Among the sites visited were a radio transmitting complex called Radio Town, the Moscow Physics Institute, a television broadcasting station, a tube and transistor plant, a television research institute, and a radio astronomy station. The observations made during their visit were reported in the January, 1958 issue of *Signal* Magazine. Some of the highlights of their report are presented here.

Radio Astronomy Station at Pulkovo

About 10 miles south of Leningrad exists the most uniquely constructed radio telescope observed. Use was made of a subterfuge to construct a telescope having a focal length of 50 meters and a physical aperture of 75 meters utilizing a section of a paraboloid. The paraboloid section is a horizontal slice that is formed by a row of flat mirrors, each mirror being adjusted in tilt to correspond to the theoretical paraboloid contour.

Plans are underway to conduct investigations at 3, 9, and 10 centimeters. For this purpose, it was shown by actual measurements that there is a resolution of 1-1/2 minutes of arc. One particular recording shows a track of a sunspot moving across the sun over a period of several days with only a portion of the mirrors used. The feed of this particular parabolic section consisted of a pillbox having an aperture of about four feet and excited in the TE mode. The installation utilized normal tubes and Soviet crystals, a bandwidth of 20 mc at an intermediate frequency of 60 mc, from which a noise figure of 13 db had been obtained.

Radio Town

A radio transmitting complex with point to point hf broadcast transmitters, Radio Town is a series of large buildings located just outside Moscow. One building contained 19 radio transmitters ranging from 15 kw to 100 kw output at frequencies up to 27 mc; forty antennas, primarily of the rhombic type; and a switching system capable of connecting transmitters in pairs or singly to any one of the forty antennas.

A second building and an adjacent annex housed six 60 kw broadcast transmitters with hf frequency ranges up to 27 mc and six arrays of half-wave dipoles, 8 x 4, 6 x 4, and 4 x 4 in width and height for operation at various frequencies. Any transmitter or pair of transmitters could be connected to the antennas at a master control board.

Television Research Institute at Leningrad

The Institute employs a staff of 3000. The work done here is described as advanced development rather than research. The Russians were engaged in building elaborate studio equipment for NTSC-type color television modified for the Russian frequency allocation. They were planning to locate the color subcarrier at 4.43 mc using double sideband transmission with sidebands extending 1.5 mc. The sound carrier is located 6.25 mc from the picture carrier.

Television Broadcasting Station in Moscow

Moscow has two channels each 8 mc wide. The antennas are of the batwing type one with three stacks and the other with four. One channel is used for regular broadcasts made from four to five hours daily while the other is used for special events and news broadcasts.

The stations are located in a group of buildings which was not originally built for their present function. However, it appeared that plans were in effect to build television facilities somewhat similar to our television cities in Hollywood.

One of the transmitters is a rebuilt RCA product purchased by the Russians in 1930 and having an output of 12-1/2 kw. The other is Russian built having a 7-1/2 kw output. The cameras used were either image iconoscopes or image orthicons.

Reportedly, only one coaxial link exists in Russia, 150 kilometers in length, but the Russians stated that they planned to install 60,000 kilometers of wide-band microwave circuits by 1960.

Moscow Physics Institute

Fundamental research work on the properties of solid state devices, propagation, and electron discharge phenomena is conducted at the Moscow Physics Institute. Investigations were being carried out on the characteristics of p-n junctions, checking Shockley's theory, and on the characteristics of platinum-ruthenium and platinum-rhodium welded point contact diodes, for which noise figures of about 1.5 to 3 have been obtained on X-band. Russian engineers had concluded that a positive bias gave somewhat lower noise figures.

A molecular resonance generator was shown of the Townes-Maser type utilizing ammonia. On the basis of a frequency standard of unknown reliability a frequency stability of 1 in 10^9 with an output of 10^{-9} watt had been obtained. The authors noted completeness of equipment found in these laboratories.

Svetlana Tube and Transistor Plant

Here are situated facilities for designing and constructing receiving tubes, automatic tube manufacturing equipment, transistors and high power transmitting tubes.

Though operations were not mechanized to the same extent as in the U.S., they were nevertheless, quite similar. A lot of the handwork, however, will be replaced by assembly line techniques. The authors noted that the receiving tube section was making 200,000 6AK5's per month. Transmitting tubes were being manufactured up to 240 kw rating with a number of tubes with 1 megawatt peak, 2 kw average pulse ratings up to 200 mc.

Abstracted from an article in *Signal*, Vol. XII, No. 5, Jan. 1958. Article by A. J. Jensen, Bell Telephone Labs.; C. L. Rouault, General Electric Co.; R. F. Schulz, Sylvania Electric Products; and J. N. Dyer, Airborne Instruments Labs.

