

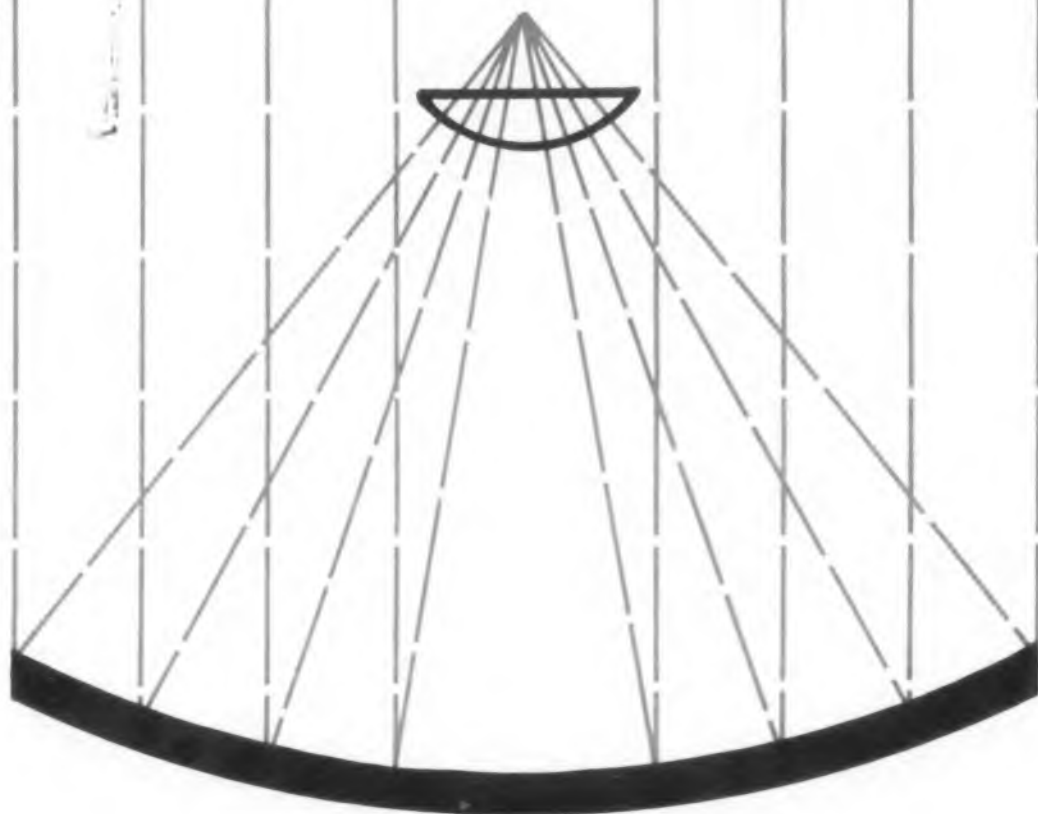
ELECTRONIC DESIGN

MAY 27, 1959

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SERIAL RECORD

MAY 25 1959

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First of a Series of Articles on Infrared
Starting This Issue page 22

GIVE YOUR PRODUCTS MORE RELIABILITY AND BETTER PERFORMANCE WITH

FREED QUALITY

MINIATURE PULSE TRANSFORMERS



- Meets all requirements of MIL-T-27A
- Small size and weight
- Ideal for computer applications

CATALOG #	APPLICATION	TURNS RATIO
EPT-1		1:1
EPT-2	Impedance	2:1
EPT-3	Matching	3:1
EPT-4		4:1
EPT-5	and	4:1
EPT-6		5:1
EPT-7	Interstage	2:1:1
EPT-8	Coupling	5:1
EPT-9		3:1
EPT-11		1:1
EPT-12		1:1
EPT-13	Blocking	2:1
EPT-14	Oscillator	1:1.4
EPT-15	Memory core &	5.5:1PP
EPT-16	Current driver	3.3:3.3:1PP
EPT-17	Current driver	6:1
EPT-18	Current Transformer	11:1
EPT-19	Pulse Inversion	6:1:1

*Supplied both molded and cased



HERMETICALLY SEALED DC TO DC and DC TO AC TRANSISTOR CONVERTERS

- Meets MIL Specifications
- Maintenance Free, Long Life Operation
- Exceptionally High Efficiency
- Highly Compact Package
- No Moving Parts

By combining the best square loop magnetic materials with the latest in transistor development Freed transistor converters solve power supply problems of operating communications equipment from low voltage batteries. AVAILABLE FROM STOCK DC to DC CONVERTERS

Freed No.	Input VDC	Output VDC	IDC	Size
MAC-6 2 1	6.3	150	.049	2 3/8 W x 2 1/4 D x 3 1/2 H DC2B
MAC-6 3 1	6.3	195	.080	3 1/8 H x 3 9/16 x 3-1/16 JB
MAC-12 2 1	12.6	300	.043	DC2B
MAC-12 2 2	12.6	180	.072	DC2B
MAC-12 4 1	12.6	390	.100	JB
MAC-12 4 2	12.6	245	.170	JB
MAC-12 4 3	12.6	350	.120	JB
MAC-12 4 4	12.6	225	.218	JB
MAC-26 2 1	26	250	.100	DC2B
MAC-26 2 2	26	600	.043	DC2B
MAC-26 2 3	26	360	.072	DC2B
MAC-26 4 1	26	600	.140	JB
MAC-26 4 2	26	450	.190	JB
MAC-26 4 3	26	450*	.190	JB

*Tap at 225 Volts. Also available for AC Square wave output at slightly higher ratings.

Freed No.	Input Voltage	Output VA	Output Voltage and Frequency	Regulation	Weight
MAC-16 36 1**	6 volt battery	150 watts maximum Fixed Load	115 volts* 60 cycles		7 lbs.
MAC-12 20 1**	12 volt battery	150 watts maximum Fixed Load	115 volts* 60 cycles		7 lbs.
MAC-12 36 1**	12 volt battery	350 watts maximum Fixed Load	115 volts* 60 cycles	10%	16 lbs.

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- Inductance: 1 Millihenry to 1000 Henry
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- Variable DC test voltage: 50 to 1000 volts
- Resistance range: .1 megohm to 4,000,000 megohms

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- Frequency Range 20 KC to 500 KC
- High Q
- Exact Tuning Without Trimmers
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Cat. #	NOMINAL IND. MHY MIN.	MAX.	AVERAGE Q	SELF RES. FREQ. MC
VHI-1	1.1	1.75	95	2.2
VHI-2	1.7	2.5	95	1.9
VHI-3	2.3	3.7	95	1.6
VHI-4	3.	4.5	100	1.4
VHI-5	4.	5.7	100	1.3
VHI-6	5.5	7.5	100	1.
VHI-7	7.	10.5	100	.9
VHI-8	10.	15.	100	.85
VHI-9	14.5	20.5	100	.6
VHI-10	20.	30.	100	.55

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- No Tubes
- No Moving Parts
- Accurate Regulations
- Fast Response
- Fully Automatic



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CAT. #	SUPPLIED EITHER MIL. OR COMMERCIAL		OUTPUT VOLT.	OUTPUT VA.
	INPUT VOLT.	LINE FREQ.		
MCV-620L	95-130 v	60 cps	115	20
MCV-670L	95-130 v	60 cps	115	70
MCV-6130L	95-130 v	60 cps	115	130
MCV-670F	95-130 v	60 cps	6.4	70
MCV-6130F	95-130 v	60 cps	6.4	130
MCV-420F	95-130 v	400 cps	6.4	20

MAGNETIC AMPLIFIERS

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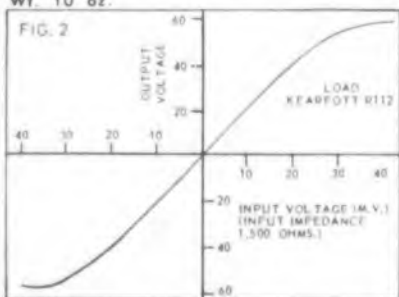
Power Gain 2 x 10⁶



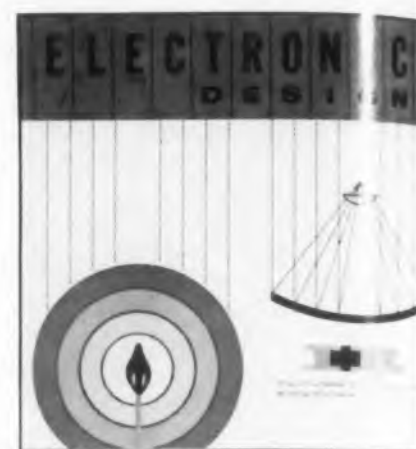
Transistor Preamp. MAT-1 Wt. 10 oz.

Mag. Amp. MAF-5 Wt. 18 oz.

Motor



HIGHLIGHTS OF ISSUE



Infrared Radiation Series (cover) 22

Latest, up-to-date information on infrared techniques, measurements and component evaluation will be presented in a series of articles starting in this issue. Prepared by members of GE's Light Military Electronics Dept. of the Advanced Electronics Center, the series offer valuable design information on detector selection, measurement and calibration. Procedures for calculating atmospheric transmission characteristics and spectral response will also be included.

Fast Character "Painter" Reads Out on Conventional Scopes 120

This unusual character generator reads out on conventional scopes. It can present one character, or many. It can even display on several scopes at the same time. And it's easy to use.

Watch For These Features

Next issue we start a new regular section entitled Designing Your Future. An article by E. N. Kaufman, "How To Get Ahead, The Do's and Don'ts" establishes some sound ground rules for success in engineering. In subsequent issues we will discuss such things as: how to evaluate your job, how to size up a company, how to land the job you want.

Next issue also includes our special staff report on problems in selecting diodes. The report includes many helpful hints garnered from successful diode users.

NEW PRODUCTS, INCLUDING THE VERY LATEST, START ON PAGE 70 THIS ISSUE.

Send for NEW TRANSFORMER AND INSTRUMENT CATALOGS

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Fast Character Painter

Reads Out on Conventional Scopes 120
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Sorensen DFCD 250-2AR developed for Arma Corporation

Sorensen Specifies

G-V Thermal Time Delay Relays

"...to enhance reliability..."

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CIRCLE 2 ON READER-SERVICE CARD



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Good-All

New SLIM-LINE TYPE 602 PLATFORM BASE CAPACITORS

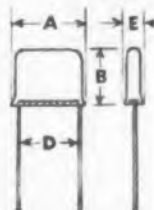
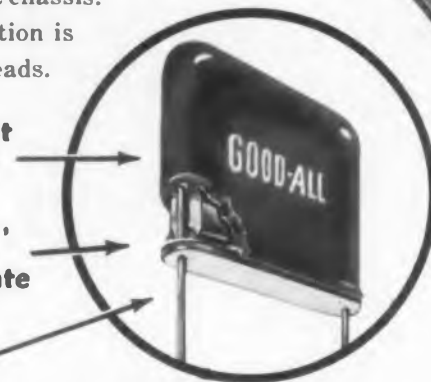
...tailored for transistors

This is a special-purpose version of the popular, space saving Good-All SLIM LINE (Type 601PE) and is designed to meet rugged vibration requirements. The mounting platform of Epoxy-glass laminate securely seats the 602 capacitor on a printed circuit chassis. Added stability under vibration is provided by heavy gauge leads.

Tough, moisture-tight
Epoxy coating

Miniature "platform"
of Epoxy-glass laminate

Heavy Gauge leads
precisely spaced



TYPE 602 DIMENSIONS (AVAILABLE IN 50 VOLT RATINGS ONLY)

CAP. (Mfd.)	A	B	D	E	CAP. (Mfd.)	A	B	D	E
.01	.562	.300	.440	.200	.10	.650	.525	.558	.225
.022	.562	.339	.440	.210	.15	.671	.650	.558	.260
.033	.531	.386	.440	.210	.22	.748	.717	.558	.296
.047	.531	.433	.440	.235	.33	.843	.780	.690	.312
.068	.575	.480	.440	.260					

SPECIFICATIONS

INSULATION RESISTANCE—Greater than 75,000 megohms when measured at 100 volts D.C. at 25° C for a maximum of 2 minutes.

WINDING CONSTRUCTION—Extended foil (non-inductive) MYLAR* Dielectric.

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CAPACITY TOLERANCE—Standard tolerance is 20%.

*DuPont's trademark for polyester film.

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CIRCLE 3 ON READER-SERVICE CARD

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Molecular Electronics

Stirs Thinking at Two Conferences

MICROMINIATURIZATION continues to generate vast interest in the electronics industry, but the focus is swinging ever sharper to the basic nature of the material rather than packaging. Invitations to pioneer in this new area of molecular electronics were issued at two key parleys this month—the 1959 Electronic Components Conference in Philadelphia and the National Aeronautical Electronics Conference in Dayton, Ohio.

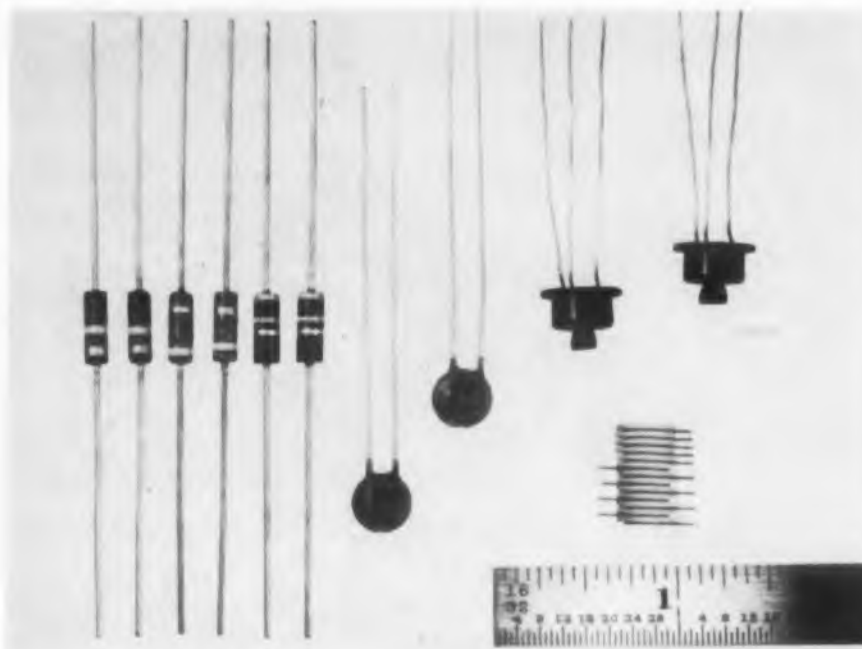
In a keynote address at the three-day Philadelphia gathering, Dr. Jack A. Morton, vice president of Bell Telephone Laboratories, advised system and component designers to “change their basic viewpoints and start asking different questions.”

“The system designer must start at a new level of synthesis,” he said, “specifying his needs only in terms of basic system functions with properly weighted objectives. This, in turn, will stimulate his imagination and effort to higher levels of sophistication in system organization and logical design.”

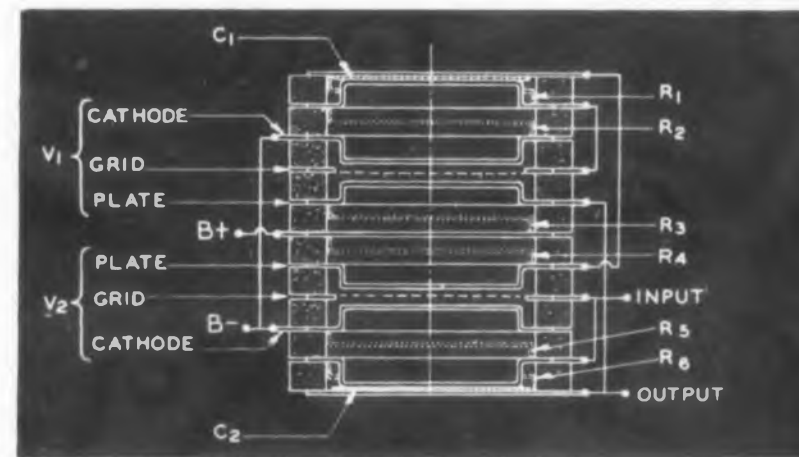
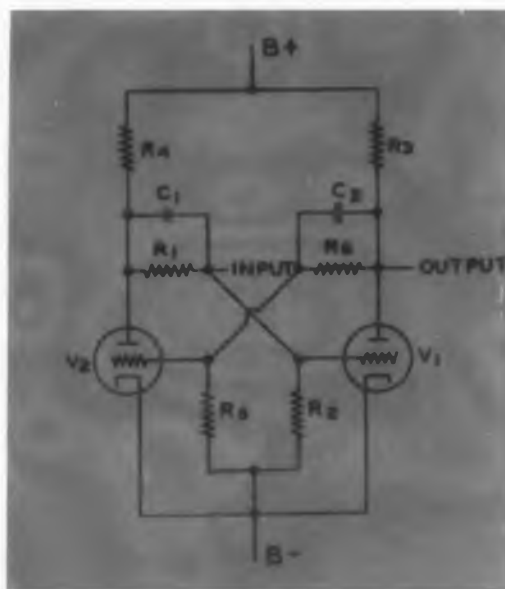
The component designer, Dr. Morton went on, must not be impeded by such circuit-element concepts as resistors, capacitors, inductance, tubes and transistors. “He must go directly to the physics of electrons, atoms, phonons and photons in seeking basic functions,” the official said.

This view was supported by Donald G. Fink, director of research for the Philco Corp. Microminiaturization will be advanced, he asserted, by scientists and engineers working together. He called the engineers the “old timers” in the industry, and the scientists, such as physicists and chemists, the “new timers.”

At the same time, Mr. Fink cautioned against the indiscriminate use of micro devices. Putting micromodules in television sets with large picture tubes or in radios with large speakers is not too sensible at present, he pointed out. But putting like units in space vehicles or in more compact



Module at lower right, a “red hot” operating unit, is called a TIMM. Designed by GE for space applications, it comprises the equivalent of conventional transistors, capacitors and resistors, with which it is shown.



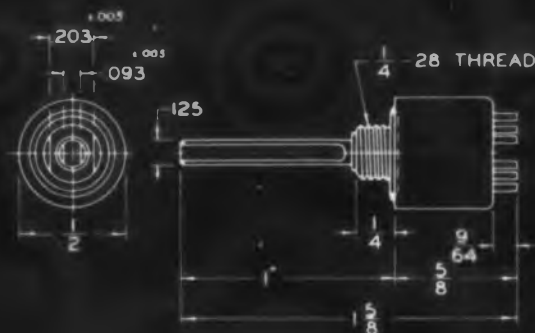
Cross-section and schematic diagram of a typical TIMM, unveiled at the 1959 Electronic Components Conference.

The smallest rotary switch ever made!

Daven's New Series G Sub-Miniature Switch... 1/2" Diameter!

A new sub-miniature rotary selector switch, developed by DAVEN, is specifically suited for application in missiles, aircraft, handy talkies, field pack sets, frog-man communication equipment, and all types of mobile apparatus. This explosion-proof, waterproof switch has the same reliability as its bigger brothers... but in a fraction of the space. It meets applicable military specifications on temperature, humidity, corrosion, vibration, acceleration, shock and immersion.

This unit is available as a single pole, 10 position switch and can be obtained with up to four poles on a single deck.



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Contact Resistance: Less than .008 ohm.

Contact Rating: 1 ampere, 250V D. C. into resistive load.
350 MA, 100V D. C. into inductive load.

Insulation Resistance: 200,000 megohms between any two terminals or between any terminal and shell.
Measured at 25° C., 50% RH, at sea level.

Life Expectancy: 50,000 cycles minimum
Shaft and case: Stainless steel
Panel and hub: Glass filled epoxy
Contacts and terminals: Silver alloy
Rotors: Rhodium plated beryllium copper



LIVINGSTON, NEW JERSEY

TODAY, MORE THAN EVER, THE DAVEN © STANDS FOR DEPENDABILITY!

NEWS

computers would be of great benefit, he noted.

At the Dayton conference at the Wright Air Development Center (WADC), Lt. Col. George F. Watkins, chief of WADC's Electronic Components Laboratory, said the Air Force hoped to stimulate industrial activity in molecular electronics. When equipment is made small enough, he predicted, men will not have to perform the functions of guidance and control in spaceships.

The molecular approach aims to do as many operations as possible in a single element. It is another step toward putting components into packages on the order of two million per cubic foot. WADC is already embarked on its own program. Roy Sadow, coordinator of the project, told the conferees that the air center planned immediate development of microminiature thermo converters; fixed-tuned, high-gain amplifiers, delay circuits, shift registers and static commutators.

Information-handling functions appear to be the most adaptable to molecular advances, Mr. Sadow said. He noted four facets of the WADC program:

- Applied basic research.
- Techniques.
- Survey and circuit usage of functions.

Development of subassemblies. The techniques include work on thin film, pyrolytic deposition, sputtering and the environmental conditions that affect these.

The studies also include a comprehensive cataloguing of the physical phenomena of effects, designed to list every possible application with molecular electronics. Examples include the Hall Effect, electroluminescence, Peletier Effect (electronic refrigerator) and Faraday rotation.

A by-product of the techniques has resulted in a new dielectric film for high-temperature capacitors. Deposited between molybdenum

◀ CIRCLE 4 ON READER-SERVICE CARD

ELECTR

isks, the film shows excellent dielectric characteristics above 600 C.

Maj. D. B. Netherwood, acting chief of WADC's Advanced Development Branch, is coordinating work on the mathematical phase of the program. Working with Ohio State University and the Burroughs Corp., his group is attempting to determine the logical bases for molecular advances.

Meanwhile microminiaturization continues to move forward with new packaging techniques. General Electric unveiled at the Philadelphia conference its concept of building several radio tubes and their circuits in one tiny ceramic-stacked module for space vehicles. The devices are called TIMMs (Thermionic Integrated Micro Modules). They differ from other packaging concepts in that the aim is to confine heat rather than expel it and to put it to work operating vacuum devices.

A complete circuit, such as a multivibrator or an amplifier, occupies a space no larger than that of a pencil eraser. It operates at nearly red-hot temperatures, taking advantage of high-frequency and reliability features of thermionic electron tubes.

The electron tubes used have no heaters, and auxiliary cooling is reduced or eliminated. The heat losses generated within the equipment increase the over-all efficiency of operation.

Resistors built into the ceramic modules consist of a resistive film on the inside of evacuated and sealed ceramic insulators. Resistors of from one to 500 K have operated stably at 700 C, GE reported.

Built-in micro-miniature capacitors, with synthetic mica as the dielectric, have shown a change of less than 5% in operation over a temperature variation ranging 0 to 700 C.

The heater-less electron tubes built into the stacks have a self-biasing characteristic. No grid current flows until the grid is at least two volts positive with respect to the cathode.

A typical circuit module can contain 10 diodes, 14 triodes, 14 re-



THE SHRINKING MAN'S FILTER

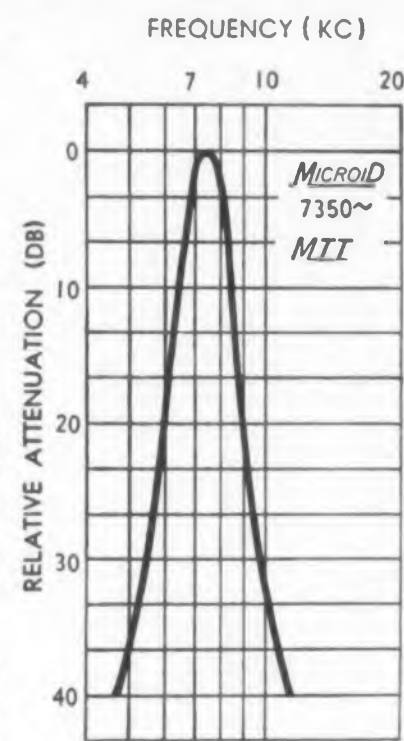
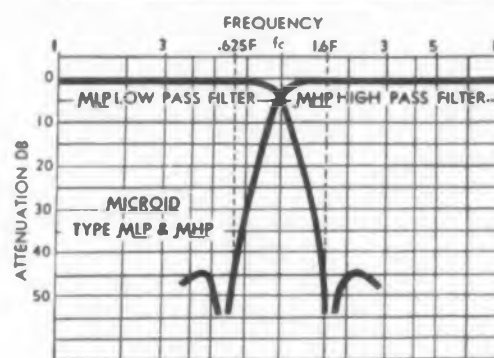
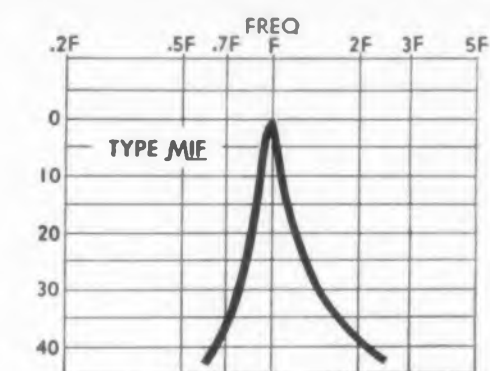
Although worlds apart in purpose, practitioners of the art of head shrinking and Burnell & Co. miniaturization engineers are both expert in reducing to size. For example, Burnell's new microminiature **MICROID** filters are particularly valuable in transistorized circuitry and only a step away from micro-module use. Range of the new Type **MTI** band pass filter is 7.35 kc to 100 kc, band width 15% at 3 db and +60% -40% at 40 db. Size is 1/2" x 19/32" x 15/16", weight .3 oz. Types **MLP** and **MHP** cover 5 kc to 100 kc with a standard impedance of 10K ohms. These are microminiature counterparts of the popular Burnell TCL and TCH low pass and band pass filters. The band pass filter results when cascading a TCL with TCH filter. Size is 3/4" x 1/2" x 1".

Type **MLF** microminiature interstage filters are designed for a wide variety of applications. Input impedance is 10K ohms, output to grid with a voltage gain of approximately 2:1. The 3 db band width is nominally 8%. Ranging from 7.5 kc to 100 kc, these interstage filters are provided in the same case as Type **MLP**.

Fully encapsulated, the new **MICROID** filters provide less weight, more reliability and exceed MIL specifications. We'll be glad to design and manufacture to your specifications in any quantity. Write for special filter bulletin to help solve your circuit problems.

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CIRCLE 6 ON READER-SERVICE CARD

NEWS



Floyd E. Wenger of the Air Research and Development Command, moderator of meeting in Philadelphia, attaches a microphone to Richard W. Fotland of Horizons, Inc., a speaker at the sessions.

sistors and six capacitors. These 44 components yield an operating circuit density of 250,000 components per cubic foot.

Engineering samples of TIMMs can be developed in a relatively short time, it was said, and production in quantity may be possible after another year.

Other developments in micro-miniaturization were also described at the Philadelphia meeting. Some of these were: component connections for microminiature circuits; RCA's micromodule structural design; a miniaturized ceramic transformer intermediate-frequency amplifier; miniaturized relays, and a microminiature ferroelectric digital

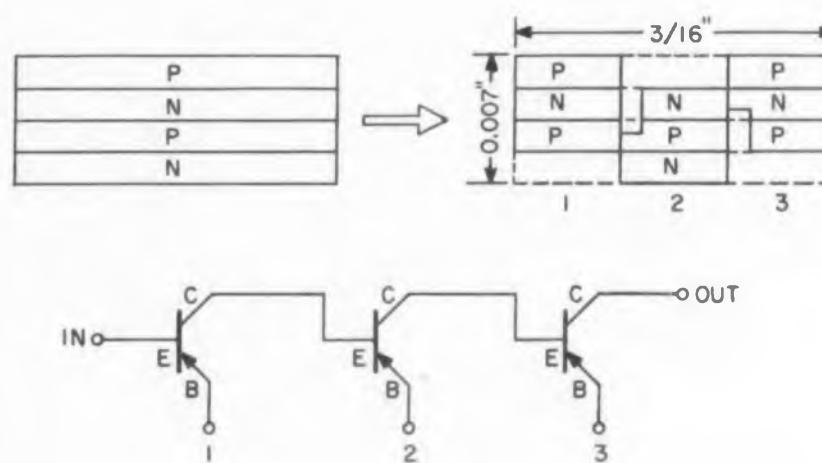
storage system.

But despite the advances, A. W. Rogers of the Army Signal R & D Laboratories, explained:

"There will always be a need for conventional components. Micro-miniaturization will have its biggest applications in low-signal-level circuits. But conventional components will be used for a long time in power applications."

Company representatives at the sessions were inclined to agree.

This conference was sponsored by the Electronic Industries Assoc., the American Institute of Electrical Engineers, the Institute of Radio Engineers and the Western Electronic Manufacturers Assoc. ■ ■

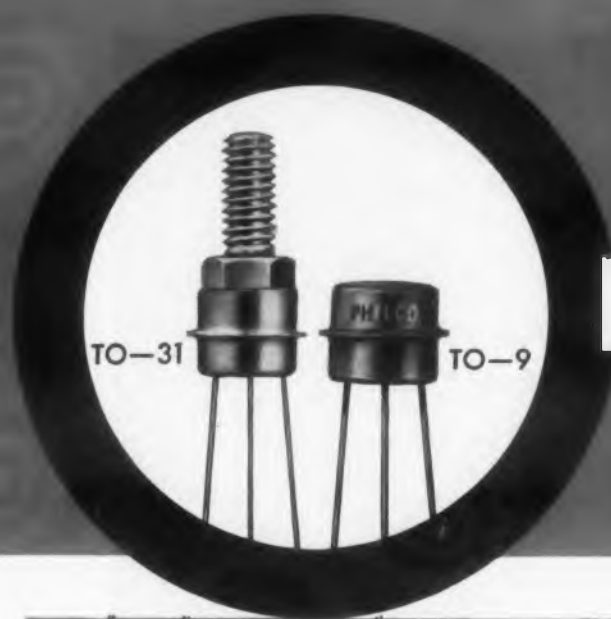


An example of how this "radical" technology is made, as shown at the WADC at Dayton conference. Four layers of stacked and eroded form the three-stage rect-coupled amplifier. has a gain of 60 db in volume of 8×10^3 cubic inches. About 37,500 stages of this type could be jammed into a cubic inch.

Five-Ton 'Tube' Created



This "radio tube," 80 ft high and weighing nearly five tons, will soon be familiar to Londoners. There is only one switch electronically: it's a dud. The oddity is a modern bronze sculpture inspired by the inside of a radio tube. The work of Geoffrey Clarke, a leading British designer, it will be erected on the tower of a 20-story office building under construction for Thorn Electrical Industries, Ltd., in London's West End.

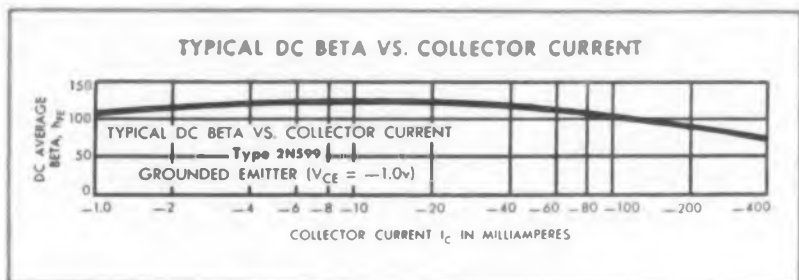
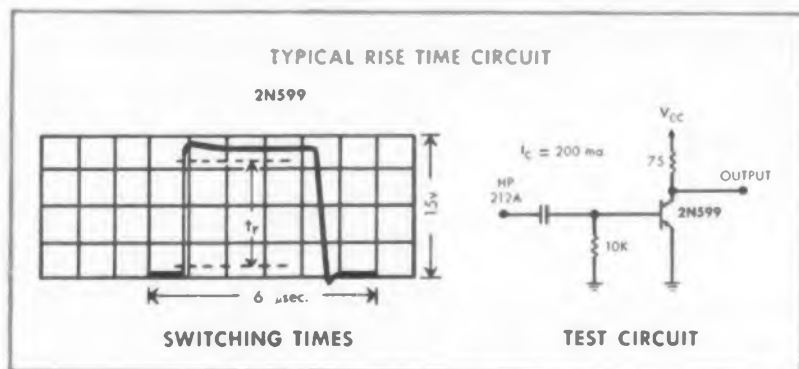


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Type	Outline	Max. Readings			General Performance		"ON" Switch Performance	
		P _r mw	V _{CE} volts	I _C ma	Min. f _{αb} mc	Typical h _{FE} V _{CE} = -1v, I _C = -100 ma	Max. V _{CE}	Max. V _{BE}
2N597	TO-9	250	45	400	3	70	0.2	0.34
2N1123	TO-31	750*	45	400	3	70	0.2	0.34
2N598	TO-9	250	30	400	5	85	0.2	0.34
2N600	TO-31	750*	30	400	5	85	0.2	0.34
2N599	TO-9	250	30	400	12	105	0.2	0.34
2N601	TO-31	750*	30	400	12	105	0.2	0.34

*Peak Dissipation at 25°C = 1 Watt



Make Philco your prime source for all transistor information and prices. Write Dept. ED-550

- High Dissipation: to 1 watt peak at 25°C
- High Current: Max. I_C = -400 ma
- High Temperature: 100° C Max.
- High Voltage: Max. V_{CB} to -45v
- High Frequencies: Min. f_{αb} to 12 mc

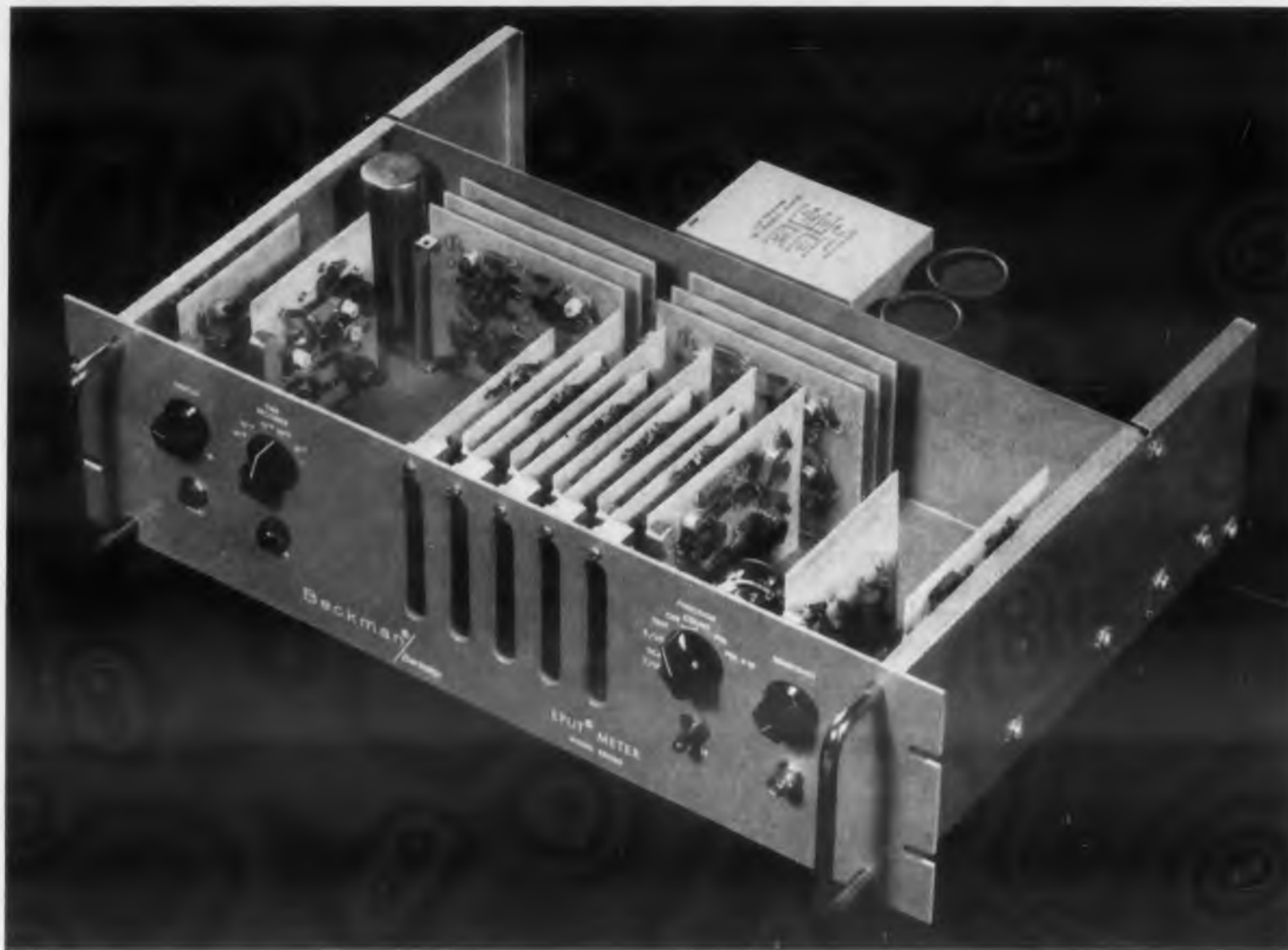
Philco's complete family of PNP germanium alloy junction transistors is available in both studded and unstudded cases (TO-31 and TO-9), permitting operation at power levels as high as 1 watt peak. They offer the designer complete flexibility, providing a choice within each form factor to meet circuit requirements for voltage, gain and frequency. These transistors feature a unique, patented, cold-welded *copper* housing and internal construction that result in lower junction temperatures at normal operating power levels. (K factor as low as 0.1° C/mw.) Their design insures improved life and reliability at temperatures as high as 100° C.

The high beta of these transistors at high current makes them particularly applicable to medium speed flip-flops, logic gates, drum writers and core-driver circuits. The 30v to 45v collector rating provides the high level logic swings required in many data processing equipments. The entire family is available in production quantities . . . and in quantities 1-99 from your local Philco Industrial Semiconductor Distributor.

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Please send 4-page Technical Bulletin on Model 5310 EPUT Meter

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Built exclusively of solid-state components, this new Beckman/Berkeley Eput[®] Meter exhibits dependable operation at temperatures from -5°F. to 150°F. under actual test - meets the most stringent requirements for both military and industrial use.

All circuits except the power supply are mounted on easily replaceable plug-in modules of only six different types. The time base is generated by digital circuits requiring no adjustment.

OTHER IMPORTANT FEATURES INCLUDE:

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CIRCLE 8 ON READER-SERVICE CARD

NEWS

Army Gets New Storage Tube

A barrier-grid storage tube capable of resolving 800 to 1200 TV lines at 75 per cent contrast has been developed for the Army.

Said to operate with considerably less signal shading than similar units now available, the tube should find application in radar and infrared moving target indicator work, and binary digital information storage and processing.

The new component utilizes a single electrostatically focused and electrostatically deflected electron beam for both "writing" and "reading" information on a spherically curved target. The target consists of a metal bowl, with a thin dielectric layer fused to its concave side, and a curved, fine mesh screen fused in turn to the dielectric.

The tube was developed by International Telephone and Telegraph Corp. in cooperation with Army Signal Research and Development Laboratories, Fort Monmouth, N.J.

Risky Job? Let Mobot Do It



Arm-like device at right belongs to Mobot, a mobile robot developed by Hughes Aircraft Co. for jobs too dangerous for humans. Mobot, operating a drill here, works with aplomb in such risky spots as radioactive rooms and underwater salvage areas. Its electropneumatic "fingers" can exert a 200-pound squeeze or handle delicate items with tweezer-like care. The operator directs the actions with electronic "reins."

Wrong Name

In the photograph of "The Panel of Experts" which appeared in the meeting report of 1954 Solid State Circuit Conference, (ED, April 15, p. 44) the second from the left is Mr. Amos Okun, Manager Circuit Design, Computer Department, GE. For the panel, he championed diode logic circuits.

New Principles Broaden Use, Cut Size of Ultrasonic Flaw Detectors

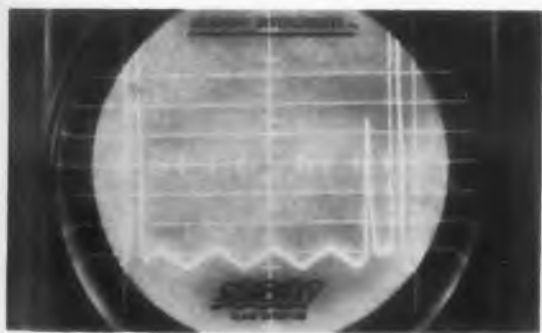
Starting from the pulse-echo detection principle, Bronson Instrument designers, in Stamford, Conn., have developed an ultrasonic detector that operates over a continuous range of frequencies, develops a pyramidal distance marker, and weighs half as much as comparable units.

A novel broadband amplifier, based on a new approach to current broadbanding practice, gives the unit its continuous frequency range. This eliminates changing of transducers, frequencies, and retuning. The Sonoray Model 5 automatically adjusts to any transducer within its range of 0.4 to 0.10 mc. Quick disconnects cut frequency-changeover time to 5 seconds.

New circuits permit for the first time generation of a pyramidal distance marker, which makes weak signals, or those at critical points, easier to detect. The pyramid corresponds to the ultrasonic path and greatly simplifies flaw detection.

A bright trace coupled with circuitry that gives high resolving power permits detection of small flaws only 1/8th of an inch below the surface of a part at very low frequencies.

Redesign of conventional circuits cut down power consumption, making possible the 50% weight saving. Efficient packaging and the greatly reduced power supply needs led to the 65% volume cut.



Unique Pyramid Marker shows on face of new ultrasonic flaw tester.

Coming: Atomic Lighting

Atomic lamps that might eventually be used as warning lights, buoy markers or for signaling on life rafts are under experimentation in Great Britain.

Gaseous radioactive isotopes such as tritium and krypton 85 are particularly suitable for use in light sources. The light is obtained from phosphorus activated by beta particles, which are emitted in the decay process of the radioactive isotopes.

The A.E.I. Lamp and Lighting Co. of London is seeking to increase by tenfold the present experimental output of .0045 lumens, an efficiency a little more than 30 lumens per watt.



2N393



2N1122

HIGH-SPEED, HIGH-GAIN MICRO-ALLOY TRANSISTORS for modern computer circuitry

Types 2N393 and 2N1122 Micro-Alloy Transistors combine high gain with excellent high frequency response to meet demands of high-speed computer switching applications in the megacycle range. Low saturation resistance, low hole storage, and exceptionally good life characteristics make these micro-alloy transistors top performers in general high frequency applications and computer circuits.



Made by electrochemical manufacturing techniques, Sprague Micro-Alloy Transistors are uniformly reliable, as well as reasonably priced for transistors with such excellent operating parameters.

All Sprague transistors—micro-alloy, micro-alloy diffused base, and surface barrier types—are now produced in Sprague's completely new spotless semiconductor facility.

For engineering data sheets on the types in which you are interested, write Technical Literature Section, Sprague Electric Company, 347 Marshall Street, North Adams, Massachusetts.

Sprague micro-alloy, micro-alloy diffused base, and surface barrier transistors are fully licensed under Philco patents. All Sprague and Philco transistors having the same type numbers are manufactured to the same specifications and are fully interchangeable. You have two sources of supply when you use micro-alloy and surface barrier transistors!

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2N501
MADE FOR ULTRA-HIGH SPEED SWITCHING

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NEWS

Meeting Sum-up: We're Closing In On Ideal Power Source From Many Sides

Power sources developed from thermoelectricity, thermionic conversion, fuel cells, galvanic cells, and dynamic heat engines held the spotlight at the Thirteenth Annual Power Sources Conference, Atlantic City, N.J.

Among the highlights:

- Efficiencies up to eight percent have been reached with nuclear sources using water to dissipate thermal radiation.
- A 22-lb, packaged solar unit has been developed to produce five watts.
- Near-future shelf life of three to five years is now anticipated for dry cells.
- Microminiaturization has produced up to 20-fold size and weight reductions in once miniature devices.

Space Applications Already History

Dr. N. W. Snyder of the Advanced Research Projects Agency, Washington, opened the conference by outlining power needs for space vehicles ranging from weather-surveillance equipment to manned satellites to stations in outer space. The possible applications of solar, nuclear, and chemical energy sources were analyzed in terms of relative weight, plant capacity, and service lifetime.

Nuclear and Thermal Sources Still Costly

Nuclear energy, capable of high-energy density independent of temperature, has been hampered by the need for heavy shielding to achieve safety from radiation effects. The use of alpha emitters, devoid of gamma ray radiation, promises freedom from hazards in handling.

Efficiencies of nuclear-heat-to-electrical energy conversion have been pushed up to six per cent. Up to eight per cent efficiency has been gained by using water to dissipate thermal radiation.

Conversion of thermal to electrical energy, by thermoelectric generators and thermionic converters, which have no rotating parts, offers reliability and long life. Dr. A. D. Steele described the 5 w thermoelectric generator, developed by the Minnesota Mining and Mfg. Co. under the A. E. C. Snap III program. The unit, publicly displayed at the White House earlier this year, uses lead-telluride p- and n-elements heated by alpha particles emitted by Polonium 210.

Theoretical and experimental results for close-spaced thermionic vacuum- and gas-filled converters were outlined by Dr. V. C. Wilson of the G. E. Research Lab. Dr. Hatsopoulos of M. I. T., comparing thermoelectric and thermionic converters, concluded that relatively low-temperature

on every count

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Raytheon Germanium Computer Transistors meet the stringent requirements of Military specifications including electrical, mechanical, and environmental tests. Switching currents to 1 ampere; high frequency, high gain; low saturation resistance; H_{FE} control at high current. Available in both TO-5 and SUBMIN packages.

Raytheon General Purpose Germanium Transistors including high frequency, audio frequency, low noise and radio receiver types. Available in TO-5 and SUBMIN packages.

Raytheon Diffused Junction Silicon Rectifiers in both wire-in and stud types, welded, hermetically sealed. Noted for their high forward conductance, exceptional reverse recovery.

Raytheon Silicon Diodes, featuring low reverse current, high forward conductance and excellent stability in high temperature applications. All subject to environmental quality control. Available in a wide range of characteristics.

Raytheon Germanium Diodes in a wide variety of both popular and special types—point contact and gold bonded. Available in standard and small glass packages.

Raytheon Circuit-Paks of Transistors, Diodes, Rectifiers and other components offer better utilization of space, ease of assembly and extreme reliability. These compact, encapsulated, complete, subassemblies, such as Phase Comparators, Bridges, Choppers, and Flip-Flops are available from stock or to your specifications.



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thermoelectric devices could be thermally cascaded with higher-temperature thermionic units to achieve high over-all conversion efficiency of heat to electricity.

Solar Energy Coming Down to Earth

Considerable interest focused on the several solar-energy papers. Mr. G. Hunrath, of the Signal Corps R & D Lab, analyzed design of a double-ring solar-cell grouping for satellites.

RCA's efforts to develop more efficient p-n junction solar cells by using gallium arsenide was detailed by Dr. J. J. Loferski. Present silicon cells provide about 11 percent efficiency—gallium arsenide only about six percent; future research may move gallium arsenide past silicon.

According to Dr. Maria Telkes, Curtiss-Wright, as much as 100 to 125 w/sq ft of solar energy are concentrated on the Earth's surface during a summer day. Solar conversion efficiencies of even 10 per cent can deliver a large amount of useful power when combined with large area collectors. Slides of various spherical and parabolic reflector designs were shown to illustrate the research efforts.

Dry Cells Hold Their Own

Recent developments in sealed nickel-cadmium batteries, silver-oxide cells, and calcium-lead grid alloys were disclosed with test results accumulated from field reports. Advances in dry cell reliability and long life were stressed.

Fuel-cell devices can convert chemical to electrical energy without an intermediate thermal conversion step. Low-temperature fuel cells and Redox-type cells were described; efficiencies up to 70 percent are theoretically possible. Since no moving parts, except for accessories, are required, quiet operation and long life may be expected. Dr. H. F. Hunger, of the Signal Corps' R & D Lab, reviewed basic concepts and surveyed latest developments in each type of fuel cell.

V. J. Kublin, also of the Signal Corps R & D Lab, suggested that to achieve smallest over-all system packaging, power sources must be fully investigated to obtain highest power density and reliability.

Sponsored by the Power Sources Division of the U. S. Army Signal Research and Development Laboratory, Fort Monmouth, N.J., the April 28-30 meeting was attended by over 1000 engineers. Thirty-nine papers were presented by leading experts from military and commercial development laboratories throughout the country.

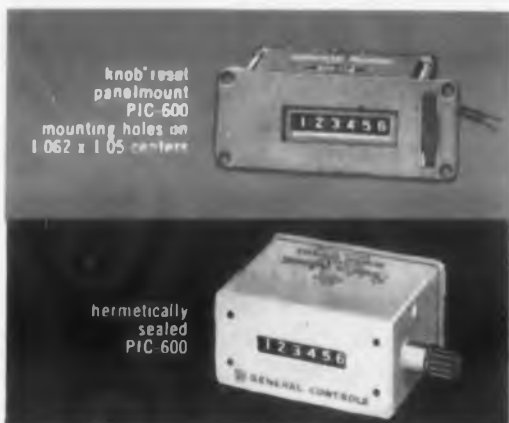
The full text of all papers is scheduled for publication in September, 1959. Copies can be ordered from the U. S. Army Signal R & D Laboratory, Fort Monmouth, N.J.; price is \$10 for the first copy and \$5 for each additional copy mailed to the same address.

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PIC-600 quiet electric counter offers great advantage for low level DC circuits - draws only .14 amperes from 30-volt transistor circuit.

QUIET OPERATION Efficient magnetic circuit and balanced mechanical action result in smoother operation with reduced noise



RECTIFIED FOR AC Eliminates AC hum—gives DC operating reliability from 25/40/50/60 cycles.

50 MILLION COUNT LIFE On life tests at 1000 cpm pass 100 million counts.

1000 COUNTS PER MINUTE Much higher speeds with suitable actuating impulses.

BALANCED ARMATURE Smooth, quiet operation and low friction in any position.

Also available to count dozens, coins, pairs, quads, etc.

URNS COUNTER FOR POTENTIOMETER
Gives hundredth turn readings visible when fingers are on adjusting knob. Registers to 999 and repeats. Friction lock secures setting. Available with dial light and for remote operation.



INDEXING METER WITH SWITCH
Developed for use with wire and tape recorders. Switches are actuated automatically at fixed "index numbers" for which the unit is built. Many variations available for a wide range of application.

LOW BACK-LASH COUNTER ASSEMBLY
Rugged, add-subtract revolution counter assemblies widely used as indexing registers for potentiometers, variable capacitors and other digital readout requirements. Wide choice of optional features.



7-DIGIT REVOLUTION COUNTER
Non-reset. Adds or subtracts 10 counts per shaft revolution. Top-coming or top-going shaft rotation. Totally enclosed in die cast housing. Available sealed; also with adaptor for flexible shaft drive.

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NEWS

NBS Semiconductor Study Sparks Design Ideas

A SEVEN-PROJECT research program underway at the National Bureau of Standards is developing new solid-state data that may soon be put to work by electronic design engineers.

The NBS investigation breaks down this way:

- Crystal growth and purification studies—important because solid-state materials are evaluated on the basis of electron and lattice theories. Some results: over 100 crystals of indium antimonide (InSb) have been grown by the Kyropoulos technique; impurities have been reduced to 1 to 10 parts in 10^8 .

- Electrical property measurements—conductivity, Hall effect (to distinguish between n- and p-type semiconductors), and thermoelectric-effect measurements are made down to liquid-helium temperatures. Properties vary widely—energy gaps of the important III-V compounds (combinations of elements from the III-B and V-B columns of the periodic table) range from 3.0 to 0.16 ev.

- Optical measurements—mainly in the infrared region because of interest in semiconductors as infrared detectors.



Nuclear magnetic resonance investigates the solid state in this rig. Probe holding sample between pole pieces of large magnet, center rear, connects through oscillator circuit in small box, power supply, lock-in detector, and modulator, all in console, to strip-chart recorder. Magnet power supply is at left.

Copper-doped indium antimonide gives fairly large photosignals at liquid-helium temperatures in the far infrared range up to 35 C. N-type InSb with a slight copper impurity shows interesting quenching effects.

- Carrier lifetime studies—these lead to critical-value figures.

- Mechanical and electromechanical studies—resistivity tests of InSb under tensile stress have confirmed its energy band structure.

The temperature or frequency dependence of mechanical damping often reveals relaxation peaks and attenuations which relate to impurities. These internal-friction studies have been made on InSb up to its 523 C melting point.

- Nuclear magnetic resonance—one of the most useful techniques for studying defects and impurities in semiconductors



Crystal-growing furnace at the National Bureau of Standards grows crystals by the Kyropoulos technique. Coil surrounds hot vacuum chamber from which metal-coated seed crystal is withdrawn to cool in large crystal form. Zone melting purifies crystal forming substance.



intermetallic compounds under study include oriented crystal of indium-antimonide, left; cavitron-cut sample of same material prepared for elasto-resistance measurements, center; and specimen of magnesium-tin for optical investigations, right.

Development of theory—new principles are constantly being sought. From studies thus far, the Bureau notes, have come a theory for transport phenomena in a strong magnetic field, and a better understanding of the electronic energy-band scheme of rutile (TiO_2) containing vacancies or impurities.

NBS in Solid-state Research 10 Years

The Bureau of Standards started researching semiconductors in 1949 with studies on the properties of rutile in crystalline form. These evaluations led to improved understanding of the electronic behavior of rutile and to a useful device—the titanium dioxide rectifier.

By 1952 the agency was leading research on a new group of semiconductors—the III-V binaries. Many crystals of aluminum-antimonide, gallium-antimonide, and indium-antimonide were prepared and analyzed. Indium-antimonide proved very promising, and much attention is still being focused on it.

Other materials studied in the last five years are magnesium-tin and semiconducting gray tin.

What of the future? The Bureau plans to continue concentrating on a few materials. TiO_2 will receive particular emphasis in the next year.

“Electrical, optical and magnetic investigations of this material,” the Bureau says, “will provide valuable information concerning the role of impurities in the conduction mechanism.” ■ ■

after routing,
clip and save



a continuing series on technical topics of specific interest to engineers

What makes mica the unique dielectric?

Mica is as old as the earth itself. Ancient Hindu writings show that mica was thought to be the remains of lightning flashes from which sparks had emanated and had become preserved in the earth. It was therefore regarded as being endowed with extraordinary properties, and was used in medical ritual. The replacement of such charming stories with modern technical knowledge has, however, not altered the fact that mica is endowed with extraordinary properties.

Mica is found in pegmatite rock, formed in the early stages of the cooling of the earth's mass. Crystals of mica were formed under high heat and pressure, and in the presence of moisture vapor and magnetic fields. The physical and chemical changes during this period served to impart a unique stability in physical, chemical and electrical properties. The chemical structure of mica is represented as $\text{H}_2\text{KAl}_3(\text{SiO}_4)_3$, which is Muscovite; India Ruby is one of the grades of exceptional quality and is used in most mica capacitors. Other types of mica, to name a few, are Phlogopite, Lepidolite and Biotite, of which only Phlogopite is of limited interest in experimental capacitors for very high temperature operation.

Mica is found in varying degrees of purity, some with less mineral or vegetable constituent, or stain, and some with more nearly perfect physical integrity—that is, free from cracks or air inclusions. As a result, raw mica must undergo careful physical examination and be graded according to quality and size. Sangamo has had over 35 years experience in the selection and processing of mica, together with a knowledge of mica capacitor production. Capacitor grades of mica film are generally obtained from the Bihar, Bengal, or Madras provinces of India. Mica for other purposes may be found in Canada, Brazil, Argentina, Madagascar, Africa, Russia, New Hampshire, South Carolina and South Dakota. This list is by no means complete. An idea of the magnitude of the task of selecting suitable mica can be obtained from the fact that only an estimated ten per cent of all the world's mica deposits are suitable for use in mica capacitors.

The earliest mica capacitor was probably made by Matteucci, a contemporary of Faraday's, about 1845. However, capacitors did not become commercially interesting until the advent of radio in the early years of this century, as a result of the growth of electrical technology. Both the electrical and electronics industries have depended significantly upon mica. Mica insulation between commutator segments in rotating machinery and the mica spacers in vacuum tubes are still vital to these industries.

In capacitors, the choice of dielectric material is as important as the method of construction. Mica, because of its sheet form, lends itself to stacked construction, resulting in a lower inductance assembly than can be obtained in wound capacitors. Mica capacitors are therefore suitable for very high frequency operation.

The mechanical or dimensional stability of mica allows blanking or die-cutting of dielectric plates to a desired size with only a very few thousandths of an inch variation. Precise assemblies may therefore be obtained and result in a greater ability to achieve accurate miniaturization. Electrodes may be permanently bonded to the mica dielectric plates by screening on conducting silver paste. This process has been refined to a high degree of accuracy, and results in superior electrical stability when compared to laying foil between mica plates to form the electrodes. Silvered mica



capacitors exhibit exceptional stability in extremes of temperature.

The Q and dielectric constant (therefore, the capacitance) of mica change very little over wide ranges of frequency and temperature. Such small changes are due to the fact that the molecular structure of mica is essentially non-polar—that is, the molecules of mica do not have an unbalanced electrical charge. Thus they are not free to swing freely as magnets do (mica is practically non-magnetic) when in the presence of an electric field. Such fields are present when the capacitor is charged. Movement of the molecules would result in heating by the friction of their motion. Poor dielectrics exhibit considerable heating, as is shown by the heat developed in wood and glue in the process of laminating plywood in dielectric heating devices.

Heating effects may become very pronounced when high frequency alternating voltages are applied. The rapid changes in the direction of current flow cause polar molecules to literally vibrate about their rest position. The low heating of mica under such conditions is evidenced by the fact that certain types for transmitting applications will carry apparent currents to 50 amperes, at a few megacycles, resulting in only a few degrees temperature rise.

Minimum dielectric heating is very essential since it has been shown that the life expectancy of a capacitor is reduced by a factor of approximately one-half for each ten degree centigrade rise in temperature.

All mica capacitors do not possess the ultimate characteristics of natural mica, since designs and manufacturing procedures differ according to original intent and application. However, the characteristics shown in the table could be realized under ideal conditions.

Characteristic	Approximate or Ideal Value
Dielectric Constant	7 (resulting in a moderate degree of miniaturization)
Q	3000 or greater
Power Factor	0.05% or less
Self Resonant Frequency	Up to 500 megacycles
Insulation Resistance	100,000 megohms or greater
Operating Temperatures	Up to 230°C. (85°C standard for commercial types)
Temperature Coefficient of Capacitance	0 to +70 parts per million per degree centigrade
Capacitance Drift or Capacitance Retrace	0.05% or less

At Sangamo all mica capacitors are designed and manufactured to exceed the physical and electrical requirements of applicable military specifications. The wide variety of Sangamo mica capacitor types allow flexibility of design and superior products for the most critical applications to meet individual specification requirements. Engineering catalog and bulletin giving full information on types and characteristics are available upon request for your examination.

SC59-3

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7-DIGIT REVOLUTION COUNTER
Non-reset. Adds or subtracts 10 counts per shaft revolution. Top-coming or top-going shaft rotation. Totally enclosed in die cast housing. Available sealed; also with adaptor for flexible shaft drive.

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The NBS investigation breaks down this way:

- **Crystal growth and purification studies**—important because solid-state materials are evaluated on the basis of electron and lattice theories. Some results: over 100 crystals of indium antimonide (InSb) have been grown by the Kyropoulos technique; impurities have been reduced to 1 to 10 parts in 10^8 .

- **Electrical property measurements**—conductivity, Hall effect (to distinguish between n- and p-type semiconductors), and thermoelectric-effect measurements are made down to liquid-helium temperatures. Properties vary widely—energy gaps of the important III-V compounds (combinations of elements from the III-B and V-B columns of the periodic table) range from 3.0 to 0.16 ev.

- **Optical measurements**—mainly in the infrared region because of interest in semiconductors as infrared detectors.



Nuclear magnetic resonance investigates the solid state in this rig. Probe holding sample between pole pieces of large magnet, center rear, connects through oscillator circuit in small box, power supply, lock-in detector, and modulator, all in console, to strip-chart recorder. Magnet power supply is at left.

Copper-doped indium antimonide gives fairly large photosignals at liquid-helium temperatures in the far infrared range up to 35 C. N-type InSb with a slight copper impurity shows interesting quenching effects.

- **Carrier lifetime studies**—these lead to critical-value figures.

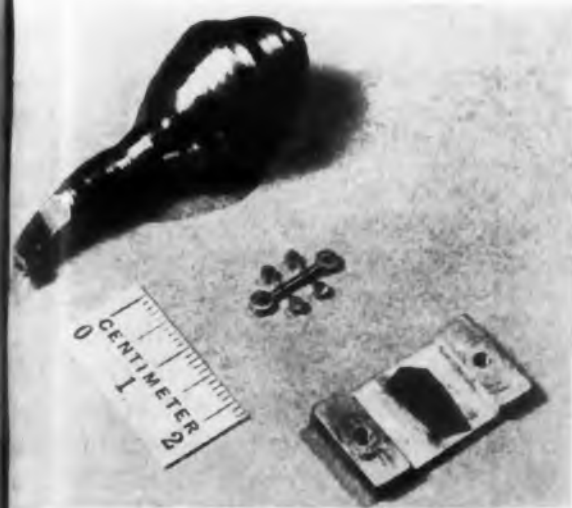
- **Mechanical and electromechanical studies**—resistivity tests of InSb under tensile stress have confirmed its energy-band structure.

The temperature or frequency dependence of mechanical damping often reveals relaxation peaks and attenuations, which relate to impurities. These internal-friction studies have been made on InSb up to its 523 C melting point.

- **Nuclear magnetic resonance**—one of the most useful techniques for studying defects and impurities in semiconductors.



Crystal-growing furnace at the National Bureau of Standards grows crystals by the Kyropoulos technique. Coil surrounds hot vacuum chamber from which metal-coated seed crystal is withdrawn to cool in large crystal form. Zone melting purifies crystal-forming substance.



intermetallic compounds under study include oriented crystal of indium-antimonide, left; cavitron-cut sample of same material prepared for elasto-resistance measurements, center; and specimen of magnesium-tin for optical investigations, right.

Development of theory—new principles are constantly being sought. From studies thus far, the Bureau notes, have come a theory for transport phenomena in a strong magnetic field, and a better understanding of the electronic energy-band scheme of rutile (TiO_2) containing vacancies or impurities.

NBS in Solid-state Research 10 Years

The Bureau of Standards started researching semiconductors in 1949 with studies on the properties of rutile in crystalline form. These evaluations led to improved understanding of the electronic behavior of rutile and to a useful device—the titanium dioxide rectifier.

By 1952 the agency was leading research on a new group of semiconductors—the III-V binaries. Many crystals of aluminum-antimonide, gallium-antimonide, and indium-antimonide were prepared and analyzed. Indium-antimonide proved very promising, and much attention is still being focused on it.

Other materials studied in the last five years are magnesium-tin and semiconducting gray tin.

What of the future? The Bureau plans to continue concentrating on a few materials. TiO_2 will receive particular emphasis in the next year.

“Electrical, optical and magnetic investigations of this material,” the Bureau says, “will provide valuable information concerning the role of impurities in the conduction mechanism.” ■ ■

after routing,
clip and save



Mica is as old as the earth itself. Ancient Hindu writings show that mica was thought to be the remains of lightning flashes from which sparks had emanated and had become preserved in the earth. It was therefore regarded as being endowed with extraordinary properties, and was used in medical ritual. The replacement of such charming stories with modern technical knowledge has, however, not altered the fact that mica is endowed with extraordinary properties.

Mica is found in pegmatite rock, formed in the early stages of the cooling of the earth's mass. Crystals of mica were formed under high heat and pressure, and in the presence of moisture vapor and magnetic fields. The physical and chemical changes during this period served to impart a unique stability in physical, chemical and electrical properties. The chemical structure of mica is represented as $\text{H}_2\text{KAl}_2(\text{SiO}_3)_2$, which is Muscovite; India Ruby is one of the grades of exceptional quality and is used in most mica capacitors. Other types of mica, to name a few, are Phlogopite, Lepidolite and Biotite, of which only Phlogopite is of limited interest in experimental capacitors for very high temperature operation.

Mica is found in varying degrees of purity, some with less mineral or vegetable constituent, or stain, and some with more nearly perfect physical integrity—that is, free from cracks or air inclusions. As a result, raw mica must undergo careful physical examination and be graded according to quality and size. Sangamo has had over 35 years experience in the selection and processing of mica, together with a knowledge of mica capacitor production. Capacitor grades of mica film are generally obtained from the Bihar, Bengal, or Madras provinces of India. Mica for other purposes may be found in Canada, Brazil, Argentina, Madagascar, Africa, Russia, New Hampshire, South Carolina and South Dakota. This list is by no means complete. An idea of the magnitude of the task of selecting suitable mica can be obtained from the fact that only an estimated ten per cent of all the world's mica deposits are suitable for use in mica capacitors.

The earliest mica capacitor was probably made by Matteucci, a contemporary of Faraday's, about 1845. However, capacitors did not become commercially interesting until the advent of radio in the early years of this century, as a result of the growth of electrical technology. Both the electrical and electronics industries have depended significantly upon mica. Mica insulation between commutator segments in rotating machinery and the mica spacers in vacuum tubes are still vital to these industries.

In capacitors, the choice of dielectric material is as important as the method of construction. Mica, because of its sheet form, lends itself to stacked construction, resulting in a lower inductance assembly than can be obtained in wound capacitors. Mica capacitors are therefore suitable for very high frequency operation.

The mechanical or dimensional stability of mica allows blanking or die-cutting of dielectric plates to a desired size with only a very few thousandths of an inch variation. Precise assemblies may therefore be obtained and result in a greater ability to achieve accurate miniaturization. Electrodes may be permanently bonded to the mica dielectric plates by screening on conducting silver paste. This process has been refined to a high degree of accuracy, and results in superior electrical stability when compared to laying foil between mica plates to form the electrodes. Silvered mica

REFERENCE
DATA FILE
Folio 59-3

SANGAMO

a continuing series on technical topics of specific interest to engineers

What makes mica the unique dielectric?

capacitors exhibit exceptional stability in extremes of temperature.

The Q and dielectric constant (therefore, the capacitance) of mica change very little over wide ranges of frequency and temperature. Such small changes are due to the fact that the molecular structure of mica is essentially non-polar—that is, the molecules of mica do not have an unbalanced electrical charge. Thus they are not free to swing freely as magnets do (mica is practically non-magnetic) when in the presence of an electric field. Such fields are present when the capacitor is charged. Movement of the molecules would result in heating by the friction of their motion. Poor dielectrics exhibit considerable heating, as is shown by the heat developed in wood and glue in the process of laminating plywood in dielectric heating devices.

Heating effects may become very pronounced when high frequency alternating voltages are applied. The rapid changes in the direction of current flow cause polar molecules to literally vibrate about their rest position. The low heating of mica under such conditions is evidenced by the fact that certain types for transmitting applications will carry apparent currents to 50 amperes, at a few megacycles, resulting in only few degrees temperature rise.

Minimum dielectric heating is very essential since it has been shown that the life expectancy of a capacitor is reduced by a factor of approximately one-half for each ten degree centigrade rise in temperature.

All mica capacitors do not possess the ultimate characteristics of natural mica, since designs and manufacturing procedures differ according to original intent and application. However, the characteristics shown in the table could be realized under ideal conditions.

Characteristic	Approximate or Ideal Value
Dielectric Constant	7 (resulting in a moderate degree of miniaturization)
Q	3000 or greater
Power Factor	0.05% or less
Self Resonant Frequency	Up to 500 megacycles
Insulation Resistance	100,000 megohms or greater
Operating Temperatures	Up to 230°C. (85°C standard for commercial types)
Temperature Coefficient of Capacitance	0 to +70 parts per million per degree centigrade
Capacitance Drift or Capacitance Retrace	0.05% or less

At Sangamo all mica capacitors are designed and manufactured to exceed the physical and electrical requirements of applicable military specifications. The wide variety of Sangamo mica capacitor types allow flexibility of design and superior products for the most critical applications to meet individual specification requirements. Engineering catalog and bulletin giving full information on types and characteristics are available upon request for your examination.

SC59-3

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Lambda Power Supplies have been the first choice of engineers in every independent poll



The only power supplies guaranteed for 5 years

This unprecedented five-year guarantee is the strongest proof of consistent trouble-free power supply performance ever offered. It is bolstered even further by a series of independent surveys which prove that Lambda equipment is preferred by more than 50% of the engineers who specify power supplies.

CHECK LIST: LAMBDA REGULATED DC POWER SUPPLIES

Model	Style	Voltage Range (VDC)	Current Range (MA DC)	Regulation Impedance Ripple (Table I)	6.3 VAC Output (Amps)	Meters	Output Voltage Control	Output Terminals	Size Weight (Table II)	Price (U.S. and Canada) F.O.B. Factory College Pt., N. Y.
REGULATED POWER SUPPLIES—RACK MOUNTING										
TRANSISTORIZED										
LT-1095	Rack	0-32	0-1000	A	—	None	Rear	Rear	S-1	285.00
LT-1095M	Rack	0-32	0-1000	A	—	2 1/2" rect	Rear	Rear	S-1	315.00
LT-2095	Rack	0-32	0-2000	B	—	None	Rear	Rear	S-1	365.00
LT-2095M	Rack	0-32	0-2000	B	—	2 1/2" rect	Rear	Rear	S-1	395.00
TUBE REGULATED										
C-200	Rack	0-200	0-200	C	10A	None	Rear	Rear	S-2	184.50
C-200M	Rack	0-200	0-200	C	10A	3 1/2" rect	Rear	Rear	S-2	214.50
C-201	Rack	125-325	0-200	C	10A	None	Rear	Rear	S-2	159.50
C-201M	Rack	125-325	0-200	C	10A	3 1/2" rect	Rear	Rear	S-2	189.50
C-202	Rack	325-525	0-200	C	10A	None	Rear	Rear	S-2	169.50
C-202M	Rack	325-525	0-200	C	10A	3 1/2" rect	Rear	Rear	S-2	199.50
C-400	Rack	0-200	0-400	O	15A	None	Rear	Rear	S-2	259.50
C-400M	Rack	0-200	0-400	O	15A	3 1/2" rect	Rear	Rear	S-2	289.50
C-401	Rack	125-325	0-400	O	15A	None	Rear	Rear	S-2	244.50
C-401M	Rack	125-325	0-400	O	15A	3 1/2" rect	Rear	Rear	S-2	274.50
C-402	Rack	325-525	0-400	O	15A	None	Rear	Rear	S-2	259.50
C-402M	Rack	325-525	0-400	O	15A	3 1/2" rect	Rear	Rear	S-2	289.50
C-800	Rack	0-200	0-800	E	20A	None	Rear	Rear	S-3	340.00
C-800M	Rack	0-200	0-800	E	20A	3 1/2" rect	Rear	Rear	S-3	370.00
C-801	Rack	125-325	0-800	E	20A	None	Rear	Rear	S-3	315.00
C-801M	Rack	125-325	0-800	E	20A	3 1/2" rect	Rear	Rear	S-3	345.00
C-802	Rack	325-525	0-800	E	20A	None	Rear	Rear	S-3	360.00
C-802M	Rack	325-525	0-800	E	20A	3 1/2" rect	Rear	Rear	S-3	390.00
C-1500	Rack	0-200	0-1500	F	30A	None	Rear	Rear	S-4	550.00
C-1500M	Rack	0-200	0-1500	F	30A	3 1/2" rect	Rear	Rear	S-4	580.00
C-1501	Rack	125-325	0-1500	F	30A	None	Rear	Rear	S-4	575.00
C-1501M	Rack	125-325	0-1500	F	30A	3 1/2" rect	Rear	Rear	S-4	605.00
C-1502	Rack	325-525	0-1500	F	30A	None	Rear	Rear	S-4	650.00
C-1502M	Rack	325-525	0-1500	F	30A	3 1/2" rect	Rear	Rear	S-4	680.00
20	Rack	200-325	0-100	G	3A	None	Rear	Rear	S-5	59.50
20M	Rack	200-325	0-100	G	3A	3 1/2" rect	Rear	Rear	S-5	89.50
29	Rack	100-200	0-100	H	3A	None	Rear	Rear	S-5	69.50
29M	Rack	100-200	0-100	H	3A	3 1/2" rect	Rear	Rear	S-5	99.50
32	Rack	200-325	0-300	J	2 @ 5A	None	Rear	Rear	S-6	139.50
32M	Rack	200-325	0-300	J	2 @ 5A	3 1/2" rect	Rear	Rear	S-6	169.50
33	Rack	100-200	0-300	J	2 @ 5A	None	Rear	Rear	S-6	154.50
33M	Rack	100-200	0-300	J	2 @ 5A	3 1/2" rect	Rear	Rear	S-6	184.50
50R	Rack	0-500	0-500	K	2 @ 5A	4 1/2" rect	Front	Fr & rear	S-7	420.00
		0-50	Bias	L						
		0-200	High Imped.	M						
REGULATED POWER SUPPLIES—PORTABLE AND BENCH										
25	Bench	200-325	0-100	G	3A	None	Front	Front	S-8	69.50
28	Bench	100-200	0-100	H	3A	None	Front	Front	S-8	79.50
50	Bench								S-9	440.00
										See Model 50R above
71	Portable	0-500	0-200	N	2 @ 5A	3 1/2" rect	Front	Front	S-10	310.00
		0-50	Bias	P						
		0-200	High Imped.	Q						

TABLE I
DC OUTPUT VOLTAGE REGULATION,
IMPEDANCE, RIPPLE

REGULATION	Internal Impedance (ohms)		Ripple, rms (millivolts or %)
	Line (105-125 VAC)	Load (min to max)	
Less than	Less than	Less than	Less than
A	0.15% or 20MV	0.15% or 20MV	0.50 1 mv
B	0.15% or 20MV	0.15% or 20MV	0.025 1 mv
C	0.15% or 0.3V	0.25% or 0.5V	6 3 mv
D	0.15% or 0.3V	0.25% or 0.5V	3 3 mv
E	0.15% or 0.3V	0.25% or 0.5V	1.5 3 mv
F	0.15% or 0.3V	0.25% or 0.5V	0.75 3 mv
G	1%	1%	10 10 mv
H	1%	1%	10 5 mv
J	1%	1%	4 10 mv
K	0.15% or 0.1V	0.5% or 0.3V	2 8 mv
L	0.1%	unregulated	3,300 2 mv
M	0.1%	unregulated	17,500 5 mv
N	0.15% or 0.3V	0.15% or 0.3V	4 5 mv
P	0.1%	unregulated	5,500 2 mv
Q	0.1%	unregulated	25,000 5 mv

TABLE II
SIZES AND WEIGHTS

Size	H x W x D (inches)	WEIGHT	
		Net (lbs)	Shipping (lbs)
S-1	3 1/2 x 10 x 14%	35	65
S-2	5 1/4 x 10 x 14%	53	80
S-3	7 x 10 x 14%	84	100
S-4	8 3/4 x 10 x 14%	120	140
S-5	5 1/4 x 10 x 8	18	23
S-6	10 1/2 x 10 x 9 1/4	42	52
S-7	10 1/2 x 10 x 14%	88	140
S-8	8 x 14 x 6	18	23
S-9	12 1/2 x 22 x 15	110	150
S-10	13 x 8 1/4 x 14 1/2	48	85

GENERAL SPECIFICATIONS

Sufficient tolerance is incorporated in the specifications to allow for normal commercial component and tube deviations. Tube replacements may be made with any equivalent tubes meeting E.I.A. specifications.

INPUT 105-125 VAC, 50-60 CPS, single phase. Exceptions: Models 50, 50R and 71 — 105-125 VAC, 50-60 CPS.

DC OUTPUT Voltage Range: Continuously variable over ranges specified, except where otherwise noted.

Current Range: The current ranges given apply to the entire DC output voltage range, and for input voltages from 105 to 125 VAC. No "de-rating" is necessary.

Polarity: Either positive or negative terminal may be grounded.

AC OUTPUT The AC output is unregulated, isolated and ungrounded. It has a value of slightly higher than 6.3 V

(when fully loaded) at an input of 115 VAC. This value allows for voltage drop in connecting leads. Dual outputs may be connected in series or parallel.

DUTY CYCLE Continuous duty at full load.

METERS Where meters are indicated, a separate voltmeter and milliammeter are provided.

OVERLOAD PROTECTION Ample protection is provided against external overload and internal failure conditions by means of fuses.

Circuit breakers of the magnetic, "trip-free" type are employed in Models 50, 50R, 71 and LT series as protection against external overloads. And in the LT series, the transistor complement is independently protected by special transistor circuitry.

STYLE Rack Models are designed for mounting on standard 19" relay racks.

Bench Models are provided with compact, specially-designed, ventilated cabinets equipped with carrying handles. The power supply units may be removed from their cabinets for mounting in standard relay racks (except Models 25, 26 and 71).

RATINGS AND COMPONENTS All components used are of the highest quality and are operated well within manufacturers' ratings. Hermetically-sealed, oil-filled capacitors are used exclusively, except in LT series, where special high purity foil, long-life electrolytics are used. "C" and "LT" series power supplies use hermetically-sealed magnetic components exclusively. Ample safety factors are provided in the design to insure the long life, and the dependable, trouble-free operation so desirable in industrial and laboratory applications.

All specifications and prices subject to change without notice.



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NEWS

Radio Parley Eyes Moon

A radar-equipped satellite may give man his first accurate knowledge of the depth of the moon's surface layer. The technique involving calculation of the power-reflection coefficient at different wave lengths, was among ideas presented at a three-day conference in Washington this month of Union Radio Scientifique Internationale (U.R.S.I.).

W. Fensler, T. Senior and K. Seigel, of the Radiation Laboratory, University of Michigan, proposed the moon-measuring method. They showed that the power-reflection coefficient would be a function of the number and depth of lunar layers and of the electromagnetic constants associated with them. Calculations would be telemetered to earth by the satellite.

In another discussion, V. Eshleman, P. Gallagher and R. Barthele reported that moon echoes could be used to determine cislunar ion densities. Working at Stanford University, the three have been investigating the ionized medium between the earth and the moon, with prime interest in the density beyond the ionosphere.

Predictions of the performance of radio propagation paths through the use of meteorological parameters were described by L. G. Abraham. He analyzed radio and weather data for a year on a propagation link from Bedford, Mass., to General Electric's Research Lab at Schenectady, N.Y. Water-vapor content and stability index were found to be the most significant meteorological variables.

J. Holladay and K. Wright of Collins Radio Co., Cedar Rapids, Iowa, showed the effect of antenna height on transmission over a 172-mile scatter circuit. In their investigation, a 15-foot parabolic antenna was moved from ground level to 200 feet above ground and compared with a second 15-foot antenna on the ground. The results showed no decrease in transmission loss because

of increased antenna height.

A paper presented by Robert Coates described measurements of lunar radiation being conducted by the Naval Research Laboratory with a 10-foot parabolic antenna and a Dicke-type radiometer. Many scans have been made across the moon at different times of the lunar month. These records are asymmetric, and the amount of asymmetry is a function of the phase of the moon. The sunlit part of the moon surface is considerably lighter at 4.3 mm than the dark part, Mr. Coates noted. The difference between light and dark areas is more pronounced at 4.3 mm than at 8.6 mm wave length.

Looking into the future, Dr. Lloyd V. Berkner told the conference that radio-relay satellites might soon make it possible to telephone any part of the world for 20 cents. The satellite would revolve around the earth at an altitude of 22,700 miles. Two billion phone messages a year could be handled, Dr. Berkner said. He divided the 20-cent charge this way: 10 cents for the ground end of the call and 10 cents for satellite relay.

Hermetic Heat Sealing

Transistors, diodes, relays and crystals can be sealed in five to seven seconds by localized rf heating using new machinery designed to seal glass-to-glass, glass-to-metal, and metal-to-metal.

Developed by Hermetic Seal Corporation, the equipment eliminates soldering or projection welding and completely seals components in one-fifth of normal time.

Correction

Credit for development of the Satellite Tape Recorder, which appeared in the News section (ED, Apr. 15, p. 17) was given to Minnesota Mining and Mfg. Co. The corrected credit should be given to John Licht, scientist, U. S. Army Signal Research and Development Laboratory, Fort Monmouth, N.J., for the design and development of the recorders.



Transistor Engineer Wanted, To Head Laboratory, Italy



olivetti

Olivetti (Italy) has established a subsidiary in Milan for the production of silicon and germanium transistors and diodes.

It is now looking for the right person to head the existing development laboratory.

These are the requirements: (1) At least 5 years experience in transistor development

(2) Degree of Master of Science in Physics

(3) Willingness to move to Italy and learn Italian.

It would be desirable if you were familiar with present applications and future potentialities of transistors and diodes, in order to contribute actively to the general policy of the new firm.

Salary will be commensurate with experience and ability. Transportation and moving expenses will be paid.

Written replies will be sent to all applicants.

Chosen candidates will be invited for a personal interview in New York City, expenses paid.

Please write, enclosing detailed resume, to Project

T. D. L., Olivetti, Ivrea, Italy.

WASHINGTON REPORT



Ephraim Kahn

Weapons System Concept under Investigation

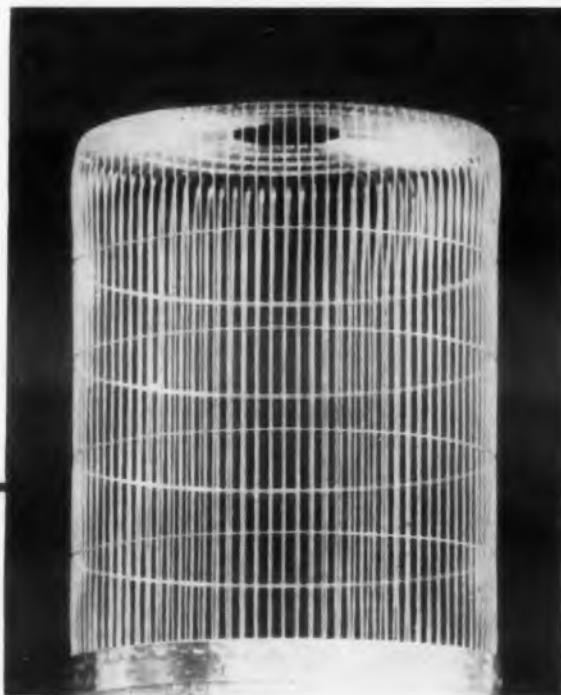
The weapons system concept, which is basic to a large proportion of government purchases of electronics, is being given a rough going-over by the Congress. Regardless of its merits as a method of producing military end-items, it has become a political football. Hostility to the weapons system as a way of doing business has long been a staple of the Small Business Committees of the Congress. These groups do not, however, have the power to recommend new laws, though individual members may introduce bills that reflect committee activity.

Dissatisfaction with present military buying practices has also been expressed by the General Accounting Office and a number of members of the Hebert (D., La.) Subcommittee of the House Armed Services Committee, which has made a special investigation of the weapons system concept. Chairman Hebert is "persuaded more and more that the weapons system concept is nothing new," and that it is a "job the government should have been doing in the past but was not doing." Now, he says, "it's being shifted to private industry, while keeping the same number of people at the Pentagon."

Much Congressional criticism is keyed to the notion that procurement under weapons system contracts results in inadequate cost control, particularly in regard to second-tier subcontracts. Congressman Porter Hardy, Jr. (D., Va.) wonders what are the "incentives to keep prices down." As he sees it, there is a "gain" for the prime contractor "when the subcontractor's price goes up."

Sharpest criticism of weapons system procurement was made by the General Accounting Office. Since this agency carries a great deal of weight with Congress, its opinion may well tip the scales against enactment of the bill introduced by Senator Saltonstall (R., Mass.) which is supported by the EIA. The Saltonstall bill, S. 500, is designed to give the military greater flexibility in contracting. Its objective is to cut lead-time in design and development of ad-

platinum clad tungsten wire is most efficient for high temperature applications



Platinum clad tungsten wire is ideally suited to modern requirements for high power vacuum tube grid and other high temperature applications. Because of its superior physical properties at elevated temperatures, tungsten provides the more rigid, refractory core material required by high power tubes; it also exhibits lower interaction with platinum. Unlike molybdenum, platinum clad tungsten is readily hot-stretched to take a permanent setting and lends itself to fabrication into grids employing conventional fixtures and spot welding procedures. Available in diameters from .001" and up. Write for Technical Bulletin.

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The Deoxo Catalytic Purifier is combined with an extremely efficient automatically operated drying unit to provide oxygen-free hydrogen that is ideally pure and dry. The combined units are identified as the Deoxo Dual Puridryer. It supplies hydrogen with less than one part oxygen per million — dried to a dew point of -100°F . No inert gas purging is needed. The Deoxo Dual Puridryer can also be used with other gases such as: Nitrogen, Argon, Helium and saturated hydrocarbons, with equally fine performance. Write for descriptive literature.

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DIVISION

vanced and complex weapons. In the interest of speed, it would allow the military to resort more often to procurement through a single commercial manager, erase legal distinctions between purchases by bid and by negotiation, and exempt from renegotiation specified contracts.

GAO sees grave perils in the Saltonstall bill, including "a real danger" that it might aggravate the problems it is intended to cure. If all "operational systems" were placed under weapons-system-type contract, GAO thinks that the entire national defense might become dependent on the "skills, integrity, and business acumen" of a limited number of companies. "Without questioning the integrity of industry," GAO believes "that a contractor without real competition could become complacent and could allow itself to become so concerned primarily with matters of major interest only to its own organization that such matters as delivery time, quality of product, and emergency needs of the government would become of secondary concern."

A number of other serious objections to greater use of weapons system contracting were also raised by GAO. Among them: (1) danger that potential competitors might be denied subcontracts by the prime contractor, which could tend toward monopoly and dominance of the prime contractor in any given area of weaponry. (2) Impairment of the Military Services' ability to perform their missions if the operational system contractor acquired so much delegated authority that the military became excessively dependent. (3) Less ability on the part of the government to exercise control over such items as operational capability and quality, since government engineers and scientists would be inclined to move over to the private firms that would be responsible for actual design, development, and production. (4) Absence of stiff controls over contracting would not provide an incentive for low-cost and efficient production.

Advertised competitive bidding, says the GAO, should be used in government procurement except when it is "impracticable or against the public interest." In fact, GAO believes "that the only way to be certain supplies or service are being offered at truly competitive prices is to obtain full and free competition," since "supplies and services which are susceptible of procurement by formal advertising will, overall, be obtained at substantially lower prices on that basis." This phrasing, of course, leaves open the possibility of negotiated contracts.

Design and development of new weapons was found by GAO to justify the use of performance specifications in contracting. The Saltonstall bill would encourage the use of performance specifications.

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MEETINGS

Calendar of Events

June

- 1-3 IRE-PGMITT National Symposium, Paine Hall, Harvard University, Cambridge, Mass.*
- 1-3 National Symposium in Microwave Theory and Techniques (IRE), Cambridge, Mass.
- 3-5 Armed Forces Communications and Electronics Association Annual Meeting, Washington, D.C.
- 4-5 Third National Conference on Production Techniques (IRE), San Mateo, Calif.
- 8-11 Semi-annual Meeting, American Rocket Society, San Diego, Calif.
- 10-12 Second International Symposium on Gas Chromatography (ISA), East Lansing, Mich.
- 14-18 American Society of Mechanical Engineers, Semi-annual Meeting, Chase-Park Plaza Hotel, St. Louis, Mo.
- 15-18 Summer Meeting, Institute of Aeronautical Sciences, Los Angeles, Calif.
- 15-20 First International Conference on Information Processing, Paris, France*
- 15-20 Symposium on Electromagnetic Theory, Univ. of Toronto, PGAP, URSI, University of Toronto, Ont., Canada
- 16-18 International Symposium on Circuit and Information Theory (IRE), Los Angeles, Calif.*
- 17-20 1959 Engineering Progress Exposition, National Society of Professional Engineers, Hotel Commodore, New York City, N.Y.
- 17-27 International Plastics Exhibition, London, England
- 21-26 Summer and Pacific General Meeting AIEE, Olympia Hotel, Seattle, Wash.
- 22-26 ASEE-ASTM Symposium on Education in Materials, Atlantic City, N.J.
- 24-26 Second Nuclear Instrumentation Symposium, Idaho Falls, Idaho
- 24-28 International Conference on Medical Electronics, UNESCO, Rockefeller Institute, IRE-PGME, Paris, France
- 29-1 National Convention on Military Electronics (IRE), Washington, D.C.*

* Indicates meetings described herewith.

1959 IRE National Symposium, June 1-3.

Sponsored by PGMITT, Paine Hall, Harvard University, Cambridge, Mass. Papers to be presented include those on microwave amplifiers, phase shifters, and filters. Another group includes microwave research in Japan, various universities, and industrial laboratories. An evening session involves a visit to the Cambridge Electron Accelerator. Other topics cover masers, analytical technical techniques, ferrites, variable reactance diodes and their use in parametric amplifiers. Arrangements can be made through W. H. From, Ewen Knight Corp., 206 A Street, Needham, Mass. Registration fee is \$3.00 for IRE members, \$5.00 for non-members, students, free. Ladies program included.

COAX HYFEN CONNECTORS

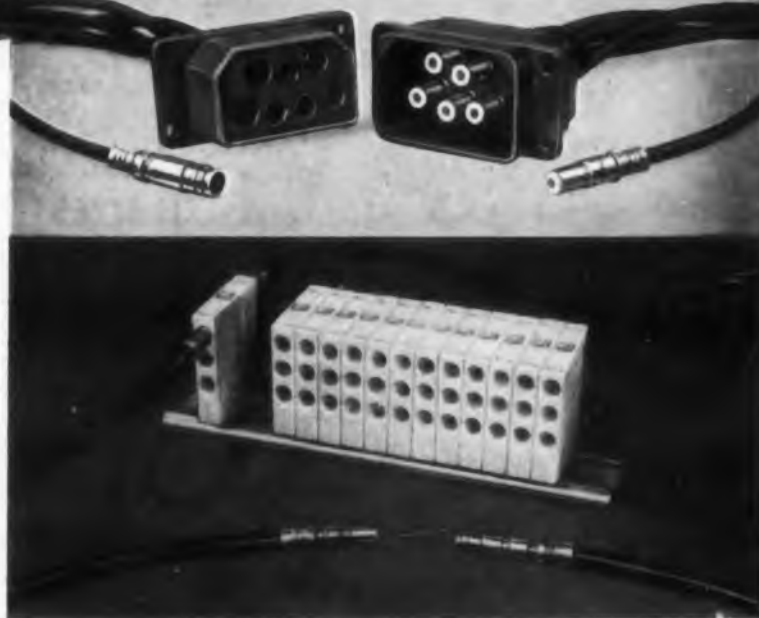
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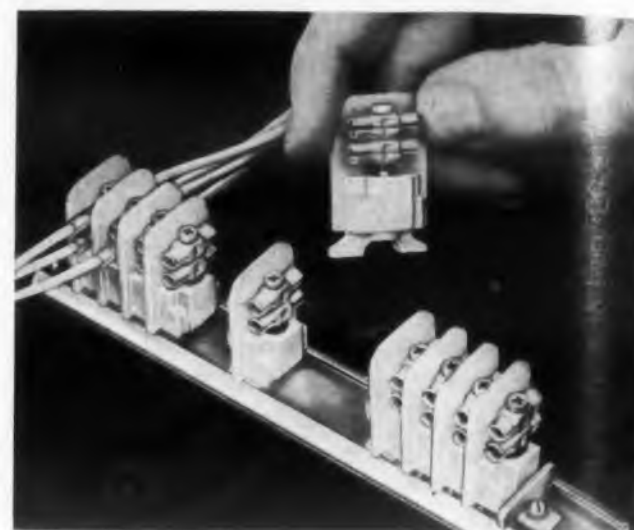
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Toronto, Canada

NEW PRODUCT

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The Burndy Corporation, Omaton Division, has available for immediate delivery its new terminal block development, the MODULOK,[®] which employs the principle of crimp-type, snap-in contacts, combined with the convenience and versatility of modular design. Individual modules, molded of Zytel 31, a nylon compound having extremely low water absorption characteristics, can be snapped together or apart. These modules are inserted into separate steel tracks up to 32 inches in length, and are secured in place by end locks. Although new, MODULOK has already found application in early warning systems, missile ground control systems, and associated fields.

Modules are available with either 2 or 4-tier spring-loaded sockets which may be set for quick-disconnect for rapid ring-out, bussing, or circuit changes. A twist of a screwdriver transforms the quick-disconnect into a permanent connection. Up to 30 modules per foot of track can be accommodated. The unique spring-loaded, cup-shaped sockets exert continuous, uniform pressure in either position. Contact tips are the solderless crimp-type applied to wire ends.

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CIRCLE 17 ON READER-SERVICE CARD

ELECTRONIC DESIGN • May 27, 1959

EDITORIAL

Technical Seminars on Tour

There are a growing number of electronic component and instrument manufacturers who are conducting technical seminars for customer-engineers.

Many such seminars have been held before in conjunction with national conventions. Companies take a hotel suite and invite engineers to attend lectures put on every hour or so. The latest trend is for a company to put on a one-day course in the vicinity of a customer's plant. Magnetics Inc. of Butler, Pa., has pioneered very successfully in this area. We have attended several of their seminars in New York City and therefore speak with enthusiasm. Edgerton, Germeshausen & Grier, Inc. have recently completed a second annual technical seminar.

Spectrol Electronics Corporation has announced a nationwide tour beginning June 1 to demonstrate the application of electro-mechanical assemblies and solid-state devices to electronic equipment. Spectrol plans to conduct 45-minute technical meetings followed by question and answer periods. Evening programs have been held by William Brand & Co. for engineers in various areas. Mycalex Corporation of America has conducted day-lectures at over a dozen giant electronic companies across the country.

In the face of the ever increasing number of regional and national technical meetings put on by professional groups and of the sectional meetings put on by these groups, one would think engineers would become over-saturated with knowledge.

There is one important distinction. Seminars put on by companies are at a down-to-earth practical level. They are designed to give engineers information that can be put to use immediately. These seminars are not broad surveys or disclosures of recent development work.

If the company's lecturers are at all skilled, the technical seminar should be a very useful and helpful service.

We have long been convinced that equipment design engineers have not taken advantage of knowledge possessed by manufacturers of components and instruments. There is no sure answer as to just how they can get this knowledge efficiently. The technical seminar, however, looks like a good approach.

James G. Kopp

LEFT: STUD 7/16—11/16
CENTER: AXIAL LEAD TOP HAT
RIGHT: STUD INSULATED

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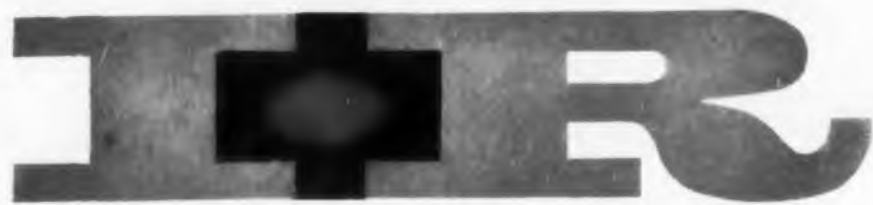
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Evaluating . . .

Infrared Photon Detectors

Fred Rosell

General Electric Co.
Light Military Electronics Dept.
Advanced Electronics Center, Ithaca, N. Y.

Infrared photon detectors are becoming available to systems designers in increasing numbers. But performance data for these detectors is often scanty. This article reviews responsivity, noise equivalent power, detector noise considerations, and suggests some approaches when data is lacking.

PROPER choice of an infrared detector depends on the application at hand and the conditions of use so that no single "figure of merit" exists. For instance, the systems designer must consider the target's radiant power, the transmission of the atmosphere, typical backgrounds which will be encountered, the scanning method employed. Therefore, the best he can do is to consider each detector independently in view of the systems application. To this end, certain detector parameters are furnished by the detector manufacturer and certain others should be furnished but are not. To make an intelligent detector

PHOTON DETECTORS differ from thermal detectors in that their response is proportional to the number of photons incident upon them rather than the total energy. In photon detectors, electrons are optically excited by the absorption of photons, while in thermal detectors, a quantity of heat changes one of its properties, such as its resistance.

choice, the system designer must understand these parameters and make extrapolations where the data does not exist.

Detector Parameters

In the design of infrared systems, the designer needs a rather complete knowledge of the detector. The following data should be available at the beginning of system synthesis:

- The responsivity of the radiation detector as a function of spectral wavelength and modulating frequency.
- The complete noise energy density spectrum generated by the detector including its dependence on cell parameters such as area, geometry, temperature, impedance, etc.
- Practical consideration such as impedance levels encountered, biasing levels, polarization effects, etc.

Where the above data is available, the performance of the detector in any detector noise limited system can be predicted quite accurately. Even where some data is missing, one can make estimates based on the most likely results to be expected with the data given.

Responsivity

The function of an infrared detector is to convert an infrared radiation signal incident upon

it to an electrical signal suitable for electronic processing. For various reasons, the radiation signal is generally chopped or modulated prior to detection so that the electrical signal is time varying. In addition to its time varying properties, the infrared electromagnetic radiation has some spectral distribution associated with it. The response of the detector is a function of the wavelength of this incident radiation as well as its time varying properties. Since both time varying electrical signals and electromagnetic infrared radiation have wavelength and frequency associated with them, it is customary to differentiate between them by speaking of the wavelength of infrared radiation λ and the frequency of electrical signals f .

Under specific test conditions, the transfer function of a given detector may be written:

$$R_o(\lambda, f) = \frac{V_o(\lambda, f)}{W_o(\lambda, f)} \frac{\text{Volts}}{\text{Watt}} \quad (1)$$

where V_o refers to the electrical voltage out of the detector and W_o refers to the incident radiation. $R_o(\lambda, f)$ is also referred to as responsivity. These relationships are shown schematically in Fig. 1. Most photoconductors may be characterized by a single time constant in the spectral wavelength region of interest, and this time constant is independent of spectral wavelength. If

this be the case, either wavelength or frequency dependence can be integrated out. For example,

$$R_o(f) = \int_0^{\infty} R_o(\lambda, f) d\lambda \quad (2)$$

and

$$R_o(\lambda) = \sqrt{\int_0^{\infty} |R_o(\lambda, f)|^2 df} \quad (3)$$

The method of integrating differs for the two cases because infrared radiation is usually given in terms of power per unit wavelength (watts/micron), while electrical signals are specified in terms of a Fourier energy density.

The integration in the latter case is then an application of the Fourier integral energy theorem. This integration with respect to frequency does not take place within the detector but rather, in the electronic equipment following it. Consequently, this form is rather artificial. Actually, the detector integrates with respect to λ and with this assumption, the block diagram of the detector can be drawn as in Fig. 2. This block form is more representative of the actual detector. However, it is sometimes convenient to speak of response to monochromatic radiation and therefore the integration represented by Equation 3 is sometimes convenient in analysis.

Since the detector can usually be characterized by a single time constant, the frequency response function $R_o(f)$ can be written:

$$R_o(f) = \frac{R_o(0)}{1 + j2\pi f\tau} \quad (4)$$

or

$$R_o(f) = \frac{R_o(0)}{[1 + (2\pi f\tau)^2]^{1/2}} \quad (5)$$

Note that for frequencies small with respect to $1/2\pi\tau$, $R_o(f)$ is approximately equal to $|R_o(0)|$ and above this frequency $|R_o(f)|$ is about equal to $|R_o(0)|/2\pi f\tau$. The frequency $1/2\pi\tau$ is often called the crossover frequency.

Signal to Noise Considerations

One of the distinguishing features of military infrared systems is that one must often work close to the detector noise level. The noise generated within a detector is a function of frequency and the bandwidth of measurement. If an ideal filter is used for measurement, the rms noise voltage V_n is given by:

$$V_n = \left[\int_{f_1}^{f_2} |V_n(f)|^2 df \right]^{1/2} \quad (6)$$

where $V_n(f)$ is the noise energy spectrum. The rms electrical signal due to monochromatic incident radiation can be calculated:

$$V_s(\lambda) = \left[\int_{f_1}^{f_2} |R_o(\lambda, f) \cdot W_s(\lambda, f)|^2 df \right]^{1/2}$$

In specifying detector performance, it is customary to modulate the radiation of a frequency well below the crossover frequency so that

$$V_s(\lambda) = R_o(\lambda, 0) \left[\int_{f_1}^{f_2} |W_s(\lambda, f)|^2 df \right]^{1/2}$$

With this simplification, the rms signal to rms noise ratio at the detector's output terminals may be written

$$\frac{V_s(\lambda)}{V_n} = \frac{R_o(\lambda, 0) \left[\int_{f_1}^{f_2} |W_s(\lambda, f)|^2 df \right]^{1/2}}{\left[\int_{f_1}^{f_2} |V_n(f)|^2 df \right]^{1/2}}$$

In this equation, it is assumed that the noise is generated within the detector and is not due to fluctuations in incident radiation. In the event that radiation noise is limiting, the noise voltage would be a function of detector responsibility, which in turn is a function of both frequency and spectral wavelength.

Noise Equivalent Power

A most important conception in detector comparison is that of Noise Equivalent Power, or NEP. NEP is defined as the rms radiant energy, measured in watts, which is incident upon the detector and results in an rms signal to rms noise ratio of unity at the detector's output terminals. This quantity is also called minimum detectable power. An analytical expression for NEP can be obtained from equation (9) by setting $V_s(\lambda)/V_n$ equal to unity and solving for the rms radiant power:

$$NEP(\lambda, \Delta f) = \left[\int_{f_1}^{f_2} |W_s(\lambda, f)|^2 df \right]^{1/2}$$

when $\frac{V_s}{V_n} = \text{unity}$

$$= \frac{\left[\int_{f_1}^{f_2} |V_n(f)|^2 df \right]^{1/2}}{R_o(\lambda, 0)} \quad (10)$$

where $\Delta f = f_2 - f_1$. This equation holds only for a particular detector at a given temperature, bias current, detector geometry and for frequencies below crossover. It can be seen that if the complete noise spectrum and responsivity is given, the detector's NEP is determined for the partic-

ular detector. For other detectors of the same kind and under similar operating conditions, it is usually found that NEP is a function of detector area. The exact relationship must be known for accurate design, but if it is not given, it is customary to assume the square root of detector area. Thus, one can to a certain extent normalize NEP to unit area as follows

$$NEP'(\lambda, \Delta f) = \frac{NEP(\lambda, \Delta f, A)}{A^{1/2}} \text{ measured} \quad (11)$$

Also, NEP is sometimes normalized to unit bandwidth by assuming that the rms noise depends on the square root of bandwidth, thus

$$NEP'(\lambda) = \frac{NEP(\lambda, \Delta f, A)}{A^{1/2} (\Delta f)^{1/2}} \text{ measured} \quad (12)$$



Fig. 1. Block diagram representation of an infrared detector.



Fig. 2. Alternate block diagram representation with radiation wavelength dependence integrated.

This bandwidth normalization will be further discussed. As can be noted, the smaller NEP is, the better the detector. Some authors prefer to use the inverse of NEP which is then called Detectivity.¹ This has the advantage that the larger the Detectivity, the better the detector.

Detector Noise

For purposes of infrared detector comparison, it is customary to consider only noise generated within the detector itself. This noise spectrum is usually complex and varied. Some of the common noises encountered are Johnson or "resistor" noise, contact noise, current noise, and generation-recombination noise. For accurate description of detector performance, the complete noise spectrum must be available and usually is not. In these cases, one must make approximations.

(Continued on page 24)

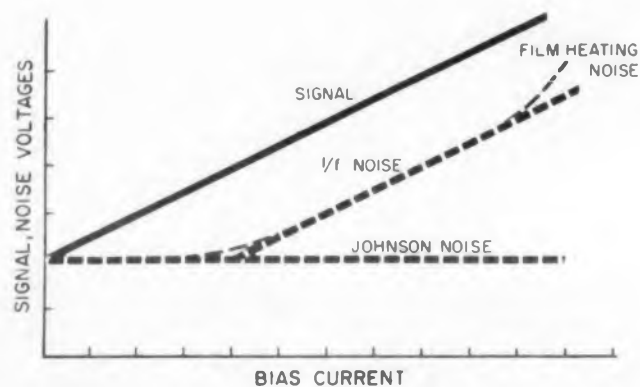


Fig. 3. Effect of increase of bias current on low frequency signals and noise voltages. Detector heating starts after the plateau has been reached for many photoconductors.

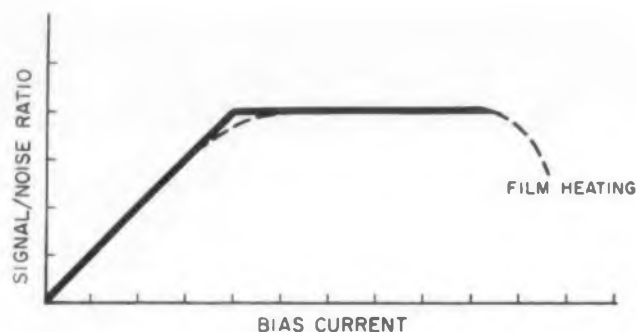


Fig. 4. Effects of increasing bias current on low frequency signal-to-noise ratios for many photoconductors.

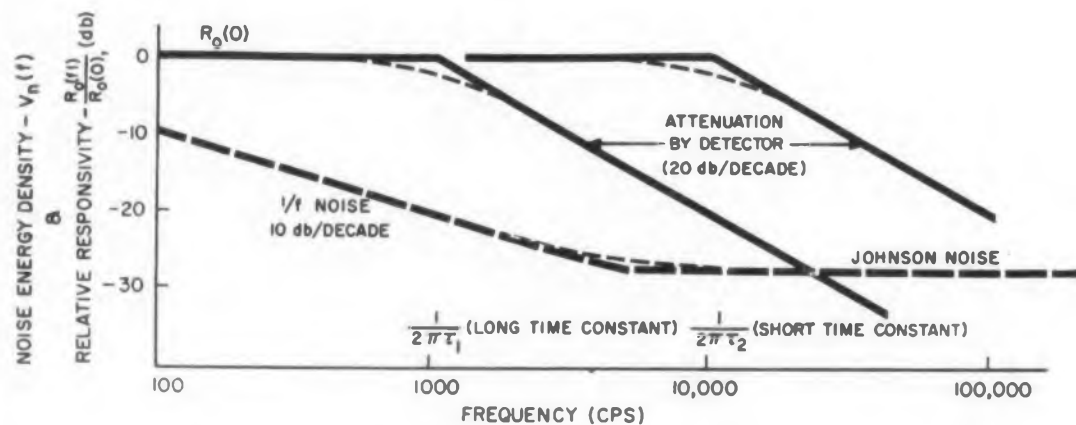


Fig. 5. Responsivity and noise energy density for long & short time constant detectors. Slopes of the curves are shown in db per decade.

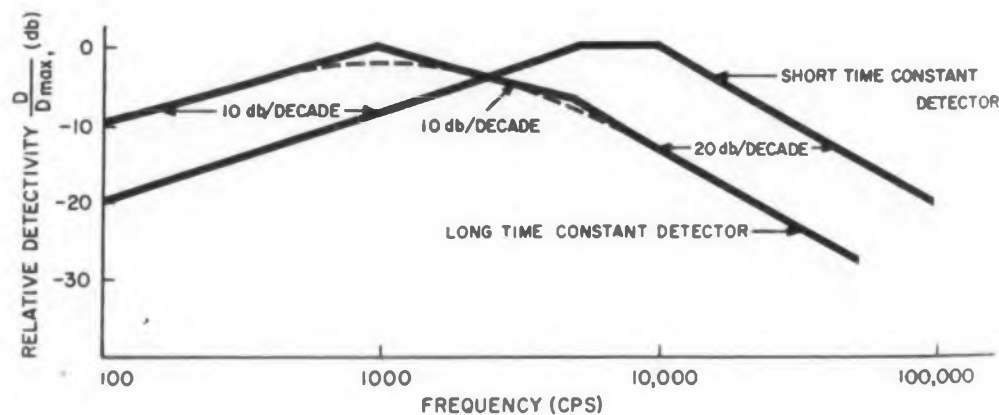


Fig. 6. Detectivity for the two detectors in Fig. 5. Slopes of the curves are shown in db per decade.

Generally, it will be found that two types of noise are dominant, a low frequency noise which decreases with frequency, and a high frequency noise which, for practical purposes, is uniform with frequency. The former noise is usually bias current dependent, the noise power decreasing inversely with frequency. Even where no bias current exists, as in photovoltaic detectors, some such low frequency noise is noted. In these cases, the noise is generated at contacts, across semiconductor junctions, etc. However, in these cases, the $1/f$ noise power generally falls below Johnson noise quickly; at frequencies as low as 1 kc.

If the low frequency noise spectrum is bias current dependent, the bias current is usually increased to as large a value as is possible. The advantage in doing so is that while the noise power increases signal power increases at the same rate. On the other hand, current independent noises do not change and therefore their effective contribution can be reduced. This effect is illustrated in Figs. 3 and 4. Note that as bias current is increased, the signal-to-noise ratio or Detectivity reaches a plateau and remains at this level until photoconductor heating takes place.

With most photoconductors, a current noise decreasing with frequency dominates at frequencies below 5 and 10 kc and is essentially flat thereafter. However, with some of the newer photoconductors, the current noise drops below flat noise at frequencies below 1 kc even when biased. In the case of lead sulfide, the bias current can usually be adjusted that only current noise need be considered to frequencies well beyond the crossover frequency. For some of the newer photoconductors with very short constants, current noise will drop below the white noise spectrum before the crossover frequency is reached. While it is somewhat risky to assume that the high frequency noise spectrum is due to Johnson noise, this is probably the best one can do without more specific information.

The optimum use of a detector hinges on the

noise characteristic. With lead sulfide detectors the signal frequency response is approximately uniform to the crossover frequency, and signal power drops at a $1/f^2$ rate thereafter. Noise power drops at a $1/f$ rate to well beyond the crossover frequency. At low frequencies then, signal to noise power ratio improves with frequency at a $1/f$ rate out to the crossover frequency and then drops at a $1/f$ rate.

In contrast, for fast detectors, it is advantageous to increase the chopping rate to the point where $1/f$ noise drops below the white noise spectrum. No further improvement is realized until you reach the crossover frequency when the signal to noise power ratio drops at $1/f^2$. These relationships are illustrated graphically in Figs. 5 and 6.

A complete noise spectrum of the detector is desirable. If this cannot be obtained, the designer should get at least one measurement of NEP at low frequencies and one at high frequencies and some notion of where current noise drops to the high frequency value of noise. In the worst case where only a low frequency NEP is quoted, one should assume that the detector noise drops to Johnson Noise at a fairly low frequency to be conservative. With a liberal adjustment in NEP accounting for the fact that production detectors will seldom meet the performance of laboratory specials, the result should not be greatly in error.

Very often, detectors are specified in terms of Jones " S_J " which is defined as follows:

$$S_J = \frac{NEP(\lambda, A, \Delta f)_{measured}}{A^{1/2} \ln(f_2/f_1)}$$

Jones " S_J " is derived² for, and is particularly appropriate for detectors with a $1/f$ noise power spectrum and whose NEP is square root of area dependent. For $\Delta f = f_2 - f_1$ small, it can be shown that

$$S_J = \frac{NEP(\lambda, A, \Delta f)_{measured}}{A^{1/2}} \sqrt{\frac{f_c}{\Delta f}}$$

where f_c is the chopping frequency. Most detec-

tors are evaluated at frequencies low enough that Jones S_f is reasonably accurate. The danger in using this parameter is that for fast detectors, a continual improvement in signal to noise with increased chopping frequency is expected, whereas, such improvement actually ceases where the $1/f$ noise power spectrum drops below other noises has been shown.

Practical Limitations

The impedance level of modern photoconductors usually falls in two categories; those with very high impedances (1-100 megohms), and those with very low impedances (10-1000 ohms). Either is rather difficult to use with vacuum tube inputs. With high impedance detectors, no special difficulties are encountered at low frequencies, where $1/f$ noise is dominant with the exception of vibration effects and stray pickup in the leads. At higher frequencies, these problems are aggravated and in addition, stray capacitance becomes a problem. While the noise level of the detector may drop, at higher frequencies to Johnson noise, this drop is partially offset by the load impedance's noise figure. For example, a matched load impedance at the same temperature as the detector has a noise figure of 2 and even worse when the load impedance is at a higher temperature.

In many instances, the detector's sensitivity may be nonuniform or vary with distance from either electrode. In any event, the primary noise limitation in a practical circuit may be in the electronics rather than the detector, although the detector causes the problem. Such considerations may influence the choice of detector. However, the NEP sensitivity criterion does not factor such problems in.

Most photoconductive detectors sensitive to radiation longer than 3-4 microns must be cooled to liquid nitrogen temperatures or below and are very sensitive to temperature changes about the operating temperature. Also, the cooled detector's sensitivity is a fairly strong function of background radiation to the point where cooling below a certain temperature does not increase sensitivity appreciably. In fact, under certain conditions, one can obtain improved response only by decreasing aperture.³

Thus, it can be seen that practical considerations can drastically alter any conclusions reached on the basis of NEP alone. ■ ■

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1. R. Clark Jones, "Methods of Rating the Performance of Photoconductive Cells," *Proc. of IRIS*, June 1957, Vol. 2, No. 1.
2. R. C. Jones, "Advances in Electronics," Vol. 5, Academic Press, 1953.
3. R. W. Began, et. al., "Cooled Infrared Detectors," (unclassified) *Proc. of IRIS*, March 1958, Vol. 3, No. 1 (confidential).



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For

RF Bypass Capacitors

Dr. Richard E. Lee

Manager, Circuit Development Branch
Texas Instruments, Inc., Dallas, Tex.

Dr. Richard E. Lee is charged with the responsibility of developing new transistor circuits and applications. In this article he shows how to select bypass capacitors, using their series resonance if possible.

THE OPTIMUM value of an rf bypass capacitor should be selected on the basis of its impedance vs frequency characteristic. The series resonant frequency of the optimum capacitor should be approximately in the center of the operating frequency band of the circuit.

This insures that the rf bypass capacitor will have the lowest net impedance. And capacitors of smaller capacitance and possibly smaller physical size can be used to give better performance.

The simple equivalent circuit for a fixed capacitor is a series RLC network, where R is due to dielectric losses and L is usually due to the inductance of the leads. Since lead inductance in a rf capacitor is a significant factor, it is possible to select a value of capacitance that makes a series resonant circuit at the intended operating frequency. For a series resonant circuit, the net impedance includes only the series loss resistance of the capacitor. With the usual mica, or ceramic,

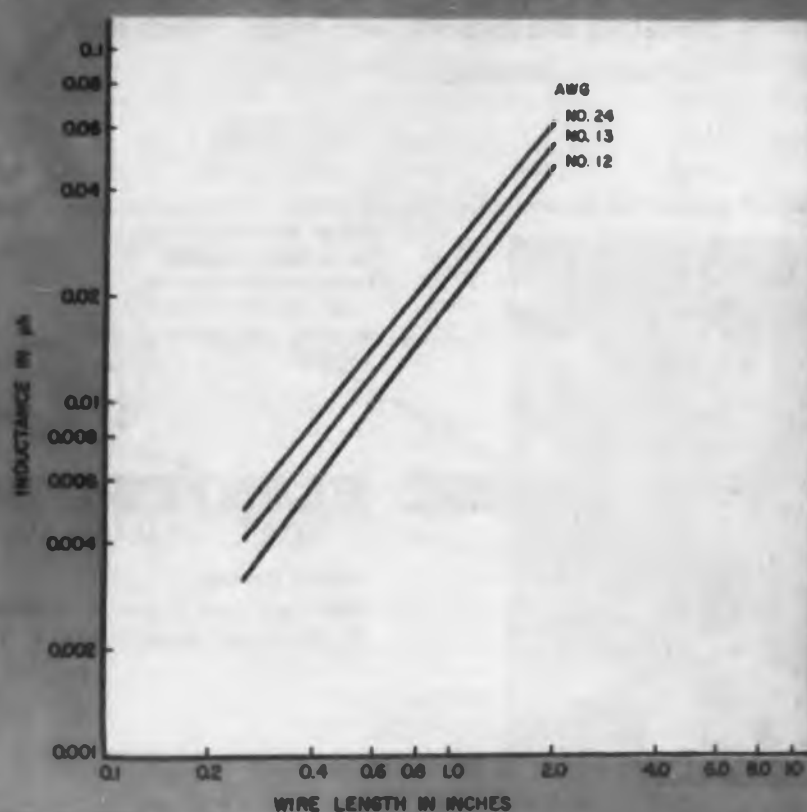
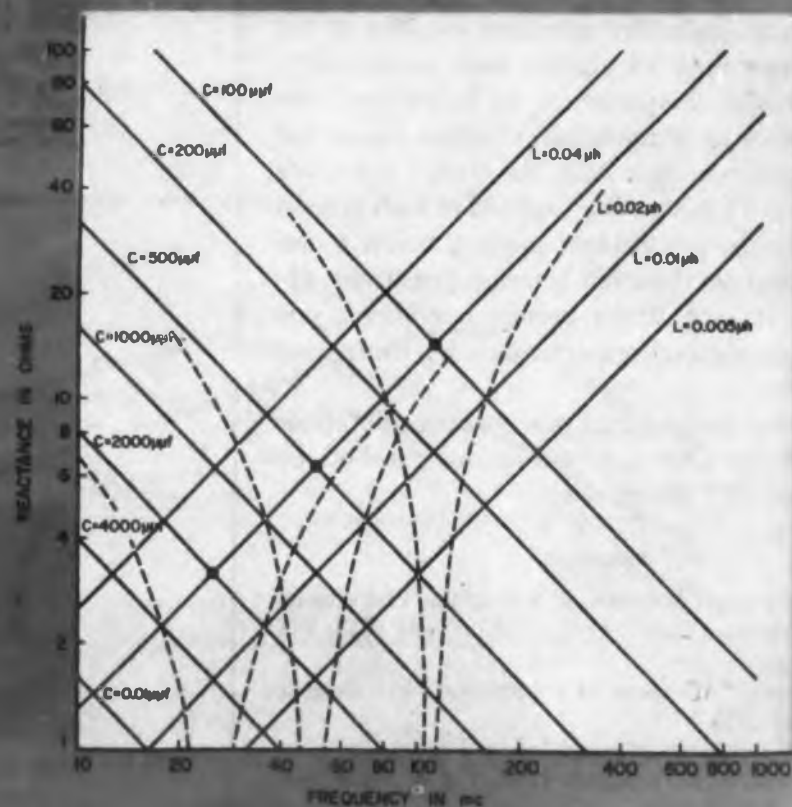


Fig. 1. (left) Inductance vs. length of a straight round wire.

Fig. 2. (right) Reactance vs. frequency for various L and C values.



dielectric of capacitors, the dissipation factor is very low. Thus, the equivalent series resistance is very small.

Lead Inductance

Consider the lead inductance and its effect upon the choice of capacitor values. The inductance of a straight piece of copper wire may be computed from:

$$L = 0.00508 l \left[1n \frac{4l}{d} + \frac{d}{2l} - 0.75 \right] \mu h$$

where l = wire length in inches

d = wire diameter in inches

Using this equation, the inductance of various lengths of AWG No. 12, 18, and 24 wire was calculated and the results plotted in Fig. 1.

The reactance vs frequency data for various values of lossless L and C elements is shown in Fig. 2.

Examples

The following examples show the significance of Figs. 1 and 2.