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a must for missile measurements

FM Telemetering equipment is quickly and accurately checked with the unique instruments described below. All are immediately available against DX Priorities.

FM DEVIATION METER model 928/2
Freq. Range: 215 to 260 Mc, directly calibrated.
Modulation Freqs: 50 cps to 120 kc.
Deviation Ranges:
0 to 100, 200 and 400 kc, or to order.
Accuracy of Measurement: 3%.
Built in crystal standardization, aural and visual monitoring, counter type discriminator. Instrument is ruggedized and waterproof.

FM DEVIATION METER model 928,
similar to 928/2, covers 20 to 500 Mc.

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FM, continuously variable:
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Stability: .0025% per 10 min.

AMPLITUDE MODULATOR model 1102 For use with any Sig Gen. Gives monitored AM, 0 to 80% with zero FM. Handles any wave shape.

EDDYSTONE FM/AM RECEIVERS, models 770 R. 770 U
Model 770U covers 150 to 500 Mc, 770R covers 19 to 165 Mc. Both are sensitive, stable, directly calibrated and have excellent logging scales.

AS SUPPLIED TO: US Signal Corps, Wright Patterson AFB, Navy Electronics Lab, AEC, Convair, Martin, Douglas, McDonnell, GM, Chrysler, etc., etc.

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CIRCLE 128 ON READER-SERVICE CARD

SERVICES FOR DESIGNERS

High Power Linear Accelerator

Applied Radiation Corporation is offering for sale or lease to physics and electronics laboratories, a high powered traveling wave linear electron accelerator, designed for research in nuclear and solid state physics. The Mark 1-F4 linear electron accelerator emits high energy electrons, x-rays, or neutrons, as desired. Its electron beam, variable in energy from 2 to 10 million electron volts, can penetrate material of unit density up to 1-1/4 in. thick from one side. At full power (4kw), it can process a maximum of 3000 megarad-pounds per hour.

Applied Radiation Corp., Dept. ED, Walnut Creek, Calif.

Instrument Repair Service by L&N

A new factory instrument repair service is now available through Field Offices of the Leeds & Northrup Company, 4934 Stenton Avenue, Philadelphia 44, Pa. With this new service the user may specify the type of repair to be made on his equipment. Emergency service is available. A new folder, EN(6), gives details of this instrument repair service.

Noise Interference Measured

A new radio interference measurement facility has been completed by Sprague Electric Co., North Adams, a custom interference measurement service on all types of electrical machinery such as synamotors, actuator motors, vibrator power supplies, etc., as well as on electronic equipment. Coupled with the new measurement service is an expanded interference filter sample shop and pilot plant to expedite service to customers with interference problems. This service is for missile, electronic equipment, and portable tool manufacturers, both on the East and West coasts.