Assume that we must tolerate a 0.44 in. lead length of No. 24 wire on each lead. Since each lead has an inductance of 0.01 μh , the total series in the equivalent circuit is 0.02 μh . Assume also that we want the optimum bypass capacitors for 50, 49 and 110 mc circuits. For the stated L value, the optimum C values are 2000, 500, and 100 μf , respectively, as shown in Fig. 2. In each case, the series resonant frequency, f_0 , is circled at the point where the capacitive and inductive reactances are equal. Net impedance curves (assuming a zero dissipation factor) for each optimum capacitor were then added to Fig. 2.

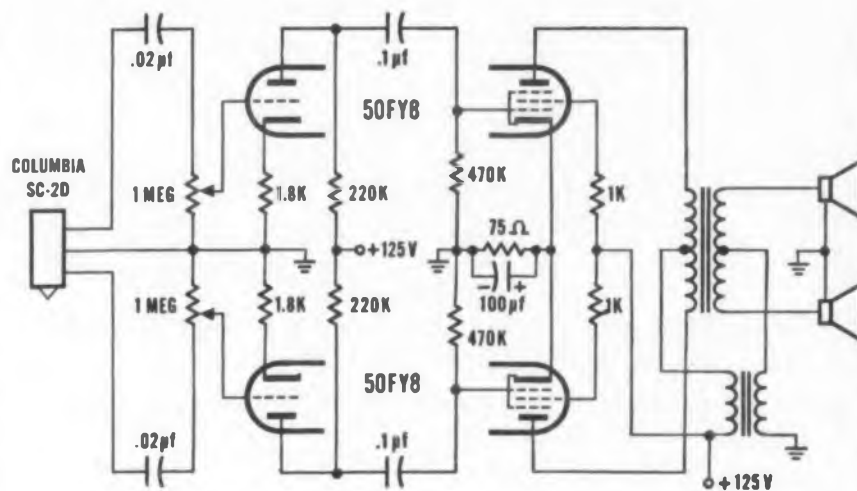
Consider the result of using too large a value of C . Assume that 2000 μf is specified as the value for a bypass capacitor in a 110 mc circuit. For the same total lead inductance, we know from the previous example that a 2000 μf capacitor had a net inductive reactance of approximately 3.2 ohms at 5 mc. Therefore, although this capacitor had a net inductive reactance of approximately 3.2 ohms at 25 mc, it has a reactance of 14.5 ohms at 110 mc. The optimum value for 110 mc is a 100 μf capacitor as shown in Fig. 2. This capacitor produces a net impedance of 1 ohm or less at frequencies from 107 to 115 mc, and an impedance of 10 ohms or less from 80 to 155 mc.

Measuring f_0

To measure the approximate value of f_0 , connect the capacitor leads together (using the same lead length as required in a circuit) and couple this one-turn loop into a grid-dip meter. The resultant f_0 will not be exactly the series resonant frequency for the same capacitor when soldered in a circuit, because the L of a small one-turn loop is not the same as the L of two small straight lengths of wire. The measured value of f_0 is usually within 10 per cent of the true value. ■ ■

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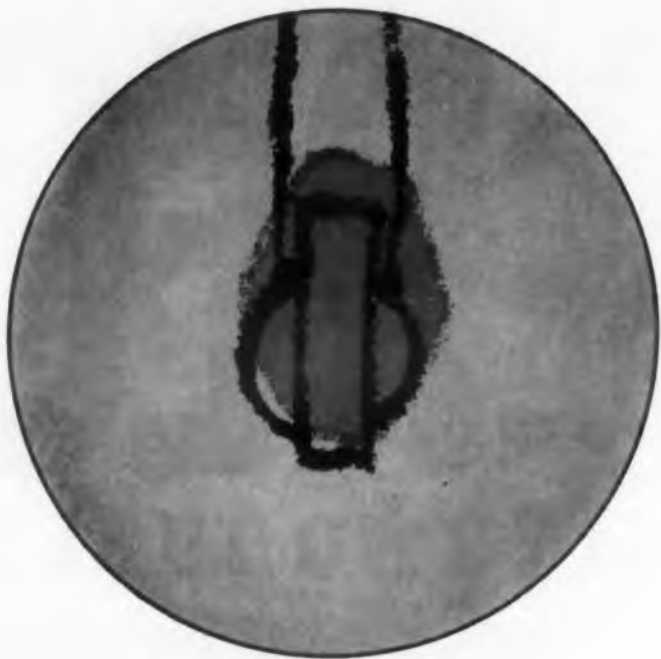
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TYPICAL CLASS A OPERATION OF 50FY8

CHARACTERISTIC	TRIODE	PENTODE
Heater	50 volts at 150 ma	
Plate voltage (volts)	125	125
Grid 2 voltage (volts)	—	125
Grid 1 voltage (volts)	—1.5	—13.5
Plate current (ma)	2.5	50
Grid 2 current (ma)	—	10
Transconductance (μ mhos)	2000	7500
A-c load resistance (ohms)	—	2000
A-f input voltage (vrms)	0.3	—
Max. power output (watts)	—	3.5
Distortion	Approx. 10%	

Important max. ratings for pentode section are: Plate and grid 2 voltages, 150 volts. Plate and grid 2 dissipations, 8 and 2 watts respectively. Heater-cathode voltage (heater negative or positive to cathode), 200 volts.



Disadvantages of the common dielectric materials led to the evaluation of vinyl silicone as a potting compound. It has proven to be highly successful as an insulator in airborne power supplies.

PETROLEUM derivative oils, e.g., highly purified mineral oil, provide the most widespread insulation for sealed power supplies due to excellent dielectric properties. But this material has two major drawbacks: limited temperature stability and a relatively low flash point which presents a fire hazard if the sealed container develops a leak.

Silicone fluids such as the methyl siloxanes overcome these problems by virtue of higher thermal stability and flash points but present some unique problems of their own. The coefficient of thermal expansion is greater than mineral oil by a factor of more than two. Low-surface tension allows the fluid to penetrate the most minute flaws in the sealed container. Even though a leak is detected, the silicone oil on the surface makes repair extremely difficult. Lastly, rapid and successive electrical deterioration occurs if any arcing takes place. Thermal expansion can be accommodated by the use of expansion bellows or, in the case of small power supplies, the use of a filling material. This filler must closely match the dielectric constant of the fluid, to displace the oil from the interstices of the assembly. It thereby reduces the volume of oil, hence expansion, which then allows sealing in a container that can adapt to the lesser volumetric changes by "oilcanning."

Utilization of a pressurized dielectric gas or a vapor-liquid phase combination overcomes some

of these objections but also necessitates heavier container construction and again presents the problem of possible leaking due to fatigue or thermal stresses.

Vinyl Silicone is the Answer

Solventless vinyl silicone potting resins appear to fill all the insulation requirements of small power supplies, and completely resolve the prob-

lem of leaks associated with pressurized gas or fluid dielectric power supplies. But vinyl silicone will not in all cases replace an oil-filled power supply, because the rate of heat transfer is lowered to some extent when compared to the oils. However, it can be used as a direct replacement for mineral oil and silicone fluids if the thermal output is moderate or if the design loses the effect of convective heat transfer by the use of filling mate-

Potting with Vinyl Silicone

W. A. Ernst

Supervisory Engineer

and

F. T. Parr

Development Engineer

Air Arm Division

Westinghouse Electric Corp.

Baltimore, Md.



Fig. 1. Power supply (left) a block of polymerized vinyl silicone resin (center) and power supply cover can.

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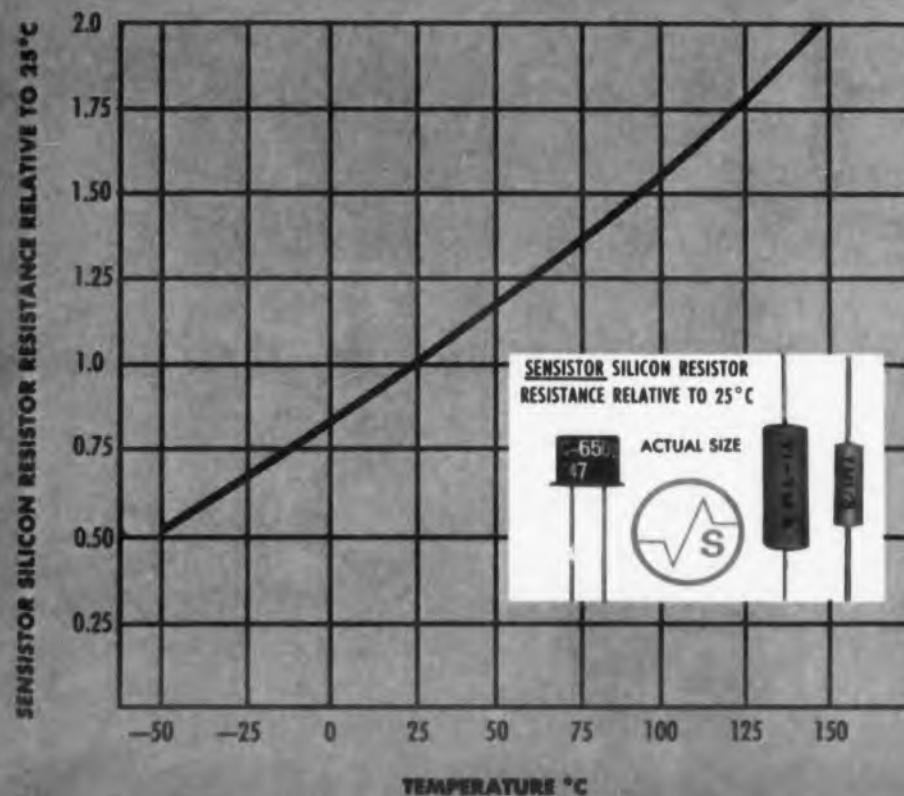
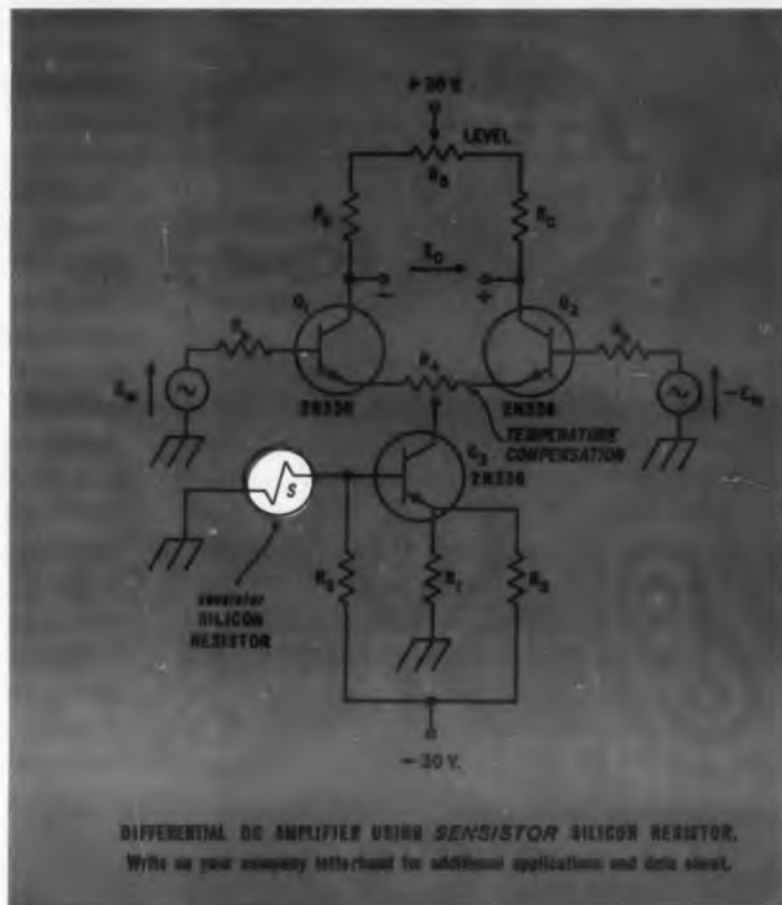
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TI APPLICATION NOTE



HOW TO INCREASE DIFFERENTIAL DC AMPLIFIER STABILITY WITH *sensistor** SILICON RESISTORS



Low drift transistor amplifier circuit using *sensistor* silicon resistor gives drift performance superior to vacuum tube amplifiers for low source impedance applications.

The *sensistor* silicon resistor has a unique positive temperature coefficient of $+0.7\%/^{\circ}\text{C}$ plus a constant rate of change as shown in the graph to the right. Over a 15°C temperature range, the *sensistor* silicon resistor's temperature-resistance curve approaches linearity to an extent that allows its use as a compensating component in a differential D-C amplifier.

This low drift amplifier finds a wide range of low source impedance applications in airborne telemetry where the performance of other types of D-C amplifiers is limited by weight requirements, acceleration, shock, and vibration. It is particularly useful with low level transducers such as thermocouples, strain gages and accelerometers.

DESIGN CONSIDERATIONS

TI 2N338 silicon transistor provides excellent performance as a low drift DC amplifier when used in circuits such as the one shown above.

For optimum performance keep $(2R_b + R_c)$ as small as possible, preferably less than 2000Ω , and the collector currents of Q_1 and Q_2 should remain below $100\mu\text{A}$.

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Drifts as low as $6\mu\text{V}/^{\circ}\text{C}$ will result if the compensating circuit composed of Q_1 , *sensistor* resistor S and their biasing resistors is used with a matched pair of transistors.

CIRCUIT OPERATION

Sensistor resistor S and its biasing resistor R_1 serve as a voltage source which has an output linearly related to temperature... level potentiometer R_6 adjusts output voltage E_o to zero when E_{i1} is zero... potentiometer R_5 adjusts for minimum output drift due to ambient temperature changes. As temperature increases, the resistance value of S also increases causing the base of Q_1 to go more negative, thereby reducing the collector current of Q_1 . This temperature-dependent current is fed into the differential amplifier through R_6 .

Depending on the wiper position of R_6 , the correcting signal may be positive, negative or zero. When the wiper is centered, zero correction results. As temperature increases, output voltage E_o tends to go more positive if the R_6 wiper is placed nearer the Q_2 emitter and negative if the wiper is placed nearer Q_1 . The optimum setting for R_6 can be determined by cycling over the desired temperature range to give a minimum drift for changes in ambient temperature.



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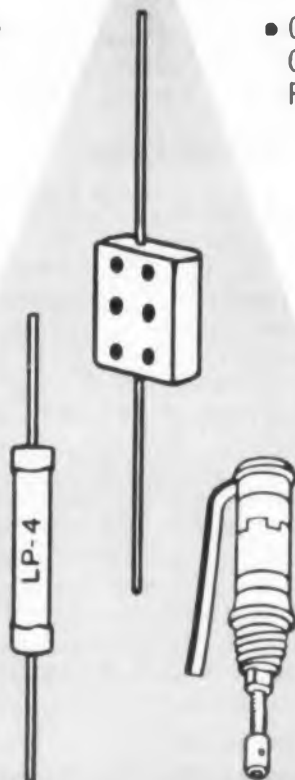
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materials to reduce the volume of the dielectric fluid. Fillers such as silica or sand greatly increase the thermal conductivity, however.

When this factor is considered in the design phase, increased reliability is assured. In addition, since the vinyl silicone is a solid, the resistance to arcing and corona is comparable to the conventional silicone rubbers.

Chemically the vinyl silicone is closely related to the widely used silicone fluids of the dimethyl siloxane type. Electrically, the uncured vinyl silicone also behaves quite similarly to the linear silicone fluids and this feature is used advantageously in the subassembly testing stages.

Catalyzed with benzoyl peroxide the resin cures to a rubber-like solid with very low shrinkage. The curing itself is generally accomplished with 0.5 percent to 1 percent of the peroxide and can be accomplished at between 80 to 150 C. Gelation is generally achieved in one to two hours at 80 C, although the pot life of the catalyzed resin is in excess of six months at room temperature.

Sealing is Easier

This short gel time permits sealing of the container only for a length of time sufficient to allow gellation to occur and therefore greatly simplified seals can be used. The sealing can be accomplished by applying an elastomeric coating to the edge of the base and when the cover is crimped over, sealing is complete.

Briefly the vinyl silicone differs from the well known silicone resins or varnishes, silicone rubbers and silicone fluids but slightly. Silicone resins and varnishes vary between brittle and semirigid materials. The vinyl potting compound when cured is characteristic of a material between a gelatin and a rubber. Shrinkage during cure can be minimized. The gel structure of the vinyl silicone is not rigid like a casting resin and therefore some external support is required. This can be the actual container used for potting, and the structure itself can be much lighter than that required for oil insulated supplies.

Resilience of the resin serves two very useful functions. It allows crack free operation over a wide range of thermal cycling, by its ability to accommodate large differentials in the thermal expansion of the embedded components. It also provides a vibrational dampening to protect the internal components.

The coarse grade of sand used as a filter also serves two purposes. It increases the coefficient of thermal conductivity and it reinforces the vinyl polymer.

Passed Mil Specs

Application of the vinyl potting compound to power supplies has so far been limited to fairly small units 3 x 4 x 6 in. (Fig. 1), with design voltages varying from 1-3 kv and test voltages up to 6 kv. The containers are almost identical to those

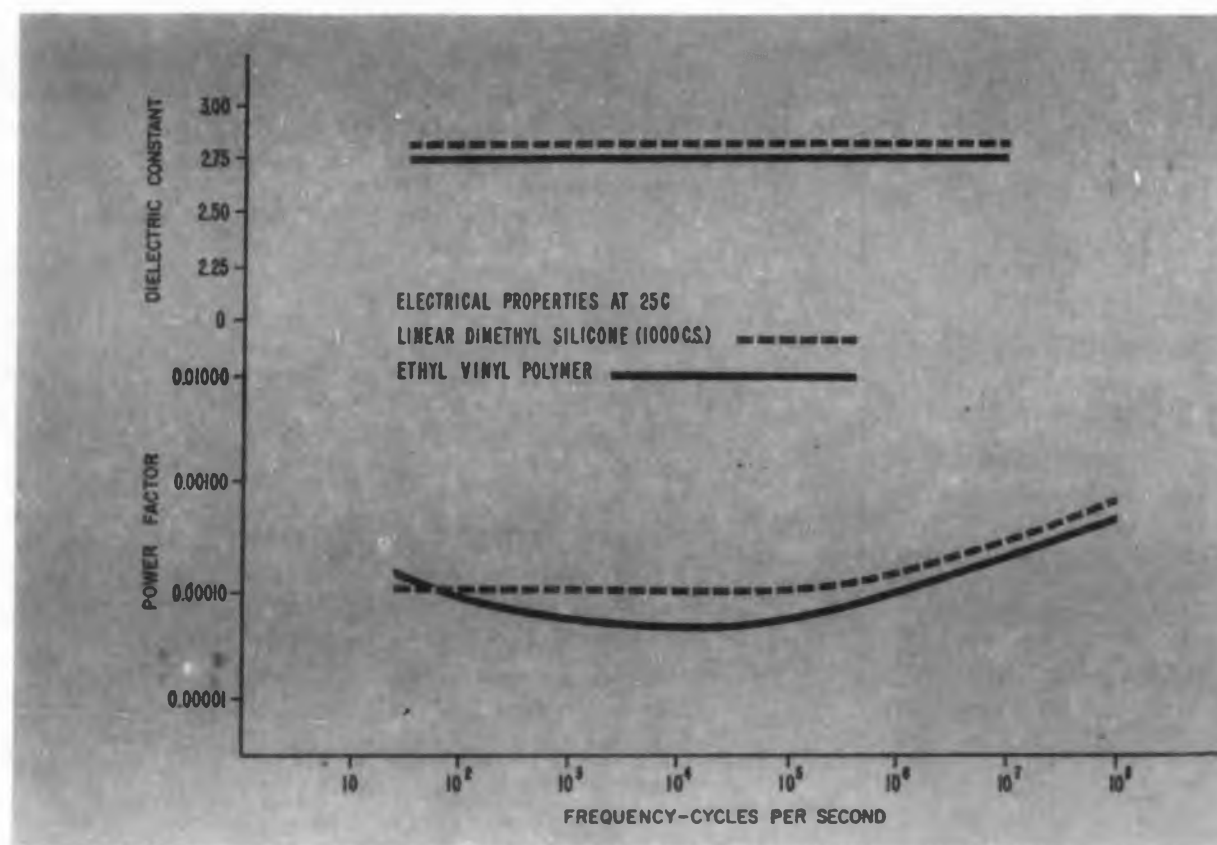


Fig. 2. Comparison of electrical properties of dimethyl silicone fluid and vinyl silicone polymer.

used or oil filled units except that a larger port is used to introduce the filler and resin. The structure itself can be made very much lighter since there is no need to withstand pressures of thermal expansion of oil or gas. Hermetic sealing is unnecessary since the resin itself permits the units to withstand very high humidity. Sample units with holes drilled through the metal casing at critical points have passed the requirements of MIL-E-5272A humidity tests. The possibility of almost direct substitution of polyvinyl siloxane for silicone fluids is apparent from an examination of Fig. 2. Properties are very similar.

Uncured fluid may be used to test the indi-

Table I Physical and Electrical Properties of Ethyl Vinyl Silicone Resin

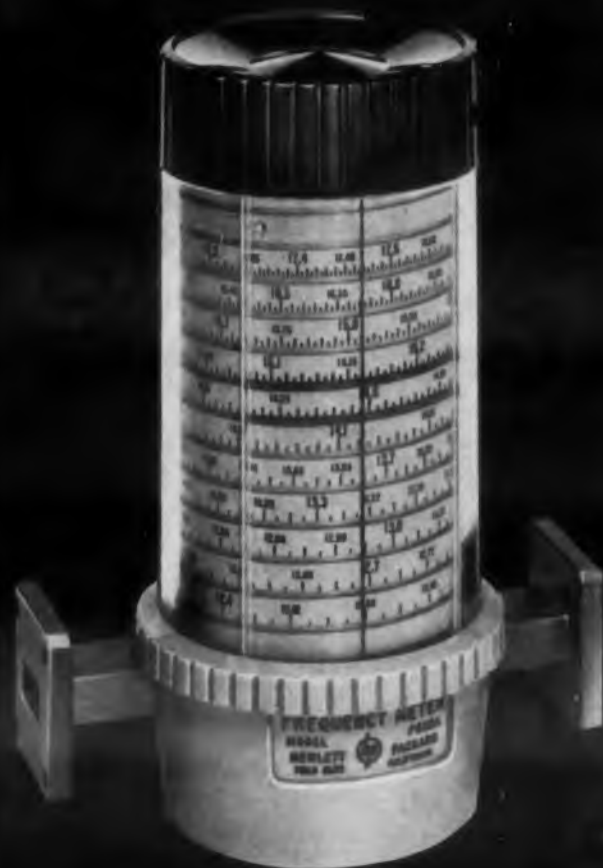
Tests	Values
Viscosity at 25 C	3500-4500 centistokes
Temperature coef. of visc.	0.6
Refractive index	1.4044
Weight loss of polymer 168 hours at 200 C	2.8 percent
Shrinkage on cure	0.4 percent
Thermal shock (MIL-C-16923) (except 200 C to -55 C cycles)	passed
Specific gravity (Cured)	0.976
Dielectric strength (uncured)	300 v/mil
Thermal conductivity (Cured)	
unfilled	5.4 BTU/hr./in./sq.ft./F
sand filled 1:1	16.0 BTU/hr./in./sq.ft./F
Volume Resistivity at 25 C	10^{14} ohm/cm
at 125 C	10^{14} ohm/cm
Dielectric Constant	
60 cps	2.80
1 kc	2.80
100 kc	2.80
1.26 mc	2.80
Power Factor	
60 cps	0.01
1 kc	0.01
100 kc	0.01
1.26 mc	0.02
Dielectric Strength	300 v/mil

vidual components and assembly prior to potting at full voltages. Normally in the manufacture of a power supply the transformer is separately tested in oil and the wired assembly is tested before assembly into the container. Excellent electrical properties (Table I) and long pot life allow the same procedure to be followed, and when the unit is potted there are no rejects because of leaking or residual uncured testing fluids.

The advent of the solventless silicones is not a panacea for all potting or liquid dielectric problems but based on our own and some of our vendor's experiences they should provide one firm step forward in improving reliability. ■ ■



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SPECIFICATIONS

Model	Accuracy	Frequency Range KMC	Fits Waveguide Size (in.)	Length (in.)	Price
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H530A	0.1%	7.05 - 10.0	1¼ x ¾	3½	120.00
X532A	0.08%	8.20 - 12.4	1 x ½	4½	150.00
P532A	0.1%	12.4 - 18.0	.702 x .391	4½	210.00
K532A	0.1%	18.0 - 26.5	½ x ¼	4½	230.00
R532A	0.2%	26.5 - 40.0	.360 x .220	4½	250.00

Other specifications: Models 532A: Resetability 0.01%, backlash 0.005%, SWR at resonance 1.3:1 approximately. Dip at resonance, 1 db or more.

For complete details, call your representative or write direct.

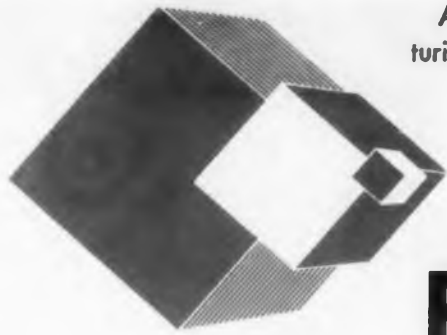
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Packaging Missile Electronics

Although this article does not disclose radical innovations in the field of miniaturization, an understanding of present applications may enable design engineers to get an added feel for military requirements.

Alvin Steinberg

Reliability Branch, R & D Division
Army Rocket & Guided Missile Agency

GREATER demands in accuracy and reliability of missiles are changing the appearance of the missile electronic package. Our first generation of systems, the Nike Ajax and Corporal, used Jan or commercial parts with conventional World War II wiring in typical block boxes. In the present day systems, Nike Hercules, Hawk, La Crosse, and Dart, a transition is evident by the admixture of some printed wiring boards, encapsulated sub-assemblies, and a wide use of nonstandard parts.

The next generation may use guidance packages of throw-away microminiature assemblies where space restrictions are imposed by waveguides and hydraulic systems, rather than by electronic and electro-mechanical assemblies.

Corporal Missile

To define the problem in packaging electronics, consider the Corporal. A Corporal battalion is authorized some 320 vehicles of equipment. Both

operators and maintenance technicians are highly skilled and well trained for their mission. Obviously, the use of microminiature parts, modular packaging amenable to machine assembly, and a revision of operation and maintenance concepts to allow more replacement and less repair would reduce the complexity of present operations.

In Fig. 1, a typical Corporal wiring and layout, note the absence of support ribs in the chassis and the maze of wiring. The Corporal system is not to

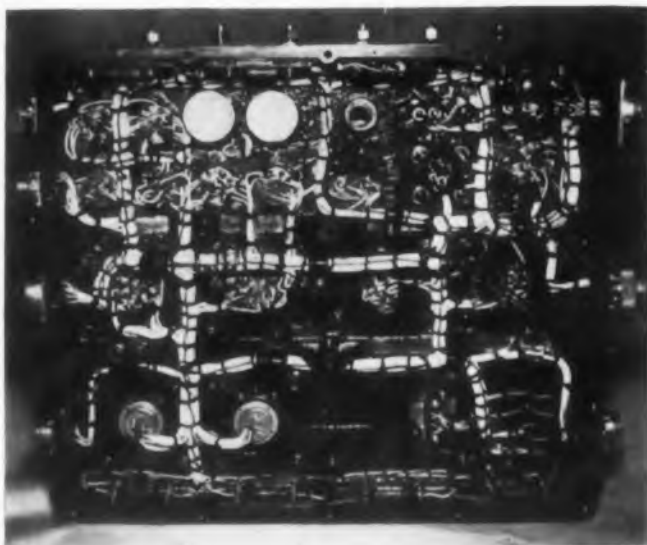


Fig. 1. Original layout of the electronics package in the Corporal.

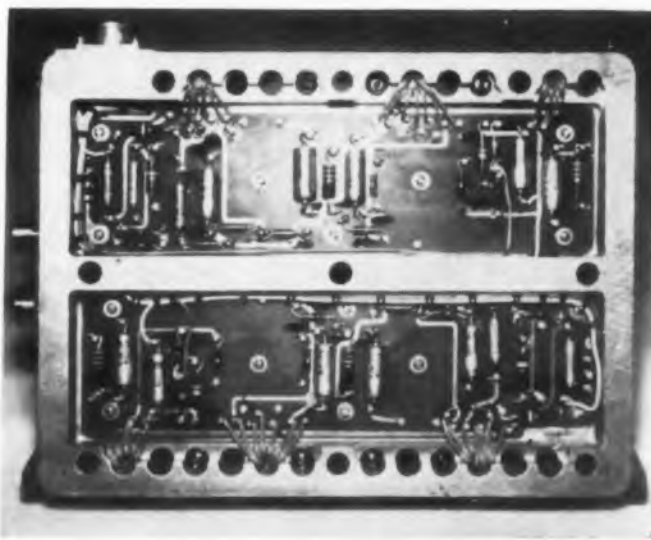


Fig. 2. New configuration of Corporal package is much less complex.

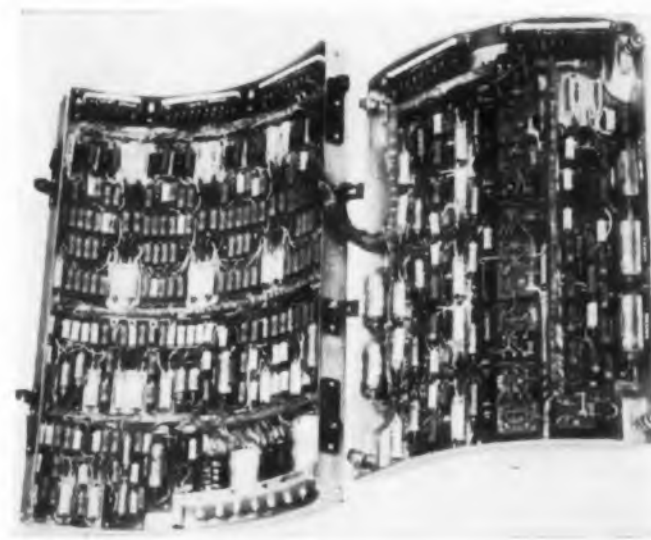


Fig. 3. How the cylindrical platters in the Hawk are assembled.

be written off because of outdated packaging. Readiness dates prevented the designers from incorporating new techniques during research and development.

The Corporal III system has modern ground equipment and would correct these outdated features. Furthermore, in field test firings, the Corporal IIA has demonstrated a higher reliability than any other Army missile system. This reliability has been the result of many factors including a product improvement program whereby over half the missile electronic circuits as noted in Fig. 1 were converted to configuration as shown in Fig. 2.

Hawk Missile

A picture of our progress can be portrayed by a look at our present day developments. The Hawk missile-borne electronics is packaged principally within two units: the seeker and the autopilot. Many parts have been made nonstandard by additional environmental requirements: that is, by further selection processes at the plant. The Hawk

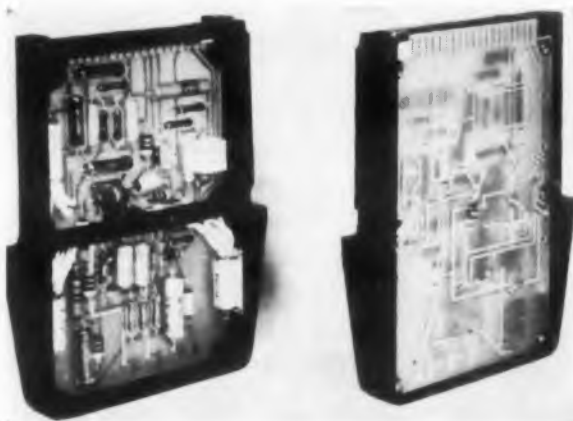


Fig. 4. Module for the Hercules.

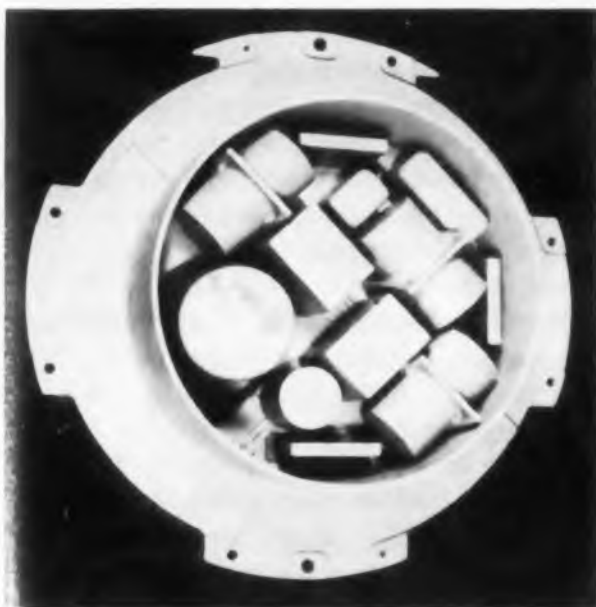


Fig. 5. Makeup of the Hercules "mushroom." This is the instrument side.

missile electronics part count, Table 1, is over 1570 electronic parts exclusive of cables and connectors.

Parts are laid out within the cylindrical section of the missile for ready accessibility. Batteries, dynamotors, and large heavy hardware are mounted along the longitudinal axis whereas the circuit parts are neatly mounted on curvilinear laminates in periphery and parallel to the missile skin. Raytheon was directed to provide for repair by part replacement and a more accessible layout for the electronic parts would be hard to visualize. Fig. 3 shows the nature of the assembly of the cylindrical platters. Electronic part density in the Hawk missile is in the vicinity of 2000 per cubic ft. The present day maxima using printed wiring boards is around 50,000.

Hercules Missile

Nike Hercules' guidance package has undergone a recent packaging redesign. Old design is shown in Fig. 4. The new package is a "modular" one with subassemblies more readily accessible and is commonly called the "mushroom guidance" package. The Hercules missile electronic parts count, Table 2, is approximately 724 parts.

Actually, for a tactical operation, the parts count for the Hercules might be considered less than the 700 items assembled. Over half the parts are mounted in printed wiring boards and therefore would not be subject to individual replacement. The Western Electric process for assuring good solder points to printed wiring boards requires a 3 cycle thermal shock after soldering. Field replacement of an item to the board where soldering is involved, is not planned. The high failure items, vacuum tubes, are mounted on the cast frames that house the printed board assembly and are replaceable if need be although even this item is considered better replaced at 5th echelon.

There are 22 printed wiring boards in the Hercules guidance package. Reliability tests showed no general necessity for encapsulation, therefore, only one subassembly is sealed in epoxy resin and a second unit in silastic rubber. The majority of the coils, however, have been encapsulated for better configuration with respect to assembly in the modules and for environmental protection.

The Hercules part density is approximately 2000 per cubic ft. A Hercules module and a mock-up of Hercules "Mushroom" instrument side are shown in Fig. 5.

La Crosse Missile

The La Crosse I missile guidance package in contrast to Hawk, provides all presently available techniques of assembly. The five missile electronic assemblies contain 20 potted subassemblies and use 18 printed wiring laminated boards. The La Crosse electronic parts count for the missile is about 697 as shown in Table 3. La Crosse chassis

Table 1. Hawk Parts Count

Capacitors:	
Ceramic	46
Mica	46
Tantalum	35
Tantalum	156
Glass	73
Electrolytic	3
Titanium Dioxide	8
Total	367
Tubes:	
	146
Crystals and Crystal Diodes:	
	81
Transformers:	
	55
Resistors:	
Composition	484
Wirewound	11
Deposited Carbon	373
Total	868
Inductors:	
AF Reactors	3
AF Toroids	3
RF Coils	46
RF Toroids	3
Others	4
Total	59

Table 2. Hercules Parts Count

Capacitors:	
Mica	29
Paper	97
Tantalum	7
Glass	6
Ceramic	9
Others	13
Total	161
Resistors:	
Composition	77
Wirewound	23
Deposited Carbon	214
Variable	15
Total	329
Vacuum Tubes:	
	35
Transistors:	
	28
Crystals and Crystal Diodes:	
	120
RF Inductors:	
	18
Audio Coils and Transformers:	
	19
Other Parts:	
	14

Table 3. La Crosse Parts Count

Capacitors:	
Mica	102
Glass	32
Paper	40
Tantalum	2
Ceramic	3
Variable	5
Total	184
Resistors:	
Wirewound	23
Composition	207
Deposited Carbon	53
Variable	13
Total	296
Inductors, AF:	
	15
Inductors, RF:	
	109
Diodes & Crystals:	
	30
Tubes:	
	47
Relays:	
	10
Miscellaneous:	
	26

Higher-Temperature Capacitors:

New Dielectric Materials Help Break the Heat Barrier

By Marc F. Warmuth, Staff Engineer, Airborne Accessories Corporation

Special Mylar*, Teflon† and mica constructions permit continuous operation up to 600°F

Three new types of special high-temperature motor-starting capacitors, utilizing Mylar, Teflon and mica dielectric respectively, have been developed recently by Airborne. The Mylar and Teflon types are wound of very thin metallized film for greatest possible miniaturization. The mica type is wound of a sandwich of aluminum foil and thin, pure mica ribbon, metallized mica not being procurable. All are encapsulated with thermoplastic polyamide or thermosetting epoxy resins (depending on temperature range) in sealed, cold-drawn steel cans with fused glass terminals. This construction provides low inductance units of exceptional mechanical sturdiness and environmental resistance.

As an alternate construction for less demanding applications, encapsulation in epoxy sleeves, with leads brought out through potted ends, is also available.

Mica for highest temperatures

The great advantage of mica as a dielectric is its ability to maintain its physical and electrical characteristics at temperatures up to 1000°F. All dielectric materials undergo severe reductions in

insulation resistance at high temperatures, but with mica the critical value is reached around 600°F. Full voltage ratings up to this point are thus permitted. And with the right epoxy resin impregnant, mica capacitors are well able to withstand overtemperatures without damage... if not simultaneously subjected to full rated voltages.

Mica capacitors are three to four times larger than Mylar or Teflon units of comparable capacitance and voltage rating. This is because a greater thickness of dielectric must be used in addition to a separate layer of aluminum foil.

Mylar and Teflon for intermediate high temperatures and small size

Mylar can be worked continuously up to 300°F and Teflon up to 400°F. For applications below these limits, but above the normal 185°F limit of more conventional insulating materials, metallized Mylar and Teflon offer high dielectric strength. They make possible wound capacitors of very small size with good voltage ratings and excellent capacitance-to-volume ratios.

A further advantage of metallized Mylar and Teflon capacitors is their self-healing characteristic. The short occurring when the dielectric is ruptured

instantly burns the thin metallic coating back from the edges of the rupture, making further flashover impossible. Yet the amount of metallic coating burned away is so minute that hundreds of such self-healings have little effect on capacitance. Resistance to overvoltages can thus be considered excellent. Resistance to overtemperatures, on the other hand, is not an outstanding characteristic of Mylar or Teflon—a design factor to keep in mind.

Summary

MYLAR: For intermediate high temperatures, high voltage and smallest size. Continuous operation at 300°F with ratings up to 1000 WVDC. Capacitance variation with temperature good, but not as good as that of Teflon or mica types.

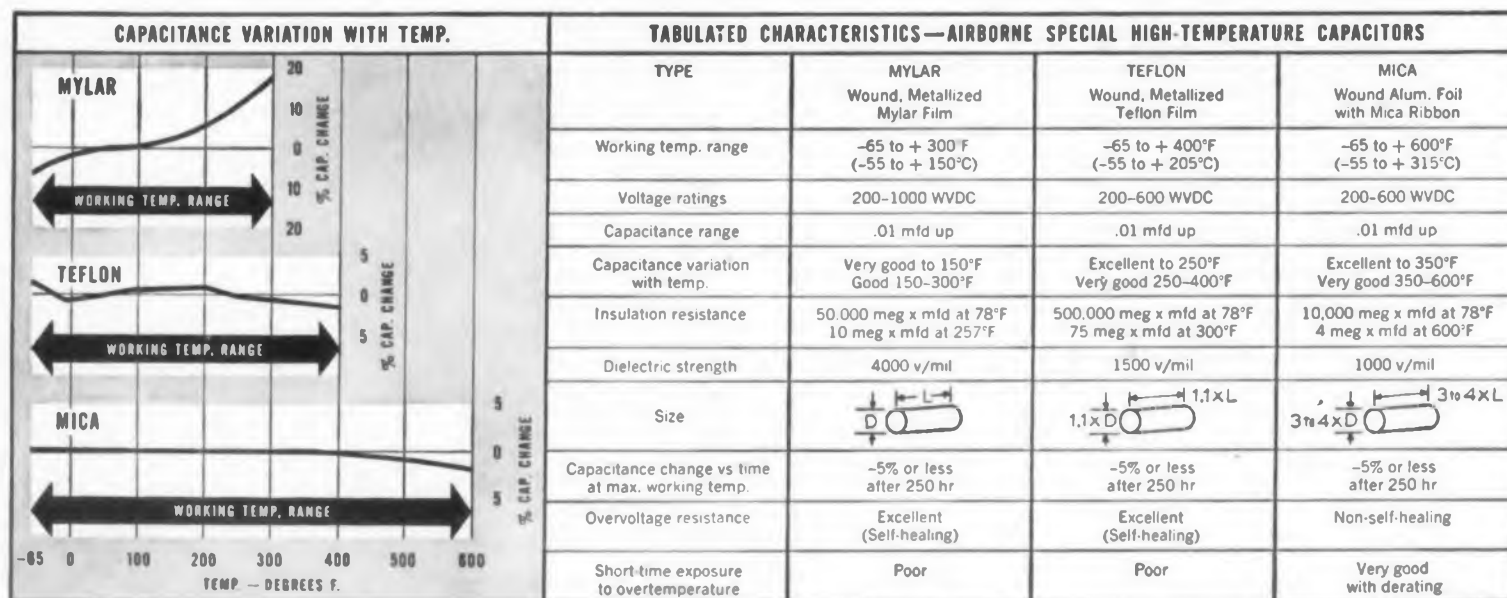
TEFLON: For intermediate high temperatures and small size. 600 WVDC up to 400°F without derating.

MICA: For highest temperatures. Continuous operation, 600 WVDC without derating up to 600°F. Higher temperatures possible with derating. Larger in size than equivalent Mylar or Teflon capacitors.

For proposals on your specific capacitor requirements, write AIRBORNE ACCESSORIES CORPORATION, HILLSIDE 5, N. J.

*DuPont's tm for its polyester film

†DuPont's tm for its tetrafluoroethylene resin



CIRCLE 26 ON READER-SERVICE CARD

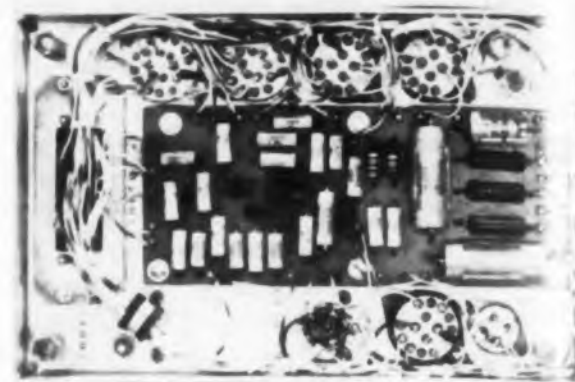


Fig. 6. Lacrosse chassis wiring.

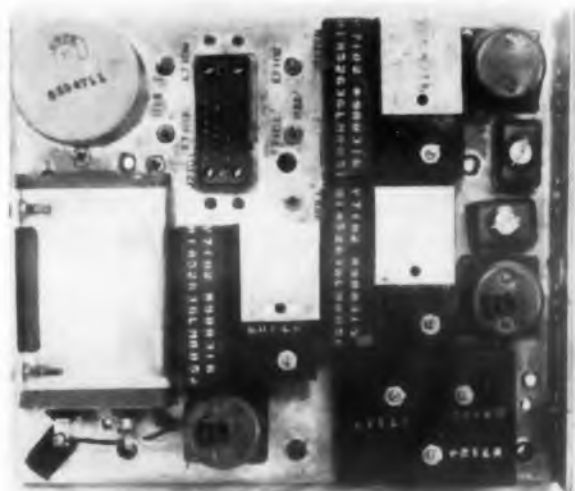


Fig. 7. Top view of the Lacrosse electronics package.

Table 4. Missile Electronic Parts

Total Parts	Hawk	Hercules	La Crosse
Non-Standard	1570	602	697
Type Maintenance—Replacement	90% Part	50% Modules	80% Part and Potted Assy

wiring and layout are shown in Fig. 6 and 7.

The La Crosse guidance package is subdivided into five chassis, replaceable by an operator when failure is evident as indicated by an automatic tester. Piece part repair within the five chassis is accomplished by back-up Ordnance Corps maintenance technicians. Parts density in the La Crosse I missile is of the order of 1000 per cubic ft. Many rf cavities contribute to the relative low part density. Hawk, La Crosse and Hercules are compared in Table 4.

Maintenance Problems

Until early this year, the maintenance philosophy promulgated by the Ordnance Corps for missile systems was based on AR 750-5, that is, the traditional five echelons. By interpretation, field repair meant test equipment for fault isolation to

the piece part and repair by part replacement.

This maintenance philosophy has been modified, and repair is now permitted by replacement of modules. Accordingly, the Sergeant, Nike Zeus, and La Crosse Mod I systems will be packaged in modular form and a reduction in field repair and maintenance skills is evident in their Table of Organization and Equipment.

Use of nonstandard parts is of great concern in the industrial phase of a missile program. Each part peculiarly stocked as a replacement part adds an additional burden on the supply system. Furthermore, if the part is a new development which may be inadequately tested, it is also a threat to reliability. Many of the parts in the systems discussed have been made non-standard by the addition of specifications for environmental extremes of temperature and shock not contained in the Mil Spec of the comparable part.

A part selected by environmental testing does not necessarily have a greater resistance to failure than one not so selected. However, complex missiles can hardly be expected to function unless constructed under extreme conditions of quality control and this begins with incoming inspection of electronic parts. Reliability takes precedence over standardization.

By the reliability formula or the product rule, the overwhelming number of missile-borne electronic parts makes the guidance package the most suspect for in-flight failures. There is no evident relationship between reliability and missile electronic part selection and assembly. In field test firings the missile with the greatest part-count has shown the greatest reliability. Factors other than complexity must be more influential in field operations.

Miniaturization of components in servo or hydraulic systems would pay off greater dividends in space savings than in the electronic area. For example, the electronic package in one guided missile is only 2 per cent of the total weight of the missile and 2 per cent of the volume.

Miniaturization efforts on electronic parts and assemblies will be the trend for our future systems. The criteria of reliability and ruggedness point toward miniaturization as a possible solution for better performance. Although the Hawk, Hercules, and La Crosse I may derive no benefit from the miniaturization efforts described at this symposium, our missile designers are anxious to incorporate new features in the next generation of systems now in the planning stage.

More detailed information on the equipment described in this article will be found in the complete paper to be published in our Proceedings of the Symposium on Microminiaturization of Electronic Assemblies. For further information on the proceedings, turn to Reader Service Card and circle 10.

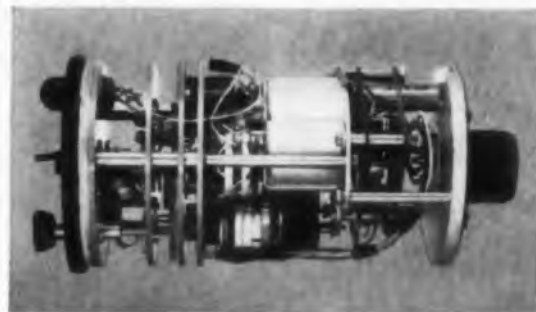
THOMAS A.

EDISON

launch range computer calculates distance from aircraft to target— automatically



Computer indicator shows distance from aircraft to target in miles. Light indicates when aircraft is too close to target for missile launching.



Edison computer contains two control transformers, servo motor, transistor-magnetic amplifier, gear train with slip clutch and integrally lighted indicator with pushbutton reset, all in a compact package weighing only 44 ounces.

New Edison range computer is a tactical instrument used in air to ground release of guided missiles. Unit computes automatically the distance from the aircraft to a ground target. Pilots formerly had to perform this problem manually.

With this new instrument, pilot pushes button on computer — and flies either a 20 or 40 mile course at right angles to target. At end of run, indicator shows distance to target in miles. If he is within proper range he may then release missile.

This range computer is another example of Edison's capability in research, design and production.

Thomas A. Edison Industries

INSTRUMENT DIVISION

55 LAKESIDE AVENUE, WEST ORANGE, N. J.

EDISON ENGINEERING OFFICES ARE LOCATED IN: CHICAGO; DALLAS; DAYTON; LOS ANGELES

CIRCLE 27 ON READER-SERVICE CARD





NWL DC POWER SUPPLY

40 KV at 3 amp.

The ripple frequency of this unit is extremely low due to a full wave 6 ϕ power supply. The model shown here is a 130 KVA, 3 phase unit and can be furnished with either askarel or ordinary transformer oil.—This unitized power supply is just one of many special transformers and equipment that are custom-built by NOTHELPER.

Each NWL DC Power Supply is tested for core loss, polarity, voltage, corona, insulation breakdown and aging characteristics and must meet all customer's requirements before shipment. We shall be pleased to quote you up to 300 KV and up to 500 KVA, depending on your individual requirements.

Casing & Wiring manufactured by
Research Cottrell, Inc.
Bound Brook, N. J.



ESTABLISHED 1920



Notthelper

SAY: NO-TEL-FER

NOTHELPER WINDING LABORATORIES, INC., P. D. Box 455, Dept. ED-5, Trenton, N. J.
(Specialists in custom-building)

CIRCLE 28 ON READER-SERVICE CARD

DESIGN FORUM

Measure Fine Wire

Fast With



Cross-sections of fine wire.
Note typical surface imperfections detected by Sylvania Out-of Roundness Instrument.

IF YOU'VE ever tried to measure fine wire with a barrel micrometer, and tried to get the same reading twice in a row, you can imagine what the electron tube manufacturer is up against. For grid laterals, he needs wire diameters that vary in diameter from 0.006 to 0.003 inches.

He needs to know if the wire has surface imperfections like flats and ridges. (Such "flashy" wire makes inferior grids). He may want to detect diameter differences in the order of five millionths of an inch. He wants to know if the wire is out of round. And he'd like to check for these imperfections while the wire is on the reel.

Sidestepping the usual techniques, D. R. Kestetter, Section Head of the Materials Engineering Group of Sylvania Electric Products Inc., Emporium, Pa., developed an electronic Out-of Roundness Tester.

This instrument, available from Sylvania Equipment Development Plant, uses variations in reflected light to detect surface imperfections in wire samples. The wire passes through a detection head at about five feet per minute. The head has a light source and a sensitive phototube whose output is amplified by a high gain dc amplifier, then fed to a 500-0-500 μ a meter. The meter needle oscillates back and forth from the center position depending on the uniformity of the wire.

Excellent spools of wire show out-of-roundness in the form of meter deflections of 50 to 100 μ a. Very poor wire will deflect the meter some 300 to 500 μ a.

If a scope is used as the display device, instead of a relatively slow microammeter, the

wire can be examined at extremely high speeds—limited by the maximum rpm of the take-up spool.

Calibration is Easy

For reproducible results, the instrument must be calibrated for each wire size. This is done by switching resistance (7 ohms) in series with the light source (reducing the light intensity about 10 per cent), and adjusting the sensitivity so a specific change in reflected light from a given piece of wire will produce an equivalent change in meter deflection.

It's a Great Instrument, But . . .

It has its limitations. The instrument doesn't know one imperfection from another. Flats, ridges, and fissures all appear as surface imperfections but the tester doesn't tell which is which. It can't distinguish between true out-of-roundness and nonuniformities caused by oxides, discoloration, or other foreign surface material irregularities.

Fortunately, in the manufacture of grids and other items requiring such fine wire, the wire surface condition is usually quite uniform from the standpoint of oxides and contamination.

The instrument may not be the ultimate, but it certainly represents a distinct step forward in precise measurements of roundness and uniformity in small diameter wire. ■ ■



Instrument for fine wire measurements detects 0.000005 in. differences in diameters.

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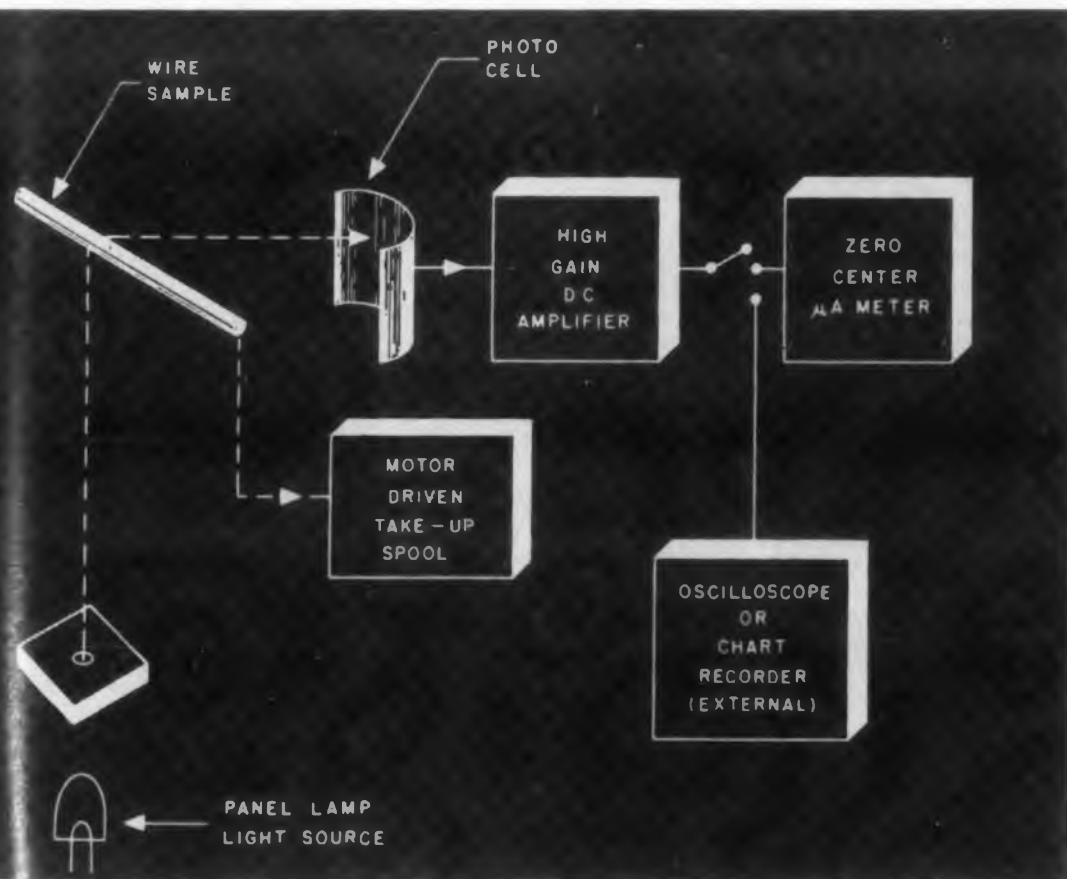
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ECTRONIC DESIGN • May 27, 1959



Variations in light reflected from wire detect surface imperfections.

Design Tips . . . on liquid cooling

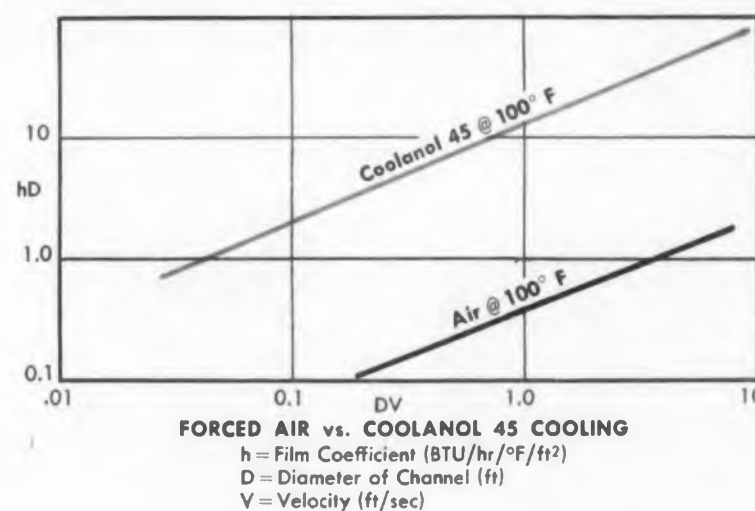


NO. 3: DESIGN MINIATURIZATION

PROBLEM: Increase heat dissipation capacity of cooling system and reduce its size and weight.

SOLUTION: Choose liquid cooling with Coolanol 45.

EXAMPLE:



This graph shows how liquid cooling with Coolanol 45 can make possible smaller, lighter, more efficient cooling systems than forced air. Coolanol 45 requires less heat-transfer area for the same heat load, a volume flow rate as much as 25 times lower, smaller cooling channels, and no bulky fins, fans or blowers. When you need to standardize, simplify or miniaturize a cooling system design, choose Coolanol 45 . . . efficient heat transfer coolant-dielectric and hydraulic fluid from -65° F. to 400° F.

SEND FOR NEW DESIGN BOOKLET

"Design Tips on Liquid Cooling with Coolanol 45" discusses static and dynamic cooling methods, how to apply the package concept to cooling design, how to simplify and standardize cooling and hydraulic units. It gives you a step-by-step solution of a typical cooling problem to show you how to apply principles of heat transfer in actual practice. For your copy of this new booklet, circle the reader-service number . . . or write direct:



Coolanol: Monsanto T. M., Reg. U. S. Pat Off.

MONSANTO CHEMICAL COMPANY, Organic Chemicals Division
 Aviation Fluids Department, St. Louis 66, Missouri

When you need a synthetic fluid, come to Monsanto—creator of fluids for the future
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Lavoie test instruments are known and relied upon right around the world. Superlative design, consistent reliability and the industry's prime order of accuracy are the ingredients which continue to stamp all quality instruments bearing the Lavoie name.

Here are four representative units, each of which invites your trial and the beginning . . . or continuation . . . of a lifelong, rewarding association with the Lavoie standard of quality.



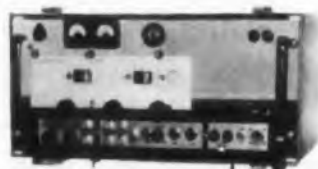
LA-302 ROBOTESTER

Provides the immediate profits of the automated approach to volume testing as well as for unique individualized test programs. High-speed sampling, go/no-go indication, with digital readout of fault isolation.



LA-20W SPECTRUM ANALYZER

Features 1 to 44 Kmc range in one instrument, selection of square law, linear or log detection, 10-KC resolution at 3 db points, regulated filament and plate supplies. Unit illustrated is only one of a full line of spectrum analyzers.



LA-70A FREQUENCY METER

Frequency measurements from 20 mc to 3000 mc with .0001% accuracy. Oven-controlled crystal oscillators, direct dial reading and light in weight for ease in portability. Ideally qualified to accommodate stringent FCC communications requirements.



LA-90 FREQUENCY STANDARD

New design approach to crystal oven thermal regulation permits frequency stability of 1 part per 10⁶ per day at low cost, in small package. Oven temperature stability of 0.01%. Output frequency (basic LA-90 unit): 1 mc, 5 mc, 100 kc, 10 kc, 1 kc.

Technical literature describing these units in detail is available on request. Detailed technical data may also be supplied on a selection of Pulse Generators, WWV Receivers and Crystal Ovens and a diversified line of quality test equipment for laboratory and plant.

Lavoie Laboratories, Inc.
MORGANVILLE, NEW JERSEY

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Designer's Dilemma: Electronic or Mechanical Multiplexers?

M. M. Kranzler

Applied Science Corp. of Princeton
Princeton, N. J.

RELIABILITY, cost and function—these interrelated factors govern the choice of either electronic or mechanical multiplexer. The first two principal factors are detailed in the text, while all functional parameters are outlined in the adjoining table.

In evaluating the reliability of a multiplexer, the

Functional Parameters of Electronic and Mechanical Multiplexers

Characteristic	Electronic General Range	Mechanical General Range	Preferred
Size (Sealed)	1/2 cu in. per channel to 1 cu in. per channel	1/4 cu in. per channel to 1/2 cu in. per channel	Mechanical
Cost	\$50 to \$100 per channel	\$5 to \$30 per channel	Mechanical
Accuracy	1 to 5%	0.1 to 1%	Mechanical
Contact Res.	—	0.25 to 50 ohms	Mechanical
Open Ckt Impedance	2 K to 1 meg	20 to 1000 meg	Mechanical
Effect on Transducers	Back Currents up to 3 ma	None	Mechanical
Life at 80 C	1000 to 5000 hr	5 to 1000 hr	Electronic
Power Input	2 to 10 w	10 to 20 w	Electronic
Sampling Speed	5 to 20,000 samples per sec	From 0 to 2500 samples per sec	Electronic
Speed Regulation	0.01 to 5% to 85 C	±2 to ±25% to 150 C	Electronic
Max. Operating Temperature	—55 C	—55 C	Mechanical
Min. Operating Temperature	—55 C	—55 C	Mechanical
Vibration	up to 35 g	up to 35 g	Electronic
Duty Cycle	10 to 95%	50 to 95%	Electronic
Rise Time	1 to 10%	5 to 10%	Electronic
Phaseability	±1%	±5%	Electronic
Type of Signal Input	0 to +5 v 0 to -5 v ±2.5 v 25 K	0 to 15 mv 0 to 100 v	Mechanical
Max. Source Impedance	25 K	500 K	Mechanical
Min. Load Impedance	1 meg	100 ohms	Mechanical

Widest Option in Low-Power Rotary Switches

cost
ease of parts inspection
redundancy
circuit design
complexity of design
reliability
function

design engineer should consider:
Complexity of Design. The price of specifying a multiplexer with a potential life of 10,000 hr, if 500 all that is required, is complexity. Advantage of mechanical devices shows up in multipole applications: the addition of 30 more channels calls for 60 more stationary contacts and two more wipers and springs. Adding a pole to an electronic commutator may mean 200 more components.



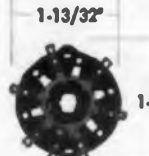



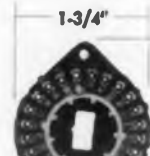



Ease of Parts Inspection. Mechanical parts are easier to inspect than electronic components. This is important in quality control work.

Circuit Design and Redundancy. Oscillators are more reliable than dc governed motors although they hold a lesser edge over ac devices. Electronic devices all have some sort of channel sequencer which is also a series element, although some redundancy is feasible. Intra-circuit shorts or opens are more harmful electronically and can cause catastrophic failures, but a mechanical switch gives warning before failure.

Basic Component Failures. If the function can be chosen to coincide with the speed and pulse shape limitations of mechanical devices, for short term reliability, the mechanical device is superior. At high commutation speeds, coupled with long or extremely accurate pulse shapes, the electronic switch assumes prominence.

The price of electronic equipment is between two to five times more expensive than the equivalent mechanical device. Costs are proportional to the number of channels electronically but the mechanical switch is priced almost like a step function. The cost of mechanical components is higher than for electronic equipment, but fewer replacement items are required. Instituting a design change in sampling speed is small for electronic equipment and high for mechanical devices. Changes in the number of channels or signal level are less expensive mechanically. ■ ■

Acknowledgment: This article is adapted from a paper by the author contained in the Proceedings of the 1958 National Symposium on Telemetry.

SECTIONS				
 <p>THROW: 30°, 36°, 45° INSULATION: stator glass silicone; rotor, KEL-F</p>	 <p>THROW: 30°, 45°, 60°, 90° INSULATION: phenolic, Mycalex, ceramic</p>	 <p>THROW: 25.7°, 30°, 36°, 45°, 60° INSULATION: phenolic, ceramic</p>	 <p>THROW: 18°, 20°, 30°, 36°, 45°, 60°, 90° INSULATION: phenolic, Mycalex, ceramic</p>	 <p>THROW: 30°, 36°, 45°, 60°, 90° INSULATION: phenolic, Mycalex, ceramic</p>
 <p>THROW: 20°, 40° INSULATION: phenolic</p>	 <p>THROW: 15°, 30° INSULATION: phenolic</p>	 <p>THROW: 20°, 40° INSULATION: phenolic, Mycalex</p>	 <p>THROW: 12.85°, 25.7° INSULATION: phenolic</p>	 <p>THROW: 12.85°, 18°, 25.7°, 36° INSULATION: phenolic</p>

METAL PARTS AND FINISHES

STANDARD COMMERCIAL—Punched steel parts are lead-coated, cold-rolled steel. Parts such as nuts, lockwashers, etc., are cadmium-plated steel. Shafts may be cadmium-plated steel, brass, or aluminum. Brass parts are unplated.

TROPICAL OR 50-HOUR SALT SPRAY MILITARY SPECIFICATIONS—All steel and brass parts are cadmium-plated and chromate-dipped. Stainless steel parts are passivated.

200-HOUR SALT SPRAY MILITARY SPECIFICATIONS—All brass parts are nickel plated. All stainless steel parts are passivated. Shafts, "C" washers and index springs, balls and plates are stainless steel.

CONTACTS



Famous Oak double wiping, high-pressure design. Riveted or eyeleted in place and keyed from turning. Rotors shorting or nonshorting.

TYPE 1—Contacts are spring brass, silver-plated. Rotors are brass, silver-plated. Temperature limit: 100°C constant ambient.

TYPE 2—Contacts, spring tempered-silver alloy. Rotors, coin-silver alloy. Temperature limit: 100°C constant ambient.

TYPE 3—Contacts and rotor blades made of Oak alloy

CMS-202. This is a special alloy for high temperature operation to 150°C.

GOLD-PLATED CONTACTS—Type 1 or 2 contacts may be gold-plated .0002" thick. Not to be confused with gold flash.

FOR PRINTED CIRCUITS—Standard Oak contacts with a lug extending from the terminal end. Lug inserts in board for dip soldering.

ACCESSORIES



AC SNAP SWITCHES—36 models for use on most switch types. All are UL approved.

POTENTIOMETERS—Customers' choice. Mounts on rear of Oak switches. Operates by switch shaft or separate concentric shaft.

ELECTROSTATIC SHIELDS—Used between sections. Sizes and shapes for all switches.

BEARING STRAPS—Added shaft support on long switches. Steel, brass, and phenolic.

MOUNTING BRACES—Prevents frame twist on long switches due to torsion.

SPECIAL SHAFTS—Hollow, dual-concentric, and triple-concentric for many switches.

OAK MFG. CO.

1260 Clybourn Ave., Dept. D, Chicago 10, Illinois
Phone: MOhawk 4-2222

When your design calls for a low-power rotary switch, you want a unit that matches job requirements exactly—not an "almost" fit. But in the process you don't want the switch to involve a lot of extra tooling and delay either. At Oak, the above options, plus numerous other alternatives in construction, are pretooled for economy, service, and convenience.

Specify your low-power switches the easy way—from the most diversified, the most "ready-to-go" line available.

CIRCLE 31 ON READER-SERVICE CARD

Generate Groups of "n" Pulses With Variable Rep Rates

IT IS often necessary to generate groups of constant numbers of pulses with varying pulse repetition rates. Normally, one-shot multivibrators are used for on-off periods, but they require adjustment for different pulse rep rates.

The logic circuitry described here provide the desired results. All the flip flops used are identical, and the device allows variation in on-off periods.

The circuitry has been used to generate repeti-

tion rates from 100 to 1000 pps, and seven stages of counters have been used to generate 88 pulses on and 2 pulses off—to simulate a commutator output.

The block diagram of Fig. 1 and the circuit of Fig. 2 show a convenient way to generate groups of pulses with a constant ratio between the number of pulses in a group and the spacing between groups, regardless of the pulse rate.

The waveforms of Fig. 3 are for a device to

generate groups of 15 pulses with a space between groups equivalent to that of a pulse. When two pulses have been counted by the first flip flop in the counter chain, a pulse is sent to the gate operator flip flop to open the gate and let the square wave pulses through to the output.

The counter chain continues to operate, and when the fourth flip flop reverts to its original state, thus indicating an accumulated count of 16 pulses, an off signal is sent to the gate operator to close the series gate.

The gate remains closed till two more pulses have been counted, and the action repeats.

Obviously, it is most convenient to have the sum of the pulses in a group and the pulse spacings between groups equal to some power of 2 so that a straight binary counting chain can be used.

However, conventional feedback techniques can be used so any desired preset output can be obtained. Additional flexibility is available by choosing either leading or trailing edges from the flip flops in the counter chain as gate operator triggers.

John H. Porter, President, Portronics, Inc., Tarzana, Calif.

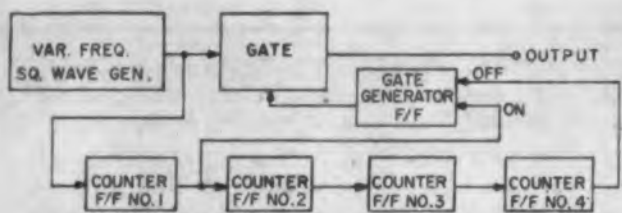


Fig. 1. above Block diagram for a pulse generator with constant ratio between number of pulses in a group and spacing between pulses.

Fig. 3. right Waveforms for a "15 on, 1 off" pulse generator.

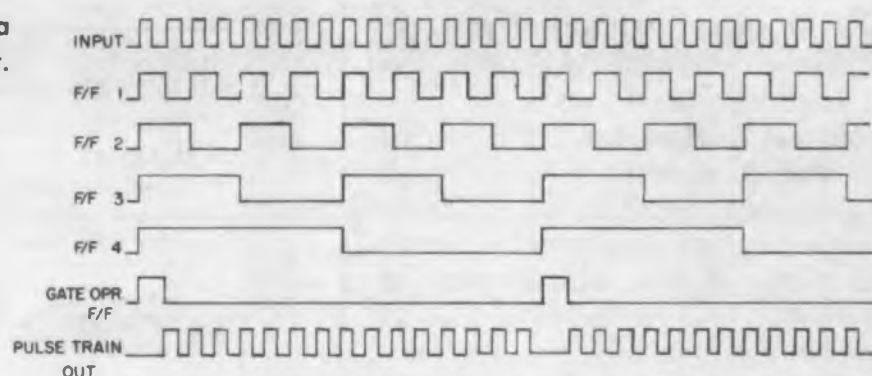
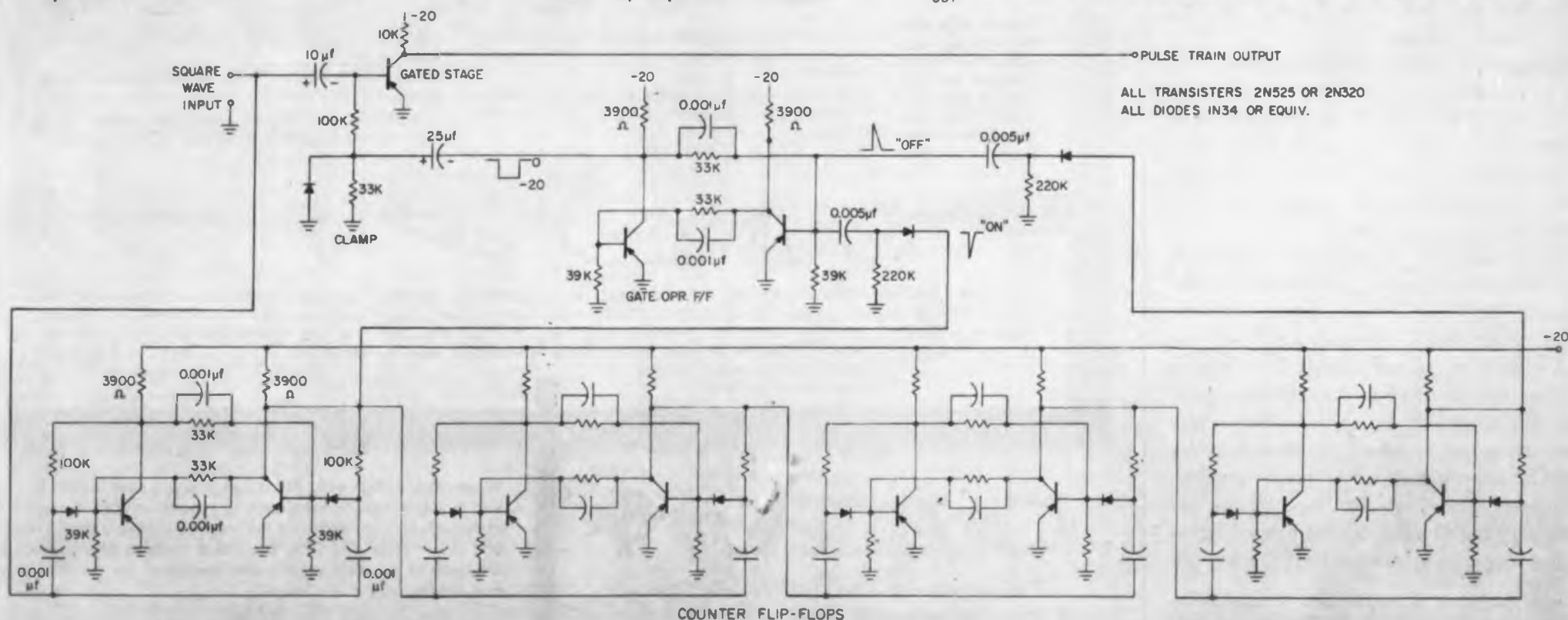
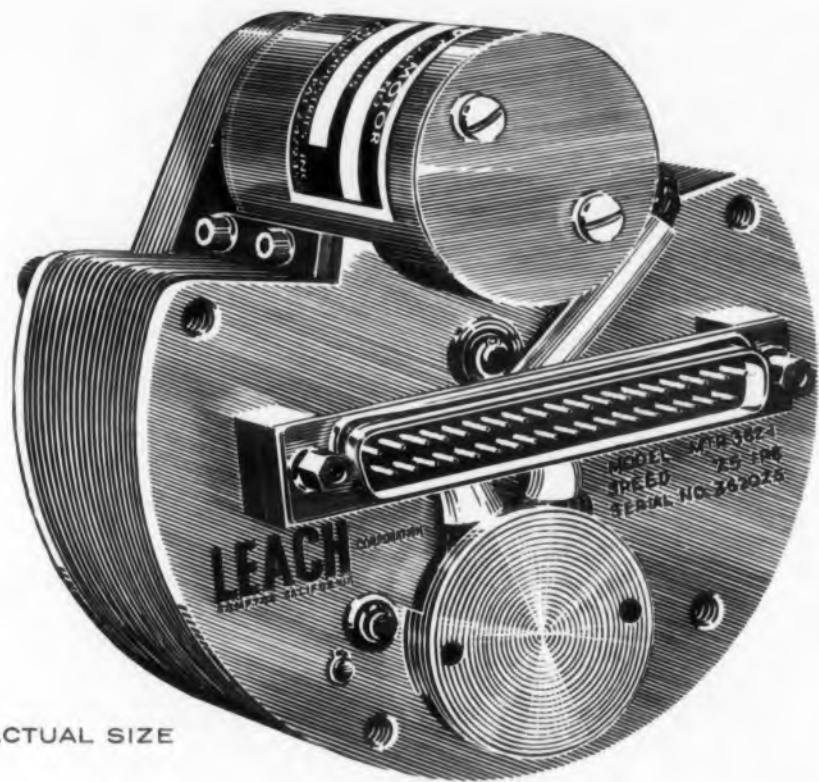


Fig. 2. below The pulse train generator circuit. Each of the four flip-flops are identical.



built to take it
...designed to tell
the whole story
with impact!



ACTUAL SIZE

MINIATURE TAPE RECORDER

Testing under severe environments... in extremely limited space? Inet's rugged Miniature Magnetic Tape Recorder simultaneously records data on 1 to 14 in-line channels, never loses a record because it's built to survive high impacts.

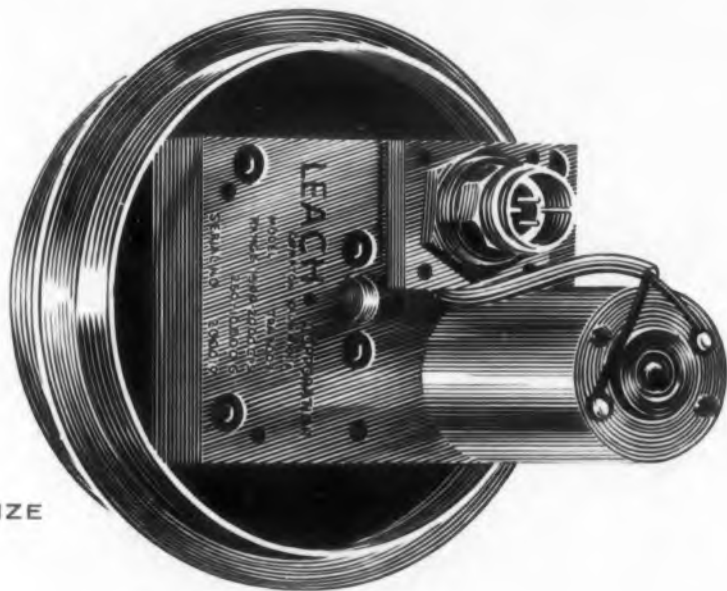
Weighs just 24 ounces and operates at tape speeds of from $\frac{1}{4}$ to 15 inches per second in a temperature range of -50°F to $+200^{\circ}\text{F}$. Among its features: precision in-line recording head; adjustable motor speed and tape tension; and molded rubber pressure roller and drive wheels.

APPLICATIONS: in-flight and static tests; atmospheric, blast, explosion and wind tunnel studies; and acceleration and actuation tests.

Write for complete specifications.

LEACH MINIATURES

newest
new products
from Leach/Inet



ACTUAL SIZE

TRIAxIAL RECORDING ACCELEROMETER

The compact, self-contained unit shown above is Inet's 6-ounce Triaxial Recording Accelerometer... attached to a $1\frac{1}{2}$ -inch-radius missile nose section.

This rugged unit has three sensing elements—reeds—that directly sense and record data on structures and components subjected to high-acceleration loads. It operates on 6 volts in a temperature range of -50°F . to $+160^{\circ}\text{F}$., requires no connections to external devices except a power source. The unit records data on acceleration-time history along each of three mutually perpendicular axes. Among its applications: water-entry shock studies; ground impact, blast, and explosion studies; and various other tests, including rocket motor, target impact, sled, and switch actuation tests.

Write for complete specifications.

RELIABILITY
➔ **LOOK TO LEACH**
INET DIVISION... LEACH CORPORATION
18435 SUSANA ROAD, COMPTON, CALIFORNIA

DISTRICT OFFICES AND FIELD REPRESENTATIVES IN PRINCIPAL CITIES OF U. S. AND CANADA • EXPORT: LEACH CORP., INTERNATIONAL DIVISION
CIRCLE 32 ON READER-SERVICE CARD

New, Electro Instruments all-electronic, totally transistorized digital voltmeter

50 conversions per second • 1000 megohms input impedance • Fully automatic ranging



Model 8409 Voltmeter and Ratiometer

all the features you want in a medium-speed digital voltmeter

- 3 ranges, 9.999/99.99/999.9 volts
- Automatic, manual and remote ranging
- Automatic polarity
- One digit accuracy
- 4 digit in-line visual readout
- BCD and decimal electrical output
- Direct printer operation—local/remote control
- New 5¼" x 19" front panel
- Modular construction throughout
- Provision for external reference voltage

Plus accessory modules for every application

AC: All transistorized Model 110; considerably faster AC/DC conversion than presently available models. Fully automatic ranging and direct AC voltage readout on the Model 8409.

Ohmmeter: All transistorized Model KIM-000. Provides constant current through test resistor with negligible power dissipation. Voltage measurements made across resistor and read out directly in ohms with fully automatic ranging.

Also scanners, code converter modules, print control modules and many others to solve all digital problems—from simple voltmeter applications to complex data logging systems.



Ask your  representative for complete information.

Electro Instruments, Inc.

3540 Aero Court San Diego 11, California

CIRCLE 33 ON READER-SERVICE CARD

IDEAS FOR DESIGN

The Better Mousetrap Makes Hot Detector

This device is a simple but effective fire alarm for temporary use in unattended areas where flammable articles may be stored or where electrical equipment must operate without supervision.

As illustrated in Fig. 1, a mousetrap is mounted on a ceiling with a nylon thread keeping it cocked. The thread is fastened to a far wall. The business end of the mousetrap keeps it taut a few inches below the ceiling.

Connections from the alarm circuit are made to the mousetrap as shown in Fig. 2. At the first blast of overhead air, the nylon will soften and part, giving an almost instantaneous alarm.

Nylon thread should be used in preference to cotton, as it will not fail and give a false alarm.

Robert M. Slater, Tennessee Valley Authority, Knoxville, Tenn.

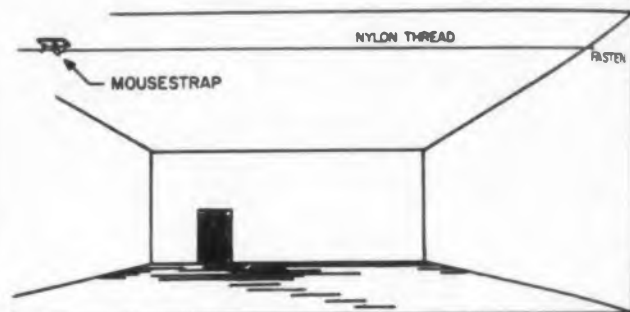


Fig. 1. Nylon thread and a mousetrap can serve as an almost instantaneous fire detector.

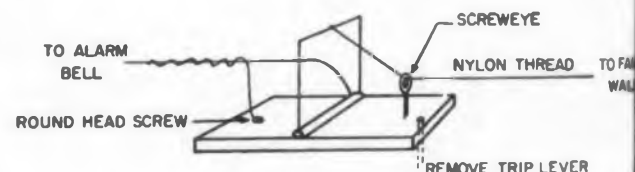


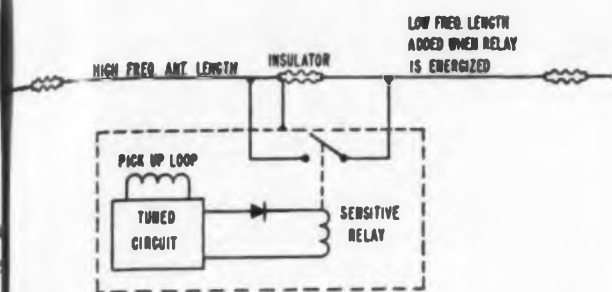
Fig. 2. Mousetrap, prepared for fire detection.

Variable Length Antenna

It is often necessary to transmit on several frequencies using the same antenna. Usually a compromise must be made for the antenna length. It would be very desirable to have an antenna whose length could be varied, depending on the transmitted frequency.

One solution, shown in the figure, uses a tuned circuit, a crystal detector, and a sensitive relay—all mounted in a weather-proof housing. The tuned circuit is tuned to the lower of two frequencies which are to be transmitted. The weather-proof housing is suspended at the end of the high frequency antenna wire.

When transmitting at the higher frequency



The sensitive relay is not energized, so only the lower frequency, switches in additional antenna length when the low frequency is transmitted.

Two-frequency antenna. The relay, powered by the short antenna is in operation.

When the lower frequency is transmitted, it energizes the tuned circuit and operates the relay. This switches in enough antenna wire to provide proper loading.

The system requires no batteries. It switches antenna lengths automatically, the relay being powered by transmitted rf power.

Robert Marie, Project Engineer, Perfect Circle Corp., Hagerstown, Ind.

Pulsed Hartley Provides Constant Level Sinusoids

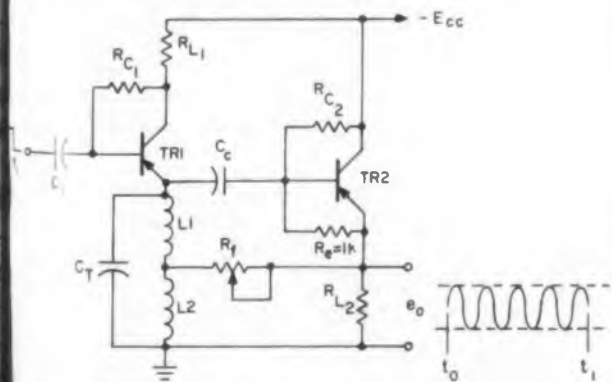
The circuit shown is a transistorized version of linear pulsed oscillator, also known as a pulsed Hartley oscillator. This oscillator features an amplitude-stable output.

In the circuit the component values of R_{C1} , R_{L1} , R_{C2} , R_{L2} , and C_c depend on the transistors used and on the collector supply voltage.

If $L1 = L2$, and $M = K \sqrt{L1 L2} = K L1$, then the coupling capacitor $C_c = 2(L1 - M)$. The feedback resistor R_f must be greater than $0.46 \sqrt{L/C}$, where $L = L1 + L2$.

To get the first cycle to start with a negative swing, an npn transistor should be used instead of pnp, the collector supply should be reversed, and the input pulse should be inverted.

Irving Bayer, Project Engineer, Skiatron Electronics and TV Corp., New York, N.Y.



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IDEAS FOR DESIGN

Zener Diodes Improve Relay Operation

Many relays are characterized by high pull-to drop-out current ratios. In driving these relays with vacuum tubes, several problems present themselves.

Sufficient bias must be applied to keep the tube's quiescent current below the drop-out value while, on application of a dc signal, sufficient plate current must flow to pull the relay in.

The use of fixed grid bias may be difficult, as it requires a negative power supply. Also the input signal may exist with respect to ground, so if the input signal is available at a low impedance, it may ground out the bias. If, on the other hand, the input has a high impedance source, the circuit loses sensitivity to the input signal, which is just what is to be avoided.

The circuit of Fig. 1 does not work because the cathode resistor gives too much degeneration.

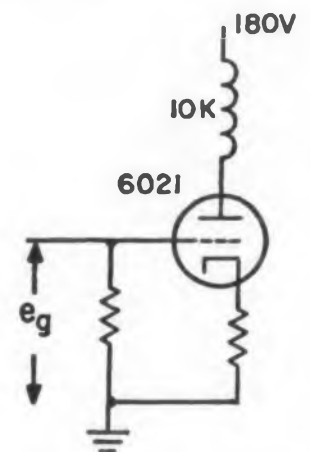


Fig. 1. This relay drive circuit doesn't work because the cathode resistor provides too much degeneration if it is to provide adequate bias.

The circuit of Fig. 2 requires a very heavy grid resistor and still suffers from degeneration; so large grid signal voltages are required.

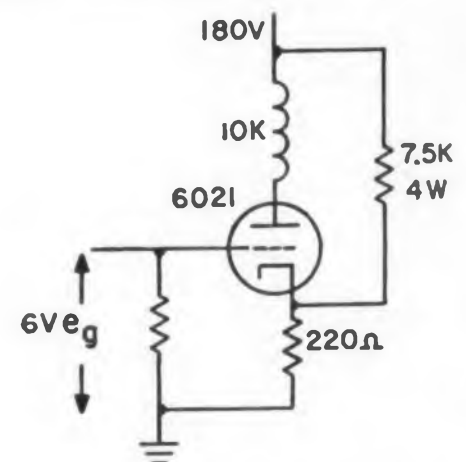


Fig. 2. This circuit doesn't work either because the cathode resistor still causes too much degeneration and a large grid drive is still required.

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Specifications:

Frequency Range:	10 MC to 12.4 KMC	Bandwidth:	Variable. High Freq.: 3 db point adjustable 1 KC to 2 MC. Low Freq.: 3 db point switched from 100 cps to below 10 KC.
Input Signal:	CW, FM, AM or pulse	Output:	1 v rms maximum into 1,000 ohms
Input Signal Level:	Varies with frequency and individual crystals	Oscilloscope Frequency Range:	100 cps to 200 KC
Accuracy:	Depends on input signal. With stable, noise-free CW signal, accuracy approaches that of frequency counters.	Vertical Sensitivity:	5 mv rms/inch at mixer output
Oscillator Frequency Range:	100 MC to 220 MC (fundamental) Above 12.4 KMC (harmonic)	Horizontal Sweep:	Internal, power supply frequency with phase control; or external, 1 v/inch, 20 cps to 5 KC.
Stability:	Less than 0.002% change per minute after warmup	Price:	\$750.00 (cabinet) \$735.00 (rack mount)
Amplifier Gain:	Variable to 40 db or more		

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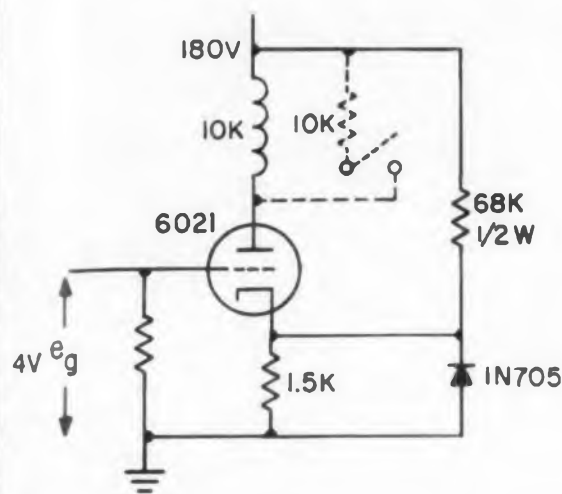


Fig. 3. This circuit works very well, curing the pull-in and drop-out defects.

The circuit of Fig. 1 does not work because the use of a Zener diode; it requires only a low power resistor; and it reduces the required grid voltage.

The circuit of Fig. 3 cures the pull-in defect nicely. By adding a 10 K resistor, and using one of the normally open relay contacts, as shown by the dashed lines in the drawing, the drop-out defect is cured too. The relay drops out at a higher voltage because the resistor shunts some of the current.

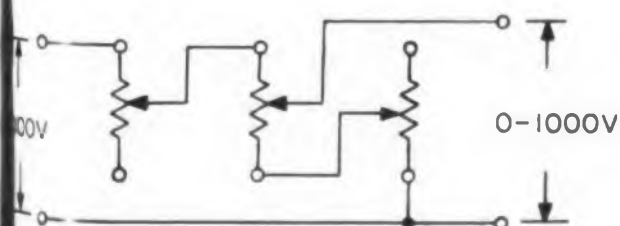
Dr. H. B. Weisbecker, Director of Research, Manson Labs., Stamford, Conn.

Ganged Pots For Higher Voltages

Conventional potentiometers usually have a limiting voltage rating of about 500 v. For many experimental circuits, potentiometers of higher voltage rating can be made by ganging three single units on one shaft. The terminals should be wired as shown in the figure.

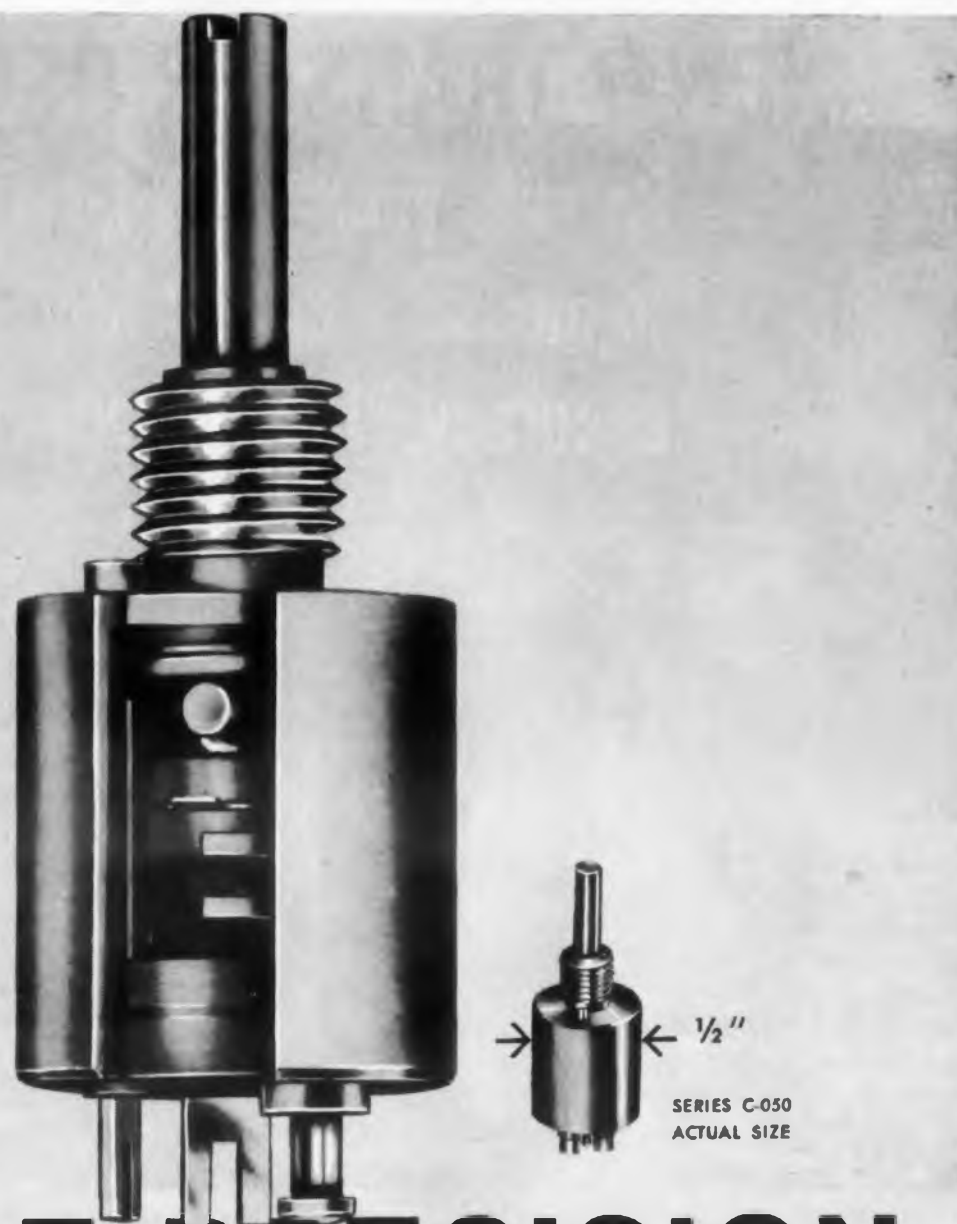
Note that the input side sees, effectively, two potentiometers, and the maximum voltage rating of the combination is raised to 1000 v. The output voltage can still be varied from zero to 1000 v. Care should be taken, of course, not to exceed the wattage rating of the pots.

H. Hsu, Senior Physicist, General Electric Co., Syracuse, N.Y.



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IDEAS FOR DESIGN

Over Voltage Protection For DC Supply Lines

In certain electrical systems overvoltage transients occur on dc supply lines. On 28 v supply lines these overvoltages sometimes reach 80 v or more and present a serious threat to transistorized equipment on the line.

A device used for "blinking-out" on the transient overvoltage is shown in the schematic. It is basically a transistorized switch in series with the supply and the protected equipment. It automatically opens when the input voltage is greater than a predetermined level and closes again when the line voltage returns to normal. The desired action is accomplished in the following manner:

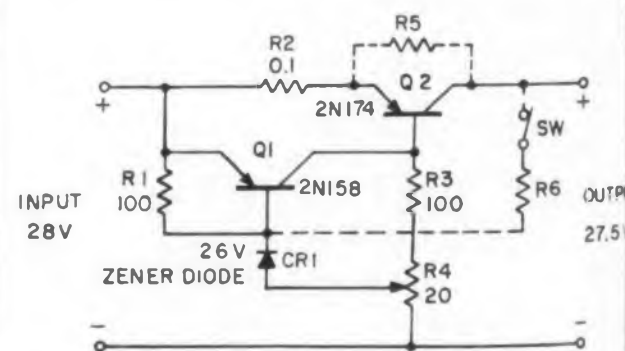
When the input voltage rises to a certain level current flows in the voltage reference diode (*CR1*). Current in this diode acts as base current for *Q1*. When base current is furnished *Q1* turns on and provides a better path for current than the *R2*, emitter-base (*Q2*) path.

Thus, current normally supplied to the base of *Q2* via the *R3-R4* path is robbed from *Q2* by *Q1*. This causes *Q2* to open, dropping the output voltage. When the input voltage returns to normal base current in *Q1* ceases, normal base current is applied to *Q2* and it closes, restoring full voltage to the output circuit.

During the transient it is possible for the full transient voltage to appear across *Q2*. Resistor *R5* acts as a bypass and prevents the output voltage from going to zero, in cases where the full transient is not desired across *Q2*. With the addition of positive feedback (*R6* circuit) the action of the circuit can be made quite sharp and can even be made to latch-off. A push-to-reset switch can be installed as shown by the dashed lines.

Further improvements, making the circuit suitable for use over a wide temperature and low range, can be employed if necessary.

Victor P. Holec, Engineering Department 54
Collins Radio Co., Cedar Rapids, Iowa.



This circuit blanks out dc overvoltages. A "push-to-resist" circuit is shown in dashed lines.

Slaved and Programmed Stepping Switches

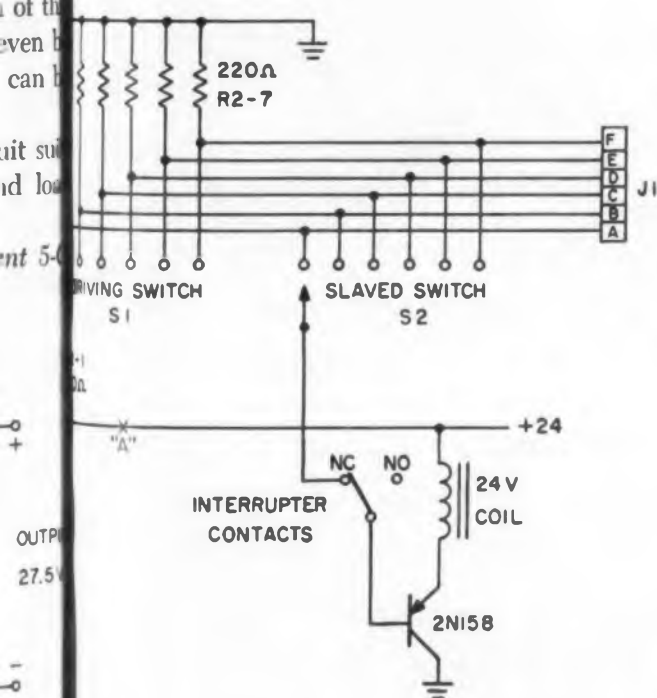
In the design of scanners and similar type equipment having very large numbers of input channels, it is often necessary to have two or more stepping switches slaved together to insure synchronization. The usual method employs 11 relays (or 11 position stepping switches) to reverse the "on-off" sense from the driving switch.

The use of these relays is obviated in the circuit shown. A bias is developed between $R1$ and the other resistors ($R2-R7$) which turns off the transistors driving the slaved switches. If the driving switch is in any position other than that of the master switch, the base of the 2N158 is simply connected to ground through a 220 resistor, and the switch is allowed to cycle. As many as 7 switches can be slaved together, and since these are available in 8 decks, 7 decks are available on each switch for data inputs. This allows an entry of 49 x 10 or 490 inputs.

In the diagram, a "fictional" stepper is shown with only 6 positions for clarity. Furthermore, only the one deck used for positioning is shown. If external programming is desired, the +24 v supply is broken at "A," $S1$ is replaced with a slaved stepper circuit, and a 24 v input signal is applied to the desired pin of $J1$.

The tensioning spring on the slaved switches must be reduced from factory settings for proper operation. Speed is not reduced when the tension is adjusted properly. Radio interference noise is less than one μv /meter/kc radiated.

George S. F. Orsten, Senior Engineer, The General Electric Co., Denver, Colo.



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	SPECIFICATION DATA				
	High Speed Switch	Med. Speed Switch	High Speed Small Signal Amplifier	Med. Speed Small Signal Amplifier	High Voltage
	2N1219	2N1220	2N1221	2N1222	2N1223
V_{CBO}	30 v	30 v	30 v	30 v	40 v
V_{CEO}	25 v	25 v	25 v	25 v	40 v
V_{EBO}	20 v	20 v	10 v	10 v	10 v
I_{CO}	.1 μa max.	.1 μa max.	.1 μa max.	.1 μa max.	.1 μa max.
h_{FE}	18 min.	9 min.	—	—	—
f_{ab}	5 min.	2 min.	5 min.	2 min.	—
h_{ie}	—	—	18 min.	9 min.	6 min.

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PATENTS

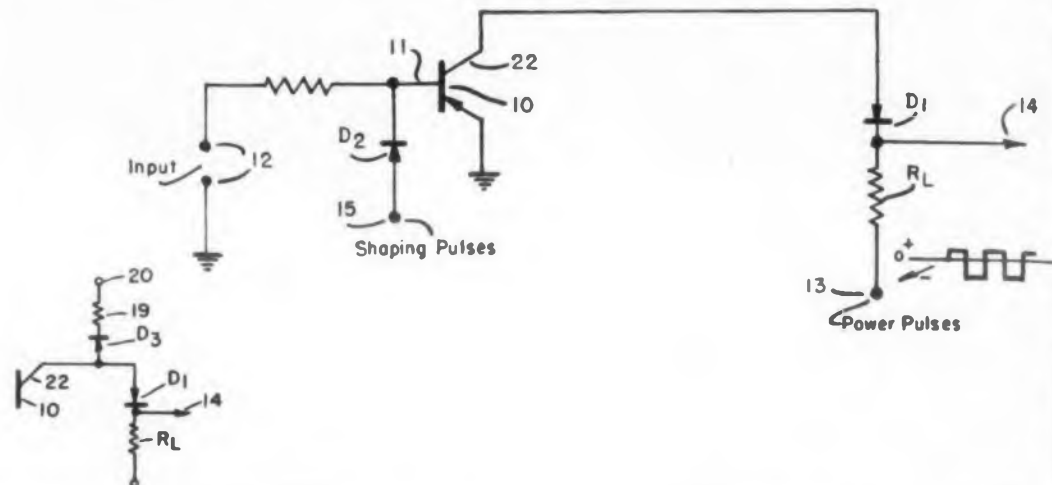
Transistor Logical Device

Patent No. 2,866,105. John Presper Eckert, Jr. Assigned to Sperry Rand Corp.

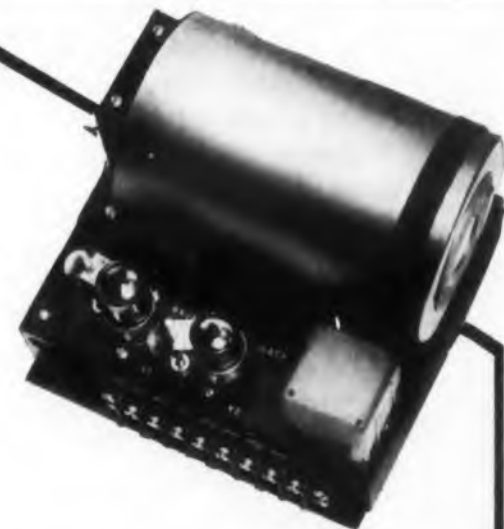
Semiconductor charge carrier storage is used to improve the gain and frequency characteristics of a transistor amplifier. The enhancement current continues to flow in the output even after the applied input has terminated. Thus power pulses which gate the transistor output are faithfully reproduced and amplified.

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ELECTRONIC DESIGN • May 27, 1957

Coaxial Line Switch

Patent No. 2,876,422. Adolph J. Wozniak.
(Assigned to Thompson Products Inc.)

Coaxial lines can be constructed so that they may be positioned close to each other with no overhang of the switch blade beyond the inner conductors. Over a wide range of frequencies, the VSWR is to approximately unity.

Fundamentally, a ground-plane type of connecting section exists between the switch blade and the surface of the wall between the outer conductors. The invention lies in shaping the switch blade to make the characteristic impedance of this section substantially less than the characteristic impedance of the coaxial lines. Switch blade 29, enclosed in metal

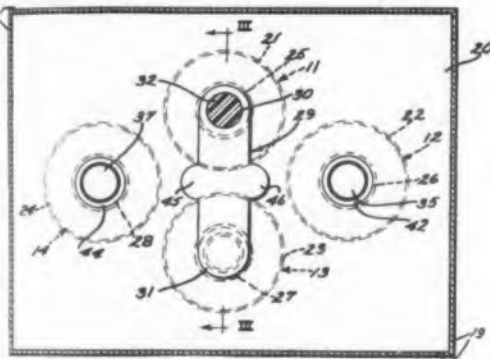
housing 19, engages inner conductor 30 and the blade may be rotated to select inner conductors 26, 27 and 28. The intermediate portion of blade 29 is increased by semicircular projecting ears 45 and 46 to produce a smooth discontinuity and the required impedance.

To improve the electrical contact, blade 19 is made of a magnetic material and magnets are mounted at the terminal ends of the inner conductors.

Variable Capacitors

Patent No. 2,855,550. Jack Elliot Bayha.
(Assigned to Emerson Radio & Phonograph Corp.)

A miniature plunger-type variable capacitor, of uniform and reproducible characteristics, is particularly useful for mass production. The spacing of the movable element, relative to the stator, is kept constant as the capacitance is varied by making the plunger effectively a cylinder of mercury in pressure contact with the dielectric. For the broadcast range, a tuning capacitor of 350 mmf is 0.25 in. in diameter and 1.5 in. long. Barium titanate, 0.015 in. thick, has a dielectric constant



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	DS FEATURES	YOUR DESIGN REQUIREMENTS
1	Pins and sockets	Easily insertable and removable
2	Terminations	Crimp-type
3	Contact retention	Withstands minimum of 25 lbs. pull
4	Crimp strength	Greater than the wire itself
5	Hand tools	Simple, fool-proof crimping, inserting and removal tools
6	Interfacial seal	Continuous dielectric separation without voids; no bonding, reversion or shrinkage of inserts
7	Environmental	Meets or exceeds MIL-C-26482 (ASG)
8	Temperature	-100°F. to 300°F.
9	Push-pull coupling	Positive ball-lock design; operates in direction of plug travel
10	Contact size	Immediately available in #20 size; others to follow
11	Shell size	Immediately available in 3, 7, 12, 19, 27, 37 and 61 contacts
12	Interchangeability	Mates with existing Deutsch DM5000, DM6500 and DM9000 series
13	Assembly	Delivered completely assembled except for insertion of contacts

For complete technical information and test report, contact your Deutsch Representative or write us for Data File 5C.



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MODEL 330-M

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FREQUENCY RANGE: continuous coverage from 0.2 cps to 20 kc, with independent control of high and low cut-off frequencies.

CUT-OFF FREQUENCY ACCURACY: plus or minus 5%.

INSERTION LOSS: zero db plus or minus 1 db in pass band.

ATTENUATION SLOPE: nominal 24 db per octave outside pass band, with peaking circuit to reduce corner-frequency loss.

MAXIMUM ATTENUATION: greater than 80 db.

INPUT IMPEDANCE: approximately 22 megohms plus 20 mmfd.

EXTERNAL LOAD IMPEDANCE: 500 ohms or greater.

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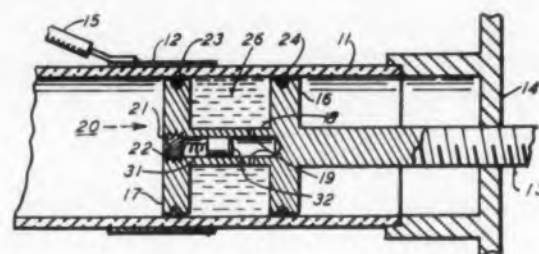
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CIRCLE 43 ON READER-SERVICE CARD

PATENTS



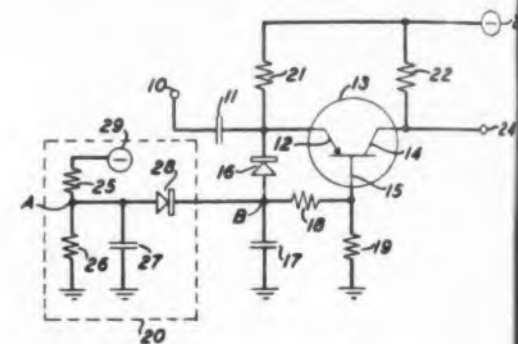
of 300; this permits the ratio of maximum to minimum capacitance to be several hundred.

In section, screw 13 drives the plunger which traps mercury 26 between the O-ring sealed outer faces 16 and 17. Spring-loaded piston 32 forces the mercury into intimate contact with the inner wall of dielectric 11. The outer plate 12 may be shaped to produce any desired capacitance versus displacement law.

Monostable Transistor Circuit

Patent No. 2,876,367. Eric E. Sumner.
(Assigned to Bell Telephone Labs., Inc.)

An extension network may be switched to increase effective capacitance so that a monostable amplifier is kept longer in



$$10 \times p = J \cdot R \cdot L$$



BMR-105
BDR-105
0015%

* This enigmatic equation was invented to emphasize the fact that JRL resistance sets are manufactured to ten times the precision of conventional high-accuracy components. For example: 17-bit binary conversion accuracy or 5-figure binary-coded decimal accuracy are achieved by simple switching of our BMR-105 or BDR-105 resistance sets. Each set is made up of independent, oil-immersed, primary-standard NB-1† style resistors. Incomparable for digital-analog conversion, programming, synthesis, calibration, to .0015% accuracy! Only \$180.00. Write for bulletin E-59-5.



RESISTOR NETWORKS, INC., A DIVISION OF
JULIE RESEARCH LABORATORIES, INC.

556 West 168th Street, New York 32, N. Y. LOrraine 8-8700

† Patent applied for.

CIRCLE 44 ON READER-SERVICE CARD

ELECTRONIC DESIGN • May 27, 1955

capacitor 17 quickly runs down through the smaller resistors 18 and 19 to reverse bias varistor 28 and the network as a re-

sult is ready for the next trigger pulse although capacitor 27 is not yet fully discharged.

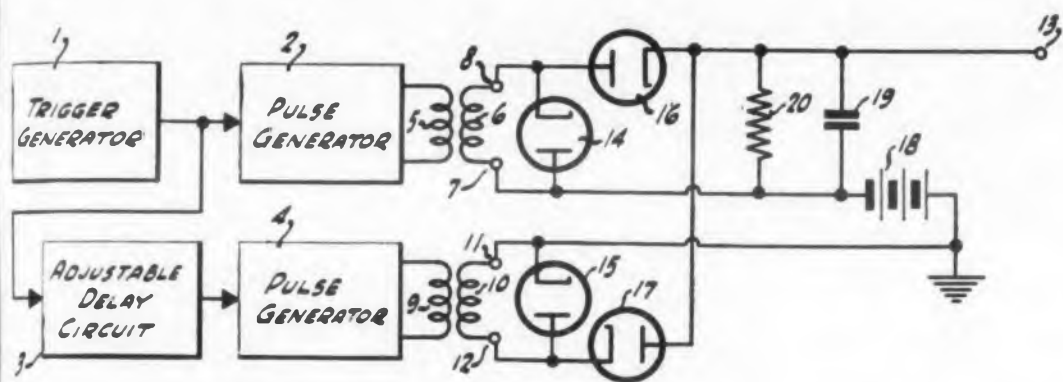
High Voltage Pulse Generator

Patent No. 2,871,380. Albert J. Morris and Joseph P. Swanson. (Assigned to Levinson Electronic Products, Inc.)

Flat top pulses, 30 kv in amplitude are generated by alternately charging and discharging a 5000 mmf capacitor. Pulse width is variable between 5 and 10 μ sec at close to 100 per cent duty cycle.

In the figure, generator pulses the

transformer to cause capacitor 19 to charge through diode 16. Subsequently, a delayed trigger fires generator 4 causing the capacitor to discharge through diode 17. Diodes 14 and 15 clamp the output voltage to that of battery 18 and the time constant of capacitor 19 combined with resistor 20 insures a flat top output pulse and limits the charging current to a safe value.



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In addition to their space and weight saving advantages, RVG Precision Potentiometers provide high accuracy characteristics you'd ordinarily expect only in conventional, larger pots. These units meet or exceed all applicable MIL specs, are rugged and resistant to extreme shock and vibration. All can be ganged. Plenty of design potential! For outline of suggested applications, write THE GAMEWELL COMPANY, Newton Upper Falls 64, Massachusetts.

RVG-8T — 1/2" diam. Trimmer and precision servo types. Rated 2 watts at 85°C derated to 0 watts at 150°C. Resistance ranges from 20 ohms to 50K ohms (100K available). Linearities: standard for trimmer $\pm 3\%$; servo $\pm 1\%$ ($\pm 0.5\%$ or better available when resolution permits). Trimmers stocked in 10 values from 100 ohms to 75K.

RVG-10 — 5/8" diam. Threaded bushing standard. Servo mount and ball bearings also available. Max. Res. 30,000 ohms: $\pm 5\%$. Min. Res. 25 ohms: $\pm 5\%$. Linearity (standard) $\pm 0.5\%$.

RVG-14 — 3/8" diam. Servo mount with sleeve bearings standard. Ball bearings also available. Max. Res. 50,000 ohms: $\pm 5\%$. Min. Res. 40 ohms: $\pm 5\%$. Linearity (standard) $\pm 0.5\%$, (special) 0.25%.



CIRCLE 45 ON READER-SERVICE CARD

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CIRCLE 46 ON READER-SERVICE CARD

Harmonic Amplitudes in Class C Operation

E. Brenner

WHEN plate current flow through a triode or a pentode occurs in pulses, the harmonic amplitudes are generally found by graphical approximations. It is possible, however, to find "exact" closed-form expressions for the harmonics if the plate characteristics are approximated through a power law of the form:

$$i_b = (e_g + e_b/\mu)^n \text{ for a triode} \quad (1)$$

and

$$i_b = P (e_g + e_{g2}/\mu_2)^n \text{ for a pentode} \quad (2)$$

when n is an exact multiple of $1/2$.

The grid voltage is given as:

$$e_g = E_c + E_{gm} \cos \omega t$$

while the plate voltage is assumed to be sinusoidal (because of the tank load) and of the form

$$e_b = E_b - E_{bm} \cos \omega t$$

Using these forms, the plate current equations can be written:

$$i_b = P(E_{gm} - E_{bm}/\mu)^n (\cos \omega t - \cos \theta) \quad (3)$$

for a triode, and for a pentode

$$i_b = P (E_{gm})^n (\cos \omega t - \cos \theta) \quad (4)$$

where θ is the angle of current flow which gives the ratio of the half of plate current flow to the period of the signal.

The plate current can be written in the form of a Fourier series, for an even function,

$$i_b = I_0 + \sum_1^{\infty} I_k \cos k \omega t \quad (5)$$

where the amplitude of the k th harmonic has the form

$$I_k = I f_{k,n}(\theta) \quad (6)$$

where I is for the triode

$$I = P (E_{gm} - E_{bm}/\mu)^n (1 - \cos \theta)^n \quad (7)$$

and for the pentode

$$I = P E_{gm}^n (1 - \cos \theta)^n \quad (8)$$

The function of $f_{k,n}$ is the current flow function for the k th harmonic and depends also on the ex-

ponent n .

In general

$$f_{k,n}(\theta) = \frac{\epsilon}{\pi} \int_0^\theta \frac{(\cos x - \cos \theta)^n}{(1 - \cos \theta)^n} \cos kx dx \quad (9)$$

where $\epsilon = 1$ for $k = 0$ and $\epsilon = 2$ for $k > 0$. The result of the integration of Eq. 9 for integral values of n is given in the table. For $n = 1/2$ and $n = 3/2$, f can be evaluated in terms of elliptic integrals. Introducing the parameter

$$\gamma_m = \int_\theta^1 \frac{x^m dx}{\sqrt{P(x)}}; P(x) = (1 - x^2)(x - \cos \theta)$$

whose dependence on θ is shown in the Figure, the expression for f which corresponds to the values $n = 1/2$ and $n = 3/2$ are as given in the table.

In the original paper tables and charts for the current flow function are given.

Abstracted from an article by D. Thielicke Nachrichtentechnik, Vol. 9, No. 2, February 1959, pp 50-55.

The current flow function $f_{k,n}(\theta)$

k \ n	0	1	2
0	θ/π	$\frac{2}{\pi} \sin \theta$	$\frac{1}{\pi} \sin 2 \theta$
1	$\frac{1}{\pi} \cdot \frac{\sin \theta - \theta \cos \theta}{1 - \cos \theta}$	$\frac{1}{\pi} \cdot \frac{\theta - \sin \theta \cos \theta}{1 - \cos \theta}$	$\frac{2}{3} \frac{\sin^3 \theta}{1 - \cos \theta}$
2	$\frac{(1 + 2 \cos^2 \theta) \theta - 3 \sin \theta \cos \theta}{2\pi (1 - \cos \theta)^2}$	$\frac{2}{\pi} \frac{\sin \theta - 1/3 \sin^3 \theta - \theta \cos \theta}{1 - \cos \theta}$	$\frac{3 \theta - \sin \theta \cos \theta (3 + 2 \sin^2 \theta)}{6\pi (1 - \cos \theta)^2}$
1/2	$\frac{\gamma_1 - \gamma_0 \cos \theta}{\pi (1 - \cos \theta)^{1/2}}$	$\frac{2 (\gamma_2 - \gamma_1 \cos \theta)}{\pi (1 - \cos \theta)^{1/2}}$	$\frac{2}{\pi} \cdot \frac{(3 - 4 \cos^2 \theta) \gamma_1 - \gamma_0}{(1 - \cos \theta)^{1/2}}$
3/2	$\frac{\gamma_0 (3 \cos^2 \theta - 1) - 4\gamma_1 \cos \theta}{3\pi (1 - \cos \theta)^{3/2}}$	$\frac{2}{5\pi} \cdot \frac{\gamma_1 (3 + \cos^2 \theta) - 4\gamma_0 \cos \theta}{(1 - \cos \theta)^{3/2}}$	$\frac{2}{\pi} \frac{2\gamma_4 - 4\gamma_3 \cos \theta - (1 - 2 \cos^2 \theta) \gamma_2 + 2\gamma_1 \cos \theta - \gamma_0 \cos^2 \theta}{(1 - \cos \theta)^{3/2}}$

(9)

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1959



(above) Setting up a diffraction image for a research study in near-infrared optics

(left) Nation's first successful re-entry tests were conducted with the Lockheed X-17

(bottom right) Research and Development facility in the Stanford Industrial Park at Palo Alto, California, provides the latest in technical equipment



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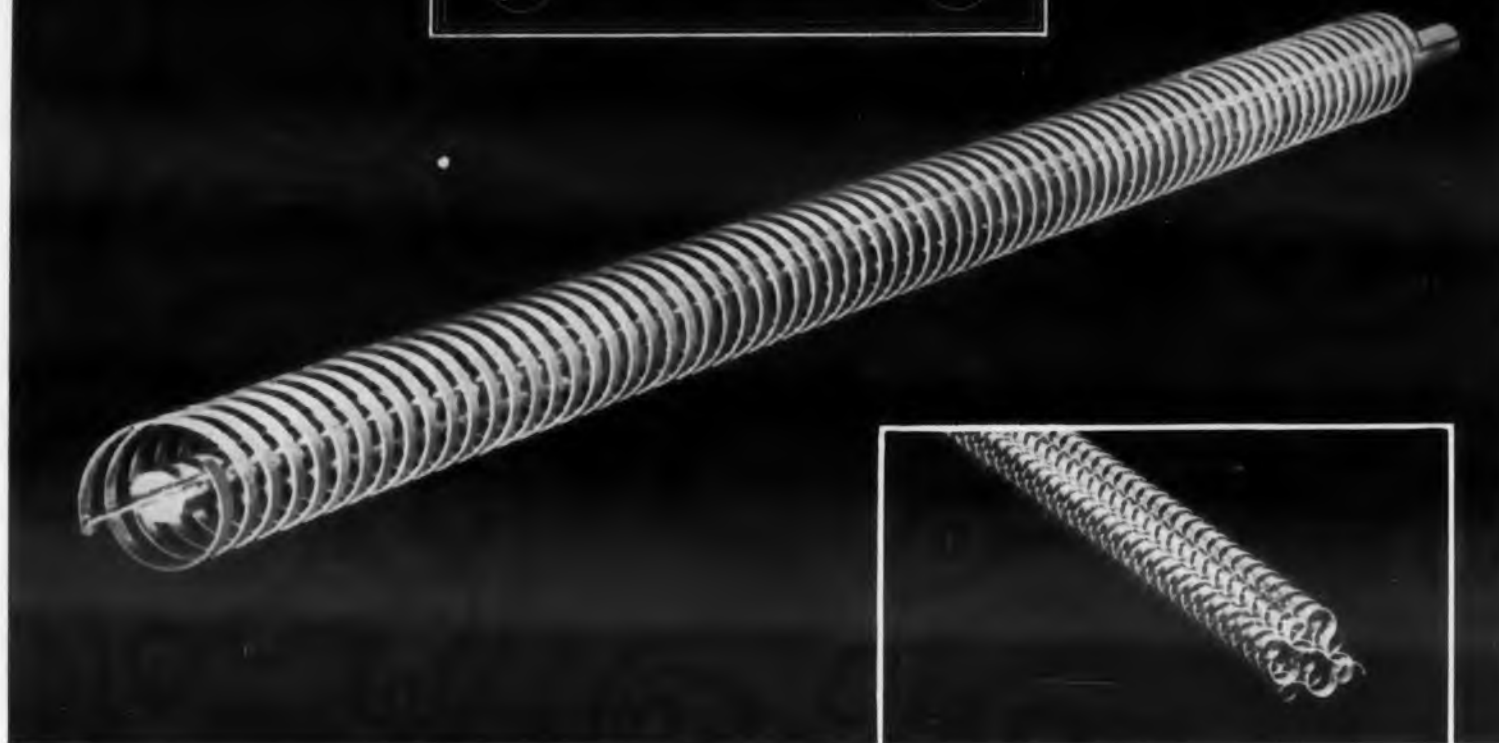
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1959

Microwave Component News

from SYLVANIA



Sylvania research in circuit "Components" paves the way for better microwave systems

RECOGNIZE THESE special traveling wave tube helices? They were developed through Sylvania's programs of applied research and product development in the continuing search for better microwave components.