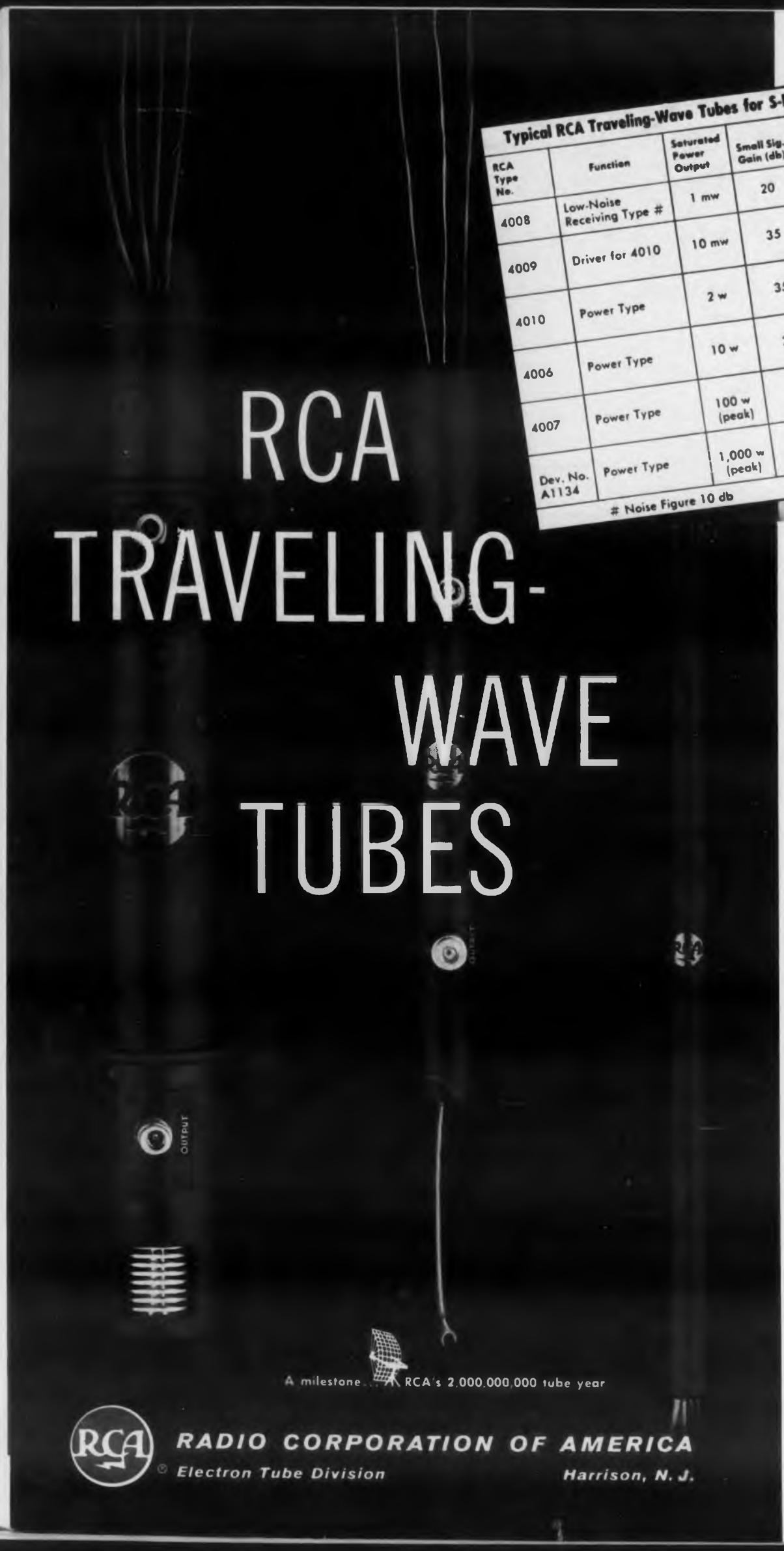
Sprague Electric Co., Dept. ED, North Adams, Mass.

◀ CIRCLE 126 ON READER-SERVICE CARD

ADVERTISERS' INDEX

April 2, 1958

...CLE 130 ON READER-SERVICE CARD ➤



Typical RCA Traveling-Wave Tubes for S-Band (2000 to 4000 Mc) Operation

RCA Type No.	Function	Saturated Power Output	Small Sig. Gain (db)	Focusing Method	Dia (in.)	Length (in.) Approx.	Weight (lb.)
4008	Low-Noise Receiving Type #	1 mw	20	Light-Weight Solenoid*	*2¼	*16	*10
4009	Driver for 4010	10 mw	35	Integral Periodic Permanent Magnet	1½	14	1½
4010	Power Type	2 w	35	Integral Periodic Permanent Magnet	1½	14	1½
4006	Power Type	10 w	25	Integral Periodic Permanent Magnet	1½	18½	3½
4007	Power Type	100 w (peak)	30	Integral Periodic Permanent Magnet	2½	20	12½
Dev. No. A1134	Power Type	1,000 w (peak)	30	Integral Periodic Permanent Magnet	2½	22	15

Noise Figure 10 db

* Including solenoid available separately

for every job in microwaves

Pacing the fast-moving advancements in tubes for microwaves, RCA offers designers a comprehensive line of low-noise and power traveling-wave tubes—for any application in the L, S, C, and X bands. These tubes feature a major improvement in traveling-wave tube manufacture: *high uniformity of characteristics maintained through rigid RCA quality control.*

RCA *power types* incorporate integral periodic-permanent-magnetic focusing—a design advantage that eliminates the need for solenoid power and reduces package size and weight.

RCA *low-noise receiving types* provide increased receiver sensitivity across octave bandwidths. And they are "tailored" to meet the requirements both in new equipment designs and in *modernization of existing microwave systems!*

Reflecting RCA's traditional engineering knowhow, RCA traveling-wave tubes are designed for military environments. For prompt service on your needs for traveling-wave tubes, get in touch with the RCA Sales Office nearest you.

GOVERNMENT SALES

- 415 South Fifth St., Harrison, N.J. HUmboldt 5-3900
- 224 N. Wilkinson St., Dayton 2, Ohio BAldwin 6-2366
- 1625 "K" St., N. W., Washington 6, D.C. District 7-1260

INDUSTRIAL PRODUCTS SALES

- 744 Broad St., Newark 2, N.J. HUmboldt 5-3900
- Suite 1181, Merchandise Mart Plaza Chicago 54, Illinois WHitehall 4-2900
- 6355 E. Washington Blvd., Los Angeles 22, Calif. RAymond 3-8361

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