Beams and Microwaves—Sylvania has accumulated unequalled experience in the study of the interplay between electron beams and microwaves.



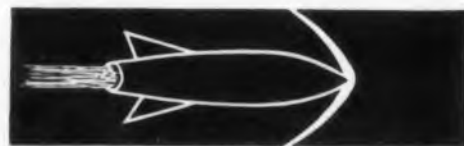
"Better Power-Bandwidth in TWT's"

The development of a Traveling Wave Tube with essentially flat power-bandwidth is a classic example of the progress being made through the theoretical investigation of microwave components viewed as RF circuits.

This experience will play a vital role

in realizing the full potential of the beam approach to parametric amplifiers, which offers a theoretical noise level of zero.

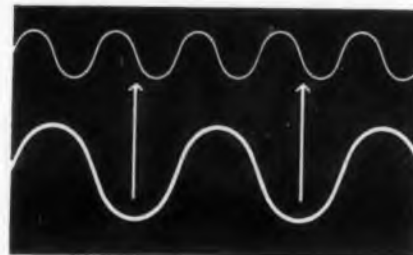
Major strides are also being made in klystrons, backward-wave magnetrons (Carcinotrons), and low-noise backward-wave amplifiers.



"Communicating with missiles in flight"

Plasma and Microwaves—Sylvania is also making thorough studies of the interplay between plasmas and microwaves. This area holds the secrets of getting communications through shock waves and exhaust of missiles in flight. And, it provides direction for the development of new microwave components such as high-speed switches and harmonic generators.

Solid State and Microwaves—Important new research promises better power sources for higher frequencies through harmonic generation, using ferrites. The work has already yielded new ferrite isolators and circulators; microwave control devices are in the development stage.



"Harmonic Generation"

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RUSSIAN TRANSLATIONS

Nonlinear and Parametric Phenomena in Radio Engineering

Part 19

A. A. Kharkevich

(Translated by J. George Adashko)

Chapter 3

Response of Nonlinear Systems to External Signals

34. Locking

If two oscillations with frequencies ω and ω_0 exist simultaneously in a linear system, these two oscillations interfere with each other and produce beats. The beat frequency equals the absolute difference in frequencies, i.e.,

$$\Omega = |\omega - \omega_0|$$

If ω_0 is constant, the beat frequency varies with ω as shown by the two dotted lines in Fig. 121.

In a self-oscillating system under the influence of an external voltage, beats are also observed, but as the frequency varies the phenomenon takes a different course. When ω increases the beat frequency first diminishes (as ω approaches ω_0) linearly. Then the beat frequency starts diminishing more and more rapidly (solid line of Fig. 121).

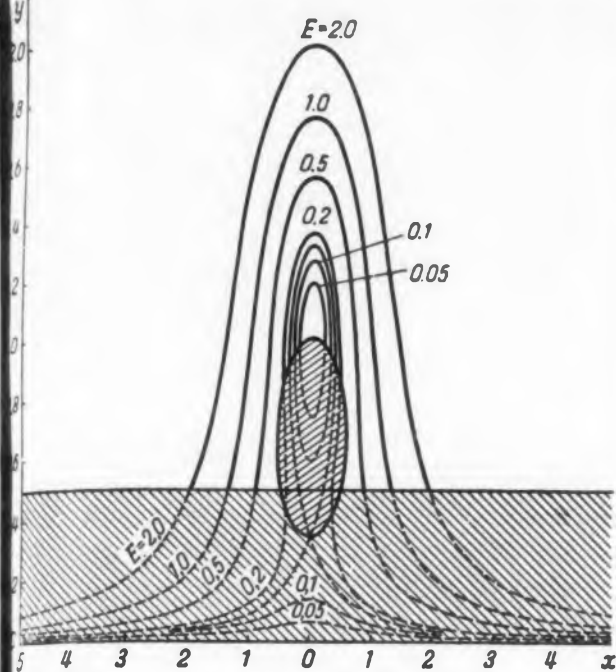


Fig. 119. Resonance curves with shaded areas representing unstable regions.

and at a certain value $\omega = \omega_1$ the beats stop. The frequency of the oscillator becomes ω_1 , in spite of the fact that it is tuned to a frequency ω_0 . A further increase in frequency to a value $\omega = \omega_2 > \omega_1$ does not change the situation. The generated frequency equals the frequency of the external voltage. There are no beats. Finally, when $\omega > \omega_2$, beats appear again.*

The phenomenon just described, whereby the external voltage forces its frequency on the oscillator, is called locking. The frequency interval $\omega_2 - \omega_1$, within which the oscillator has the same frequency as the applied voltage is called the lock-in band. Our next problem is to determine the width of this band and on what it depends.

Away from the lock-in band, the situation is in fact the same as if there were two components, a "self-oscillation" of frequency ω_0 and a "forced oscillation" of frequency ω . However, such a representation is only formal in character, since generally speaking these components are physically inseparable. This is why the terms "beats" and "beat mode," although applicable to these phenomena, have an arbitrary meaning in this case.

To solve this problem let us turn to the phenomena represented graphically by the resonance curves of Fig. 119. The stable mode represented by the solid lines of Fig. 119 is exactly the lock-in mode, when forced oscillations have the frequency of the applied voltage. The transition to the un-

is appropriate to remark here that the very term "beats" signifies the presence of two separate oscillations, the addition of which causes the beats. In the case of the nonlinear self-oscillating system we deal with a single process, which is characterized by a periodic variation of amplitude outside the lock-in band.



tough tests for incoming material



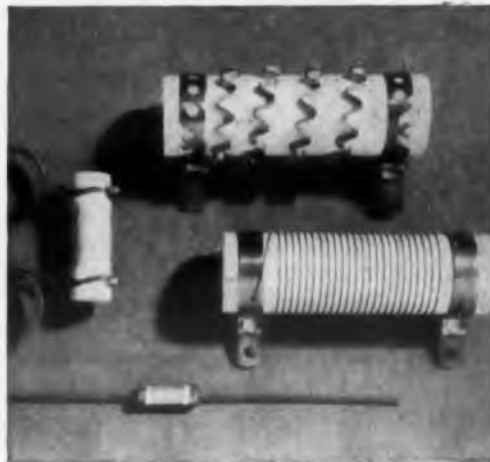
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finest alloy resistance wire



spot welded or silver brazed junctions



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Built-in VITROHM reliability, from core to final vitreous enamel, lets you solder these resistors in and forget 'em

They come in a tremendous variety of sizes, shapes and ratings, but all Ward Leonard VITROHM resistors have one thing in common: They're built for maximum reliability.

Take just one point—ceramic cores, for example: Made by Ward Leonard to exacting specs, the cores feature low-porosity, high-dielectric-strength ceramic for maximum moisture exclusion and good electrical insulation. What's more, the thermal coefficient of linear expansion of ceramic is specially selected to make the core compatible with resistance wire, enamel and terminals . . . to prevent cracking, crazing, peeling, or layer separation.

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These synchronously driven choppers handle d-c signals as small as 10^{-8} volt. Sensitive, stable performance. Available with special features such as fungus proofing, grounded housing, mica-filled base, various contact percentages. Weight: 10 oz. Prices from \$39.

ELECTRICAL CHARACTERISTICS					
Part No.	354210-2	354210-3	354210-1	354210-4	355081
Modulation Frequency	20-30 cycles	40-45 cycles	50-65 cycles	50-65 cycles	360-440 cycles
Switching Action (SPDT)	(Make-before-break) Each contact closed 55% of each cycle ($\pm 2\%$) Other actions, as specified			(Break-before-make). Each contact closed 47% of each cycle	Each contact closed 57% of each cycle ($\pm 7\%$)
Driving Coil Requirements	6.3 v. 60 ma at rated frequency				18 v. 94 ma at rated frequency
Contact Rating	100 microwatts at 6 v max.; 1.0 ma max.				
Electrostatic Stray Pickup	2×10^{-9} volts per ohm of input circuit impedance				2×10^{-10}
Electromagnetic Stray Pickup	Less than 2×10^{-6} volts, constant to within 2×10^{-7}				2×10^{-6} volts constant to 2×10^{-6}
Phase Shift	Output voltage lags driving phase by $17^\circ \pm 5^\circ$				Lags driving phase by 45° to 50°
Symmetry	Within 2%				Within 7%
Shielding	Frame and coil shield, grounded through pin No. 2				Shell and coil shield, grounded through pin No. 2
Load Characteristics	Resistive or Inductive				
Vibration Resistance	Output voltage varies less than 2% with rates of vibration from 0 to 10g				

MOTORS



Designed for chart drives, servos and balancing circuits, these motors are available in three general types: Stack type, with easily maintained sectional housing; self-lubricated, oil-sealed type; and fungus-proofed, oil-sealed military motors. Prices from \$40.

Nominal No. Load R.P.M.*	R.P.M.*	Gear Ratio	Intermittent Rated Load (oz.-in.)	Max. Starting Torque (oz.-in.)	Pull-in Torque Min. (oz.-in.)	Continuous Torque (oz.-in.)	Power (Watts) Loaded	Current (amps) Loaded	Temp. Rise °F
Two Phase Induction Motor									
330		44:1	4	10			11.5	0.11†	70
144		10:1	5	20			11.5	0.11†	70
48		30:1	15	60			11.5	0.11†	70
23		60:1	30	110			11.5	0.11†	70
Synchronous									
	180	10:1			12	12	24	0.21	100
	180	10:1			2.0	2.0	11.5	0.11	65
	90	20:1			14	12	11.5	0.11	65
	60	30:1			21	18	11.5	0.11	65
	30	60:1			42	36	11.5	0.11	65

*1/6 less at 50 cycles †Field winding 11.0 watts, balance in amplifier winding
Note: Some speeds available at 25 cycles
All motors are available in two phase and synchronous models

AMPLIFIERS



They amplify a d-c or a-c microvolt input signal sufficiently to drive one field of a two-phase balancing motor. Three stages of voltage amplification are followed by the power-output phase discriminator stage, which supplies power for the motor. Extremely low stray pickup . . . adjustable sensitivity . . . fast response. Priced from \$110 to \$250.

Gain	Sensitivity (Microvolts)	Nominal Input Impedance (Ohms)
10^6	4.0	400, 2,200, 50,000
4×10^6	1.0	400, 7,000, 50,000
12×10^6	0.4	400, 2,200, 7,000
40×10^6	0.1	2,200

POWER SUPPLY—115 v., 60 cycles (fused power line)

OUTPUT—2 to 18 ma. into 12,000 ohm load

SENSITIVITY—Continuously variable screwdriver adjustment. Recessed slot protects setting

MOUNTING—Operation unaffected by mounting position

OPTIONAL FEATURES—(a) thermocouple burnout protection, (b) without desensitizing adjustment, (c) parallel T feedback, (d) velocity damping, (e) special connecting cables and plugs, (f) without tubes, shields, and converter, (g) for 25 cycles.

MINNEAPOLIS-HONEYWELL, Wayne and Windrim Aves., Phila. 44, Pa.

Honeywell



First in Control

CIRCLE 49 ON READER-SERVICE CARD

RUSSIAN TRANSLATIONS

stable region denotes the appearance of beats. Thus, the width of the lock-in band (the interval $\omega_2 - \omega_1$ in Fig. 121) is none other than the width of the resonance curve at the boundary of the stability region. Starting with these considerations we can now readily determine the width of the lock-in band.

The equation of the resonance curves in Fig. 119 is

$$y [x^2 + (1-y)^2] - E = 0$$

At small values of applied voltage, i.e., when E is small, the curves terminate on the peak of the ellipse near $y = 1$. Inserting this value into (1) we find

$$x^2 = E$$

or, putting in the full expressions (see Section 33)

$$\frac{2\Delta\omega}{\omega_0} = \frac{E_m}{A_0}$$

The quantity to the left is precisely the relative width of the lock-in band. It turns out to be equal to the ratio of the amplitude E_m of the applied voltage to the amplitude A of the self-oscillation voltage in the absence of an external emf. Co

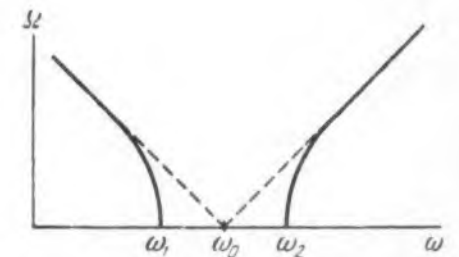


Fig. 121. The beat frequency produced by two oscillations varies with ω as shown by the dotted lines.

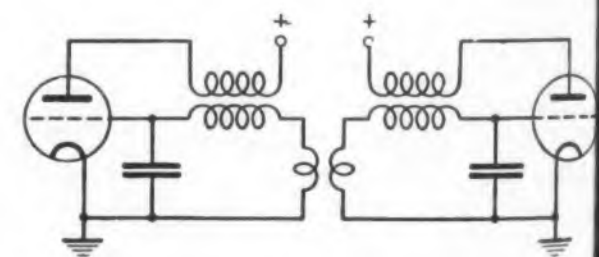


Fig. 122. Two oscillators coupled to each other.

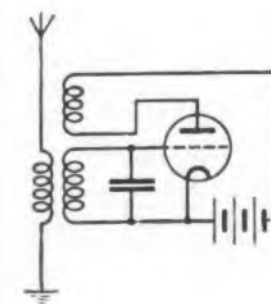


Fig. 123. The simplest type regenerative receiver.

...ring the quantity A_0 as a constant parameter
...the system under consideration, we conclude
...at the width of the lock-in band increases with
...creasing external signal.

At large values of E_m the resonance curve no
...terminates on the ellipse but on the hori-
...tal line $y = 1/2$. Inserting this value into (1)

$$x^2 = 2E - 1/4$$

$$\frac{2\Delta\omega}{\omega_0} = \sqrt{2 \frac{E_m^2}{A_0^2} - \frac{\beta_0^2}{\omega_0^2}}$$

...the second term under the square root is the
...of the initial damping of the system (i.e.,
...allowance for the feedback). This is in any
...a very small quantity, so that we can put

$$\frac{2\Delta\omega}{\omega_0} \cong \sqrt{2} \frac{E_m}{A_0}$$

For intermediate values of E_m , when the reso-
...curves terminate on the sides of the ellipse,
...can put

$$\frac{2\Delta\omega}{\omega_0} = k \frac{E_m}{A_0}$$

...as we have already established

$$1 < k < \sqrt{2}$$

...exact value of k can be obtained if necessary
...solving simultaneously equations (9) and (11)
...the preceding section.

The locking phenomenon is used in radio engi-
...to synchronize an oscillator by means of
...external voltage or for mutual synchronization
...two oscillators. If two oscillators are coupled to
...each other, as shown in Fig. 122, each oscillator
...induces in the tank circuit of the other a voltage
...which the other oscillator sees as external.

The operation of the circuit is described by a
...system consisting of two equations on type (1)
...section 33), where the right halves of the equa-
...tions play the role of the coupling terms. If both
...oscillators are identical but tuned to different fre-
...quencies, they can be mutually synchronized at a
...certain intermediate frequency, which in general
...has two possible values. But if one oscillator is
...sufficiently powerful it can be considered as an inde-
...pendent voltage source and consequently imposes
...its own frequency on the weaker oscillator.

35. The Regenerative Receiver

The simplest regenerative receiver, shown in
...Fig. 123 reduces to the circuit of Fig. 118. How-
...ever, unlike the preceding case, the feature of the
...regenerative receiver is that it operates under-ex-
...cited, although near the excitation threshold, for

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ELIMINATED GALLING,
INCREASED RESISTANCE TO
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nectors.

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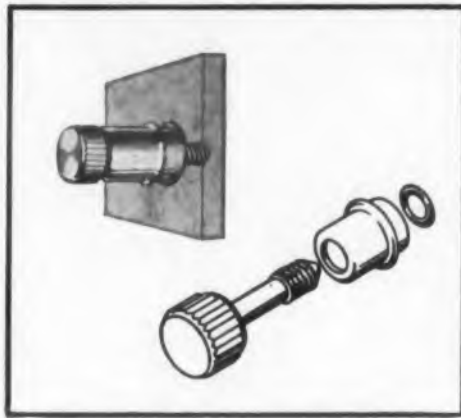
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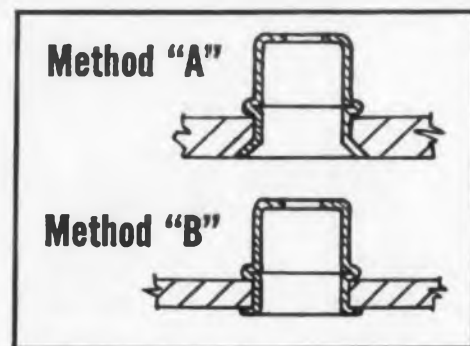
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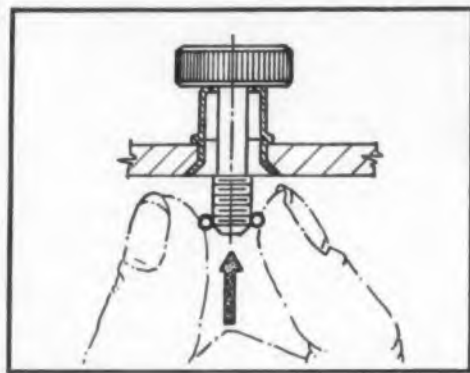


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it is there that the maximum gain is obtained.

The equation of the regenerative receiver is the same as eq (7) of Section 33.

$$\left[(\omega_0^2 - \omega^2)^2 + \omega^2 \left(2\beta_0 + \frac{1}{4} \gamma A^2 \right)^2 \right] A^2 = \omega_0^4 E_m^2 \quad (1)$$

Let us first consider the problem of the sensitivity of the receiver when tuned exactly to the received frequency, i.e., when $\omega_0 = \omega$. In this case we obtain from (1)

$$\left(2\beta_0 + \frac{1}{4} \gamma A^2 \right) A = \omega_0 E_m$$

By increasing the feedback we can bring the receiver almost to self excitation. In this case the initial damping factor

$$\beta_0 = \alpha - \frac{1}{2} \omega_0^2 MS$$

is nearly equal to 0, and we have

$$\frac{1}{4} \gamma A^2 = \omega_0 E_m$$

hence

$$A = \left(4 \frac{\omega_0}{\gamma} E_m \right)^{\frac{1}{2}} = k E_m^{\frac{1}{2}}$$

Let us find the sensitivity (or, what is the same, the gain) of the receiver, defining it as

$$\nu = \frac{dA}{dE_m}$$

Differentiating (3) we get

$$\nu = k E_m^{-\frac{1}{2}}$$

We see that when E_m tends to zero the sensitivity tends to infinity. Thus, a regenerative receiver has a variable sensitivity; the weaker the received signal, the greater the sensitivity. This is naturally a convenient property of this receiver.

In practice the maximum attainable sensitivity is limited by the internal noise of the receiver which becomes very strong near the self-excitation threshold, owing to the large gain.

In its day, the regenerative receiver played

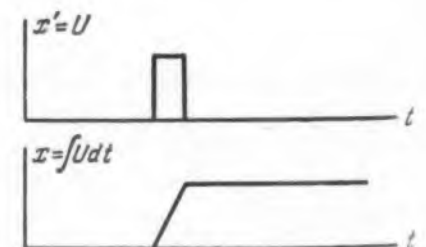


Fig. 124. A voltage pulse and its integral.

very important role because of its exceeding simplicity and high sensitivity. However, the regenerative receiver has very substantial shortcomings, namely instability and poor selectivity. Furthermore, when operating at the very threshold of oscillation it frequently oscillates, interfering with nearby receivers.

This is why the regenerative receiver was superseded by more advanced receivers, and the regenerative circuit is useful only when used as the so-called regenerative filter.

36. Pulsed Synchronization

In Section 33 we considered synchronization of an oscillator by means of a sinusoidal external voltage. In this section we shall consider synchronization by periodic short pulses. This case affords a very clear qualitative explanation of the synchronization process, and we shall make use of this opportunity. We shall not investigate pulsed synchronization analytically.

We start out as before with the circuit of Fig. 123, but assume now that the external voltage is a periodic sequence of short pulses of arbitrary shape. To explain the mechanism of synchronization we shall represent the phenomenon by diagrams in the phase plane. We must first represent graphically the action of a voltage pulse.

Let the variables be the same quantities as used in the example at the end of Section 25, namely

$$x = \int U dt, \quad x' = U$$

Let the pulse be characterized by the fact that the voltage starts varying from a certain initial value (in particular, zero) and returns after a short time to this initial value. Thus, after termination of the pulse, the voltage $U = x'$ remains unchanged, while the integral of the voltage acquires an increment determined by the area of the pulse. The relations are explained in Fig. 124 for the case of a rectangular pulse.

If we now plot the same relations in the phase plane using x and x' as coordinates, the representative point, originally in position 1, will move under the influence of the pulse to a new position 2, along the trajectory shown dotted in Fig. 124. The time of the move equals the duration of the pulse. We shall assume that the pulse is so short that the representative point jumps from 1 to 2 practically instantaneously.

As to the shape of the trajectory, it depends naturally on the shape of the pulse. But we are naturally not interested in the shape of the trajectory. All that is important to what follows is that the representative point move, in the final analysis, a distance proportional to the area of the pulse, parallel to the x axis (since the voltage is the



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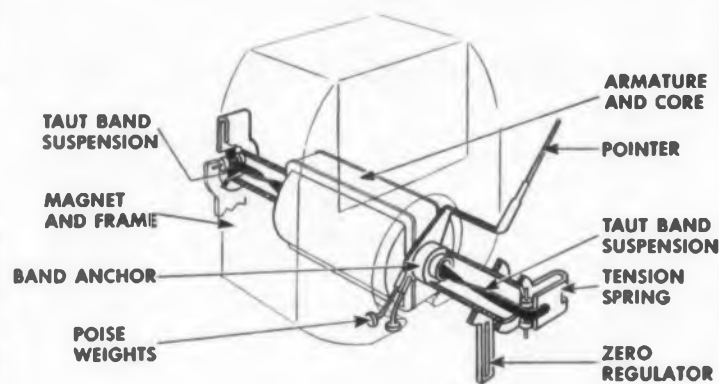
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same before and after the pulse). This shift of the representative point is indeed an expression of the action of the pulse. We shall denote it by h .

Let us now turn to the effect of synchronizing pulses on an oscillator in operation. In the absence of pulses, the operation of the oscillator is described by a stable limit cycle. The presence of the pulses, however, should lead to a closed cycle that includes the jump due to the action of the pulse. Such a cycle can be made of only a segment of a spiral as shown in Fig. 125. The scale of the abscissa is $\omega_0 x$ instead of x , to equalize the scales of both axes.

With the scales so matched, the limit cycle becomes a circle. We shall assume that the representative point moves along the spiral at a constant

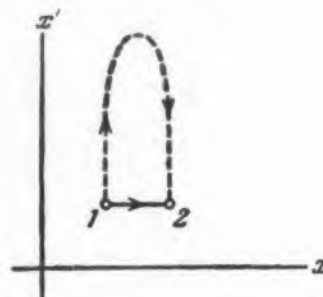


Fig. 125. The voltage pulse of Fig. 124 and its integral, plotted in the phase plane.

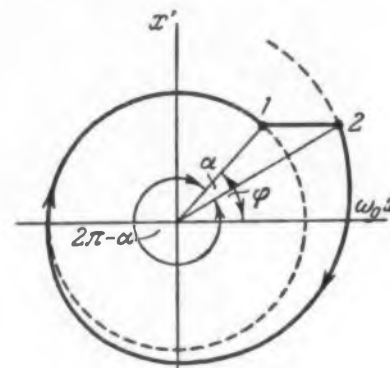


Fig. 126. The oscillator phase diagram for a case when a pulse synchronizes the oscillator to a frequency greater than the tank resonant frequency.

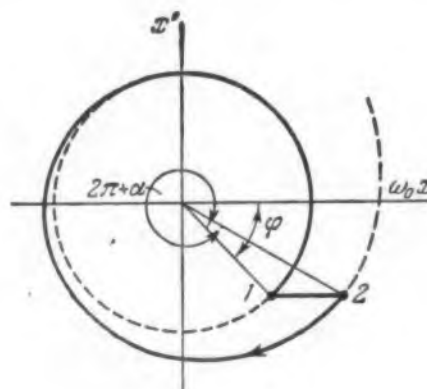


Fig. 127. The phase diagram for $\omega < \omega_0$.

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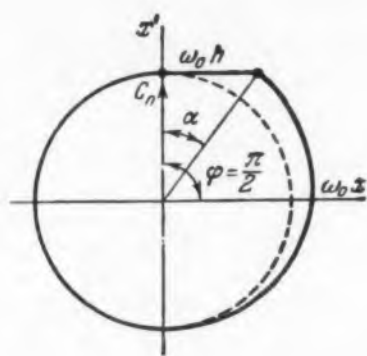


Fig. 128. The oscillator phase diagram for maximum detuning.

angular velocity and that rotation by 2π corresponds to one period of the self oscillation.

$$I_o = 2\pi/\omega_o$$

It is then immediately seen from Fig. 126 that the representative point traverses the closed cycle shown by the solid line in Fig. 126 during the time $T < T_o$. This follows from the fact that the angular displacement equals $2\pi - \alpha < 2\pi$ and consequently, less time is consumed in such a displacement. The jump from 1 to 2 occurs, according to our assumption, instantaneously.

Figure 126 corresponds, so to speak, to the case where the pulse synchronizes the oscillator to a frequency $\omega > \omega_o$. The phase diagram for synchronization to a frequency $\omega < \omega_o$ is shown in Fig. 127.

Here the representative point covers during the cycle, an angular distance $2\pi + \alpha > 2\pi$ for which the time required is $T > T_o$. Diagrams of this type make it possible to determine the width of the lock-in band.

Let us increase the angle ϕ , which determines the phase of the synchronizing pulse relative to the free oscillations of the generator. The maximum value of the angle α , i.e., the maximum detuning

$$\Delta\Omega = |\omega - \omega_o|$$

is obviously obtained when

$$|\phi| = \pi/2$$

The relations obtained in this case are illustrated in Fig. 128. We have

$$\tan \alpha = \frac{\omega_o h}{C_o}$$

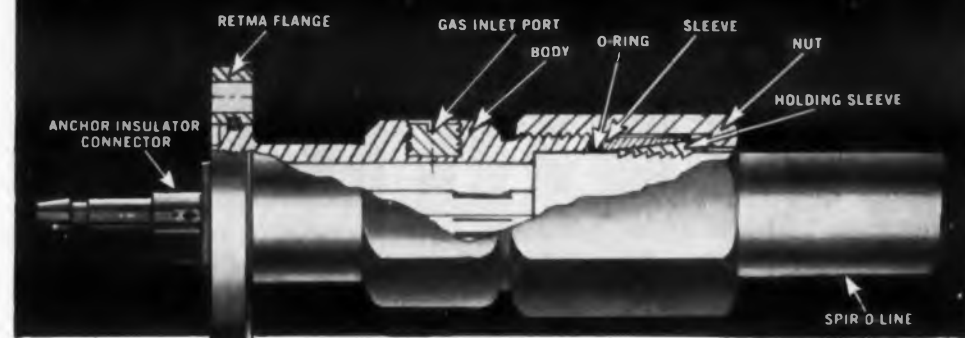
where C_o is the self-oscillation amplitude that corresponds to the limit cycle. Actually α is the small angle (in our diagrams the rate at which the spiral unwinds is greatly exaggerated). Therefore $\tan \alpha \cong \alpha$. But α is a measure of the variation of the period (relative to the self-oscillation period which is equal to 2π). Thus

$$\frac{\alpha}{2\pi} = \frac{\Delta\omega}{\omega_o}$$

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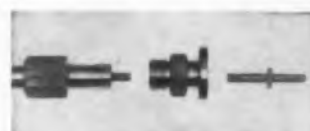
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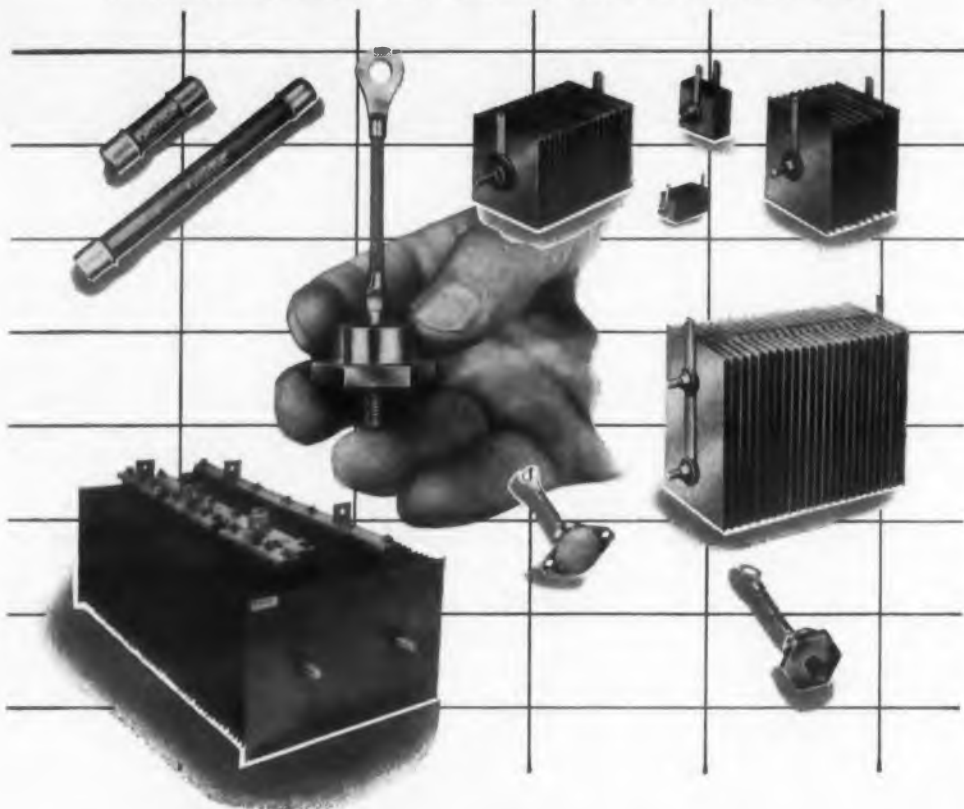
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and consequently,

$$\frac{\Delta \omega}{\omega_0} \cong \frac{\omega_0 h}{2\pi C_0}$$

This is the maximum relative detuning in one direction. The total relative width of the lock-in band is therefore,

$$\frac{2\Delta\omega}{\omega_0} \cong \frac{\omega_0 h}{\pi C_0} \cong \frac{\omega h}{\pi C_0}$$

We can transform this result still further by recognizing that $\omega h/\pi$ is none other than the amplitude of the first harmonic in the Fourier expansion of an aperiodic sequence of short pulses. This component, whose frequency is ω , is the one producing the synchronization.

Denoting

$$\frac{1}{\pi} \omega h = E_1$$

we obtain for the lock-in band

$$\frac{2\Delta\omega}{\omega_0} \cong \frac{E_1}{C_0}$$

i.e., the same result as in Section 34.

Let us note in conclusion that the connection between the detuning and the angle ϕ , which is obvious from Figs. 126 and 126, is the same as given by eq (5) of Section 22.

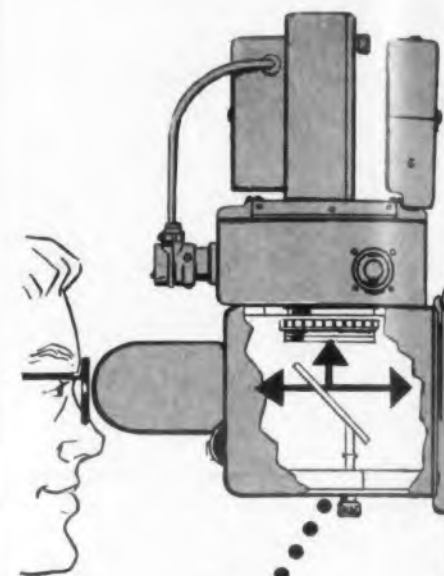
37. Synchronization of A Relaxation Oscillator

Let us now analyze the very simple mechanism of synchronization of a relaxation oscillator by means of an external sinusoidal voltage. We choose a thyatron circuit (Fig. 129) as the oscillator. This circuit differs from the relaxation oscillator with a gas-filled diode (Fig. 105) in that the firing voltage U_2 depends on the grid voltage of thyatron T , and specifically in that the firing voltage increases with increasing negative grid voltage. The extinction voltage U_1 is practically constant.

Let us note that the circuit contains a current limiter CL so that the charging current is assumed constant and consequently the voltage increases linearly while charging.

In the absence of an external voltage, the oscillator behaves as described in Section 29; the capacitor is charged to the firing voltage U_2 . At this value of the voltage the ionic conduction becomes large and the capacitor is discharged rapidly (practically instantaneously) to the extinction volt-

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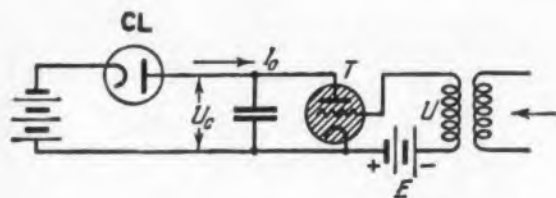


Fig. 129. A simple thyatron oscillator.

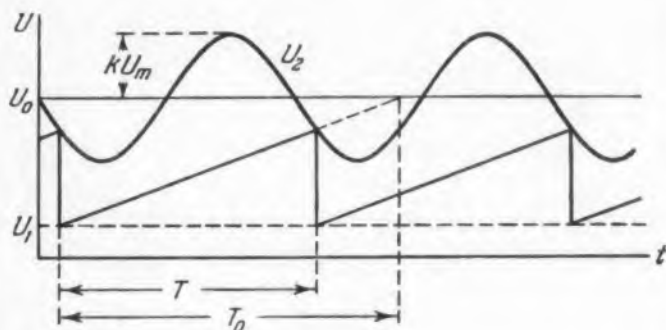


Fig. 130. A plot of the oscillation waveform for the thyatron oscillator of Fig. 129.

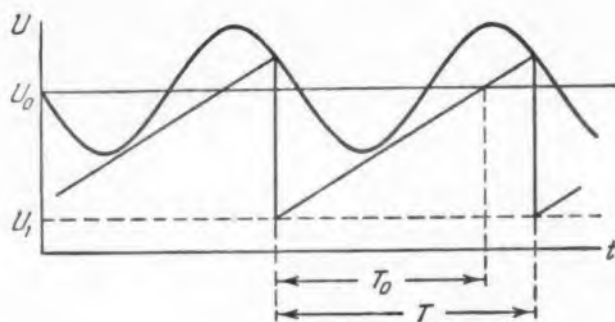


Fig. 131. When the sin of the phase angle ψ becomes negative, the oscillation period increases.

age U_1 . The charging of the capacitor is then resumed.

Let us now apply to the grid an external synchronizing sinusoidal voltage

$$U = U_m \sin \omega t$$

The firing voltage U_2 will now become a variable quantity. Let us assume that the firing voltage varies in proportion to the grid voltage. We have

$$U_2(t) = k(E + U_m \sin \omega t) \\ = U_o + k U_m \sin \omega t$$

where U_o is the firing voltage in the absence of an alternating external voltage (i.e., at a constant voltage E). Firing takes place when

$$U_c = U_2$$

i.e., the capacitor voltage becomes equal to the firing voltage. At this instant a voltage jump occurs. The capacitor voltage rises during the charging time linearly

$$U_c = U_1 + \frac{I_o}{C} t$$

Figure 130 shows a plot of the oscillation. The figure shows the periodic process and we see that the oscillation period becomes equal to the period T of the external voltage and unequal to the pe-

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RUSSIAN TRANSLATIONS

riod T_0 of free oscillations of the generator. In other words, the external voltage locks in the oscillator; the oscillator is synchronized by the external voltage.

Let us derive the fundamental equations for steady-state synchronized oscillations. If time is reckoned from the voltage jump, the firing voltage is written

$$U_2 = U_0 - k U_m \sin(\omega t + \phi)$$

The next jump occurs when

$$U_c = U_0 - k U_m \sin(\omega T + \phi) = U_0 - k U_m \sin \phi$$

But, on the other hand, during the instant $t = T$ we have

$$U_c = U_1 + \frac{I_0}{C} T = U_1 + \alpha T$$

Thus,

$$U_1 = \alpha T = U_0 - k U_m \sin \phi$$

Using the relation

$$U_1 = \alpha T_0 = U_0$$

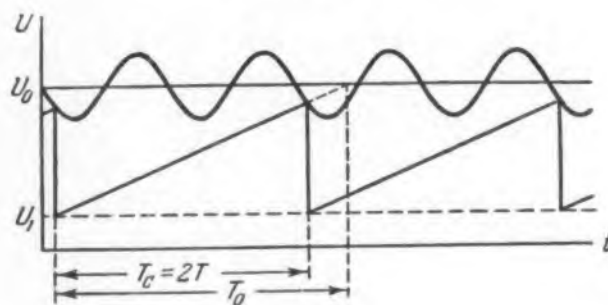


Fig. 132. A plot synchronized oscillation when $k = 2$.

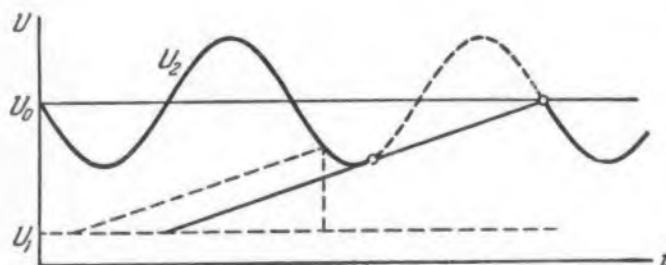


Fig. 133. This plot shows the parts of the sine wave (dotted) where synchronization is not possible.

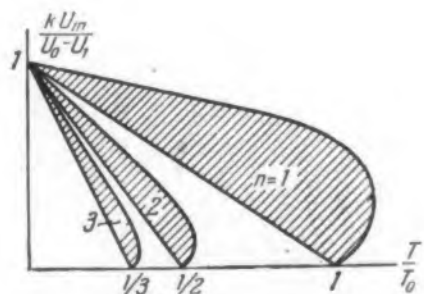


Fig. 134. Regions of possible modes of synchronization for various values of ω .



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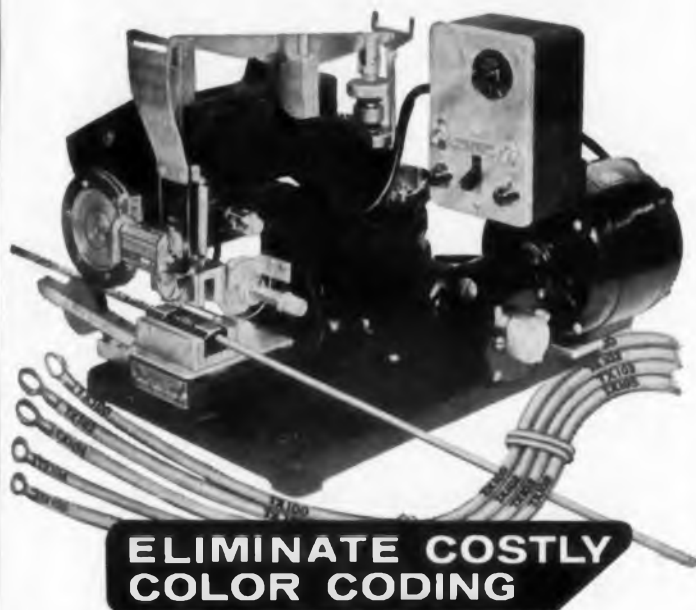
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The folder gives operating and environmental specs, coil data, contact capacities, dimensions, diagrams of contact and wiring arrangements. Write: Dept. A33-425.

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we get

$$\alpha (T_o - T) = k U_m \sin \phi$$

or

$$\frac{T_o - T}{T_o} = \frac{k U_m}{U_o - U_1} \sin \phi \quad (1)$$

or

$$\frac{T}{T_o} = 1 - \frac{k U_m}{U_o - U_1} \sin \phi \quad (2)$$

When $\sin \phi < 0$ the period acquires a positive increment, i.e., it increases. The corresponding graph is shown in Fig. 131. If we consider that the relative change in the period is small, we can equate it to the relative change in the frequency, i.e., we can put (see eq 1)

$$\frac{\omega_o - \omega}{\omega_o} \cong \frac{k U_m}{U_o - U_1} \sin \phi$$

The extreme values of $\sin \phi$ are ± 1 . We therefore find the total width of the lock-in band to be

$$\frac{2\Delta\omega}{\omega_o} \cong \frac{2k U_m}{U_o - U_1}$$

An investigation of the stability of the synchronized mode shows that the stability condition is expressed in terms of the phase of synchronization exactly as in Section 33, namely,

$$-\frac{\pi}{2} < \phi < \frac{\pi}{2}$$

The derived relations require some refinement. First it must be noted that the equality

$$U_c = U_o - k U_m \sin \phi$$

from which we determine the instant of the voltage jump, can be satisfied not only when $t = T$, but also when $t = nt$, where n is any integer. Thus, we must write in formulae (1) and (2) in the general case

$$T_o = nT$$

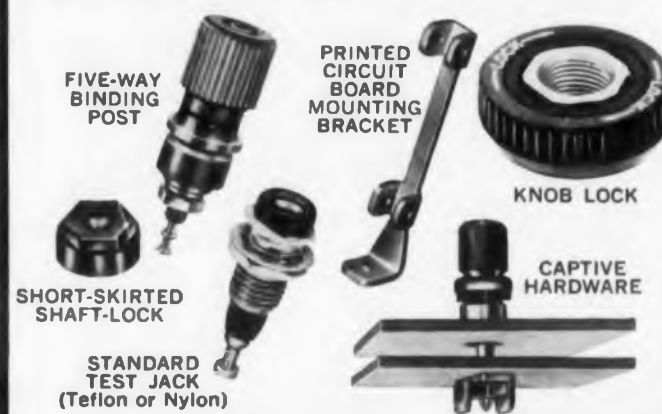
where T_o is the period of the synchronized oscillations. Figure 132 shows the graph of a synchronized oscillation with $k = 2$. This is sometimes called synchronization by means of a subharmonic.

Secondly, certain modes are not realizable for given values for U_o , U_1 , α , kU_m , and T , since the line U_o is tangent to the sine curve U_2 and cannot fall on a certain portion of the sine wave. This is shown in Fig. 133, on which the non-realizable portion of the sine wave is shown dotted.

Taking all this into account, we can plot the regions of the possible modes of synchronization at various multiples of n (Fig. 134); these regions are shown shaded on the diagram.

(This concludes Chapter 3. The fourth and final chapter will begin in the next issue of ELECTRONIC DESIGN.)

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HOW TO MEASURE VSWR



This microwave measurement bench is for the determination of Voltage Standing Wave Ratio using the slotted-line technique. Other systems utilizing directional couplers or magic tees for measurement of VSWR are known, but the use of the Slotted Section assures maximum accuracy.

Regardless of the technique used, accurate readings depend on the precision of the test instruments involved. When it comes to microwave test instruments PRD produces the widest range of the most precise equipment available anywhere in the world.

You will notice in the measurement bench shown that there are four test components separating the klystron tube mount from the Slotted Section. These are: A Slide Screw Tuner, ferrite Isolator, Level Set Attenuator, and a broadband direct reading Frequency Meter. THE USE OF THESE FOUR COMPONENTS IN THE TEST LINE IS MANDATORY FOR PRECISE VSWR MEASUREMENTS!

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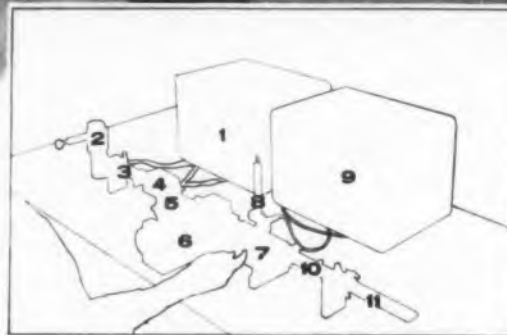
The reaction Frequency Meter accurately monitors the output of the klystron by a resonant dip on the Standing Wave Amplifier.

A Slotted Section, tuned Broadband Probe, Standing Wave Amplifier, and matched Termination complete the precision waveguide, X-band, VSWR bench. A Klystron Power Supply to provide the signal source with power and modulation and a Fixed Waveguide Attenuator to simulate the unknown are also shown.

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- 1—809 Klystron Power Supply, catalog page F-10
- 2—703 Shielded Tube Mount, catalog page F-8
- 3—303-A Slide Screw Tuner, catalog page B-14
- 4—1203 Isolator, catalog page A-21
- 5—159-A Level Set Attenuator, catalog page A-17
- 6—535 Frequency Meter, catalog page D-12
- 7—203-D Slotted Section, catalog page B-11
- 8—250-A Broadband Probe, catalog page B-12
- 9—277-A Standing Wave Amplifier, catalog page E-7
- 10—UNKNOWN—represented by a 140 Fixed Waveguide Attenuator, catalog page A-11
- 11—116-A Waveguide Termination, catalog page A-19

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NEW LITERATURE

Author's Guide

69

"It's Easy to Write for ELECTRONIC DESIGN" answers the most common questions of potential authors by succinctly suggesting areas of editorial interest and technical guidelines for manuscript submission. The guide will simplify writing problems by indicating the most suitable topics for the magazine and the best way to organize information, plus style pointers, length preference, illustrative data, and payment procedures. Here's a self-starter for electronic engineers accustomed to making design decisions and anxious to get them published. Hayden Publishing Co., 830 Third Ave., New York 22, N.Y.

Miniature Rotary Switch

70

In 16 pages this brochure covers most of the basic rotary switch configurations presently available. It provides technical data on construction, quality, operational characteristics, and environmental abilities. Janco Corp., 3111 Winona Ave., Burbank, Calif.

Shielding Magnetic Tape

71

Data Sheet 142 Engineering Report illustrates, gives tabulated summary, and fully describes a proposed technique for comparatively evaluating the effectiveness of shielding magnetic tape in Netic Co-Netic tape preservers versus unshielded tapes. Magnetic Shield Division, Perfection Mica Co., 1322 No. Elston Ave., Chicago 22, Ill.

Closed-Circuit TV Equipment

72

This eight-page illustrated bulletin describes a complete line of closed-circuit television equipment. Catalog 6-103 also illustrates a variety of cameras, camera housings, pan-tilt mechanisms, control panels, monitors, and other components for assembling complete closed-circuit TV systems. Cohu Electronics, Inc., Kin Tel Div., 5725 Kearny Villa Road, San Diego 11, Calif.

Linear Magnetic Amplifiers

73

A new standard line of low level linear magnetic amplifiers is described in Bulletin #S-921. Developed to supply military and civilian needs, the units have applications which include aircraft and missile telemetering instrumentation and industrial measurements. Completely static, the solid state devices are used in connection with such signal sources as strain gage transducers, thermocouples, resistance thermometer bridges, photo cells and meter shunts. The bulletin furnishes complete performance specifications. Also included are detailed data on principles of operation and a characteristics curve chart. Magnetic Amplifiers, Inc., 632 Tinton Ave., New York 55, N. Y.

Electrical Tapes

74

A general guide to the upper temperature limits of electrical tapes is provided in this four-page fold-out brochure. A bar graph indicates the relative life of various tape backings such as vinyl, paper, cotton, acetate, polyester, glass cloth with rubber adhesive and with silicone adhesive, polytetrafluoroethylene and silicone rubber. The graph shows maximum temperatures for: (1) continuous long term operation; (2) functional operation for days to weeks; and (3) functional operation for a short time surge of minutes to hours. Minnesota Mining and Manufacturing Co., 900 Bush Avenue, St. Paul 6, Minn.

Catalog and Calibration Manual

75

This 16-page publication covers the calibration of the newest types of process control systems. Particular emphasis is placed on the testing and calibration of those systems which use proportional currents for signal transmissions and telemetering. The complete electrical and mechanical specifications for three (3) new instruments are given: model MV-I, a combination potentiometer, signal source, and milliammeter; the model AC-I, an automatic cold junction compensator for use with all thermocouples and instruments; the model RU-I, a combination milliammeter and millivoltage "run up" source. Technique Associates, Inc., 1413 North Cornell Ave., Indianapolis, Ind.

Motors

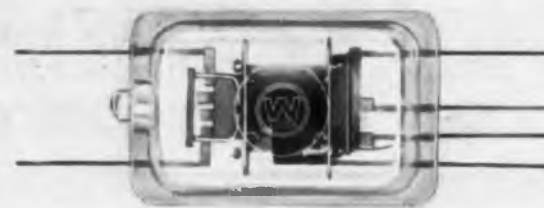
76

This 12-page bulletin lists and describes 300 standard stock reducer and nonreducer motors of various types and sizes. Horsepower ratings of nonreducer motors listed range from 1/7 to 1/500. Reducer motors, with speeds ranging from 833 to 0.7 rpm, have torques of 12.8 in. oz to 219 in. lbs. Bodine Electric Co., 2500 W. Bradley Place, Chicago 18, Ill.

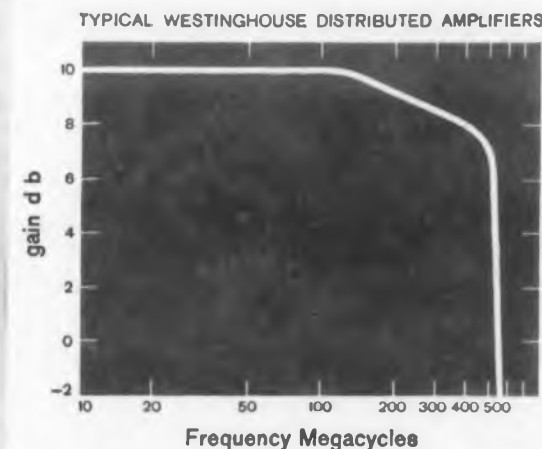
Receiving Tube Manual

A new revised edition of the "RCA Receiving Tube Manual" is available. Highlights include technical data for more than 625 receiving tubes, covering types for black-and-white and color television and series-string applications and more than 50 TV picture tubes including color types; a simplified section on basic tube theory and applications; an expanded section on electron tube applications; data on generic tube types, interpretation of tube data, and electron-tube installation. Charts for receiving tube classification and picture-tube characteristics are up-dated to include the latest data. Manual RC-19 from: Commercial Engineering, RCA Electron Tube Div., Harrison, N.J. Cost \$0.75.

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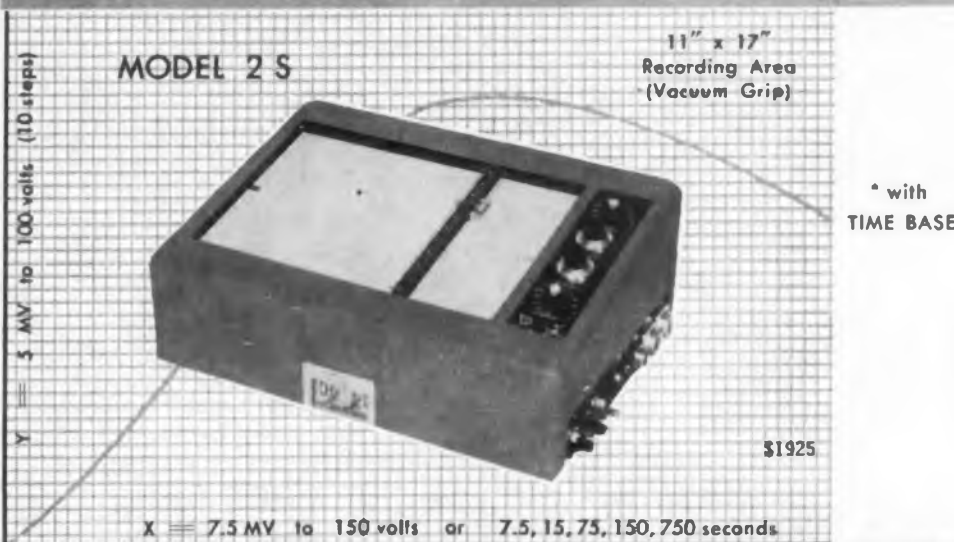
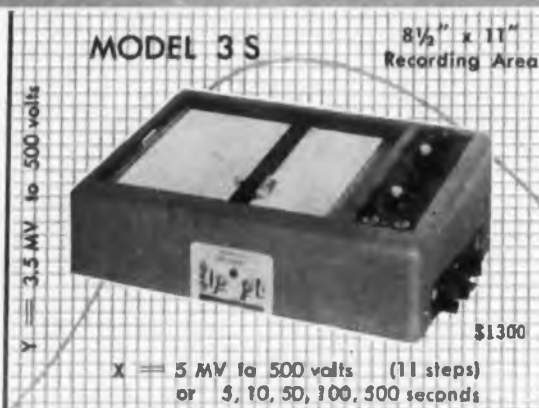
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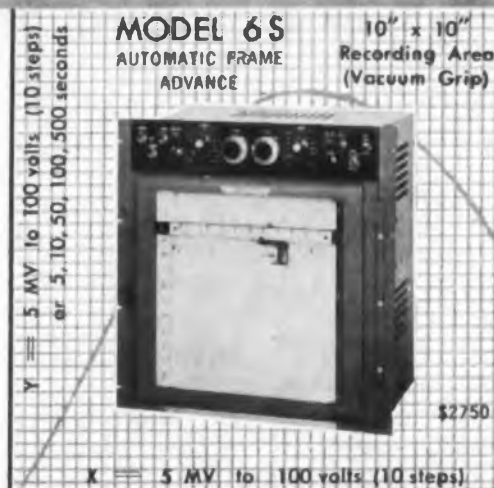
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NEW LITERATURE

Cathode Ray Tubes 79

Seventy industrial and government CR tubes are listed in this 2-color, 4-page illustrated folder. Types and technical data is cataloged as radar indicators, oscilloscopes, oscilloscope photography, industrial monitors, receiver check tubes, flying spot scanners, and industrial and government TV applications. Continental Electronics Corp., Industrial & Gov't. Div., 2724 Leonis Blvd., Los Angeles 58, Calif.

Power Packs 80

Two-color catalog sheet, No. 116, covers descriptive data on a line of miniaturized magnetic-transistor regulated power packs. These new power packs combine the characteristics of transistor and magnetic regulators and are intended for all types of electronic powering applications. The data sheet includes descriptive information on specification data, model types, and prices. Electronic Research Associates, Inc., 67 Factory Place, Cedar Grove, N.J.

Terminal Bushings and Seals

This 16-page, illustrated bulletin, E-40, describes high voltage terminal bushings and ceramic-to-metal seals. It offers specifications on an expanded line of over 100 standard sizes of high voltage terminals, feed-throughs and cable end seals. Each type of terminal is illustrated with a photograph as well as a dimensional drawing and specification chart. Also shown are various types of special hermetic seals and terminals. Write to: H. Frahme, Alite Div., The U.S. Stoneware Co., P.O. Box 119, Orrville, Ohio.

Microwave Ferrites 81

Two new microwave ferrites, R-5 and R-6, are described in this brochure entitled "General Ceramics Microwave Ferrites." Data on typical applications, hysteresis loops, magnetic and dielectric properties with relation to frequency, dimensions, and other characteristics of the materials is included. General Ceramics Corp., Keasbey, N.J.

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Aluminum Soldering

83

This handy-size brochure includes data on soldering fluxes, irons and flames, and gives complete information on actual soldering methods such as hot plate, dip, furnace, friction, glass fiber brush, and ultrasonic operations. Types and properties of aluminum solders are explained, plus the corrosion of soldered joints and their performance in aluminum. Text includes diagrammatic illustrations. Reynolds Metals Co., Box 2346, Richmond 18, Va.

Electronic Equipment

84

Short form Catalog, No. 8-A, 4 pages, provides information on the operation, construction, and features of sweep generators, plug-in markers, rf filters, detectors, and attenuators. A chart is included, listing all sweep generator models with their major performance specifications. The chart provides the basic information necessary to select the proper sweep generator for specific test or production problems involving measurement of frequency response. Telonic Industries, Inc., Beach Grove, Ind.

RF Measurements

85

Application Notes, #4, describes a dual channel system for measurement of insertion loss up to 20 db with an accuracy of 0.02 db per 10 db at any frequencies for which power sources and bolometers are available. The 8-page, two-color, brochure has been updated to include the latest equipment. Weinschel Engineering, 10503 Metropolitan Ave., Kensington, Md.

Relays

A complete line of basic general purpose relays is featured in this 16-page catalog. Relays shown range from small multi-contact midgets to sensitive, heavy duty, medium power and power types. Each is adaptable to many variations. Each relay is associated with detailed dimensional drawings, available contact arrangements, current and coil operating data, operating speeds, terminals, weights, enclosures, terminal headers and mounting information. *Catalog may be obtained by writing on company letterhead to Guardian Electric Manufacturing Co., 1621 West Walnut St., Chicago 12, Ill., attention D. O. Boucher.*



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For further information contact:

525 South Webster, Indianapolis 19, Indiana

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NEW LITERATURE

Loudspeaker

89

Selection of the proper loudspeaker for a given application is simplified by this foldout brochure. Called form 3R-3509, it permits comparison at a glance of 24 loudspeakers, horns and drivers. Information given for each unit includes response; sensitivity; power-handling capacity; and other characteristics; recommended baffle or horn, and application data. Each unit is illustrated. Radio Corporation of America, Sound Products, Building 15-1, Camden, N.J.

Drafting Equipment

90

This 100-page, 8-1/2 x 11, drafting equipment and supply catalog features: drawing tables, surveying equipment and supplies; slide rules; triangles, T-squares; drawing instruments; lettering devices; graph papers; and tracing papers, mylar and cloth. One of the sections of the catalog illustrates and describes 120 time saving, clear plastic templates. Alfred Mossner Co., 108 W. Lake St., Chicago 1, Ill.

Terminal Tester

Specifications and operating characteristics of a terminal pull tester are given in Bulletin 750e. Illustrated with photographs and drawings, the two-page data sheet describes the application, construction and operation of the air-powered tester. Hunter Spring Co., Quality Control Equipment Dept., a Div. of American Machine & Metals, Inc., 1 Spring Ave., Lansdale, Pa.

Potentiometer Catalog

This 28-page technical catalog gives specifications, diagrams and general information on a complete line of single turn precision wirewound potentiometers. Diameters include 1/2" microminiature to 5" high resolution. A series of sine-cosine, and wirewound trimming types are also included. Write to Electronic Sales Division, DeJur-Amsco Corporation, 45-01 Northern Boulevard, Long Island City 1, N.Y., and indicate company affiliation and title.

NEW NYLON & THERMO-PLASTIC PARTS from GRC

Economically mass produced on fully automatic patented machines, GRC nylon parts are available from stock in many sizes and types. GRC uses single cavity, techniques, molds in one automatic cycle gets accurate, uniform parts, ready for immediate use.

These advantages, these economies, apply too, to tiny made-to-order parts to your specifications . . . in quantities of 25,000 to many millions. Write for bulletin describing GRC's unique method for injection molding small plastic parts or send prints for quotation. Ask about our zinc alloy die castings, too!

NO SIZE TOO SMALL
Maximum size 1 1/4" long,
— .03 oz.

Be sure to see GRC
at the Design
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GRIES REPRODUCER CORP.

World's Foremost Producer of Small Die Castings

40 Second St., New Rochelle, N. Y.

NEW Rochelle 3-8600



NOW! NYLON NUTS AND SCREWS

Brand new nylon hex nuts in ten sizes (#2 thru 5/16") added to GRC's complete line of nylon screws. GRC's single cavity molding technique gives exceptional uniformity, accuracy, and economy to the outstanding properties of nylon fasteners.

Take advantage of nylon's high strength to weight ratio, built-in electrical insulating properties, stability, resilience and elasticity. GRC molded nylon fasteners, nuts and screws, set screws, screw insulators, washers, etc.—are available from stock in a wide range of types, sizes and lengths.

WRITE, WIRE,
PHONE NOW for
GRC's new catalog
of die cast and
molded fasteners.

GRIES

Multiplier Phototube Catalog

The current line of multiplier phototubes, their specifications and circuit data, in addition to detailed information on a complete line of potted voltage dividers and ultraviolet and "solar blind" response P.T.s, are presented in this new catalog. The 90-page catalog, second edition of "Du Mont Multiplier Phototubes," which revises and adds to information listed in the original publication (1956), discusses operational theory, applications, and specifications for standard and special multiplier phototubes. Write on company letterhead to the Sales Dept., Electronic Tube Div., Allen B. Du Mont Laboratories, Inc., 750 Bloomfield Ave., Clifton, N.J.

Attenuators

93

In four pages that have both graphs and pictures, this bulletin covers fixed commercial-model 50 attenuators. Their frequency range is from dc to 1000 mc, and they are usable to 2000 mc. Electrical specifications are covered in the bulletin. Peinschel Engineering, 10503 Metropolitan Ave., Kensington, Md.

Parabolic Antennas

This catalog contains data sheets on parabolic antennas and accessories. Included is technical data on passive reflectors, commercial communications antennas, unclassified military antennas and waveguide and transmission lines. Address request on company letterhead to The Gabriel Co., Electronics Div., 135 Crescent Road, Needham Heights, Mass.

Metal Enclosures

94

Catalogs No. 590 and S-159 cover metal housings and a modular console system, respectively. Pictures, dimensional data and prices are included in the catalogs. Premier Metal Products Co., 337 Manida St., New York 59, N.Y.

Plastics

95

"How to Use Sheets, Rods, Tubes, Tape and Other Shapes of Teflon" is the name of this 8-page brochure. Pictorial material and technical data on Teflon is included. Commercial Plastics & Supply Corp., 630 Broadway, New York, N.Y.

FROM JUST ONE HEAD... TO A COMPLETE



STEREO • MONAURAL • ERASE



LINE IN JUST 2 YEARS

DYNAMIC GROWTH IN MAGNETIC TAPE RECORDING HEAD PRODUCTION



A dependable source serving the industry with precision quality magnetic heads created individually to your exact specifications and quantity requirements. Let our design engineers and production people solve your tape recording head problems . . . write, wire or call for details.

MICHIGAN MAGNETICS, INC.

Vermontville, Michigan

ENTERTAINMENT • SPECIAL APPLICATION



CIRCLE 96 ON READER-SERVICE CARD



SS-5
DP-DT spring return
0.5 amp @ 125v ac-dc
U.L. Inspected

SS-15
SP-ST pushbutton, momentary
contact, 1 amp @ 125v ac
U.L. Inspected

SS-16
3-position special
0.5 amp @ 125v ac-dc

THINK HOW YOU CAN



SS-31
3-Position, 3 amps
@ 125v ac
U.L. Inspected

SS-32
SP-DT, 1 amp
@ 125v ac-dc
U.L. Inspected

SS-33
DP-DT, 3 amps
@ 125v ac
U.L. Inspected

IMPROVE YOUR PRODUCT



SS-50
DP-DT miniature
0.5 amp @ 125v ac-dc
U.L. Inspected

SS-8
SP-DT, optional
detent, 1 amp @ 125v ac

SS-27
SP-DT spring return
1 amp @ 125v ac
U.L. Inspected

WITH THESE LOW COST



SS-26-1
SP-DT, 1 amp
@ 125v ac
U.L. Inspected

SS-9
SP-DT spring return
1 amp @ 125v ac
U.L. Inspected

SS-18
3-position special
1 amp @ 125v ac
10-1000 cycles

STACKPOLE SWITCHES!

Get This GUIDE TO MODERN SWITCHING ▶

Ask for 8-page Switch Bulletin RC-11D
World's largest slide switch line—over 12 low cost standard types—dozens of economical adaptations. NEW colored knobs. Special conventional and miniaturized switches designed and produced for large quantity users. Electronic Components Division, STACKPOLE CARBON COMPANY, St. Marys, Pa.



CIRCLE 97 ON READER-SERVICE CARD

HIGH-RELIABILITY COMPONENTS



New DIGITAL MOTORS

Positive lock — bi-directional stepping motors

These bi-directional digital motors are designed to withstand severe environmental requirements and are operable under high shock and vibration. In its function the digital motor indexes and locks positively.

The motors are available for angular rotation of 30° or 36° at a rate of up to 40 pulses per second.

ULTRASONIC DELAY LINES Custom-designed



Development engineers can now employ new concepts in existing and projected applications. These delay lines are small in size, hermetically sealed and vibration proof.

SPECIFICATIONS

Delay range... 5 to 6000 microseconds
Meets tolerances of... ± 0.1 microsecond
Signal to noise ratio... Greater than 10 to 1
Input and output impedance... 50-2000 ohms
Carrier frequency... 100 kc — 1 mc
Delay to pulse rise time... Up to 800:1

TIME DELAY RELAYS Instant reset — voltage compensated



Curtiss-Wright "IR" thermal time delay relays reset the instant that they are de-energized. Variations from 22 to 32 volts will not affect the time delay specified.

SPECIFICATIONS

Time delay... Preset 20 to 180 seconds
Contact arrangement SPST, SPD, DPDT
Temperature comp... -65°C to +125°C
Weight... 4½ ounces
Terminals... Hooked solder type
Mounting... Bracket or stud

WRITE FOR COMPLETE COMPONENTS CATALOG 159

ELECTRONICS DIVISION

CURTISS-WRIGHT

CORPORATION • WEST CALDWELL, N. J.

CIRCLE 107 ON READER-SERVICE CARD

NEW LITERATURE

LC Tuners 108

Bulletin No. 216 illustrates and describes the electrical and mechanical characteristics of a new LC tuner series. The 4-page bulletin also includes resonant frequency vs capacitance load charts, and self resonant frequency vs screw-turns graphs for each of the units. JFD Electronics Corp., 6101 Sixteenth Ave., Brooklyn 4, N.Y.

Markers 109

Twenty most common pressure-sensitive materials used for marking, labeling, sealing, holding products and components are described in this 12-page catalog, No. 132-A. It includes serial numbering, logos, trademark reproduction for temporary or permanent identification. Technical and engineering application information on a wide range of tapes is shown in chart form to enable the proper type of self-sticking material to be specified for end product use. W. H. Brady, 727 West Glendale Ave., Milwaukee 9, Wis.

Strip-Chart Recorders

In eight pages this brochure describes strip-chart recorders that are light weight and compact. Full scale balancing time is 1 sec. These units are of the null-balance potentiometer type. A tabulation of potentiometer versus galvanometer characteristics is given. A wide range of module input chassis, accessories and chart-speed options are described. Varian Associates Instrument Div., 611 Hansen Way, Palo Alto, Calif.

Tantalum Capacitors

Data on an expanded line of tantalum wire electrolytic capacitors is provided in bulletin 148F. These subminiature capacitors have good shelf and operating stability, high capacitance for small size, and ability to operate efficiently in temperature extremes. The bulletin provides a listing of new values which will now be stocked by distributors for immediate delivery. Ohmite Manufacturing Co., 367 Howard St., Skokie, Ill.

designed for continuous duty.

360 - 440 CPS BENCH TYPE Variable Frequency Power Supply

Operating from standard 115v 60 cps power, the Model 1460 provides 400 cps 100-130 volt supply at any bench position. Utilization of units of this type allows testing at 400 cps - 10% at any individual position without interference with any other test position. The unit can be easily operated by unskilled personnel.

Catalog "M" describing this unit as well as other CML generators in the power range of from 50 VA to 80 KVA in single and three phase units and frequency range of 20 cps to 60 KC with all specifications listed, is yours on request.

Our design engineering department is at your service to design and custom-build a power supply unit for your specific need.



WHERE
DEPENDABILITY
IS OF
PRIME
CONCERN

OUTPUT - 100 V. A.
DISTORTION - 2%
STABILITY - 1 CPS
REGULATION - 1%



COMMUNICATION MEASUREMENTS LABORATORY, INC.

350 LELAND AVENUE, PLAINFIELD, NEW JERSEY

CIRCLE 112 ON READER-SERVICE CARD

ELECTRONIC DESIGN • May 27, 195

Synchro Data Chart 113

Detailed definitions of the electrical parameters of synchros and resolvers are given on this chart, suitable for wall-mounting. Also tabulated are the various connections for Null measurement. This chart has been revised in accordance with the latest releases of BuOrd Specification, RP-461. Theta Instrument Corp., 48 Main St., East Paterson, N.J.

Technical Data 114

How companies purchasing test instruments can cut instrument costs as much as 10 per cent through use of a centralized source of organized technical information is shown in this 8-page booklet. Described in detail is a completely new concept of industrial procurement which saves extensive engineering man-hours and the time of key company personnel in tracking down the right instrument, in locating qualified manufacturers, and in comparing and evaluating competitive specifications and prices prior to purchase. Technical Information Corp., 41 Union Square, New York 3, N.Y.

Diodes And Transistors 115

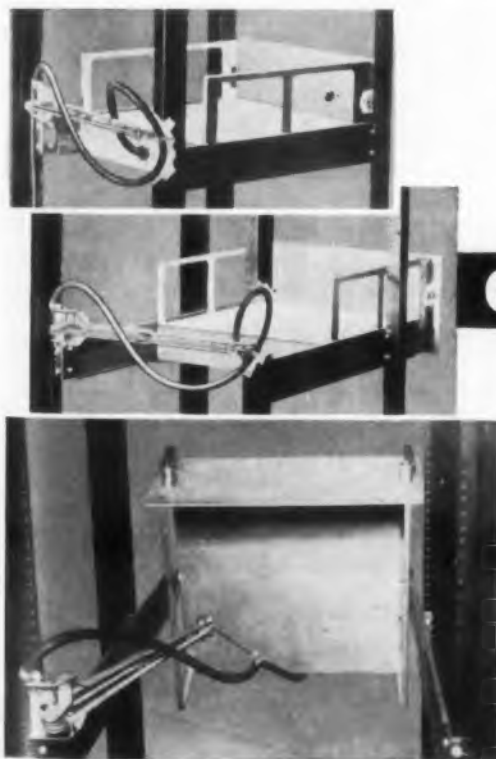
In 12 pages this brochure describes the company's silicon diodes and transistors. A description of characteristics, the tests performed on the units and a tabular listing of the units available are included. Sperry Rand Corp., Sperry Semiconductor Div., South Norwalk, Conn.

Chassis Knockouts 116

With pictures and dimensional data, bulletins E-274, E-275 and catalog 35-E provide data on chassis knockouts and a hydraulic knockout punch driver. Greenlee Tool Co., Div. of Greenlee Bros. & Co., Rockford, Ill.

Snap Acting Switches

Information on the application of industrial limit switches has been included in publication IC 3-1959. Part 1 of this publication defines terms used in connection with precision snap-acting switches and remains unchanged. Send \$0.30 to National Electrical Manufacturers Assn., 155 E. 44th St., N.Y. 17, N.Y.



PREVENTS ENTANGLING COMPONENTS

CABLE RETRACTOR

Withdrawal of a chassis for service and its return to position no longer presents the old bugaboo of cable entanglement with and damage to tubes and components in the chassis immediately below it.

This new cable retractor's double action maintains a constant tension and correct suspension of cable at all times—permits adequate cable length for full extension and tilting of chassis without hazard of snagging.

May be used with all types of chassis or drawer slides, is adjustable to fit varying chassis lengths, is simple to install, and has proven thoroughly reliable in operation.

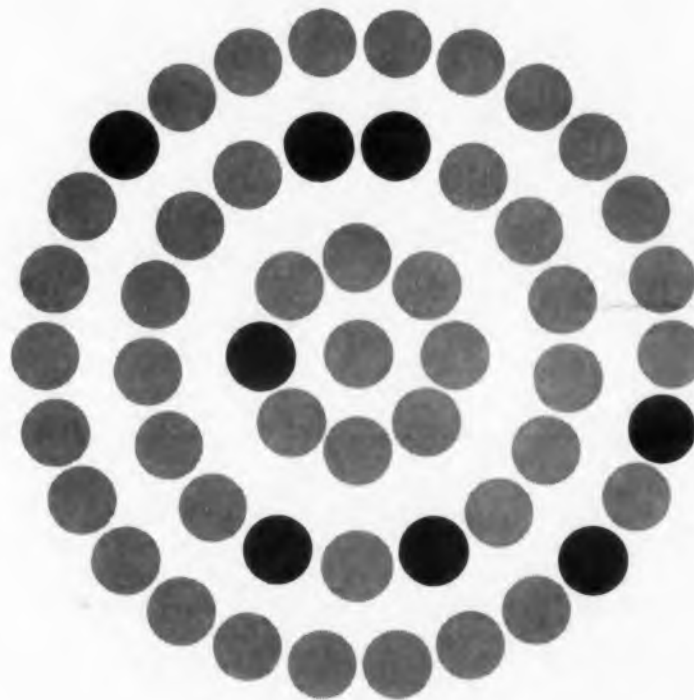
Mounts on rear support rails on standard 1 3/4" hole increments. Cadmium plated cold rolled steel.

Write for complete data

ORegon 8-7827

WESTERN DEVICES, INC.

600 W. FLORENCE AVE., INGLEWOOD, CALIF.



**At MOTOROLA in PHOENIX...
There's an uncommon opportunity to
BE RECOGNIZED in engineering circles**

It's the nature of us humans to be stimulated... to do better work... when others in the same profession know about our accomplishments. At Motorola in Phoenix, the *project approach* assures the engineer that his sparks will not be smothered by anonymity. Every Motorola engineer is provided responsibility commensurate with his ability; his contributions as a member of a project team form the basis for his career advancement. Motorola, heavily engaged in diversified electronics research and production, encourages each engineer to carry his idea through to practical reality. If you are attracted by a creative atmosphere such as this — and by the sunny atmosphere of the nation's most enjoyable climate — write to Mr. Kel Rowan, Department B-6.



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Electronic Engineers, Mechanical Engineers, Physicists—SYSTEM ANALYSIS, DESIGN AND TEST—Radar • Missile Guidance • Navigation • Combat Surveillance • Communications • Field Engineering • Data Processing and Display—CIRCUIT DESIGN, DEVELOPMENT AND PACKAGING—Microwave • Pulse and Video • Antenna • Transistor • R-F and I-F • Servos • Digital and Analog TECHNICAL WRITERS AND ILLUSTRATORS, QUALITY CONTROL ENGINEERS, RELIABILITY ENGINEERS

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for VENTILATED RELAY RACK CABINETS, CONTROL CONSOLES, BLOWERS, CHASSIS, 'CHASSIS-TRAK', RELATED COMPONENTS

CIRCLE 117 ON READER-SERVICE CARD

CIRCLE 870 ON READER-SERVICE CARD



IMPULSE

A DIGEST OF NEW DEVELOPMENTS
IN ELECTRONICS AND AUTOMATION

PUBLISHED BY ROME CABLE CORPORATION, ROME, N. Y.
PIONEERS IN INSTRUMENTATION CABLE ENGINEERING

ELECTRONIC "SEEING EYE." Soon the blind may carry electronic walking sticks to tell them of steps or falls in their path. One such cane is now being produced experimentally by Stromberg-Carlson Division of General Dynamics Corporation. The cane, fitted with two electronic oscillators, senses obstructions ahead of the walker when the tip is held 6 inches or so off the ground, warns him through a vibration in the handle and a whistling sound in a tiny earphone. Operated by batteries, it looks like an ordinary cane except for a thicker handle which houses equipment.

CALL FOR MICROMODULES ANSWERED. Under the heading of "Ideas wanted: \$10 million reward," this column mentioned not long ago that the Army was looking for ideas that could lead to the development of micromodules. It wasn't long before the call was answered: a new micromodule concept has been developed that can reduce many military electronic items to at least one-tenth (and up to one-thousandth) of their present size. Micromodules "no bigger than a cough drop" have recently been produced experimentally by one manufacturer—including entire assemblies of transistors, wiring and other elements. The unit can function as an amplifier, oscillator filter and the like to meet specific needs. Any more ideas, anyone?

COLOR-BLIND COLOR CODE. One risk of color coding conductors in multi-conductor cable is that of errors due to color blindness. This problem comes up more often than you might suppose and hampers quick, positive circuit identification. So . . . Rome Cable makes instrumentation cable that uses a single-color (neutral) insulation compound and is marked with conductor number and spelled-out color designations. With the color or number printed right on the insulation throughout each length, the cable is error-free—even to color-blind technicians. Of course, you can also get Rome cable that's strictly coded by color and tracer stripes, if you want. There's a complete run-down in Bulletin RCD-400. Write for your copy.

GREATER THAN TRANSISTORS? The field of thermoelectricity (TE) is attracting a large number of firms in anticipation of technological changes which may prove even greater than those brought on by the advent of transistors. One news service agency (name furnished on request) recently has completed a survey of a group of 100 research organizations and manufacturing firms known or reported to be interested in TE. TE should be useful in several areas, including generators for earth satellites and consumer products, possibly even turbine generators. Might be interesting to watch.

CABLEMAN'S CORNER. The subject of cable testing is an important one. This is the phase of production that determines whether or not the cable you are purchasing is in accordance with your standards and requirements. In the field of electronics and automation, cables are required to suit various stringent electrical, mechanical, and/or chemical environments. Many years of study and testing have gone into the design of test equipment to be used for these critical tests. It is not enough to know that a cable has been tested in a manner that is "essentially" the same as the required standard. Slight variations in equipment design or methods of tests can mean the difference between conformance and non-conformance. Make sure the test data you receive gives a true picture of the performance of your cable. When you need cable, call on a cable specialist. Our number is Rome 3000.

These news items represent a digest of information found in many of the publications and periodicals of the electronic industry or related industries. They appear in brief here for easy and concentrated reading. Further information on each can be found in the original source material. Sources will be forwarded on request.

CIRCLE 120 ON READER-SERVICE CARD

NEW LITERATURE

Electrical Insulating Materials 121

GET-2929, 12 pages, describes in text, tables and pictures the characteristics and application range of insulating materials for electrical insulation systems. It includes technical data on available products including mica mat, varnished cloths and papers, insulating varnishes, wire enamels, "Irrathene" irradiated polyethylene, sealing and filling compounds, insulating finishes and adhesives. General Electric Co., Schenectady 5, N.Y.

Crystal Oven 122

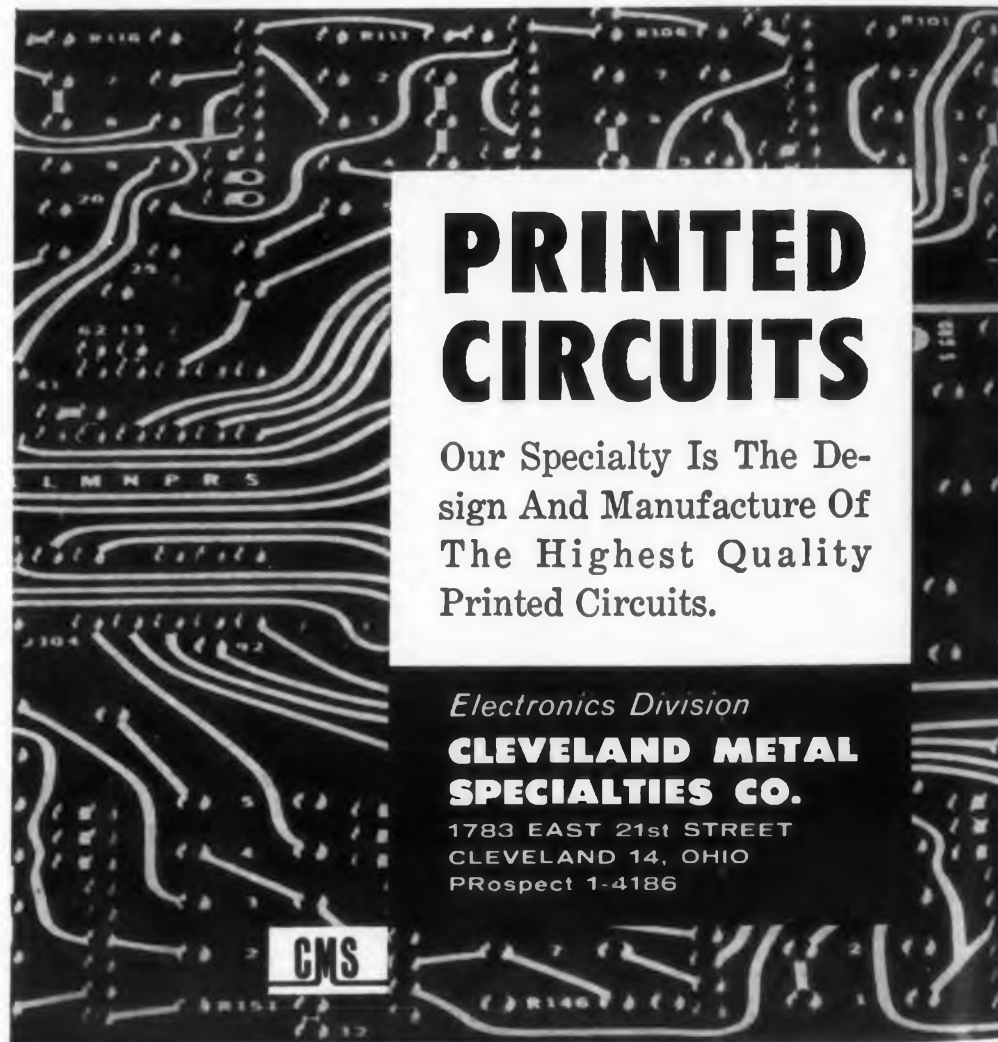
A miniature change-of-state crystal oven is described in bulletin RF-594. The bulletin details construction and applications of the model 35c Thermal-Set crystal oven, which is small in size and has precise temperature control, freedom from thermal oscillation or contact noise, low power consumption and long-term cavity temperature stability. Robertshaw-Fulton Controls Co., Aeronautical and Instrument Div., Santa Ana Freeway at Euclid Ave., Anaheim, Calif.

Transistors

Entitled "Transistor Characteristics and Interchangeability Guide," this booklet lists the characteristics and ratings of a wide variety of transistors used in entertainment, industrial and military applications. It contains a substitution chart and guide to manufacturers for close to 70 popular types. Including a glossary of transistor parameter symbols and definitions, the 20-page booklet lists mechanical specifications and connections for a complete line of transistors and sockets. Sylvania Electric Products Inc., 110 Main St., Buffalo, N.Y.

Ultrasonics

Ultrasonics is the name of a new magazine containing information of general interest in the ultrasonics field as well as about applications of ultrasonics in industry, service organizations, medical establishments and the military. It is published quarterly. Write to: Acoustica Associates, Inc., 26 Windsor Ave., Mineola, L.I., N.Y.



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GMS

CIRCLE 125 ON READER-SERVICE CARD

Microwave Equipment 126

The firm's 6 kmc microwave communication system is described in bulletin CM-71, 2 pages. Contained are operating characteristics, channel capacity and details on frequencies in which the equipment may be used. General Electric Co., Communication Products Dept., Lynchburg, Va.

Epoxy Resins 127

This comparison chart, 2 pages, lists uses and compares the properties of the company's epoxy systems. The resins are designed for impregnating, potting, coating, sealing, and coating of electrical components. Mitchell Rand Mfg. Corp., Murray St., New York 7, N.Y.

Wire Table 128

Table ZK-5 permits, from the wire AWG number, determination of wire's diameter in inches, area, weight, length, and resistance at 68 F. A table of equivalents relates fractions of the inch with decimal millimeter measurements. Alpha Wire Corp., 200 Varick St., New York 14, N.Y.

Servo Motors Catalog 129

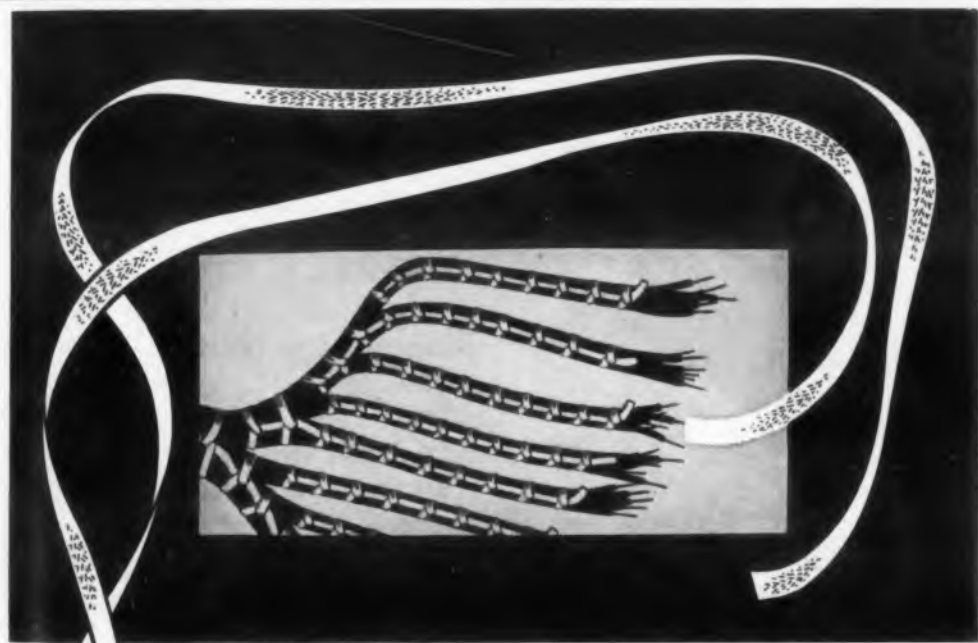
Twenty-page catalog No. 5000 lists and fully describes all basic models of a complete line of precision made servo motors, sizes 8 to 29, for scientific, military and industrial applications. Included are dimensional drawings, and physical, electrical and mechanical characteristics. John Oster Mfg. Co., Avionic Div., 1 Main, Racine, Wis.

Instruments 130

Panel instrument catalog, No. 59-1, 8 pages, provides general information and technical data on such units as: voltmeters, millivoltmeters, microammeters, milliammeters, and portable instrument. Pictures and physical dimensions are also included. The Triplett Electrical Instrument Co., Bluffton, Ohio.

Atmosphere Chart 131

Wallet size, this "ARDC Model Atmosphere Chart" relates altitude to temperature, pressure in millimeters of mercury, pressure in inches of mercury and pressure in pounds per square inch. Conrad, Inc., Conrad Square, Holland, Mich.



for every lacing need . . . **BEN-HAR LACING TAPES**

BEN-HAR "TEFLON® GLASS"—fibers are Teflon coated before braiding for unique non-slip action. Knots hold. No heat shrinkage. Chemically inert. Flame-proof. Non-absorbent. Color fast. Practically indestructible.

BEN-HAR DACRON®—excellent dimensional stability and heat resistance. Available plain, waxed, or synthetic rubber treated.

BEN-HAR NYLON—meets Gov. Specs. MIL-T-713A. Flat braided nylon available in same finishes as above.

BENTLEY, HARRIS

Flexible **INSULATIONS**

WRITE FOR SAMPLES AND PRICES

Bentley, Harris Manufacturing Co., 200 Barclay St., Conshohocken 3, Pa.

CIRCLE 132 ON READER-SERVICE CARD

ELECTRONIC DESIGN • May 27, 1959

TWO RELAYS IN ONE



a time-delay relay and a load carrier, too

Kind of small, this Heinemann Type A Relay. Weighs only three ounces. Yet, it can do *two* jobs for you. In addition to providing a controlled time delay (anywhere from 1/4 to 120 seconds), it can serve as a load carrier, itself. The relay may be energized continuously. This simplifies things nicely. You don't have to use auxiliary lock-in circuits or load relays—not unless you need more than three amps' contact capacity.

D.P.D.T. switching is clean and decisive, just as it should be for healthy operation. The timing element is hermetically sealed, and this, too, keeps the relay in top form throughout its long service life.

Cost? Definitely calculated to win favor and influence your buying decision. Check on it, you'll see.

FOR DETAILED SPECIFICATIONS, REQUEST BULLETIN 5003.

HEINEMANN

ELECTRIC COMPANY

156 Plum St., Trenton 2, N. J.

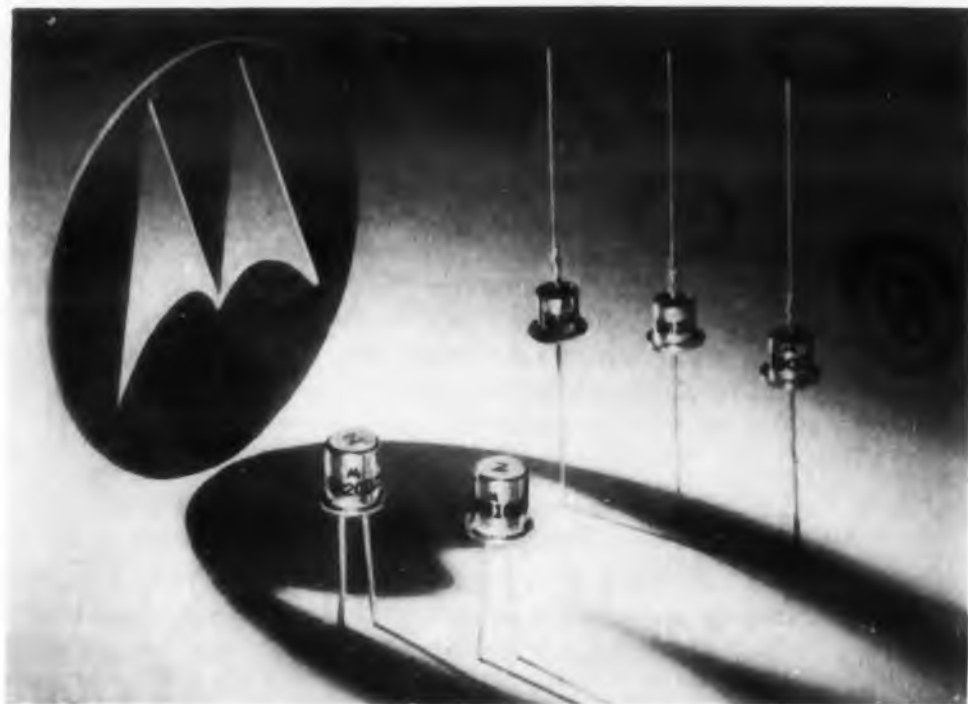


S.A. 1870

CIRCLE 133 ON READER-SERVICE CARD

NEW PRODUCTS

Covering all new products that might generally be specified by an electronics engineer engaged in the design of original equipment.



ZENER DIODES

Rated at 1 and 1.5 w, these silicon Zener diodes are rated at from 10 to 200 v. Types 1MZ, 1 w, and 1.5MZ, 1.5 w, are in hermetically sealed packages designed to meet or exceed the mechanical and environmental requirements of MIL-E-1 and MIL-S-19500. The units are tested at both high and low currents to insure a sharp knee on the breakdown curve and to eliminate unstable units.

Motorola Inc., Semiconductor Products Div., Dept. ED, 5005 E. McDowell Rd., Phoenix, Ariz.

CIRCLE 134 ON READER-SERVICE CARD



ACCELEROMETER

Measuring 1.1 x 1.5 x 0.8 in., this potentiometer-type accelerometer has a 2% accuracy over a -10 to +30 range. Designed for telemetering and control purposes, the model 4205 uses silicon fluid for protection against shock and vibration. Temperature range is from -55 to +82 C.

Pacific Scientific Co., Dept. ED, 6280 Chalet Dr., Los Angeles, Calif.

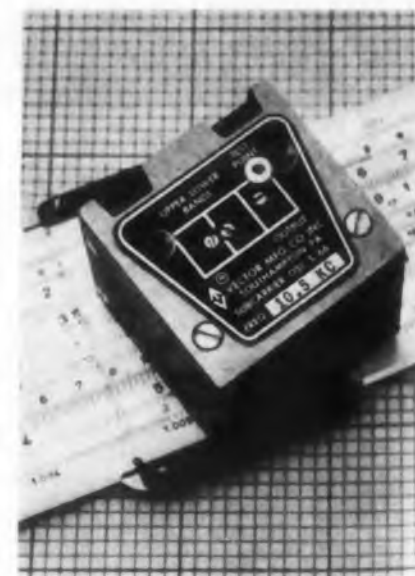
CIRCLE 135 ON READER-SERVICE CARD

TRANSISTORIZED OSCILLATOR

Completely transistorized, this voltage controlled subcarrier oscillator contains a drift free, compensated dc amplifier, a free-running multivibrator, and a low pass filter. The unit has been qualified to operate at up to 140 C and requires less than 1/4 w at 28 or 14 v dc. It is available in all IRIG(RDB) frequencies and special frequencies to 300 kc. Standard units are supplied with frequency deviation limit, sensitivity and output potentiometer, and an output voltage test point.

Vector Manufacturing Co., Inc., Dept. ED, 3040 Overland Ave., Los Angeles 34, Calif.

CIRCLE 136 ON READER-SERVICE CARD



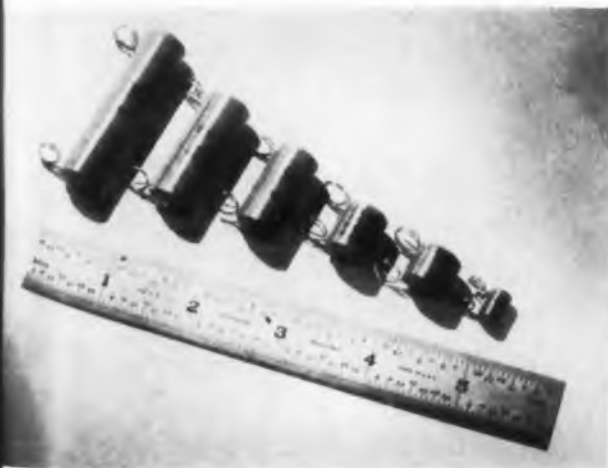


TAPE PERFORATOR

This tape perforator has a punching speed of forty columns per second. The unit has a simplified drive mechanism which requires only one eccentric and one cam-generated motion. Standard models will accept any standard tape size up to 1 in. in width and any code column to 8 channels. Safety features include an interlock to prevent the feed from advancing tape until a column has been punched.

Telecomputing Corp., Data Instruments Div., Dept. ED, 12838 Saticoy St.

CIRCLE 137 ON READER-SERVICE CARD



RESISTORS

Resistance tolerance to 0.005% is obtainable in these precision wirewound resistors. Having an operating temperature range from -65 to +135 C, they are available in 40 sizes and wattages. The line surpasses the requirements of MIL-R-93B and MIL-R-9444. Size ranges is from 1/4 x 5/8 in. to 1/2 x 2 in., with wattages from 1/8 to 10 w.

Leonard Electronics, Dept. ED, 1209 Olympic Blvd., Montebello, Calif.

CIRCLE 138 ON READER-SERVICE CARD

*first in
Performance
Reliability
and Quality*

Kepeco

TRANSISTORIZED V.R.P.S.*

*VOLTAGE
REGULATED
POWER
SUPPLIES



Model SC-32-2.5



Model
SC-18-2M

0.1% REGULATION
STABILITY

MODEL	DC OUTPUT VOLTS	DC OUTPUT AMPS.
SC-18-0.5	0-18	0-0.5
SC-18-1	0-18	0-1
SC-18-2	0-18	0-2
SC-18-4	0-18	0-4
SC-36-0.5	0-36	0-0.5
SC-36-1	0-36	0-1
SC-36-2	0-36	0-2
SC-3672-0.5	36-72	0-0.5
SC-3672-1	36-72	0-1

the most
complete
line of
POWER
SUPPLIES

0.01% REGULATION
STABILITY

MODEL	DC OUTPUT VOLTS	DC OUTPUT AMPS.
SC-32-0.5	0-32	0-0.5
SC-32-1	0-32	0-1
SC-32-1.5	0-32	0-1.5
2SC-32-1.5	0-32	0-1.5
DUAL OUTPUT	0-32	0-1.5
SC-32-2.5	0-32	0-2.5
SC-32-5	0-32	0-5
SC-32-10	0-32	0-10
SC-32-15	0-32	0-15
SC-60-2	0-60	0-2
SC-60-5	0-60	0-5
2SC-100-0.2	0-100	0-0.2
DUAL OUTPUT	0-100	0-0.2
SC-150-1	0-150	0-1
SC-300-1	0-300	0-1

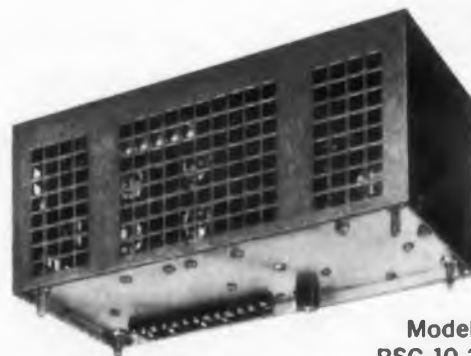
0.02% REGULATION
STABILITY

COMPACT PACKAGE TYPE

MODEL	DC OUTPUT VOLTS	DC OUTPUT AMPS.
PSC- 5-2	0-7.5	2
PSC-10-2	7.5-12.5	2
PSC-15-2	12.5-17.5	2
PSC-20-2	17.5-22.5	2
PSC-28-1	22.5-32.5	1
PSC-38-1	32.5-42.5	1

Kepeco
offers more than
120 standard voltage
regulated power supplies
covering a wide range
of transistor, tube
and magnetic types.

For complete specifications,
write for Brochure B-591



Model
PSC-10-2



*first in
Performance
Reliability
and Quality*

Kepeco INC.

131-38 SANFORD AVENUE • FLUSHING 55, N.Y. • INDEPENDENCE 1-7000

CIRCLE 139 ON READER-SERVICE CARD

NEW PRODUCTS

Reversible Motor

Has double gear reduction



A reversible fhp motor with built-in double gear reduction, the model CO-843 is available for various inputs ranging from 6 to 48 v dc. Output shaft speeds are 10 to 100 rpm. The unit is designed so that shaft distortion is eliminated and vibration, friction, and wear are kept to a minimum. The motor is 2-7/8 in. long and has 50 in.-oz maximum output torque. The frame and gear case are die cast aluminum.

Carter Motor Co., Dept. ED, 2764A W. George St., Chicago 18, Ill.

CIRCLE 140 ON READER-SERVICE CARD

Aluminum Spheres

For silicon semiconductor devices



Available in quantity for forming alloy junctions in silicon devices, these aluminum spheres are 99.99+% pure. They can be provided in infinite size increments from 0.004 to 0.125 in. in diameter with sphericity held to ± 0.00001 in. They have these advantages in producing alloy junctions: They offer the least amount of oxide per unit volume; they can roll, thus lending themselves to automatic loading into alloying jigs; and they provide reproducible results in a specific semiconductor device.

Accurate Specialties Co., Inc., Dept. ED, 37-11 57th St., Woodside 77, N.Y.

CIRCLE 141 ON READER-SERVICE CARD

FOR THE FIRST TIME... ALL IN ONE WIRE!

WINDABILITY
SOLDERABILITY
VARNISHABILITY
RELIABILITY...

IT'S PHELPS!

- BETTER WINDABILITY — "lays in" easier.
- LOW TEMPERATURE SOLDERABILITY — no damage to copper conductor.
- IMPROVED VARNISHABILITY — safer in hot varnish solvents.
- FIELD-TESTED RELIABILITY — uniquely balanced properties provide better thermal life.



Phelps Dodge magnet wire is available in modern non-returnable spools, reels and "Pakeze" containers

Nyleze* is another example of the advanced magnet wires developed by Phelps Dodge through its Applied Research. It is a new combination of materials with highly desirable properties for use in such applications as series armatures and fields, stators, potted coils, random wound coils, toroids and other difficult winding designs. These properties suggest possibilities for cost economies and improved designs that result in better operating performance of your equipment.

*Nyleze is red in color



Any time your problem is magnet wire, consult Phelps Dodge for the quickest, surest answer!

FIRST FOR
BEST QUALITY
—FROM MINE
TO MARKET!



PHELPS DODGE COPPER PRODUCTS
CORPORATION

INCA MANUFACTURING DIVISION
FORT WAYNE, INDIANA

CIRCLE 142 ON READER-SERVICE CARD

Infrared Radiation Source

Has 500 to 1000 C temperature range



The model RS-8A Optitherm infrared radiation reference source is designed to emit black body radiation over the 500 to 1000 C range. It can be used as a standard against which other infrared sources and measuring instruments can be checked and calibrated. The temperature of the source is selected by a single control dial calibrated in deg C, and the area of the black body exit aperture is adjustable with a selector disc containing seven precision apertures. The radiation source temperature is held within $\pm 0.5\%$ despite wide ambient temperature changes, line voltage variations and transients, tube aging, and replacement of most of the individual components.

Barnes Engineering Co., Dept. ED, 30 Commerce Rd., Stamford, Conn.

CIRCLE 143 ON READER-SERVICE CARD

Precision Film Resistor

Glass enclosed



This glass enclosed precision film resistor is impervious to moisture and meets the requirements of MIL-R-10509C, characteristic B. The unit has Dumet leads which are sealed to the thermally compatible glass case, creating a hermetic seal. The leads are welded inside the case to Kovar metal discs, which are fused to the resistance element. The encapsulation does not affect the electrical properties of the unit.

Coming Glass Works, Electronic Components Dept., Dept. ED, Bradford, Pa.

CIRCLE 144 ON READER-SERVICE CARD

DESIGNERS SPECIFY P&B's MR RELAY WITH CONFIDENCE



for a host of control applications

RELIABILITY coupled with low cost are two factors which place the MR series relays high on P&B's best seller list. They are being used in a multiplicity of designs... transmitters, street lighting equipment and small motor starters, to name but a few.

Both AC and DC models are available, with AC coils ranging up to 440 volts. All are adaptable for printed circuit mounting. The wide variety of contact arrangements include:

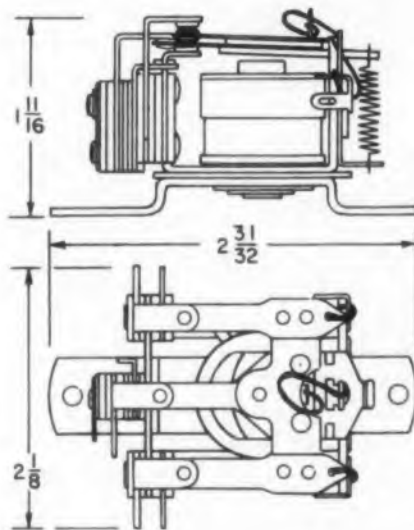
SPST-NO	SPST-NC-DB	DPST-NC	3PST-NC
SPST-NC	SPDT	DPDT	3PDT
SPST-NO-DB	DPST-NO	3PST-NO	

For more information about this medium duty, compact relay, call or write today—or get in touch with the P&B sales engineer nearest you. See our complete catalog in Sweet's Product Design File.



LM SERIES: Plate circuit relays similar to the MR. All sp and dp contact arrangements shown above are available. Coils are wound to specified resistances up to 58,000 ohms max. Sensitivity ranges from 15 mw min. (single pole) to 70 mw min. (double pole).

MR SERIES



GENERAL SPECIFICATIONS:

Breakdown: 1500 volts, 60 cycle rms between all elements.

P&B STANDARD RELAYS ARE AVAILABLE AT YOUR LOCAL ELECTRONIC PARTS DISTRIBUTOR

Temperature Range:

DC —55°C. to +85°C.
AC —55°C. to +75°C.

Pull-in: Approx. 75% of nominal dc voltage; 78% of nominal ac voltage.

Weight: 4 ozs.

Dimensions: 2 1/2" long x 2 1/8" wide x 2" high.

Mounting: Two 1/2" dia. holes. Can be adapted for printed circuits.

CONTACTS:

Arrangements: Up to 3pdt.

Material: 1/2" dia. silver. (Others available).

Lead: 8 amps @ 115 volts, 60 cycle, resistive.

COIL:

Max. Resistance: 34,500 ohms.

Power: 1.5 watts dc; 3.25 volt-amps ac. Will withstand up to 6 watts at 25°C.

Voltages: Up to 110 volts dc; up to 440 volts 60 cycle ac.

NEW PRODUCTS

3/4 Inch Servo Motor Operates to 200 C



The model 8M100 servo motor is a 3/4 in., size 8 unit that operates at ambients to 200 C and can be certified environmentally under MIL-E-5272A and MIL-T-5422. It produces 1 in.-oz torque at 0 rpm and may be fitted with a variety of output shaft configurations or gear reductions. Input power range is to 115 v ac.

Servo Dynamics Corp., Dept. E1
Somersworth, N.H.

CIRCLE 145 ON READER-SERVICE CARD

Germanium Power Transistors

Provide currents to 25 amp



Germanium pnp alloy power transistors 2N511, -A, and -B through 2N514, -A, and -B have voltage ratings of 40, 60, or 80 v and collector currents of 10, 15, 20, or 25 amp. At maximum rated collector current, $R_{\theta c}$ is 0.05 ohms maximum. Dissipation is 80 w at 25 C.

Texas Instruments Inc., Semiconductor-Components Div., Dept. ED, Box 312, Dallas, Tex.

CIRCLE 146 ON READER-SERVICE CARD

CIRCLE 147 ON READER-SERVICE CARD



POTTER & BRUMFIELD INC.

PRINCETON, INDIANA • SUBSIDIARY OF AMERICAN MACHINE & FOUNDRY COMPANY

IN CANADA: POTTER & BRUMFIELD CANADA, LTD., GUELPH, ONTARIO

DC Amplifier Transistorized



Designed for driving galvanometers from a high impedance source, the model AM 103 transistorized amplifier has an input range of ± 150 mv, an output range of ± 3 v to a 300 ohm load, and a frequency response of 0 to 10 kc. Input impedance is 10 K; long term drift, ± 0.1 mv; and power requirement, 28 v at 32 ma and -28 v at 32 ma. The octal plug-in unit is potted and hermetically sealed in a MIL-27 FA case.

Deeco Instruments, Inc., Dept. D, 14737 Arminta St., Van Nuys, Calif.

CIRCLE 148 ON READER-SERVICE CARD

XXXXP Laminate

Self-extinguishing

This XXXXP grade laminated plastic is made from cellulose paper impregnated with epoxy resin and comes in both plain and copper-clad sheets. The plain, Dilecto XXXP-31EFR, may be used as insulation for computers, radios, telemeasuring equipment, and guidance equipment. It is light and humidity resistant and has good cold-punching qualities. Thicknesses are 0.015 through 0.25 in.; sheet sizes are 38 x 38 and 38 x 38 in. The metal-clad material, Di-Clad 31EFR, is the same basic material with 1 or 2 oz copper foil on one or both sides. It can be used for printed circuit boards in the same equipment as the metal-clad material.

Continental-Diamond Fibre Corp., Dept. ED, Newark, Del.

CIRCLE 149 ON READER-SERVICE CARD

CIRCLE 150 ON READER-SERVICE CARD

**without E-W
cooling units,
electronic gear
in this hut
would
burn out
in minutes!**

The Ellis and Watts Model A-9 Unit that keeps this critical electronic gear cool has a cooling capacity of 9000 BTU's per hour. Without this vital cooling capacity the electronic equipment would burn itself out in a matter of minutes! Wherever electronic gear is used, it creates heat problems. And, in compact airborne huts these problems are especially serious.

Designing and building specialized units to keep electronic gear cool is our business at Ellis and Watts. Units of any capacity, configuration, control requirements or functions can be designed and built to any applicable military or commercial specifications. E-W Units will function perfectly in any climate conditions on earth.

For additional information on Ellis and Watts Model A-9 Unit for cooling electronic gear in airborne huts or similar installations, write for Bulletin #130-D.



ELLIS AND WATTS PRODUCTS, INC.
P. O. Box 33-D, Cincinnati 36, Ohio



Compact, Model A-9 Unit, developed especially to provide cooling in airborne huts, measures only 27 1/4" x 26 1/2" x 18 1/4" high—leaves maximum space for vital electronic equipment.



Engineers/Designers! Ask for this G-C

MICROWAVE FERRITE APPLICATION CHART

MICROWAVE FERRITE APPLICATION CHART				
MATERIAL	BAND	LOWEST OPERATING FREQUENCY**	TYPICAL APPLICATION	TYPICAL POWER LEVEL
R-1	X	8,500 megacycles	Phase Shifter	Low Power
R-4	X	7,000 megacycles	Phase Shifter	Can be used above resonance at peak power > 1 Megawatt (2)
R-4	S	2,500 megacycles	Resonance Isolator (1)	Low Power
R-5*	C	5,000 megacycles	Phase Shifter	Can be used above or below resonance at peak power > 1 Megawatt (2)
R-5*	S	2,500 megacycles	Phase Shifter	Can be used above resonance at peak power > 1 Megawatt (2)
R-5*	L	1,000 megacycles	Resonance Isolator	Low Power
R-6*	S	2,500 megacycles	Phase Shifter	Similar to R-5
R-6*	L	1,000 megacycles	Resonance Isolator	Low Power

*NEW PRODUCT

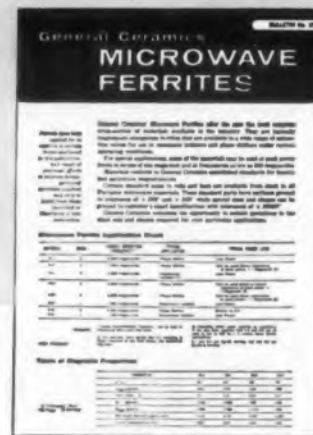
REMARKS:

(1) R-4 saturates more rapidly than R-1 resulting in faster reduction at low field losses. See hysteresis loop data.

(2) Operating power levels reported by customers. It has also been reported that R-5 and R-6 can be used as low as 500 Mc/s in certain phase shifter applications.

R-1 and R-4 are Mg-Mn ferrites. R-5 and R-6 are Mg-Mn-Al ferrites.

**Lowest Recommended Frequency—can be used at frequencies above published value.



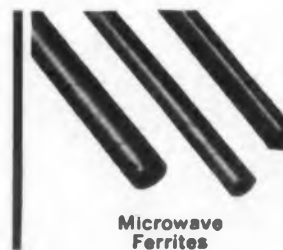
— it's included in the new General Ceramics Data Bulletin on Microwave Ferrites

This new comprehensive bulletin contains technical data on the most complete cross-section of materials in the industry, including two grades introduced for the first time. Included are hysteresis loops, magnetic and dielectric properties vs. frequency, and magnetic induction vs. temperature curves on ferrite materials R1, R4

and newly-developed R5 and R6. Application data, magnetic properties tables, and drawings and dimensions of available stock parts are also contained in new Bulletin 259. Request your copy of this informative literature, today; please address inquiries to General Ceramics Corporation, Keasbey, New Jersey—Dept. ED.

GENERAL CERAMICS

The World's Largest Producer of Microwave Ferrites



CIRCLE 151 ON READER-SERVICE CARD

NEW PRODUCTS

Spectrum Analyzers 200 cps to 25 mc range



Model SPA-3 and SPA-3/25 spectrum analyzers have frequency ranges of 200 cps to 25 and mc, respectively, with 200 cps resolution capability and up to 20 μ v sensitivity for full scale deflection. The single-package units permit analysis of pulse spectra, noise, line spectra, and other complex ultrasonic and low rf waveforms. They have a continuously variable scanning width from 3 m adjustable down to 0; variable center frequency control; variable resolution from 200 cps to 30 k and variable sweep rate from 1 to 60 cps. They also feature linear, 40 db log and power amplitude scales; a calibrated 100 db attenuator; and built-in, crystal controlled frequency markers.

Panoramic Radio Products, Inc., Dept. ED, 50 S. Fulton Ave., Mt. Vernon, N.Y.

CIRCLE 152 ON READER-SERVICE CARD

Rotor Balancer

For high speed gyros



This rotor balancer is a vibration pickup type use with small gyros and servo motors for missile guidance and control systems. It can dynamically balance motor armatures of 7 g and accommodate gyros to 32 oz and 2-1/8 in. OD. It has plug-in transducer modules that measure rotor displacements of 0.3 μ m. at 1000 to 200,000 rpm. The unit mounts in 10 x 15 in. of bench space.

M. Ten Bosch, Inc., Dept. ED, 80 Wheeler Ave., Pleasantville, N.Y.

CIRCLE 153 ON READER-SERVICE CARD

Frequency Recorder

Has 58 to 62 cps range

This frequency recorder was designed for utility and industrial applications. One of the CH line, the instrument features a 58 to 62 cps range and has an accuracy of ± 0.05 cps and completely self-contained construction. Available for compact panel flush or surface panel mounting as a portable instrument, the unit features a throw-away inkwell, 150 ft record roll, multiple chart speeds, chart supply indicator and fluorescent-lighted chart face. The recorder is also available for 50 or 60 cps applications.

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

CIRCLE 154 ON READER-SERVICE CARD

Keyboard Switch

6 pole

Available with either push on or push off or momentary action, this switch has six independent poles that can be supplied in any combination of normally open or closed contacts. It is made with 1 to 2 lb operating pressure, 1/2 in. mounting thread, 3/4 in. case diameter, 1/8 in. travel, and 1/2 amp inductive contacts at 28 v dc. Pushbuttons can be supplied in various colors and shapes engraved to individual requirements.

Pendar, Inc., Switch Div., Dept. ED, P.O. Box 3355, Van Nuys, Calif.

CIRCLE 155 ON READER-SERVICE CARD

Heat Reactive Tubing

Shrinks to fit

Type 3024 heat reactive tubing is a chemical resistant electrical insulating cover for symmetrical or irregularly contoured shapes, bars, tubes and rods. Heated for 4 to 8 min at 300 F, it shrinks to provide a tight fit.

Minnesota Mining and Mfg. Co., Chemical Division, Dept. ED, 900 Bush Street, St. Paul 6, Minn.

CIRCLE 156 ON READER-SERVICE CARD

CIRCLE 157 ON READER-SERVICE CARD



NOW
AVAILABLE IN
TRANSITRON'S
NEW
PACKAGE

SILICON CONTROLLED RECTIFIER

handling
10KW power

Transitron's Silicon Controlled Rectifier is a PNP high power bistable controlled switching device. It is analogous to a thyatron or ignitron, with far smaller triggering requirements and microsecond switching. The low forward voltage drop permits high current ratings and provides high efficiency with low cooling requirements. The PNP design permits higher voltage ratings and lower saturation resistance than power transistors. This permits the smallest packaging for high power control yet made possible.

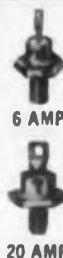
Ratings currently available extend to 10 amperes at 100°C case temperature and up to 400 volts forward and inverse ratings. Operation at 125°C is now permissible with derating. Full ratings are possible at 35°C ambient with a 5" square heat sink. The peak control power is typically 1/200,000 of the output power!

Transitron's Silicon Controlled Rectifier has been designed into a new package for more rugged, convenient, and practical application. The 11/16" hex base and the general outline coincide with EIA standards for the 20-ampere rectifier.

TYPE	MINIMUM PEAK REVERSE VOLTAGE (Volts)	MINIMUM FORWARD BREAKDOWN VOLTAGE (Volts)	MAXIMUM AVERAGE FORWARD CURRENT (amps)	
			at T case = 100°C	at T case = 25°C
TCR 102	100	100	10	20
TCR 202	200	200	10	20
TCR 302	300	300	10	20
TCR 402	400	400	10	20

Maximum Storage Temperature Range — 65°C to +150°C
Maximum Operating Temperature Range — 65°C to +125°C
Send for Bulletin TE 1356

OTHER
TRANSITRON
SILICON
PRODUCTS
FOR
HIGH POWER
USE



6 AMP

20 AMP



50 AMP



85 WATT
POWER
TRANSISTORS

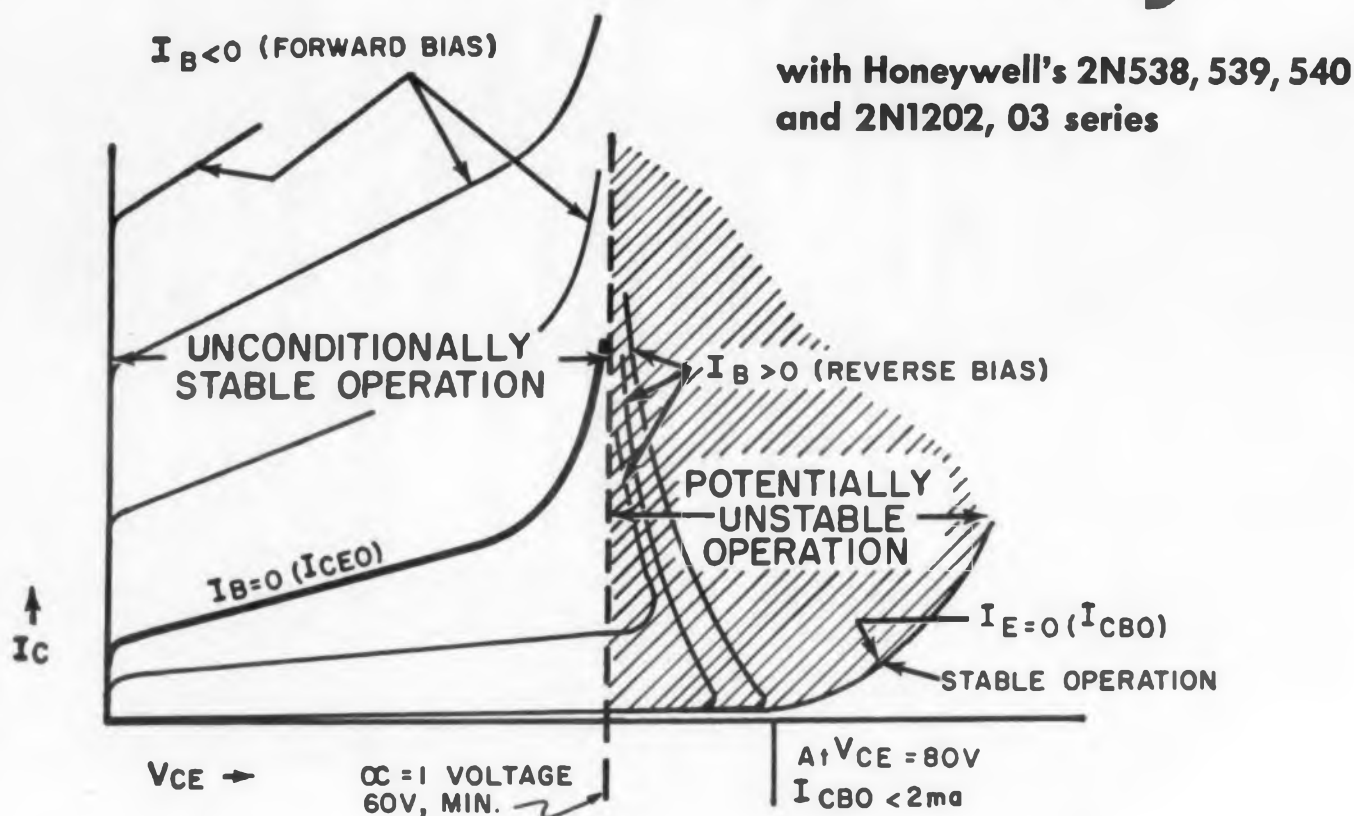


RECTIFIER
ASSEMBLIES

Transitron

electronic corporation
wakefield, massachusetts

New Honeywell formula for power transistor reliability



NOW THESE Honeywell Power Transistors guarantee minimum $\alpha=1$ voltage to insure stable operation under all bias conditions up to 60 volts. This rating permits operation of both class A and class B transformer-coupled output power amplifiers from a 28VDC source. Proper back bias extends safe operating voltage up to the collector diode design limit of 80 volts.

Contributing to the superior reliability of Honeywell Power Transistors are built-in stability through improved design and processing methods plus significant dynamic testing.

Honeywell's 2N538, 539 and 540, and 2N1202 (characterized at $\frac{1}{2}$ amp) and 2N1203 (120 volt collector diode) Power Transistor Series are rugged, hermetically sealed germanium PNP transistors suited to servo amplifier, power conversion, voltage regulation and switching applications.

These new improved Honeywell Power Transistors give you two other bonuses—new lower prices, plus 1 year warranty. For complete data on these transistors, or for a copy of Honeywell's new Technical Booklet "Fundamental Voltage Limitations of a Transistor," contact one of the following offices:

- UNION, NEW JERSEY.....(MURdock 8-9000)
- BOSTON, MASSACHUSETTS.....(ALgonquin 4-8730)
- CHICAGO, ILLINOIS.....(IRving 8-9266)
- LOS ANGELES, CALIFORNIA.....(RAYmond 3-6611 or PArkview 8-7311)
- ATLANTA, GEORGIA.....(TRinity 4-9776)

Or write Minneapolis-Honeywell, Dept. ED-5-82, Minneapolis 8, Minnesota.

Honeywell



First in Control

CIRCLE 158 ON READER-SERVICE CARD

NEW PRODUCTS

Variable Coaxial Attenuator
Has 1 to 6 kmc range



Designed with physically fixed input-output connectors, this variable coaxial attenuator is operated with a smooth sliding motion. It has a frequency range of 1 to 6 kmc, an attenuation range of 18 to 40 db, and a vswr below 1.5.

Radar Design Corp., Dept. ED, Pickard Dr., Syracuse 11, N.Y.

CIRCLE 159 ON READER-SERVICE CARD

Cable Clamps and Ties

Molded plastic

Two molded plastic wiring accessories are offered for electronic and electrical use. One is a reusable cabling tie which looks and works like a beaded key chain. Quickly attached or removed without tools, it is formed of a single piece 4-in. long and withstands a 45 lb pull. The other accessory is a cable clamp that may also be used to hold rods, tubes, capacitors, or pipes. It fastens with a screw or nail and is made of insulating material so that it cannot contribute to ground short circuits. The clamps are available in cellulose with collar ID's from $\frac{1}{8}$ to $1\frac{1}{4}$ in. and in nylon with collar ID's from $\frac{1}{8}$ to $\frac{5}{8}$ in.

Gries Reproducer Corp., Dept. ED, 400 Bedford Ave., New Rochelle, N.Y.

CIRCLE 160 ON READER-SERVICE CARD

Adjustable Viscous Damped Motor

Size 11

Designed to replace motor tachometers in feedback damping applications, the size 11 5752-05 adjustable viscous damped motor presents no null or phasing problems in the feedback loop. Damping and gain may be independently adjusted, and no load speed can be quickly adjusted to any speed from 4800 to 7300 rpm. The unit operates from -55 to $+125$ C and meets MIL-5272A specifications.

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

CIRCLE 161 ON READER-SERVICE CARD

ELECTRONIC DESIGN • May 27, 1961

Line Voltage Regulator

Broadband



The PoweRite model 4K115 line voltage regulator is fully transistorized and provides 4 kva regulated to within $\pm 0.5\%$. It operates equally well at any frequency from 45 to 400 cps. Response rate is 60 v per sec and harmonic distortion is under 0.01%. Output is preset at 115 v ac but can be varied between 110 and 120 v ac. Standard units regulate to within 0.5% over a range of ± 15 v from the set point.

Armour Electronics, Dept. ED, 4201 Redwood Ave., Los Angeles 66, Calif.

CIRCLE 162 ON READER-SERVICE CARD

AC Electronic Voltmeter Module

Plug-in

Designed for plug-in use with a remote meter, the model SPD-22 ac electronic voltmeter module will measure from 10 mv to 300 v rms full scale sensitivity, depending on the input voltage determined by the built-in attenuator. Measuring 5 x 1/2 x 4-1/4 in., it contains all vtm circuitry except the power supply. With this unit, meters being used for other readings may also be used for voltage measurement. The module imposes almost no load on the circuit being measured and has an accuracy of $\pm 3\%$ with a meter of 2% accuracy. Frequency range is 20 cps to 50 kc at 2% accuracy and 50 kc to 100 kc at 3% accuracy.

Metronix, Inc., Dept. ED, Chesterland, Ohio.

CIRCLE 163 ON READER-SERVICE CARD

Low Noise Preamplifier

Covers 400 to 500mc

Designed to operate with a 50 ohm source and load impedance, model AP-710-1 uhf preamplifier has a noise figure of 4 to 5 db and a gain of 20 db at an operating frequency of 400 to 500 mc. The unit has a self-contained power supply and fits into a 19 x 3-1/2 in. space.

Armour Electronics, Inc., Dept. ED, 2414 Reedy Silver Spring, Md.

CIRCLE 164 ON READER-SERVICE CARD

NEW BENDIX MS-R ENVIRONMENT RESISTING ELECTRICAL CONNECTOR



Now available and approved in complete conformance with MIL-C-5015D.

This new connector answers the demand from the aircraft industry for a shorter, lighter and more reliable environment resisting connector. This connector will inactivate practically all other MS types and the Military has assigned a new class letter R to insure incorporation of this better connector in all new designs.

An important reliability feature of the new MS-R connector is an "O" ring at the main coupling joint which provides for the best possible sealing and more positive inter-facial compression and assures complete performance compatibility among all approved MS-R connectors. Establishment of the MS-R connector as the "universal" military connector is testimony to the record of previous MS environmental resistant connectors using resilient inserts as pioneered by this Division. In the Bendix* connector, wire sealing is accomplished by an exclusive slippery rubber grommet which permits convenient wire threading and grommet travel over wire bundles.

Write for more complete information on this latest addition to the ever-growing family of Bendix electrical connectors.

*TRADEMARK

Bendix

SCINTILLA DIVISION
SIDNEY, NEW YORK

Bendix
AVIATION CORPORATION

Export Sales and Service: Bendix International Division, 205 E. 42nd St., New York 17, N. Y.

Canadian Affiliate: Aviation Electric Ltd., 200 Laurentien Blvd., Montreal 9, Quebec.

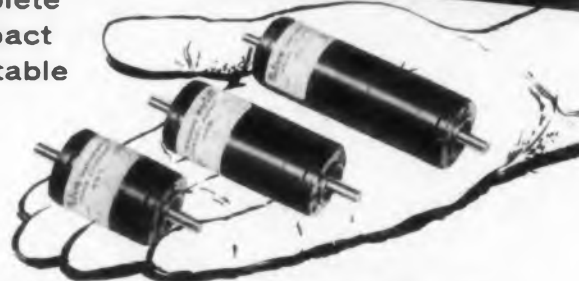
FACTORY BRANCH OFFICES: Burbank, Calif.; Orlando, Florida; Chicago, Ill.; Teaneck, New Jersey; Dallas, Texas; Seattle, Washington; Washington, D. C.

CIRCLE 165 ON READER-SERVICE CARD

New Metron Miniature Speed Changers

... Ready-to-go
in your product

- Complete
- Compact
- Adaptable



Save design, production, and assembly costs

... USE METRON SPEED CHANGERS AS COMPONENTS IN YOUR PRODUCT

- Over 400 different standard ratios! 10:9 to 531,441:1
- Small! 1.062" diameter. Overall lengths: Class A, 2-11/16"; Class B, 3-1/2"; Class C, 4-5/16"
- Transmit power either way to 100:1 ratios
- All aluminum housing
- Servo or foot mounted
- Concentric ball-bearing input and output shafts
- Hardened steel spur gears
- Permanent lubrication
- Prompt delivery on production or experimental models

ONE WEEK DELIVERY

Write for Bulletin 97

Metron

INSTRUMENT COMPANY

460 Lincoln St., Denver 3, Colo.

NEW YORK • CHICAGO • DETROIT • LOS ANGELES • CLEVELAND

CIRCLE 250 ON READER-SERVICE CARD



This handy ALPHA soldering guide contains valuable technical data. Included are:

- Prevention of silver scavenging
 - Effects of rare metals in soldering
 - Effective soldering of joints requiring high creep strength
- Get your copy... Act now!

In Chicago, Ill.
ALPHA-LOY CORP.
2250 S. Lumber St.

Other ALPHA products:
Solder Preforms.
Wide Range of Fluxes.
High Purity Metals.

ALPHA METALS, INC., 58C Water St., Jersey City 4, N.J.
Send me free your New Tips on Soldering.

Name _____ Title _____
Company _____
Address _____
City _____ Zone _____ State _____

CIRCLE 251 ON READER-SERVICE CARD



UPSTAIRS . . . WHEN THE HEAT'S ON

**PROTECT AGAINST
CORONA, HEAT
AND ALTITUDE . . .**

AMP's new Post Insulated Stratotherm Terminals and Splices are designed for gruelling circuit environments "upstairs." Post Insulated Stratotherm overcomes difficult heat and high altitude problems confronting aircraft and missile engineering . . . combine the outstanding electrical performance of compression crimping with the new insulating qualities of sealed Teflon* sleeves which deter corona effects and moisture entrapment in a wide temperature range.

OUTSTANDING FEATURES:

- temperatures as high as 500°F
- fits varying insulation diameters in a wire size range from #22 through #10 AWG
- crimped insulation ring seals termination point against corona and moisture
- high flex and impact strength
- crimp attachment by either A-MP portable power tool or manually operated A-MP hand tool

*Du Pont Trademark

Complete technical data available on request.

AMP INCORPORATED
GENERAL OFFICES: HARRISBURG, PENNSYLVANIA

A-MP products and engineering assistance are available through subsidiary companies in: Canada • England • France • Holland • Japan

CIRCLE 166 ON READER-SERVICE CARD

NEW PRODUCTS

Precision Digital Potentiometers

For 7 and 10 digit inputs



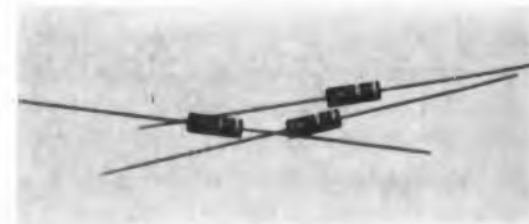
A digital to analog converter, the Digiometer converts a digital number to a precision potentiometer setting. Models are available for 7 and 10 digit inputs, and can also be built to accept binary or binary-coded decimal information. Operating time is 10 msec. The units are shock and vibration resistant and suitable for missile use.

Systems Laboratories Corp., Dept. ED, 149 Ventura Blvd., Sherman Oaks, Calif.

CIRCLE 167 ON READER-SERVICE CARD

Silicon Diodes

Have working voltages to 300 v



Silicon diodes CD1111 through CD1116 have working voltages through 300 v and forward currents of 0.25 amp at 1 v. Reverse currents below 5 μ amp at the maximum working voltage.

Continental Device Corp., Dept. ED, 129 Cerise Ave., Hawthorne, Calif.

CIRCLE 168 ON READER-SERVICE CARD

Subminiature Paper Capacitors

For transistorized applications

This hermetically sealed subminiature, type A-QF paper capacitor meets MIL-C-25A. Made for low voltage transistorized applications, the capacitor operates at temperatures from -65 to +125°C without derating. It has a capacitance variation of less than ± 3 per cent over the entire operating temperature range. The capacitor is available in ratings from 0.027 to 2 μ f. The smallest size is 0.235 in. in diam and 3/4 in. long.

Astron Corp., Dept. ED, 255 Grand Ave., Newark, N. J.

CIRCLE 169 ON READER-SERVICE CARD

Dial Assembly

Servo mounted



Series DA dial assembly permits mounting and dismantling from the front panel of any equipment. The machined groove on its rim is used in the same way as the mounting groove of a synchro. Conventional synchro clamps on the equipment panel firmly hold the dial. The unit has a 360 deg continuous range and 0.1 deg accuracy. It meets MIL-T-945A specifications and has a 5 in. OD

Theta Instrument Corp., Dept. ED, 48 Pine St., East Paterson, N.J.

CIRCLE 170 ON READER-SERVICE CARD

Transistor Curve Tracer

Displays up to five curves

Model TCT-2 transistor curve tracer can display either one curve or a five curve family. The V_c and I_c axes are directly calibrated. It displays collector voltage-collector current (output) curves for common emitter or common base connection. The unit is designed for use with any standard dc oscilloscope with single presentation possible with any standard ac oscilloscope. Emitter-base voltage for selected input currents may be measured by using an external dc meter to characterize points on the input curve.

Curtiss-Wright Corp., Inter-Mountain Instruments Branch, Electronics Div., Dept. ED, Box 8324, Albuquerque, N. M.

CIRCLE 171 ON READER-SERVICE CARD

Epoxy Molding Materials

Can be molded at pressures down to 75 psi

These epoxy molding materials can be molded in conventional compression and transfer molding equipment at temperatures of about 300 F and pressures down to 75 psi. They can be automatically preformed and molded with cure times approaching those obtained with conventional phenolic. Shelf life is 6 months. Molded parts retain good electrical properties under adverse humidity and high temperature conditions.

The Fiberite Corp., Dept. ED, 512-528 W. Fourth St., Winona, Minn.

CIRCLE 172 ON READER-SERVICE CARD

ESC advances the art of delay lines ...

by design!



145 to 1

delay time / rise time ratio

At one time the 145 to 1 delay time/rise time ratio of ESC's Model 51-43 was considered impossible—today this unit is revolutionizing delay line applications and providing greater design freedom for America's electronics industry. Such advances in the art of delay lines could come from only ESC—America's leading manufacturer devoted to the design, development and production of custom-built and stock delay lines.



ESC

CORPORATION

534 Bergen Boulevard, Palisades Park, New Jersey

WRITE TODAY FOR COMPLETE TECHNICAL DATA

exceptional employment opportunities for engineers experienced in computer components... excellent profit-sharing plan.

Distributed constant delay lines • Lumped-constant delay lines • Variable delay networks • Continuously variable delay lines • Pushbutton decade delay lines • Shift registers • Pulse transformers • Medium and low-power transformers • Filters of all types • Pulse-forming networks • Miniature plug-in encapsulated circuit assemblies

CIRCLE 173 ON READER-SERVICE CARD

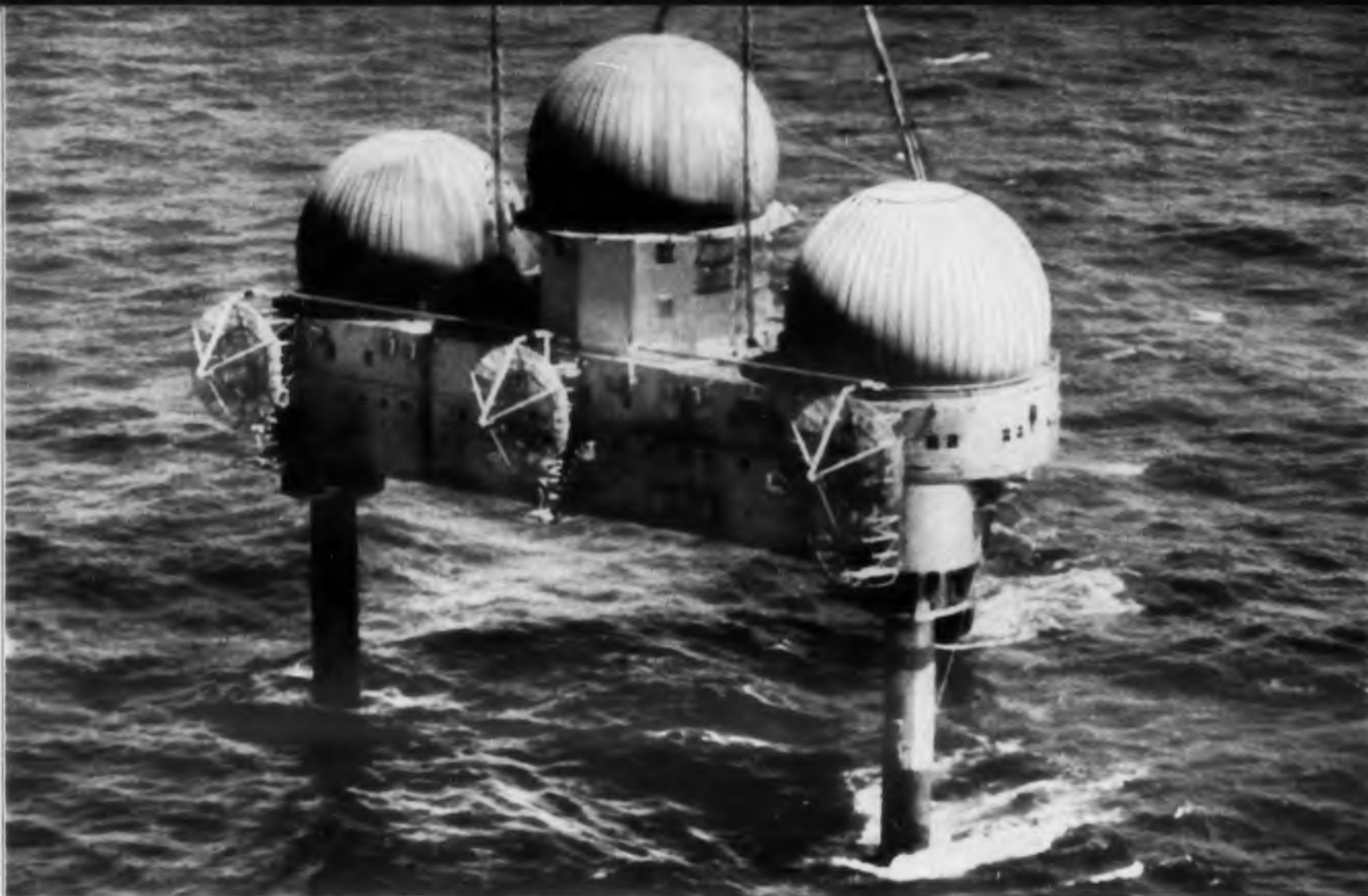


PHOTO COURTESY U. S. AIR FORCE

OFFSHORE INSTALLATION of the Texas Tower Defense System—radar network that helps safeguard the nation's shorelines. Each of the three domes houses radar antennas that constantly sweep the horizon to detect, identify and

plot approaching aircraft. Electronic instrumentation in the center dome includes the Bendix AN/FPS-20 radar unit with Tung-Sol/Chatham's VC1257 hydrogen thyratron tube, Tung-Sol/Chatham development.

Tung-Sol/Chatham VC1257 replaces four tubes in *Bendix* Texas Tower radar set!

The Texas Tower and other key defense systems have required more and more powerful radar equipment. Bendix Radio, to keep pace with this need, replaced four bulky modulator tubes in its AN/FPS-20 radar unit with a single Tung-Sol/Chatham hydrogen thyratron.

Tung-Sol/Chatham's VC1257 features vastly superior power-handling ability, up to 33MW. An internal hydrogen reservoir promotes long life and permits optimum pressure adjustment for a variety of operating conditions. In Bendix

AN/FPS-20, the VC1257 provides 7.7 microsecond pulses of 13,500 volts and 700 amperes at a pulse repetition rate of 360 pps. Output pulses need no synchronization as with multiple tube operation.

Hydrogen thyratrons, exclusive Tung-Sol/Chatham development, are available to designers for a variety of pulse modulator applications—1KW (miniature) to 50 MW. All offer benefits in operating efficiency like those gained by Bendix. For complete data, contact: *Tung-Sol Electric Inc., Newark 4, N. J.*

Engineer points out Tung-Sol/Chatham VC1257 installed in Bendix AN/FPS-20 radar equipment.



TUNG-SOL®

NEW PRODUCTS

Transistor Tester

Operates on flashlight batteries



An npn-pnp junction and point contact transistor tester, the model 71 measures small signal dc gain in the grounded emitter configuration and collector to base leakage current with an accuracy of 3%. A beta multiplier permits measurements with full scale beta ranges of 0 to 50, 100, and 200. I_{co} is measured with a full scale reading of 100 μ a. A short test light with a pushbutton switch identifies shorted transistors immediately. The portable unit operates on standard flashlight batteries.

Trans-Western Electronics, Dept. ED, P.O. Box 1473, Ventura, Calif.

CIRCLE 174 ON READER-SERVICE CARD

Miniature Pushbutton Switch

Has four lamps, four colors

The Quadlite pushbutton switch is a 7/8 in. square unit incorporating four lamps, an spdt switch, and a switch actuator. It features mechanical interlocking for master resetting or mutual cancellation and comes with color filters in combination of any of six standard colors and white. It mounts with or without barriers, or in a matrix on 7/8 in. centers, both directions. All four lamps and the color filter assembly can be easily removed from the front of a panel, and switches and lamps may be interwired or terminated independently.

Electrosnap Corp., Switch Div., Dept. ED, 4218 W. Lake St., Chicago 24, Ill.

CIRCLE 175 ON READER-SERVICE CARD

◀ CIRCLE 176 ON READER-SERVICE CARD

AC Voltage Divider

Has 1 ppm linearity

This laboratory standard measures voltage rates with a linearity accuracy of better than 0.0001 per cent (1 ppm). Model DT-72 Dekatran has toroidal transformers combined to provide seven decades of accurate voltage division. Accuracy is maintained over a wide range of audio frequencies, input voltages and ambient temperatures. The unit uses an inline dial configuration and can be mounted in a standard relay rack.

Electro Measurements, Inc., Dept. ED, 7524 S. W. Macadam Ave., Portland 1, Ore.

CIRCLE 177 ON READER-SERVICE CARD

Magnetic Shields

For shaded pole motors

These Netic Co-Netic magnetic shields permit lower cost shaded pole motors to be used in servo and other instrumentation applications. With proper grounding, effective electrostatic shielding is also accomplished. The shields reduce the radiated field to under 5 gauss and do not significantly affect motor characteristics. They are nonretentive and structurally rugged.

Perfection Mica Co., Magnetic Shield Div., Dept. ED, 1322 N. Elston Ave., Chicago 22, Ill.

CIRCLE 178 ON READER-SERVICE CARD

Meter Relays

2½ and 3½ in.

Models 195 and 95 are 2-1/2 and 3-1/2 in. round panel meter relays for over and under voltage indication, alarm systems, automatic sorting devices, low level switching, and a variety of other applications. They are available in dc meter relay types, microammeters, milliammeters, and ammeters to 10 amp, self-contained. Higher current ranges have external shunts.

Simpson Electric Co., Dept. ED, 5200 W. Kinzie St., Chicago 44, Ill.

CIRCLE 179 ON READER-SERVICE CARD

CIRCLE 180 ON READER-SERVICE CARD

NEW HIGH-RELIABILITY TANTALUM CAPACITOR SERIES



125°C operation • standard ±10% tolerance

Now, premium performance solid tantalum capacitors to fill your highest reliability requirements!

134 ratings from 1-330 µf, 6-35 v

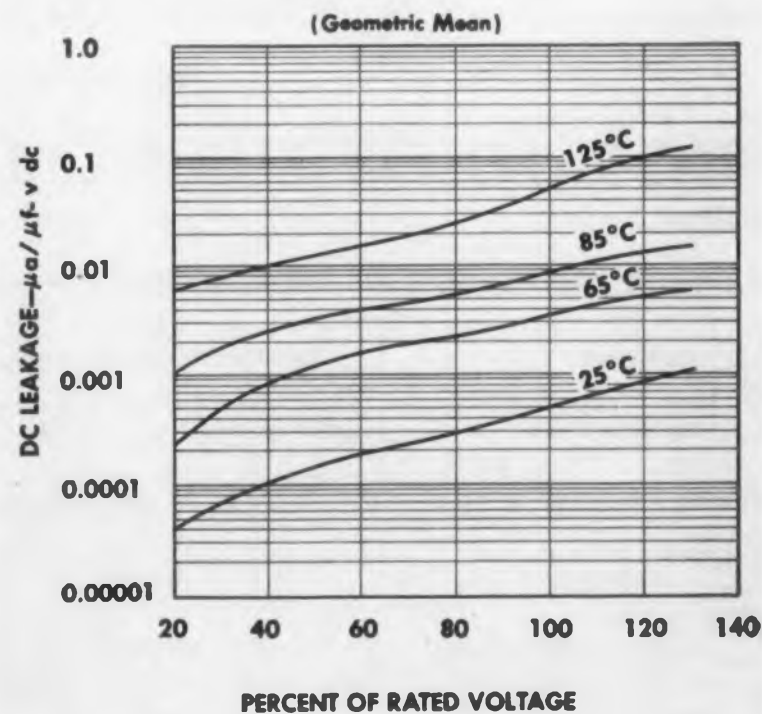
Exceeding all existing MIL specs over a full range of industry-standard ratings and case sizes, the subminiature SRM series features . . . new low dc leakage limits and long operating and storage life . . . standard ± 10% tolerance . . . operation from -80°C to + 125°C . . . ruggedized construction . . . reverse voltage capability . . . nominal voltage derating required at 125°C. TI's advanced processing techniques and 100% testing of pre-aged units assure SRM capacitors to the most exacting reliability standards.

*Trademark of Texas Instruments Incorporated



Contact your nearest TI sales office today for delivery information and your copy of the 12-page bulletin listing specifications of all 134 ratings.

DC LEAKAGE vs WORKING VOLTAGE AND TEMPERATURE



from THE WORLD'S LARGEST SEMICONDUCTOR PLANT



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We promise you will receive a reply within one week!

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Use of the following form will, we hope, reduce to a minimum the inconvenience of submitting an employment inquiry, yet will still permit us to give you a reasonably definitive reply.

Please airmail to:

Mr. Robert A. Martin, Supervisor, Scientific Employment
Hughes Research and Development Laboratories
Culver City 28, California



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Name _____

Address _____

City _____ Zone _____ State _____

College _____ Degree _____ Year _____

I am interested in one of the following types of assignment:

<input type="checkbox"/> RESEARCH	<input type="checkbox"/> PRODUCT ENGINEERING	<input type="checkbox"/> SYSTEMS	<input type="checkbox"/> OTHER: _____
<input type="checkbox"/> DEVELOPMENT	<input type="checkbox"/> TECH. ADMIN.	<input type="checkbox"/> FIELD TEST	<input type="checkbox"/> _____

I have had professional experience in the following specific areas:

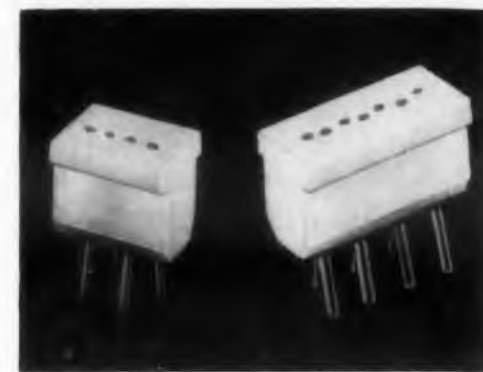
<input type="checkbox"/> CIRCUIT ANALYSIS AND DESIGN	<input type="checkbox"/> STRESS ANALYSIS	<input type="checkbox"/> R-F CIRCUITS	<input type="checkbox"/> ELECTRO-MECHANICAL DESIGN
<input type="checkbox"/> DIGITAL COMPUTERS	<input type="checkbox"/> INDUSTRIAL DYNAMICS	<input type="checkbox"/> RELIABILITY	<input type="checkbox"/> OTHER: _____
<input type="checkbox"/> GUIDANCE DEVICES	<input type="checkbox"/> MATERIALS	<input type="checkbox"/> ATOMIC AND/OR SOLID STATE PHYSICS	<input type="checkbox"/> _____
<input type="checkbox"/> MICROWAVES	<input type="checkbox"/> SYSTEMS ANALYSIS	<input type="checkbox"/> INSTRUMENTATION	<input type="checkbox"/> _____

I have had a total of _____ years of experience.

NEW PRODUCTS

Miniature Sockets

Low loss



Miniature Chemelec SX-423, -424, and -427 sockets are low loss tube and transistor units for wired or printed circuit applications. Three, four, and seven post sockets, respectively, they have Teflon insulator bodies which press fit into mounting receptacles. The countersunk spring tension socket contacts are silver plated, gold flashed brass with flared ends. Other multipost sockets are also available.

Fluorocarbon Products Inc., Dept. ED, Camden 1, N.J.

CIRCLE 182 ON READER-SERVICE CARD

Data Transmission System

High speed

Used with the company's 768G-1 Kinocard converter and an IBM 523 card reader-punch unit, the TE-206 data transmission system reproduces and transmits punch card information at a rate of 100 cards per min. The system can operate in full or half duplex and simplex modes. The TE-206 conveys information at voice frequencies over wire line, cable, carrier, or microwave telephone facilities.

Collins Radio Co., Dept. ED, 2700 W. Olive, Burbank, Calif.

CIRCLE 183 ON READER-SERVICE CARD

Reference Diode

Temperature coefficient of 0.005% per C

Having a temperature coefficient of up to 0.0005 per cent per C from -55 to +185 C, this reference silicon diode is in a case 0.29 in. long and 0.25 in. in diameter. The reference element is rated from 9 to 9.8 v at 10 ma, with Zener impedance of 15 ohms. The internal lead wire and stainless steel diode case have matched coefficients of expansion. Cases are glass-sealed and hermetically welded.

U. S. Semiconductor Prod., Inc., Dept. ED, 3536 W. Osborn Road, Phoenix, Ariz.

CIRCLE 184 ON READER-SERVICE CARD

Delay Lines

Variable



These potentiometer type delay lines come in a 1.5 in. diameter case with 3 to 30 μ sec variable delay time and 210 deg shaft rotation. A locking device can be provided for use under high vibration. The potentiometer packaging may also be ordered for delay lines of greater length, and digital shaft knobs can be supplied for accuracy in setting the delay.

Delttime, Inc., Dept. ED, 608 Fayette Ave., Ramapo, N.Y.

CIRCLE 185 ON READER-SERVICE CARD

Miniature Free Gyro

Stands up to 2000 cps vibration

Model N4100 gyroscope weighs 3.5 lbs and can stand vibration of 10 to 1000 cps at 10 g and 1000 to 2000 cps at 20 g with 2 min sweep cycles without the benefit of vibration isolators. It is a rugged, 2-axis, free unit designed for missile application. Angular displacements are indicated by a synchro pick-off on the outer gimbal. Construction throughout is of heat treated cast stainless steel and a center-of-gravity flange is provided for mounting.

Iron Fireman Mfg. Co., Electronics Div., Dept. ED, 2838 S. E. Ninth Ave., Portland 2, Ore.

CIRCLE 186 ON READER-SERVICE CARD

Thermal Switch

For activating temperatures from 113 to 1500 F

The Thyrastat is a temperature sensitive, single pole switch available in normally open and normally closed single pole types. Rated at 4, 10, 50, 100, or 300 amp, the unit is preset for activating temperatures ranging from 113 to 1500 F. It has an unlimited altitude range and a temperature range between -100 and +1500 F dependent on the activating temperature. The unit meets MIL-STD-883C humidity requirements and withstands 50 g shock for 2 to 4 msec and 2 to 20,000 cps vibration at 40 g.

Thermal, Inc., Dept. ED, 1629 Colorado St., Santa Monica, Calif.

CIRCLE 187 ON READER-SERVICE CARD



FOR "ONE-STOP" SERVICE,

FAST LOCAL DELIVERY

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RCA SEMICONDUCTOR DISTRIBUTOR

WHATEVER your requirements in Transistors and Silicon Rectifiers... industrial, military, computer, entertainment... check first with your local RCA Semiconductor Distributor. His main objective is to offer superior-quality products and outstanding service—fast!

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RADIO CORPORATION OF AMERICA

Semiconductor Products - Distributor Sales .

Harrison, New Jersey

**EIMAC TUBES
NOW IN PRODUCTION
IN AMERICA'S NEWEST,
MOST MODERN TUBE PLANT**

In San Carlos, California, Eimac's third and largest plant is nearing full production to meet the great demand for many popular Eimac electron tube families. Never before have so many advanced techniques and processes been applied to vacuum tube manufacture. Eimac's leadership in new processing methods has brought a new era of quality to electron tubes.



Ready for shipment, these Eimac ceramic tetrodes are just one of more than a hundred different tube types manufactured by Eitel-McCullough, Inc., including negative grid tubes, power amplifier klystrons, reflex klystrons and traveling wave tubes.



Eimac, San Carlos, greatly increasing production capacity, joins San Bruno and Salt Lake City facilities as Eimac's newest plant.



Final tube assembly in near-sterile "clean rooms" assures exceptional tube reliability. These rooms are pressurized with filtered, conditioned air to prevent the tiniest dust particles from entering. Even shoes are automatically vacuum cleaned as personnel enter the room through double-door air locks.



Eimac designed rotary vacuum pumps speed production, achieve hard, clean tube vacuums. Pumping Eimac tubes at high voltages and ambient temperatures assures long life and reliability. These giant rotary pumps are typical of production equipment custom designed by Eimac for transmitting tube manufacture.



Every tube meets rigid Eimac specifications before shipment. On test consoles like this, dozens of electrical characteristics are patiently tested and recorded for each Eimac tube produced. Environmental testing equipment is also available for testing for severe applications.



EITEL-McCULLOUGH, INC.
SAN CARLOS, CALIFORNIA

NEW PRODUCTS

Adjustable Capacitors
Hermetically sealed



Designed for precise circuit applications where a large capacitance of close tolerance is required, these hermetically sealed polystyrene capacitors may be adjusted over a range of $\pm 1\%$ of nominal value. Capacitance is changed instantaneously and once set, a unit will maintain its value within 0.1% for almost a year. The units employ a self-rigid type of winding which is completely non-inductive and inherently stable without external pressure.

Film Capacitors, Inc., Dept. E
3400 Park Ave., New York 56, N.Y.

CIRCLE 188 ON READER-SERVICE CARD

Gyro Test Console

Simplifies response testing

Developed to measure the transfer function and damping characteristics of rate gyros, this test console simplifies the procedure for gyro response testing. The equipment discriminates in favor of fundamental frequency to give accurate readings irrespective of harmonics and unmasked by irrelevant oscillations. It consists of low frequency decade oscillator, low frequency resolved component indicator, carrier converter, power supply, velocity pickup head amplifier, rate vibration table component, and rate vibration table.

Solartron, Inc., Western Dept. ED, 10761 Burbank Blvd., North Hollywood, Calif.

CIRCLE 189 ON READER-SERVICE CARD
CIRCLE 190 ON READER-SERVICE CARD

Miniature Pressure Switch

For missiles



Model 3486 miniature pressure switch, for missile and similar space applications, is designed for use with both hydraulic fluids and gases, and for 10 to 3000 psi systems. It is resistant to acceleration, shock, and vibration and has a temperature range of -65 to $+275$ F. Maximum weight is $3/4$ oz. Proof pressure is 4500 psi; and burst pressure is 7500 psi. The snap action unit can be supplied in spst, spdt, or dpst arrangements. Solder terminals are provided.

Frederick Co., Dept. ED, 711 W. Broadway, Mendocino, Calif.

CIRCLE 191 ON READER-SERVICE CARD

Teflon Insulated Terminals

Feedthrough and test point

Available in feedthrough and test point configurations, Loc-Fit Teflon insulated terminals are available in a variety of terminals. They require no precision drill tolerances, deburring, or chamfering of chassis preparation and can be installed by hand or with automatic production machine facilities. Loc-Fit terminal may be installed in boards with thicknesses from 0.04 to 0.062 in.

Litton Industries, Inc., U. S. Engineering Co., Dept. ED, P.O. Box 2368, Van Nuys, Calif.

CIRCLE 192 ON READER-SERVICE CARD

Signal Generator Calibrators

500 kc to 100 mc range

Signal generator calibrator types 245-D and 245-C have calibrated output ranges of 0.5, 1, and 5, 10, and 20 μ v, respectively. Both provide direct calibrated measurement of per cent amplitude of r.f. voltage at 0.025, 0.05, and 0.1 v. The units are portable and fully transistorized and require no external power source. They have an rf frequency range of 500 kc to 1000 mc; an am range of 10 to 100 μ a; and an am frequency range of 20 cps to 100 kc. The rf input requirements are 0.05 v.

Boonton Radio Corp., Dept. ED, Boonton, N.J.

CIRCLE 193 ON READER-SERVICE CARD



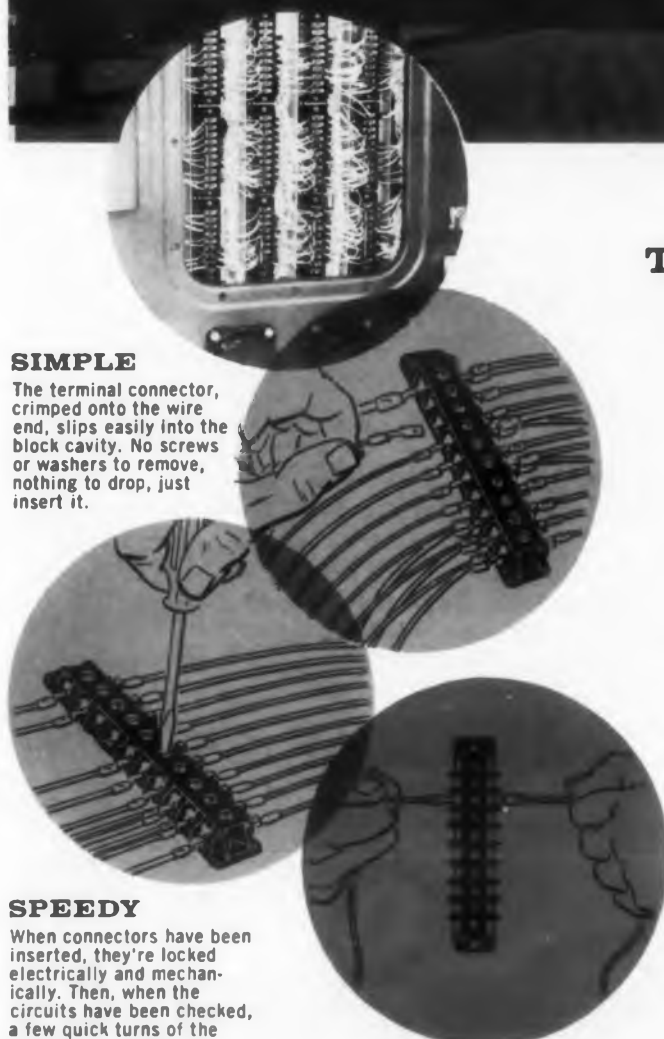
For connections you

must count on...

be sure, be safe with

TWIN LOCK TERMINAL BLOCKS

Twin Lock terminal blocks offer the ultimate in terminal reliability, speed of assembly, and versatility of application. Molded of a lightweight phenolic base with reinforced barriers between cavities, the Twin Lock block will accommodate up to 40 connections quickly and surely. Twin Lock's exclusive, insert-and-tighten two-way locking action cuts harness assembly time to a fraction of that required by any other block. Twin Lock contact points, either tin plated, gold plated or plated to customer specification, assure lowest resistance connection. Wire end connectors, compatibly plated, can be supplied for manual or automatic assembly. Available in either vertical or side entry types, the Twin Lock block is applicable wherever a fast, positive, reliable electrical connection is required. For complete information on these remarkable new blocks, write for the T-1000 and T-1010 Terminal Block Brochure.



SIMPLE

The terminal connector, crimped onto the wire end, slips easily into the block cavity. No screws or washers to remove, nothing to drop, just insert it.

SPEEDY

When connectors have been inserted, they're locked electrically and mechanically. Then, when the circuits have been checked, a few quick turns of the lock screw and they're double-locked.

SURE

When the connector has been inserted and tightened, the Twin Lock terminal block connection is positive—electrically and mechanically. Over 100 lbs. force is required to break this connection.

TWIN LOCK INCORPORATED

1024 West Hillcrest Blvd.
Inglewood, California

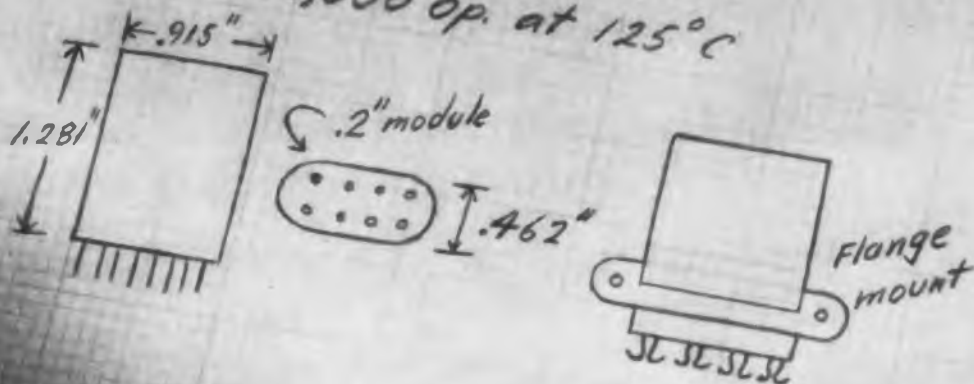
Coliseum Tower, 10 Columbus Circle,
New York 19, New York

CIRCLE 194 ON READER-SERVICE CARD

Now MICRO-MINIATURE SENSITIVE RELAYS

by Iron Fireman

IRON FIREMAN ELECTRONICS DIVISION
 SENSITIVITY—UNPOLARIZED op. power
 Model RS800—25 MW SPDT
 Model R800—40 MW DPDT
 CONTACT RATINGS—
 2 Amps at 28 V. DC or 115 V. AC
 VIBRATION IMMUN.—20 G's to 2000 CPS
 SHOCK IMMUN.—up to 100 G's
 MIN. LIFE—100,000 op. at 125°C



Sensitivity down to 25 mw.

The sensitivity ratings, vibration and shock immunities shown above are achieved for the first time in a micro-miniature package.

Where only limited power is available, the Iron Fireman R800 offers sensitivities as low as 25 MW of unpolarized exciting power and a high degree of reliability and environmental immunities.

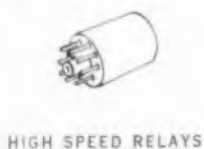
Conforming to and exceeding the test requirements of MIL-R5757C, the performance and reliability of this relay is further enhanced by separately sealing the coils within the outer shell.

Complete performance data available on request. Write to the address below.

When space, weight and sensitivity are a problem specify the Iron Fireman R800 Relay



MICRO. MIN. RELAYS



HIGH SPEED RELAYS



SLIP RINGS & BRUSHES



FREE AND VERTICAL GYROS



IRON FIREMAN *Electronics* **DIVISION**

2838 S. E. NINTH AVENUE, PORTLAND 2, OREGON

CIRCLE 196 ON READER-SERVICE CARD

NEW PRODUCTS

5-Inch Cathode Ray Tube

12 in. long



The type 5BTP flat face, 5-in. cathode ray tube is 12 in. long. It has a sensitivity of 27 v dc per in. vertically and 50 v dc per in. horizontally when operated with 800 v at the second anode and 1600 v at the third anode. The tube provides a high light output and can be operated with voltages up to 2700 and 4400 v at the anodes. It has electrostatically controlled focus and deflection and is available in P1, P2, P7, and P11 phosphors.

Waterman Products Co., Dept. ED, 2445 Emerald St., Philadelphia 25, Pa.

CIRCLE 198 ON READER-SERVICE CARD

Fixed Coaxial Attenuator

Stainless steel



Fixed coaxial attenuator model 210 has a stainless steel body and stainless steel type N connectors. Frequency range is 1 to 10 mc; attenuation range, 1 to 20 db; impedance, 50 ohms.

Weinschel Engineering, Dept. ED, 10503 Metropolitan Ave., Kensington, Md.

CIRCLE 199 ON READER-SERVICE CARD

Pulse Height Analyzer

Has 20 channel storage

A 100 channel pulse height analyzer with 20 channel storage, model PHA-120 is designed specifically for moderate and low counting spectroscopy work. A full 100 channel analysis is made and read in five steps of 20 channels. The instrument consists of a preamplifier, amplifier, amplitude digitizer, storage unit, and decade scaler.

The Victoreen Instrument Co., Dept. ED, 5800 Hough Ave., Cleveland 3, Ohio.

CIRCLE 200 ON READER-SERVICE CARD

Chopper Reference Kit

Provides 60 and 400 cps driving frequencies



The four precision dpdt instrument choppers in this reference kit have 60 and 400 cps driving frequencies and both mbb and bbm contact closures. They have removable dust covers of Co-Netic magnetic shielding for low noise characteristics and easy contact adjustment.

James Vibrapowr Co., Dept. ED, 4050 N. Rockwell, Chicago 18, Ill.

CIRCLE 201 ON READER-SERVICE CARD

Hysteresis Motors

Size 10 and 11



These size 10 and 11 gearhead hysteresis synchronous motors are 2-17/64 in. long and may be supplied in any gear reduction to 8000 to 1. They operate from -65 to +125 C. Standard units are for 26, 55, or 120 v ac, 400 cps operation.

Western Gear Corp., Electro Products Div., Dept. ED, 132 W. Colorado St., Pasadena, Calif.

CIRCLE 202 ON READER-SERVICE CARD

Elapsed Time Indicator

Dimensions less than one in.

Having a nominal diameter and length of less than 1 in. the SM-1 elapsed time indicator weighs 1.25 oz. It has a power consumption of 1.5 w. The unit is designed to operate from a 400 cps source at operating voltages to specification. The unit is designed to meet the general requirements of MIL-I-7793B.

Henta Electronics, Inc., Dept. Ed, 2635 Louisiana Ave., Minneapolis 26, Minn.

CIRCLE 203 ON READER-SERVICE CARD

Immediate delivery



rectangular connectors



...with snap-in contacts



Available now... CEC electrical connectors in large or small quantities to satisfy an exceptionally wide variety of applications — flush- or surface-mounting types... with jack-screws or guide pins... straight- or right-angle hoods... in 26-, 34-, 42-, 50-, or 75-pin configurations—all standard types with off-the-shelf availability.

Lightweight, rugged, and dependable, the Series 500-C multi-contact connectors feature easy-to-assemble snap-in contacts which simply push into place, yet permit fast, easy removal with a simple hand tool. A triple retention spring in each contact resists an axial pull of at least 20 lbs.—equal to a cable-harness pull in excess of 1,500 lbs. for a 75-pin connector.

CEC connectors represent the newest concepts of design and materials and employ a modular construction to enhance flexibility of application and speed assembly and installation.

Individual contacts accept insulated wires from size 20 to 24, and cables composed of wires from 0.054" to 0.10" in diameter are easily accommodated by the connector enclosure. Contacts are gold-plated and can be used with hand, semi-automatic, or automatic crimping methods. CEC connectors exceed the requirements of MIL-C-8384A.

SPECIAL CONNECTORS... If your application requires an unusual or special type connector often demanded by advanced technologies, you are invited to take advantage of CEC's proved experience in the design and manufacture of these custom types... designed for the particular application and environment you specify.

Write today for complete information on Series 500-C connectors, or call your nearby CEC sales and service office. Ask for Bulletin CEC 4004-X14.

Electro Mechanical Instrument Division

CEC

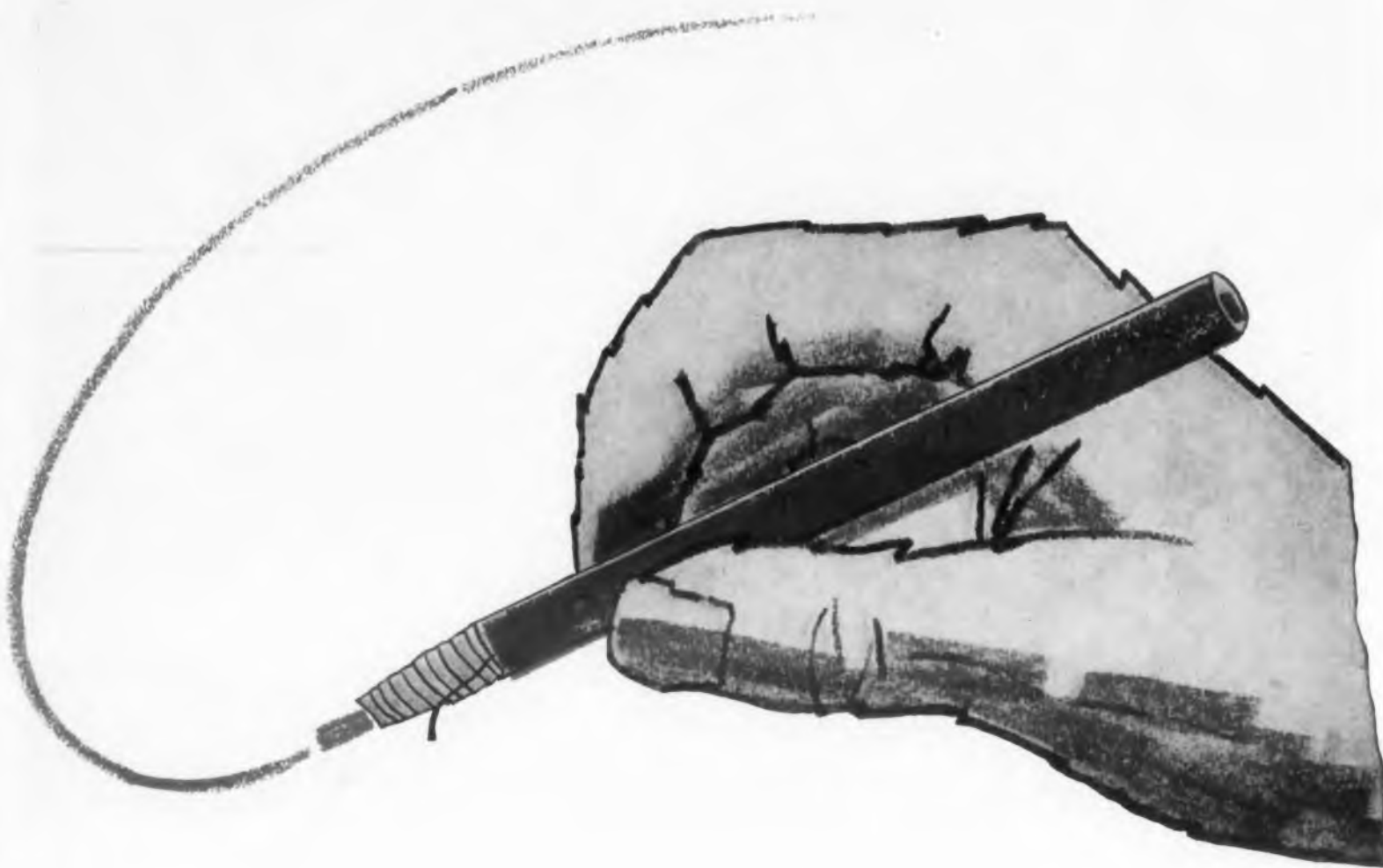
CONSOLIDATED ELECTRODYNAMICS 300 N. Sierra Madre Villa, Pasadena, Calif.

FOR EMPLOYMENT OPPORTUNITIES WITH THIS PROGRESSIVE COMPANY, WRITE DIRECTOR OF PERSONNEL



SERIES 500-C CONNECTOR... Removal of portal door exposes interior of connector for contact insertion, removal, or replacement, and allows quick inspection and adjustment of cable-harness.

CIRCLE 204 ON READER-SERVICE CARD



HANK YOU FOR YOUR COOPERATION

From time to time readers have been asked to help us rate the interest value of our editorial by indicating which articles are read completely, and which are simply noted. We have asked the same question about advertisements.

Because you have taken the time to go through the publication page by page, you have given us an indication of the kinds of articles, design information, and data you need to solve today's design problems. At the same time you have provided us with a concrete measure of *Electronic Design's* readership—highest in the electronic field.

Although we are always anxious to attract new advertisers, our prime concern is to maintain—and improve—the quality of our magazine and its service to the reader.

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NEW PRODUCTS

Digital Clocks Transistorized



Fully transistorized, these digital clocks provide reliable time duration and interval measurements. They have a direct readout, illuminated display and heavy duty output closures for data recorder entry. Time measurement is based on 60 cps line frequency, but provision is made to slave the clock to an external frequency source or time base. Clocks can be provided for operation on any frequency from 25 to 128 cps. Primary measurement of time is achieved by means of transistor flip-flop frequency division.

Electro Instruments, Inc., Dept. ED, 3540 Aero Court, San Diego 11, Calif.

CIRCLE 205 ON READER-SERVICE CARD

DC to Square Wave Power Supply Has $\pm 1\%$ frequency and voltage regulation



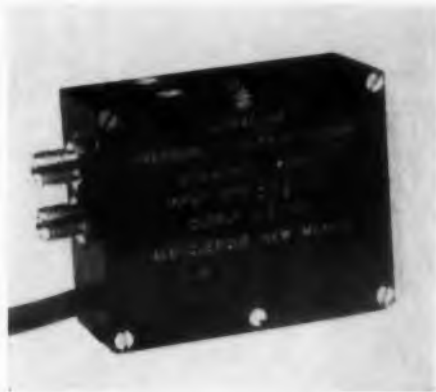
Transistorized power supply model 591AC produces 400 cps single phase, square wave power from a 28 v dc line. It delivers 50 va output with a frequency and voltage regulation of $\pm 1\%$ for input variations of 5 v. An output power of 115 v, 400 cps is standard, but any voltage from 6 to 1200 v rms and any frequency from 400 to 2000 cps can be supplied. The unit is protected against polarity reversal and short circuits and has a $\pm 3\%$ voltage drift from -55 to $+71$ C. Designed to MIL-E-5272B, it is fully encapsulated and hermetically sealed in a case 3-3/16 in. high with a 3 in. OD.

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

CIRCLE 206 ON READER-SERVICE CARD

Pressure to Voltage System

Provides 0 to 5 or ± 2.5 v dc output



Voltage controlled model DCS-4 pressure to voltage system operates from standard unregulated aircraft and missile power supplies and provides a signal output of 0 to 5 or ± 2.5 v dc over the rated pressure range. The dc output voltage level is constant within $\pm 1\%$ despite input voltage changes within the 25 to 30 v range.

Ultradyn, Inc., Dept. ED, P.O. Box 3308, Albuquerque, N. Mex.

CIRCLE 207 ON READER-SERVICE CARD

Dual Centrifugal Blowers

Deliver 150 to 500 cfm



Model M2E300A centrifugal blowers deliver 150 to 500 cfm and have panel heights from 3-1/2 to 8-3/4 in. They fit 19 in. racks and have 60 or 400 cps single or three phase motors.

McLean Engineering Labs., Dept. ED, Princeton, N.J.

CIRCLE 208 ON READER-SERVICE CARD

AC-DC Digital Voltmeter

Provides full 4-digit accuracy

With a fifth digit for dc over ranging, the model 502 4-digit ac-dc digital voltmeter provides full 4-digit accuracy across all ranges. Overall range for dc is ± 0.0001 to 1000 v with 0.01% ± 1 digit accuracy; for ac, 0.001 to 999.9 v, 30 to 10,000 cps with 0.2% ± 1 digit accuracy.

Kin Tel, Div. of Cohu Electronics, Inc., Dept. ED, 5125 Kearny Villa Rd., San Diego 12, Calif.

CIRCLE 209 ON READER-SERVICE CARD

ELECTRONIC DESIGN • May 27, 1959

FOR RADAR AND
MISSILE TRACKING

ANOTHER VARIAN FIRST

INTERNAL CAVITY PULSE AMPLIFIER
KLYSTRON with 75 KILOWATTS
average output

- RUGGED
- NON CRITICAL
- HIGH PERFORMANCE
- SINGLE PUSH-BUTTON OPERATION

1.25 MEGAWATTS PEAK POWER

Varian's VA-849 is the world's largest internal cavity Klystron. It produces the tremendously high average power of 75 kilowatts for long pulse radar and missile tracking. Features include a pulse duration time of 2000 microseconds; tunable frequency range of 400 to 800 megacycles; 40 db stable RF power gain.

Varian makes a wide variety of Highstroms and Wave Tubes for use in Radar, Communications, Test and Instrumentation, and for Severe Environmental Service Applications. Over 100 are described and pictured in our new catalog. Write for your copy — address Tube Division.

VARIAN associates
PALO ALTO 21, CALIFORNIA
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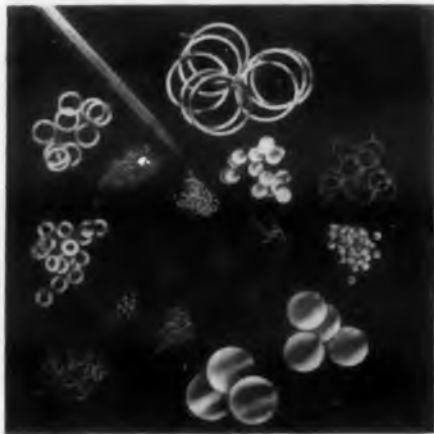
KLYSTRONS, TRAVELING WAVE TUBES, BACKWARD WAVE OSCILLATORS, HIGH VACUUM PUMPS, LINEAR ACCELERATORS, MICROWAVE SYSTEM COMPONENTS, R. F. SPECTROMETERS, MAGNETS, MAGNETOMETERS, STALDS, POWER AMPLIFIERS, GRAPHIC RECORDERS, RESEARCH AND DEVELOPMENT SERVICES

CIRCLE 210 ON READER-SERVICE CARD

NEW PRODUCTS

Semiconductor Preforms

Variety of shapes and materials



For making alloy junctions in silicon and germanium semiconductor devices, these preformed discs, spheres, washers, and pellets are available in a wide variety of alloys including lead-antimony, indium-lead, gold-gallium, aluminum-gallium, and tin-antimony. Discs have tolerances to ± 0.0002 in. on diameters with flatness held within 0.0002 in. T.I.R. Spheres range from 0.001 to 0.125 in. in diameter with tolerances to ± 0.0001 in. Washers have OD's from 0.025 to 2 in. with diameters guaranteed to ± 0.00025 in. and thicknesses to within ± 0.0002 in.

Accurate Specialties Co., Inc., Dept. ED, 37-11 57th St., Woodside 77, N.Y.

CIRCLE 211 ON READER-SERVICE CARD

Panel Indicator Light

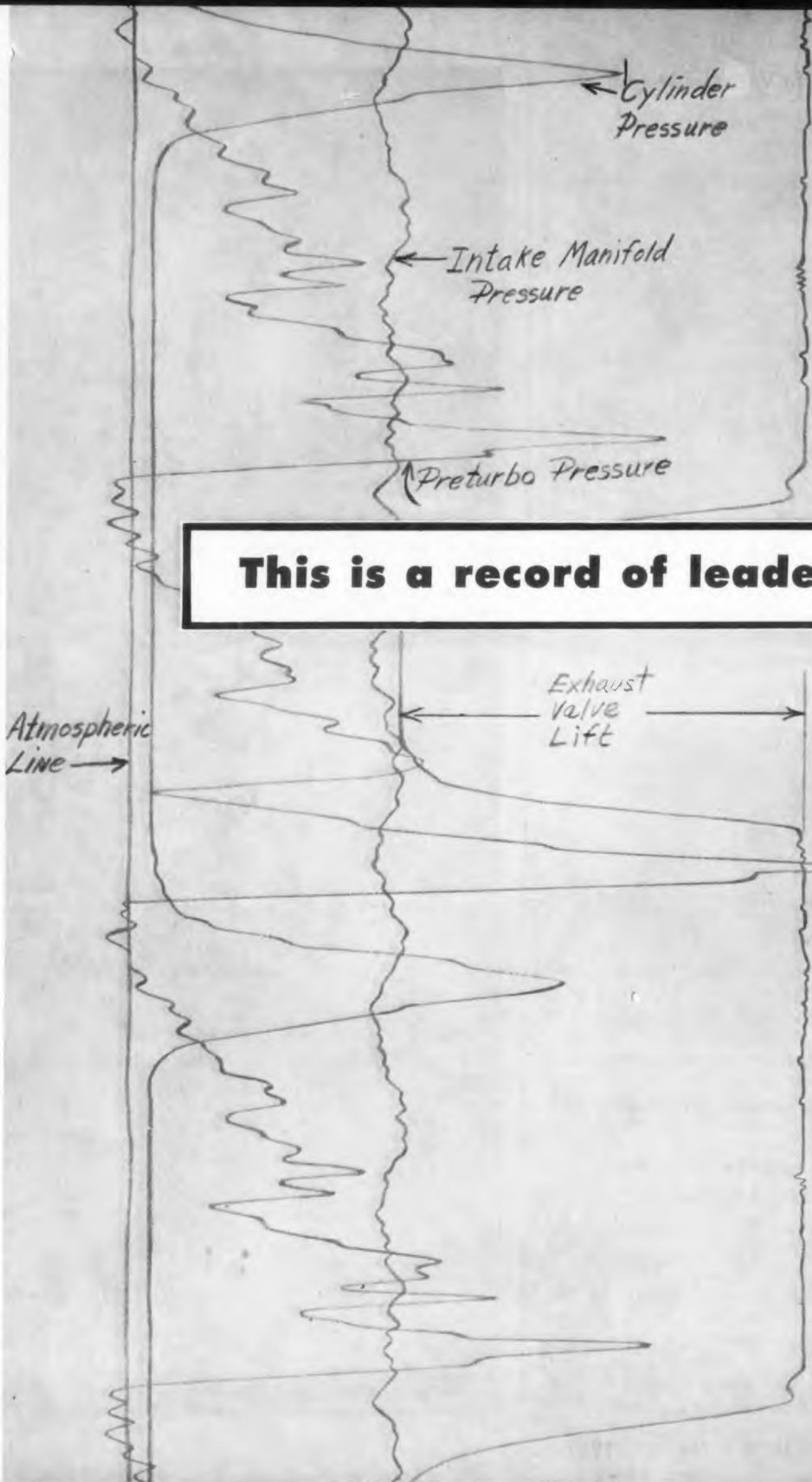
Has 1/4 in. diameter



Miniature model T-1 panel indicator light lasts 100,000 hr at 5 v or 60,000 hr at 6.3 v. Both single and two terminal types with either fixed or removable bulbs are available. The light is 1/4 in. in diameter, and the light cap, provided in red, white, green, blue, or amber, is 1/8 in. in diameter.

The Sloan Co., Dept. ED, 4029 Burbank Blvd., Burbank, Calif.

CIRCLE 212 ON READER-SERVICE CARD



This is a record of leadership



The Worthington Corporation used a Honeywell 906 Visicorder to chart the heartbeat of a Worthington Tripower diesel engine. These Tripower (oil fuel, dual fuel, or spark ignition gas) engines have a fourteen inch bore, an eighteen inch stroke, and develop more than 265 h.p. per cylinder at 450 RPM.

The Visicorder used in these tests makes a direct, instantly-readable record of the pressure variations in the exhaust manifold, cylinder, and intake manifold to determine optimum valve

timing and engine configuration. The Visicorder also produces a permanent record of strain gauge measurements taken on the frame and other critical engine parts.

For the manifold and cylinder pressures, strain gauge pressure transducers and a strain gauge amplifier were used. For the valve lift patterns, a linear potentiometer powered with a small battery was connected directly to the Visicorder.

Analysis of these data has led to changes in the Tripower engine for best performance.

in diesel engine research



Ted Dupler (left) and John McAllister, Worthington Engine Research Engineers, measure intake manifold, cylinder, and exhaust manifold pressures and valve stroke on a Tri power with a Honeywell 906 Visicorder.

The Honeywell Visicorder is the pioneer and unquestioned leader in the field of high-frequency, high-sensitivity direct recording oscillography. In research, development and product testing everywhere, instantly-readable Visicorder records are pointing the way to new advances in product design, rocketry, computing, control, nucleonics . . . in any field where high speed variables are under study.

The new Model 906A Visicorder, now available in 8- and 14-channel models, produces longitudinal grid lines simultaneously with the dynamic traces, time lines, and trace identification by means of new accessory units.

To record high frequency variables—and monitor them as they are recorded—use the Visicorder Oscillograph. Call your nearest Minneapolis-Honeywell Industrial Sales Office for a demonstration.

Reference Data: Write for Visicorder Bulletin Minneapolis-Honeywell Regulator Co., Industrial Products Group, Heiland Division 5200 E. Evans Ave., Denver 22, Colo.

Honeywell



Industrial Products Group

CIRCLE 213 ON READER-SERVICE CARD

Expanded Scale Voltmeter

Has 0.1% accuracy



Indicating true rms voltage, this expanded scale voltmeter maintains 0.1% accuracy over a wide temperature range and in the presence of up to 5% harmonic content in the power supply. It has a 250 deg scale on its 115 to 125 v dial and is housed in a single unit that includes a 3-1/2 in. panel meter.

American Machine & Foundry Co., Alexandria Div., Dept. ED, 1025 N. Royal St., Alexandria, Va.

CIRCLE 214 ON READER-SERVICE CARD

Adjustable Fixed Resistors

Rated 1/4 w at 70 C

The moving element in type R fixed resistors is self-locking and adjustable through a 25-turn range. The resistors are watertight and dust tight so that they may be potted after adjustment. They are 1-1/4 in. long and rated 1/4 w at an ambient temperature of 70 C and a maximum voltage of 350 v. Total resistance values from 100 ohms to 2 meg ± 10 and $\pm 20\%$ are available.

Allen-Bradley Co., Dept. ED, 136 W. Greenfield Ave., Milwaukee 4, Wis.

CIRCLE 215 ON READER-SERVICE CARD

Power Supply

Has three regulated outputs

This power supply, P/N 380-100, was designed to supply three separate, closely regulated output voltages: +150 v, 630 ma; -150 v, 100 ma; and -300 v, 40 ma. For airborne use, the unit will operate at +85 C at full output rating, and is completely transistorized, using no tubes. Housing is black anodized aluminum for better heat dissipation, and the power transistors are mounted directly on the cabinet.

Master Specialties Co., Dept. ED, 956 E. 108th St., Los Angeles 59, Calif.

CIRCLE 216 ON READER-SERVICE CARD

NEW PRODUCTS

Delay Line Kit

Provides delays from 0.1 to 1.6 μ sec

With individual or series connected lines in the model 120 delay line kit, any delay from 0.1 to 1.6 μ sec may be achieved in 0.1 steps. The kit contains lumped constant delay lines made up of precision toroidal inductors and temperature compensating ceramic disc capacitors. The lines have a characteristic impedance of 500 ohms and a rise time of 0.1 μ sec.

Valor Instruments, Inc., Dept. ED, 13214 Crenshaw Blvd., Gardena, Calif.

CIRCLE 217 ON READER-SERVICE CARD

Molded Capacitors

Have dual dielectric

For TV, radio, and general commercial use, these molded capacitors have a dual dielectric of both polyester film and paper. Type 160P has a fully molded case and type 161P a premolded case. Type 162P has a slotted base. The units are suited for printed circuit standup and conventional point-to-point or card mounting applications.

Sprague Electric Co., Dept. ED, 347 Marshall St., North Adams, Mass.

CIRCLE 218 ON READER-SERVICE CARD

Uncompensated Silicon

Semiconductor grade

Available in three semiconductor grades, this uncompensated silicon is free of all impurities except for minute quantities of boron. Type 43 contains less than 2.8 parts per billion boron; type 42, less than 5.6 and type 41, less than 11.2. Another silicon, type 40, is suitable for solar batteries and has a minimum resistivity of 1 ohm cm.

Sylvania Electric Products Inc., Chemical and Metallurgical Div., Dept. ED, Towanda, Pa.

CIRCLE 219 ON READER-SERVICE CARD

CIRCLE 220 ON READER-SERVICE CARD

They
look
great
going
out
...but
how about
6 months
from now?



2" SHORTER THAN THEIR PROTOTYPES!
New RCA "VC" 110° Picture Tubes offer high
reliability in slim-style very compact TV sets.



FIELD OFFICES

EAST:
744 Broad Street, Newark 2, N. J.
HUmboldt 5-3900

MIDWEST:
Suite 1154, Merchandise Mart Plaza
Chicago 54, Ill., WHitehall 4-2900

WEST:
6355 E. Washington Blvd.
Los Angeles 22, Calif.
RAYmond 3-8361

One sure way to *preclude* early-hour field failures is to specify performance-proved RCA "VC" (very compact) 110° picture tubes for your TV design. But, you ask, how can one say that brand new "VC" Picture Tubes are "performance-proved"?

Here's why...RCA "VC" 110° types employ the same heater-cathode assembly that has been used and *proven for reliability* over the past decade in RCA Picture Tubes. Now commercially available in the shorter "VC" 110° designs are the RCA-17DKP4 and RCA-21EQP4, all-new premium types. They utilize conventional 110° components and circuitry. And, with only slight changes in focusing-voltage control, they are unilaterally interchangeable with previous 110° types.

You get the performance you design for when you specify RCA "VC" Picture Tubes. Ask your RCA Field Representative for full information. For technical data, write RCA Commercial Engineering, Sec. E-18-DE2, Harrison, New Jersey.



RADIO CORPORATION OF AMERICA

Electron Tube Division

Harrison, N. J.

Low Voltage Capacitors

Operate to 175 C with no derating

LV series capacitors are rated at 15 wdc and operate continuously from -70 to +175 C without derating. They have a 0.0001 to 0.25 uf capacity range, ± 20 to $\pm 1\%$ tolerances, and a 0.1% power factor. Temperature coefficient is 100 ppm per deg C. Hermetically sealed in metal cases with 0.17 to 0.5 in. diameters and 13/16 to 1-5/16 in. lengths, the units exceed MIL-C-25A requirements.

Balco Research Labs, Inc., Capacitor Div., Dept. ED, 49-53 Edison Place, Newark 2, N.J.

CIRCLE 221 ON READER-SERVICE CARD

Fuse Posts

Glow when fuse blows

This series of indicating 3AG fuse posts has a knob design that assures illumination for instant blown fuse indication. Voltage range is from 2-1/2 to 250 v with a maximum current rating of 20 amp. They meet MIL-M-14E type CFG, can be fungus treated on request as per Jun-T-152 and Jan-C-173. Double flat spots on body permits mounting flexibility. Units measure 2-3/8 in. overall length, and 1-9/16 in. back of panel. Mounting hole is 5/8 in. in diameter.

Littelfuse, Inc., Dept. ED, Des Plaines, Ill.

CIRCLE 222 ON READER-SERVICE CARD

Midget Solenoid

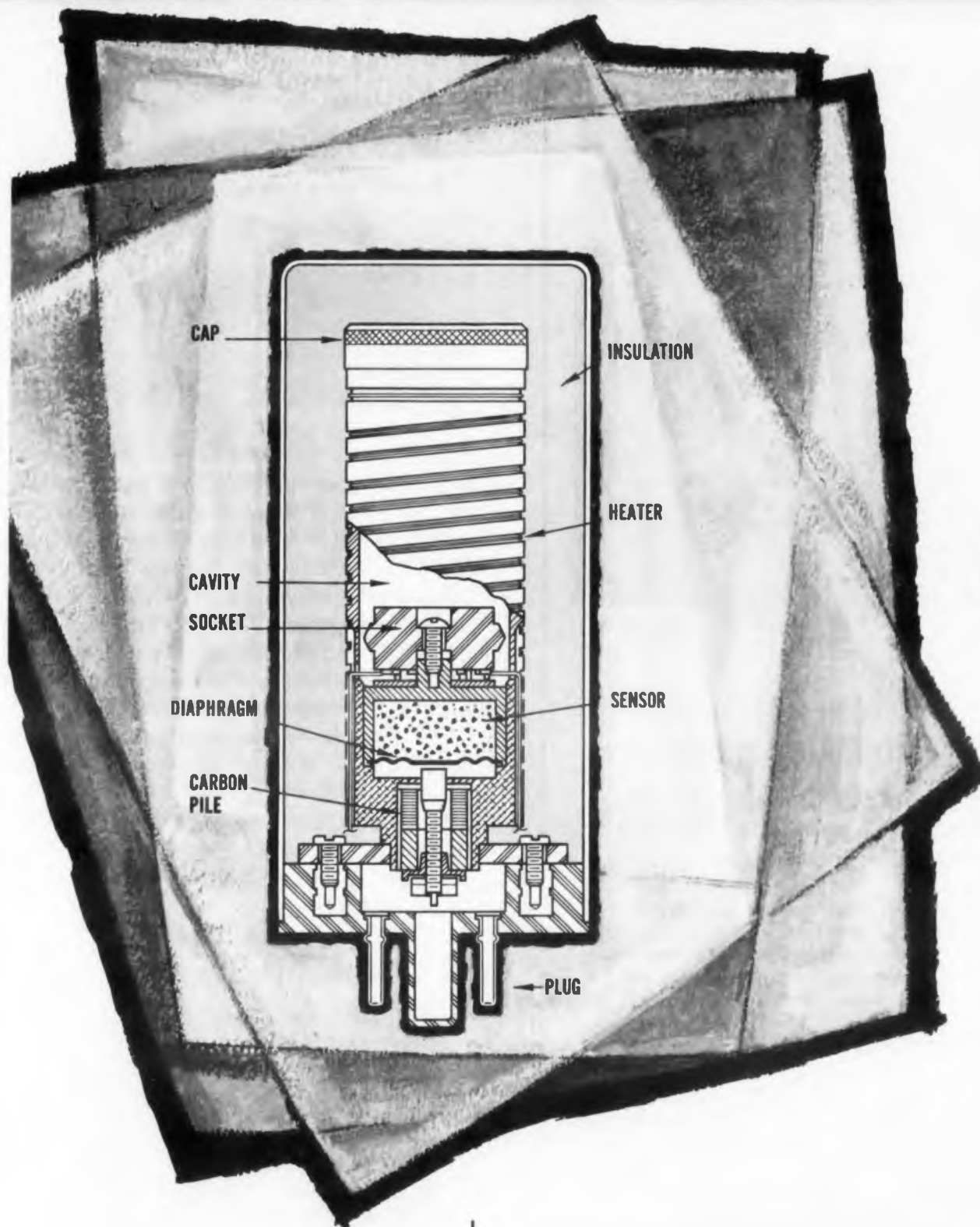
For continuous or intermittent duty

This dc midget solenoid, No. 22, is available for continuous and intermittent duty application. Designed for miniaturized assemblies, the unit has a plunger stroke adjustable from 1/32 to 5/16 in. with a maximum lift of 11 oz., continuous duty; 24 oz., intermittent duty. Overall dimensions: 3/4 x 1-1/8 x 3/4 in. wide. Coil values range from 6 to 110 Ω , dc only.

Guardian Elect. Mfg. Co., Dept. ED, 1021 W. Walnut St., Chicago 12, Ill.

CIRCLE 223 ON READER-SERVICE CARD

CIRCLE 224 ON READER-SERVICE CARD >



**NOW —
CIRCUIT
SIMPLICITY
THROUGH
ABSOLUTE
TEMPERATURE
CONTROL**

Robertshaw Crystal Oven

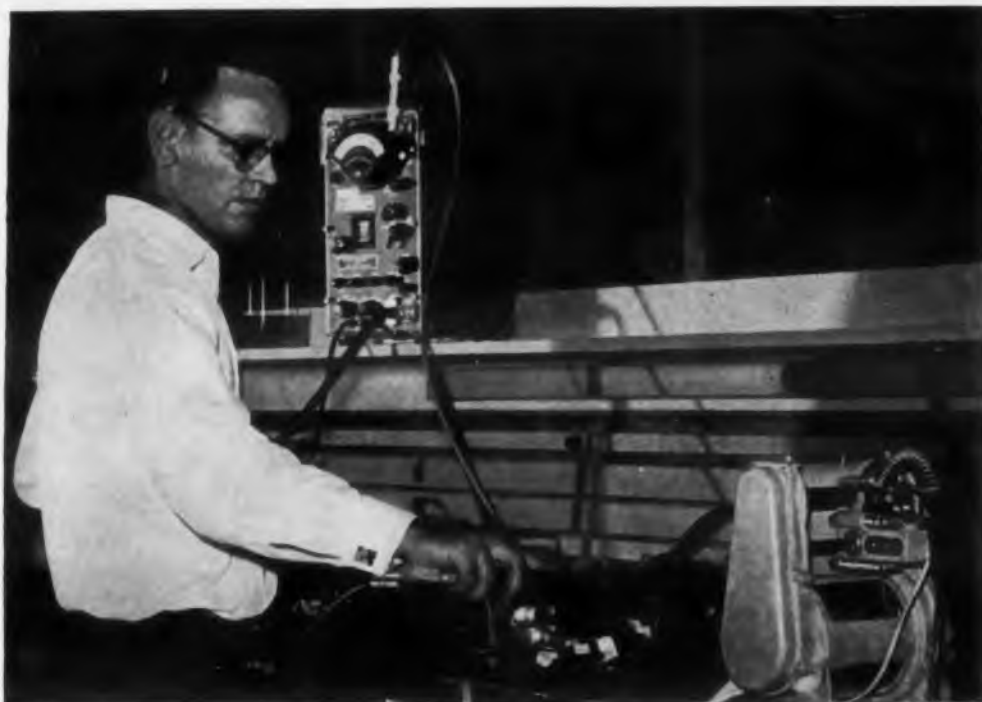
Solves Temperature Compensation Problems

Design engineers can now eliminate temperature compensating circuits and still use inexpensive, temperature sensitive components by housing critical elements in Thermal-Set, Robertshaw's latest change-of-state crystal oven. The reason—Thermal Set's extremely accurate temperature control. To accomplish this, Robertshaw has incorporated two basic features uncommon to conventional ovens—thermal stability and thermal constancy. Thermal stability, or the absence of temperature drift with time, is attained by using the melting point of pure crystalline salt as an absolute and unvarying temperature reference standard. Thermal constancy, the absence of cyclical temperature variation, results from using a proportional heat control system. Combined, these features offer unmatched thermal accuracy... the key to optimum system performance.

SPECIFICATIONS Standard Cavity Temperature: 53°C, 70°C, 87°C. Temperature Control: 0.007°C average cavity temp. change per degree ambient changes. Heater Voltage: 6.3 volts AC or DC $\pm 5\%$. Heater Power: 4.0 watts max. @ 25°C. External Dimensions: 1-7/16" x 1 7/8" x 4-1/16" seated height. Cavity Dimensions: 0.92" dia. by 1.625" deep. Weight: Approx. 6.15 oz. Mounting: Octal Plug. Cavity Sockets Available: Standard 2 or 9 pin. Special configurations and more exacting performance characteristics available on special order. Complete information in Technical Bulletin RF-594. **Robertshaw-Fulton Controls Co., Aeronautical and Instrument Division, Santa Ana Freeway at Euclid Avenue, Anaheim, California.**

APPLICATIONS

Crystals
Crystal Oscillator Circuits
Zener Diodes
Thermocouple Reference
Junctions
Transistorized Circuitry
Tuning Forks
Thermistors
Reference Networks
LC and RC Oscillator Circuits



A technician probes radiated interference from an aircraft hoist in the Los Angeles laboratory of Sprague's Interference Control Field Service Dept.

Improved Service For Radio Interference Control

Fast-growing Department of Sprague Electric Company Greatly Expands its Measurement, Control, and Consulting Engineering Facilities to Provide Fast Service.

Contractors responsible for the design and manufacture of electric/electronic equipment and weapon systems which must conform to military interference requirements will get a major assist from Sprague Electric's expanded industry service in the field of r-f interference and susceptibility.

The service includes: interference and susceptibility measurements up to frequencies of 10,000 mc; complete analysis of all test results; and comprehensive recommendations of appropriate control techniques to bring about a suppression system having the lowest weight, the lowest cost, and the greatest reliability.

Sprague's consulting service applied at the design stage already has proven to be the best approach to interference and susceptibility control. Experienced Sprague engineers invariably save valuable time in the preparation of test plans and their subsequent approval. Sprague engineers prefer to work from the design conception, analyzing original schematics and equipment drawings. This permits them to recommend optimum shielding, isolation,

and decoupling techniques before cases and layouts are finalized. Space allowances for suppression components can be made with proper attention to economy of weight and cost.

Once the equipment reaches the prototype stage, Sprague specialists will conduct tests either in the manufacturer's own plant or in one of Sprague's interference laboratories. Sprague will also direct compatibility tests on end equipment or complete weapons systems, and recommend solutions to any integration problems which might develop.

Sprague Interference Control Laboratories are located on the Pacific Coast, in the Mid-West, and on the East Coast. These laboratories are staffed by top interference and susceptibility control specialists, and are equipped with the most advanced instrumentation and model shop facilities.

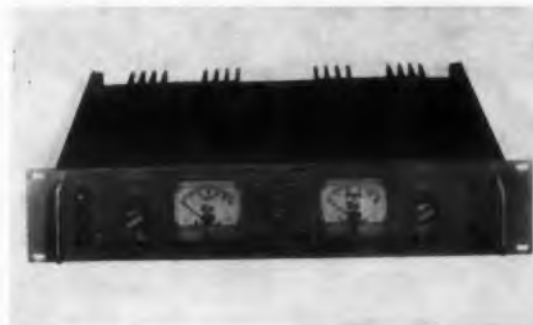
For further information, write to Interference Control Field Service Manager, Sprague Electric Co. at 12870 Panama Street, Los Angeles 66, California; 224 Leo Street, Dayton 4, Ohio; or 347 Marshall Street, North Adams, Massachusetts.

CIRCLE 225 ON READER-SERVICE CARD

NEW PRODUCTS

Power Supply

Permits many biasing arrangements



Power supply model 802A has two identical transistor regulated supplies, each independent and fully adjustable from 0 to 32 v at load currents to 1 amp. The outputs may be isolated from each other and ground to provide a variety of biasing arrangements, or they may be connected in series to provide an output of 64 v at 1 amp. Output variation is not more than 3 mv for 100% load changes and 105 to 125 v ac line changes. The unit has overload protection and occupies 3-1/2 in. of height in a standard 19 in. rack.

Harrison Labs, Inc., Dept. ED, 45 Industrial Rd., Berkeley Heights, N.J.

CIRCLE 226 ON READER-SERVICE CARD

Curve Follower

Traces pencil drawn graph



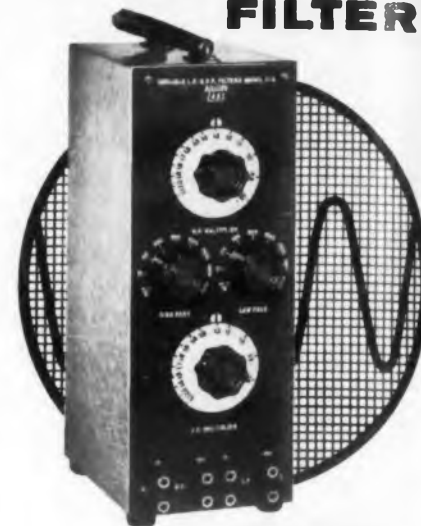
The Data-Trak curve follower translates a double pencil drawn curve on ordinary graph paper into proportional electrical signals. Any soft or medium graphite pencil may be used, and parts of the curve may be erased and changed. Shown is a three-channel function generator that simultaneously reads three charts mounted on separate revolving drums. Designed for process control and computer programming, the unit is self contained, operates on 60 cps, 115 v current, and mounts in standard relay racks. (More design details on this unit will be covered in a subsequent issue of ED.)

Research, Inc., Dept. ED, 115 N. Buchanan, Hopkins, Minn.

CIRCLE 227 ON READER-SERVICE CARD

ANALYZE NOISE

WITH AN
ALLISON FILTER



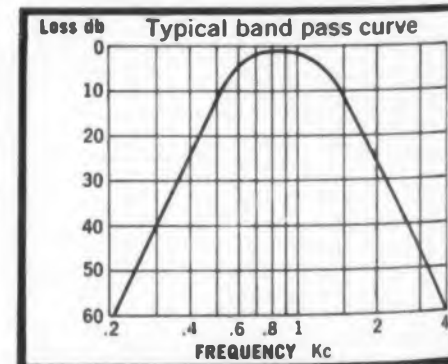
Allison 2B Filter

You can evaluate the amount of a noise and its frequency characteristics with an Allison Filter. You can make this evaluation regardless of whether the noise is continuous or intermittent, or whether it has sharp peaks. Allison Filters do not ring on transient noises. This analysis can be very important in testing equipment, preventing hearing loss, and controlling harmful or irritating industrial noises.

Allison Filters have been in constant use for a wide range of laboratory and industrial applications for nearly a decade.

ALLISON SERIES 2 FILTER SPECIFICATIONS

- Continuously variable passive network — no power supply
- Frequency range: 2A, 15 to 10,080 cycles; 2B, 60 to 20,160 cycles; 2C 9 KC to 670 KC
- Designed for use in 600 OHM circuit and with transformers for other impedances
- Low loss — approximately 2db in pass band
- Attenuation rate — 30 db per octave
- Size: 14" high, 7" deep, 5 1/4" wide
- Portable and rack models available



Write today for complete literature and prices

Allison Laboratories, Inc.

14191 EAST SKYLINE DRIVE
LA PUENTE, CALIFORNIA

CIRCLE 228 ON READER-SERVICE CARD

ELECTRONIC DESIGN • May 27, 1955

**RELIABILITY...
THE SOLUTION
TO YOUR
ELECTRONIC
COMPONENT
PROBLEMS**

Designing reliability into electronic components and instrumentation is Borg Equipment Division's business. Borg's reliable engineering, research and production facilities are at your service for commercial or military projects. Bring your component reliability problems to Borg. You'll enjoy working with our cooperative, creative engineering staff. The result will be a sound, practical and reliable solution at a considerable saving of time and money. Here are just a few of the products manufactured by Borg . . .

● FREQUENCY STANDARDS

● AIRCRAFT INSTRUMENTS

● POTENTIOMETERS

● MULTI-TURN COUNTING DIALS

● FRACTIONAL H. P. MOTORS

● SPECIAL DESIGNS

WRITE FOR COMPLETE ENGINEERING DATA

BORG

*Built
by Borg*

BORG EQUIPMENT DIVISION

CIRCLE 229 ON READER-SERVICE CARD

ELECTRONIC DESIGN • May 27, 1959



**Thermocouple
Wire**
Withstands 2000 F

Type MgO thermocouple wires withstand ambient temperatures of 2000 F plus. For use where high temperatures must be measured or where thermocouple leads must pass through hot zones, they have Chromel-Alumel or Iron-Constantan conductors and crystalline magnesium oxide insulation compacted to maximum density inside the sheath. The Inconel sheaths are immune to age deterioration and impervious to moisture, oils, ozone, and solvents. Twelve standard constructions with 15 to 28 gage wire are available and special types with specified conductor resistances can be furnished.

Revere Corporation of America, Dept. ED, Wallingford, Conn.

CIRCLE 230 ON READER-SERVICE CARD

Voltage Calibrators

For low voltage applications



Voltage calibrator models PVC101 and PVC102 generate a square wave output and have full-scale ranges of 10, 1, and 0.1 v peak-to-peak. A 10-turn precision potentiometer with a direct reading dial controls the output amplitude of each range. The units have a resolution of 1 part in 1000, a linearity of 0.1%, and a stability of 0.05% per deg C. Accuracy is $\pm 0.5\%$ of reading plus one division, and output impedance does not exceed 5 K. The units measure 7 x 5 x 3 in. and can be used grounded or floating. The PVC101 operates from 115 v $\pm 10\%$ at 60 cps and the PVC102 uses a battery.

Industrial Electronics, Inc., Dept. ED, 4730 Earlham Dr., Indianapolis 27, Ind.

CIRCLE 231 ON READER-SERVICE CARD

**GIVE AN ENGINEER
THE MOTOR HE *needs!***



**SUB-FRACTIONAL
HORSEPOWER
MOTORS
BUILT BY
BORG**

Why restrict yourself to marginal reliability?

Borg sub-fractional horsepower motors supply the quality needed in your precision equipment for longer life and continued high-level performance.

Borg-Motors are available in various models from 1/2000 to 1/750 horsepower . . . in synchronous and induction types . . . with or without gear trains. They are totally enclosed in precision machined housings.

Borg-Motors have excellent performance records on closed circuit industrial television installations, medical equipment, recorders, timing devices and many other applications.

Write for complete engineering data and the name of your nearest Borg "Tech-Rep."

WRITE FOR
CATALOG
BED-A90

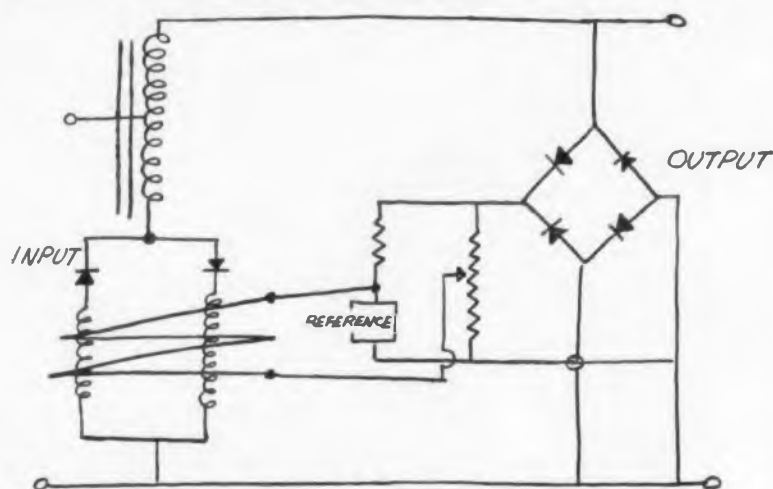
BORG EQUIPMENT DIVISION
AMPHENOL-BORG ELECTRONICS CORPORATION
JANESVILLE, WISCONSIN



MOTORS
MICROPOTS
MICRODIALS

CIRCLE 232 ON READER-SERVICE CARD

MEET MIL SPEC E4970



SIMPLIFIED MAGNETIC AMPLIFIER REGULATOR

Meeting military specifications is practically an everyday occurrence at Raytheon. But each one has a special interest.

We thought you might be interested in how a magnetic-amplifier regulator met MIL SPEC E4970. The details are available to the more academically inclined. We will simply relate the results:

Service:	400 cycles
Power:	900 watts
Input:	95 to 125 volts
Output:	115 volts $\pm 1/2\%$
Harmonic distortion:	$\pm 3\%$

The next time you have to meet military or your own rigid specifications, we'll be happy to go along.



Our slide rule and tuxedo are ready at a moment's notice. Simply contact:

VOLTAGE REGULATOR MAN
Raytheon Manufacturing Company
Magnetic Components Department
Section 6120
Waltham 54, Massachusetts



CIRCLE 233 ON READER-SERVICE CARD

NEW PRODUCTS

RF Receptacle

For printed wiring



For connecting coaxial cable to printed wiring, the ConheX type 3007 receptacle has four milled studs, rectangular in cross section, which are dip soldered to the wiring board. The center contact is held rigidly between two insulators allowing no longitudinal or rotational movement. It is soldered to the printed wiring on the face of the board. The 3007 mates with the company's type 3000 straight or type 3005 right-angle plugs or their equivalent.

Seaelectro Corp., Dept. ED, 610 Fayette Ave., Mamaroneck, N.Y.

CIRCLE 234 ON READER-SERVICE CARD



Slip Ring and Brush Assembly

Has under 50 μ v noise level

This assembly has 50 slip rings and 100 ball bearing mounted brushes packaged in a dust sealed housing 1.25 in. long. Noise levels are below 50 μ v and breakaway friction level is under 50 g-cm. The brushes are tuned to different resonance frequencies to insure constant electrical continuity in severe vibration conditions. The unit withstands 350 F and meets MIL-5400A.

Slip Ring Company of America, Dept. ED, 5456 W. Washington Blvd., Los Angeles 16, Calif.

CIRCLE 235 ON READER-SERVICE CARD

Pulse Pattern Generator

Provides 2¹⁰⁰ possible combinations



Designed to provide simulated time division pulse patterns, test model 110 generates 1 to 100 pulses in any pattern, thus offering 2¹⁰⁰ possible combinations. It provides a clock pulse every pulse time and a cycle pulse at the beginning of each pulse cycle. Pulse sequence is completely controlled from the front panel. Pulse width bias may be up to $\pm 30\%$, and pulse rate is continuously variable from 100 to 10,000 pps from an internal oscillator.

La Roe Instruments, Inc., Dept. ED, 1709B E. Montgomery Ave., Rockville, Md.

CIRCLE 236 ON READER-SERVICE CARD

RC Comparator Bridge

For in-circuit checking



Model 801 RC comparator bridge measures capacitors for actual value, leakage, and power factor and checks them in their original circuit for opens, shorts, or intermittents. It has four capacitance ranges from 10 μ f to 5000 μ f and four resistance ranges from 0.5 ohm to 500 meg. The unit checks the ratio between any two capacitors, inductors, resistors, or transformer windings with ratios of 20 to 1 or less. It also checks power factor from 0 to 60% on capacitors of 0.1 to 5000 μ f and leakage in all types of capacitors rated between 0 and 500 v dc.

Electronic Measurements Corp., Dept. ED, 625 Broadway, New York 12, N.Y.

CIRCLE 237 ON READER-SERVICE CARD

Slip Ring Assembly

High voltage



This slip ring assembly consists of 12 slip rings and brushes designed to carry 50 ma at 21 kv, ring to ring and ring to ground. The rings and terminals are proportioned to prevent corona, and the terminals serve as controlled air gaps which break down at 28 kv, protecting insulation surfaces from flashover. The unit has rhodium plated rings and chrome plated terminals that accept banana plugs, clip leads, wire ends, wire loops, and spade lugs. Dimensions are 8 x 8 x 10 in.

Genisco, Inc., Dept. ED, 2233 Federal Ave., Los Angeles 64, Calif.

CIRCLE 238 ON READER-SERVICE CARD

4000 V Power Supply

For microwave tubes



The Microline 62A1 is a 4000 v supply designed to power and modulate any klystron used to test radars and other microwave equipment. It can also operate low power magnetrons and traveling wave tubes. The unit supplies electrode voltages from ± 150 to -4000 v and automatically regulates output voltages to less than 1 part in 10,000. Switching of the beam voltmeter is also automatic. The 62A1 supplies square wave, sawtooth, and sine wave voltages for generating pulse, frequency or phase modulation information in the outputs of microwave tubes. It operates on 800 w of 60 cps, 110 v current and contains an amplifier which can boost modulation voltages from external sources.

Sperry Microwave Electronics Co., Div. of Sperry Rand Corp., Dept. ED, Clearwater, Fla.

CIRCLE 240 ON READER-SERVICE CARD

Microwave Diodes

Have 0.3 in. maximum length



For microwave equipment used in radar, communications, missiles, and satellites, Micro-Min diodes are point contact units hermetically sealed in a glass envelope. They have a maximum length of 0.3 in. and a maximum diameter of 0.105 in. Available types include detector diodes in frequencies from 0.1 to 9 kmc and mixer diodes in frequencies from 3 to 9 kmc.

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

CIRCLE 241 ON READER-SERVICE CARD

Indicator Thyatron

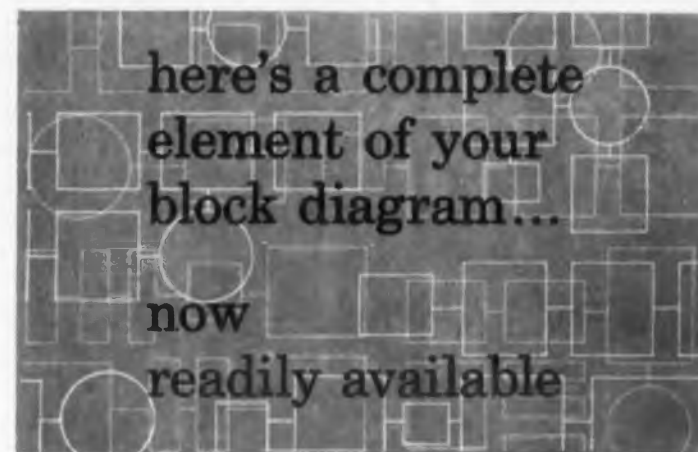
Dual control



Type WC-20 is a miniature, coincidence-control thyatron that provides a bright neon glow which may be viewed from any angle. Two coincident 4.5 v signals and a negligible control current produce the indicating glow. The tube is designed for computers, data processors, signal systems, and keyboard equipment. It has a maximum diameter of 0.31 in. and a maximum length of 1.1 in. without the leads. Filament voltage is 2.5 v ac and filament current 300 ma.

Wilter Electronics, Inc., Dept. ED, 53 Water St., South Norwalk, Conn.

CIRCLE 239 ON READER-SERVICE CARD



RPM*

*REGULATED POWER MODULE



All design, development and production work has been completed for you in these RPM power modules. Buy them as catalog items, and get these advantages:

Wide choice of overlapping adjustable voltage and current ranges—125 to 425 volts...50 to 400 milliamps.

Excellent regulation—0.05% NL to FL, or 10% line change.

Compactness—RPM units are custom designed and built with our own transformers for most efficient use of space.

Super-rugged construction includes one-piece, cast aluminum housings and JAN hardware. RPM modules can be mounted in any position.

High reliability—achieved by use of top quality components throughout, and rigid inspection during production.

Request ACDC Bulletin 400.



ELECTRONICS, INC.

2979 N. Ontario St., Burbank, Calif.
Formerly NYT ELECTRONICS, INC.

CIRCLE 242 ON READER-SERVICE CARD

MODULAR INSTRUMENT ENCLOSURES



Everything needed for top-quality, custom-appearance enclosures is made by AMCO...and shown in this new catalog!

The multi-width panels, cowlings and writing surfaces, unique with Amco, retain custom quality appearance of single unit construction. Amco's electronics know-how and wide experience in the manufacture of equipment enclosure and relative mounting and cooling accessories assure your complete satisfaction in the appearance, strength and durability of every unit. Amco cabinets and enclosures are designed to accommodate the most complex systems and provide complete service accessibility and operator convenience.

All Amco frames are direct floor-bearing.

A complete selection of basic frames can be arranged in endless variety, all chassis and equipment is mounted directly off of frame members for maximum support. Blowers, chassis slides, heavy-duty dollies and many other parts and accessories, *all made by Amco, are supplied under a combined discount rate with other components—a big savings.*

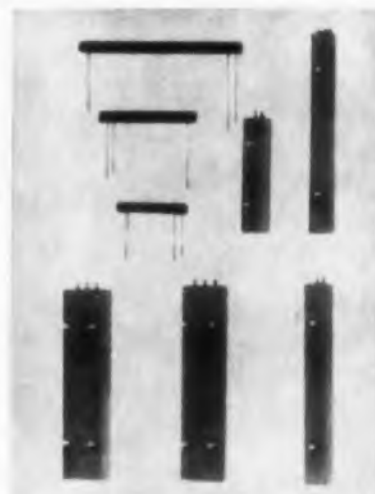
These are a few of the reasons more and more engineers depend on Amco for all enclosure needs. They find real convenience, quality and economy by doing it. If you don't have your copy of the new catalog yet, send for it now.

Realistic 3 week delivery



AMCO ENGINEERING CO.
7335 W. AINSLIE STREET • CHICAGO 31, ILLINOIS
Factory-trained representatives in all principal U. S. cities and Canada
CIRCLE 243 ON READER-SERVICE CARD

NEW PRODUCTS



Distributed Constant Delay Lines

Have 0.6 μ sec delay
per winding inch

Series 25J distributed constant delay lines have a delay period of 0.6 μ sec per inch of winding. They are available in various standard cases including hermetically sealed metal cans and epoxy encapsulated sticks for pigtail mounting. Maximum delay per 6 in. of winding stick is 3 μ sec. Several windings having the same or different delay time may be cascaded in the standard metal cans. Available impedances include 3900, 5600, or 7500 ohms with respective rise times of 0.33, 0.48, and 0.53 μ sec per 3 μ sec delay.

Technitrol Engineering Co., Dept. ED, 1952 E. Allegheny Ave., Philadelphia 34, Pa.

CIRCLE 244 ON READER-SERVICE CARD



Multiplier Phototubes

3/4 in. in diameter

Type 6362 and 6935 multiplier phototubes are 3/4 in. in diameter and have ten dynode stages. Suited for aircraft and space vehicles, scintillation probes, and spectrometers, they feature potted bases for moisture and shock resistance, socket elimination, and noise-free connections. The 6362 has silver magnesium dynodes and provides maximum stability at high voltages, and the 6935 has cesium antimony dynodes and provides high gain at low operating voltages.

Allen B. Du Mont Labs, Inc., Electronic Tube Div., Dept. ED, 750 Bloomfield Ave., Clifton, N.J.

CIRCLE 245 ON READER-SERVICE CARD

STROMBERG-CARLSON TELEPHONE HANDSETS



... for your voice communication needs

These "push-to-talk" handsets are of the most modern design available.

If your applications are in • mobile radio • intercom systems • carrier and microwave • aircraft and railroad — specify Stromberg-Carlson handsets.

No. 26: short, lightweight, sturdy. Comes with capsule-type receiver and transmitter.

No. 28: "push-to-talk" handset. Rocker-bar switch; various spring combinations.

Both models available with standard or high-gain transmitters and receivers. Superior to any other handset on the market.

Modern handset cradle for mobile or panel use



Holds handset firmly; is strong and resilient; fits any Stromberg-Carlson handset. Switch combinations with two or four Form C contacts.

Space for your company name is provided. Send for Handset Bulletin T-5005 and Cradle Bulletin T-5013. Write:

STROMBERG-CARLSON

A DIVISION OF GENERAL DYNAMICS CORPORATION
Telecommunication Industrial Sales
116 Carlson Rd. • Rochester 3, N.Y.

CIRCLE 246 ON READER-SERVICE CARD

POT HEADACHES

One day, we compiled a list of problems which confront the people who buy, use or work with potentiometers. The list included such common headaches as pot "burn-out" in the field...down time on equipment...waits of up to 90 days for replacements... maintenance of a large inventory of spares of which only 8% might be used. We decided then and there to develop a cure for these "pot headaches" and that's how our Modification Kit MLK-1 was born.

The Kit, which consists of 100 tap assemblies, 25 silver buss bar rings and 24 other components, provides a speedy and economical means of modifying or replacing potentiometers in the field. Taps and/or buss bars can be installed, on-the-spot, by field maintenance personnel, with a resultant saving of weeks, or even months of precious time. It's a great money-saver too, for with its taps and tooling, just a minimum stock of basic units (i.e. without taps or buss bars) can be modified to replace any finished pot of like design.

We will be pleased to send you literature and a reprint of a feature story on the MLK-1 Kit, which appeared in ELECTRONICS MAGAZINE.

MICRO-LECTRIC DIVISION OF MICRO MACHINE WORKS

19 DEBEVOISE AVENUE
ROOSEVELT, L. I., N.Y.
FReport 8-3222

CIRCLE 47 ON READER-SERVICE CARD
ELECTRONIC DESIGN • May 27, 1959



Control Transformer
Size 8

Control transformer model CTC-8-A-6 is a size 8, 400 cps synchro with the following impedances: $Z_{r0} = 2625$, 72.2 deg; $Z_{s0} = 465$, 75 deg; $Z_{r18} = 970$, 17 deg. Maximum error is 7 min of arc, voltage input is 11.8 v, and power input may be 0.058 w.

Clifton Precision Products Co., Inc., Dept. ED, 9014 W. Chester Pike, Upper Darby, Pa.

CIRCLE 248 ON READER-SERVICE CARD

Subminiature Switch

Has roller-plunger actuator

Type ISR-I subminiature, snap-acting switch is designed for cam operation. The plunger mechanism is integral with the mounting bracket, in which a USM5 subminiature switch is secured. The unit is rated at 2.5 amp, 30 v dc, inductive; 5 amp, 30 v dc resistive; 5 amp, 125/250 v ac and has a spdt action.

The W. L. Maxson Corp., Unimax Switch Div., Dept. ED, Ives Road, Wallingford, Conn.

CIRCLE 249 ON READER-SERVICE CARD

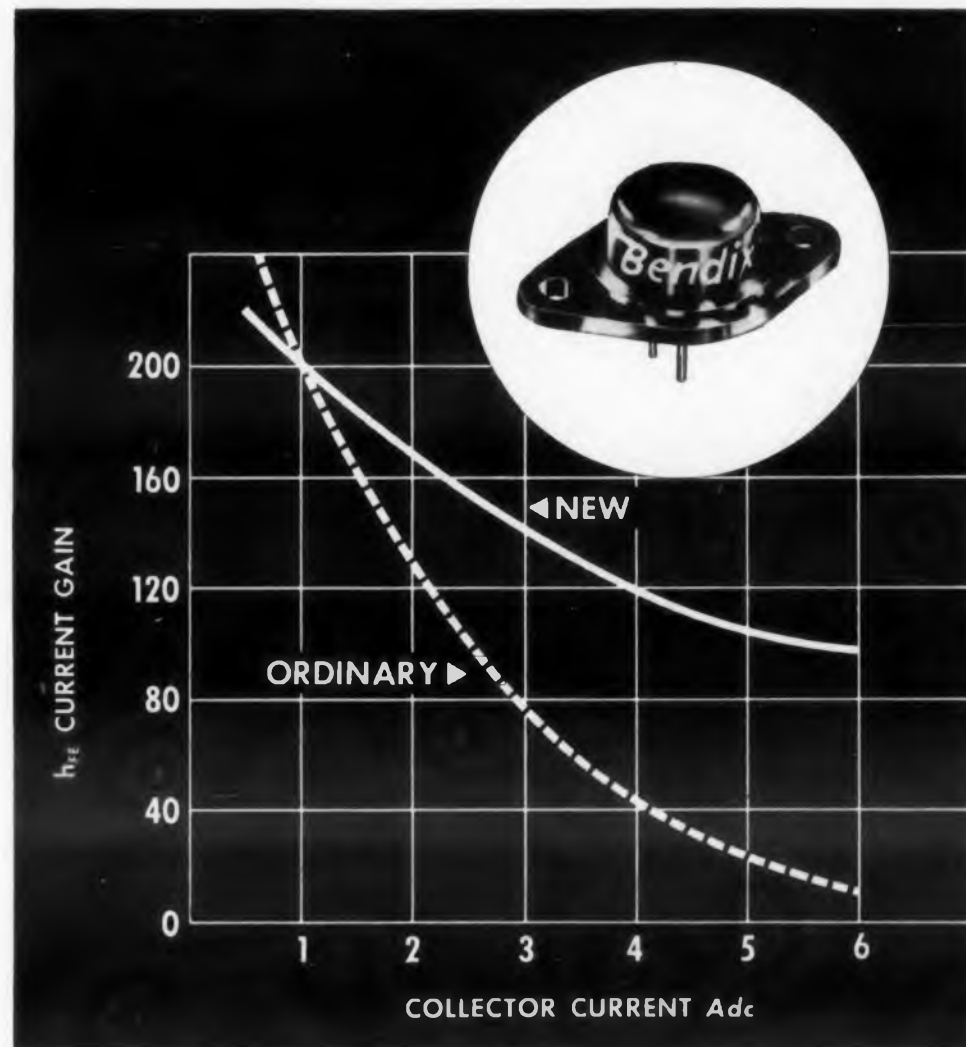
FHP Motor

Highly efficient

Designed for use in ventilators, recorders, business machines, and many other types of equipment, the Unitized motor is presently available in 4-pole, KSM 59-frame, shaded pole and permanent split capacitor ratings through 1/15 hp. The unit is up to 40% more efficient than conventional motors of the same type. A resin developed for strong holding power unitizes its parts and maintains critical dimensions. The unit can be mounted in any position and accommodates a variety of mounting arrangements.

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

CIRCLE 252 ON READER-SERVICE CARD



Solid line indicates the low beta fall-off of one of the new Bendix transistors as compared to that of an ordinary transistor.

NEW BENDIX HIGH GAIN INDUSTRIAL POWER TRANSISTORS OFFER FLATTEST BETA CURVE

Now available—a new series of power transistors with the flattest beta curve in the industry, made possible by an exclusive Bendix process. This new series has very high current gains—up to 200 at 3 Adc—and a 10 ampere peak current rating.

Featuring ten-amp performance at a five-amp price, the 2N1136,A,B; 2N1137,A,B; and 2N1138,A,B series provide:

LOW BETA FALL-OFF	→	LESS DRIVE AND LESS DISTORTION
LOW SATURATION RESISTANCE	→	GREATER CIRCUIT EFFICIENCY
VOLTAGE BREAKDOWN RATINGS	→	ELIMINATION OF BURN-OUT
CURRENT GAIN MATCHING	→	OPTIMUM CIRCUIT PERFORMANCE

Ideally suited for use in static convertors and regulators, these powerful transistors also have numerous applications in relay replacements and drivers for relays, magnetic clutches, solenoids and other loads requiring high current. In addition, their extremely high current gain and excellent hFE linearity make them the most practical and efficient television vertical output amplifiers.

For complete information, contact SEMICONDUCTOR PRODUCTS, BENDIX AVIATION CORPORATION, LONG BRANCH, NEW JERSEY.

West Coast Sales Office: 117 E. Providencia Avenue, Burbank, California
Midwest Sales Office: 4104 N. Harlem Avenue, Chicago 34, Illinois
New England Sales Office: 4 Lloyd Road, Tewksbury, Massachusetts
Export Sales Office: Bendix International Division, 205 E. 42nd Street, New York 17, New York
Canadian Affiliate: Computing Devices of Canada, Ltd., P. O. Box 508, Ottawa 4, Ontario, Canada.

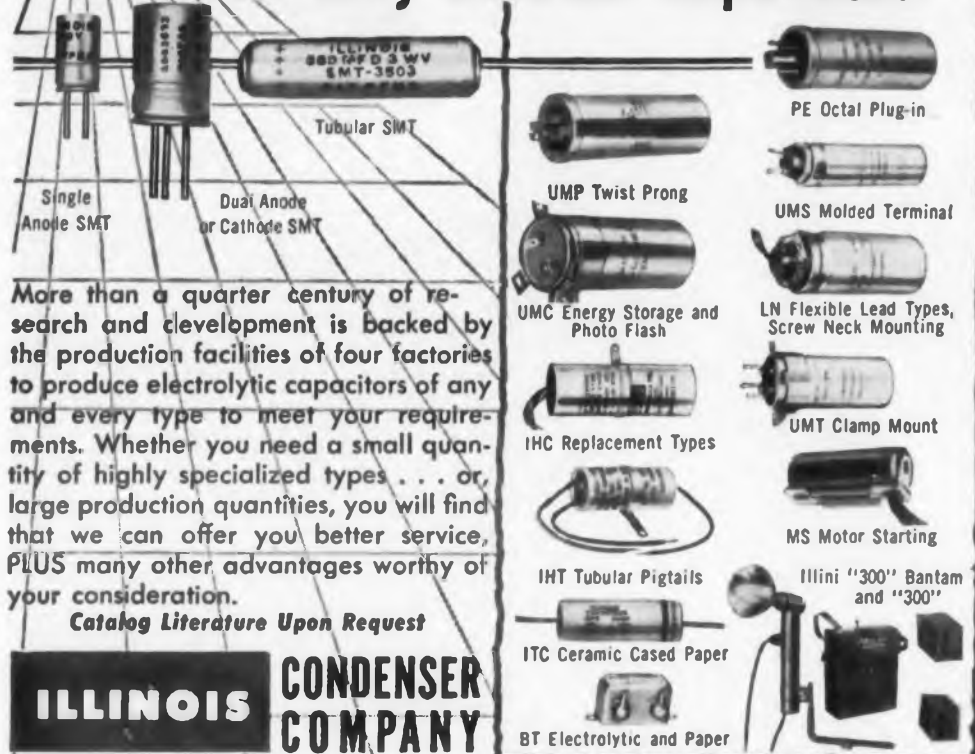
Red Bank Division



CIRCLE 253 ON READER-SERVICE CARD

ILLINOIS CAPACITORS KNOWN THE WORLD OVER
for their TIME TESTED QUALITY!

there is an Illinois Electrolytic Capacitor
for every Electronic Requirement!



More than a quarter century of research and development is backed by the production facilities of four factories to produce electrolytic capacitors of any and every type to meet your requirements. Whether you need a small quantity of highly specialized types . . . or large production quantities, you will find that we can offer you better service, PLUS many other advantages worthy of your consideration.

Catalog Literature Upon Request

ILLINOIS CONDENSER COMPANY

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CIRCLE 254 ON READER-SERVICE CARD



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These strong, 12 $\frac{3}{4}$, 12 $\frac{1}{4}$ x 5" binders offer an easy means of filing your back copies of *Electronic Design*. Each binder holds 13 normal size issues, and permits substitution of magazines if desired. Cost to *Electronic Design* subscribers is only \$3.25.

TO OBTAIN YOUR BINDER . . . SIMPLY CIRCLE ED NO. 596
(We will bill you later)

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NEW PRODUCTS

Temperature Test Chamber

-100 to +500 F range



Temperature test chamber model 6545R has a -100 to +500 F range and a 10 x 7 x 7 in. test volume. It is 10-1/2 in. high and fits a standard 19 in. rack. A direct reading thermostat automatically controls temperature within ± 2 F, and a solenoid operated valve injects liquid CO₂ for rapid attainment of low temperatures. The unit incorporates a heating element and a centrifugal blower and operates on 117 v ac.

Delta Design Engineers, Inc., Dept. ED, 7460 Girard Ave., La Jolla, Calif.

CIRCLE 255 ON READER-SERVICE CARD

Stationary Coil Clutches

Miniature

Miniature model SAC-100 and SAC-130 stationary coil clutches have minimum static torques of 15 and 55 in.-oz and consume 2 and 3-1/2 w, respectively. The electromagnetic units are completely self-contained without slip rings or brushes and can be supplied for various types of mountings. They feature zero backlash when energized and zero residual drag. Voltage ratings are from 6 to 100 v dc; current ratings, 28 to 500 ma; and resistances, 12 to 3500 ohms.

Dial Products Co., Dept. Ed, P.O. Box 456, Bayonne, N.J.

CIRCLE 256 ON READER-SERVICE CARD

Cable Retracting Device

Prevents chassis entanglements

The CR-100 cable retractor eliminates cable entanglement with tubes and components in a lower chassis when an upper one is withdrawn for service and returned to position. It maintains a constant tension and correct suspension of cable at all times, permitting adequate cable length for full extension and tilting of chassis without the hazard of snagging.

Western Devices, Inc., Dept. ED, 600 W. Florence Ave., Inglewood 1, Calif.

CIRCLE 257 ON READER-SERVICE CARD

TRANSISTOR TRANSIENT PROTECTOR



ALTO Model N210 Transistor Transient Protectors safeguard 28 volt circuits by automatically reducing high voltage spikes and surges to a safe level. Protectors include an LC filter for extremely fast spikes, a power transistor circuit for slower transients. Response time is 50 μ sec, load current 25 amps maximum, clipping level 35 volts (other values to order) and maximum input spike and line voltage 80 v total. Nominal range 24 to 32 v dc; power required 0.5 watt, 2 $\frac{1}{2}$ " x 2 $\frac{1}{2}$ " x 3 $\frac{1}{2}$ ". Prompt delivery, \$295 to \$365 each.

SUBMINIATURE TIME DELAY RELAYS



ALTO N17 Time Delay Relays use all silicon semi-conductors for utmost reliability. Delay is established by RC time-constant circuitry permitting an overall accuracy of $\pm 3\%$ and better over limited temperature range. Delay 0.05 sec to 60 sec, preset at factory. Ambient temperatures ranges -55°C to 85°C, input 24 to 32 v dc, current drain 50 ma at 28 v, shock 50 G's for 11 μ sec. \$187 to \$210 each, quantity discounts.

ALTO

SCIENTIFIC COMPANY

855 Commercial Street
Palo Alto, California
DAvenport 1-3434

CIRCLE 258 ON READER-SERVICE CARD

Today's requirements call for miniaturization,

but...



HOW



SMALL



IS

MINIATURE?

Automatic
MAKES THEM ALL!

Unit engineered to fit all available sub-miniature cables, AUTOMATIC'S Sub-Miniature Connectors are available in three types; BAYONET, PUSH-ON AND THREADED COUPLING.

Special receptacles available for printed circuit applications.

CHECK THESE FEATURES:

No special tools required for assembly. Foolproof clamping insures accurate alignment . . . positive contact . . . extra strong grip. Exclusive internal-parts design allows outside dimensions of connectors to remain constant regardless of cable dimensions.

For BAYONET, PUSH-ON and THREADED SUB-MINIATURE and MICRO-MINIATURE COAXIAL CABLE CONNECTORS, always specify AUTOMATIC. Our engineers are always ready to discuss your special requirements.

Write, wire or phone for free technical information.

Automatic
METAL PRODUCTS CORP.

322 Berry St., B'klyn. 11, N.Y.
EVergreen 8-6057

CIRCLE 259 ON READER-SERVICE CARD

ELECTRONIC DESIGN • May 27, 1959

Servo Amplifier
1 cu in.



Transistorized servo amplifier model 412 will drive 3.5 w, 40 v, center-tapped size 10 and 11 servomotors from low-level ac signals. Gain is $2500 \pm 5\%$ with 10 v output. The 1 cu in. unit is completely self-contained and requires 28 v dc excitation. Its ambient range is -55 to $+100$ C.

ACF Industries, Inc., Avion Div., Dept. ED, 11 Park Place, Paramus, N.J.

CIRCLE 260 ON READER-SERVICE CARD

Portable Meter

Measures E.I.R.

This battery powered portable meter, model 110A, with transistorized circuitry, is designed to measure dc voltages, current, and resistance. It measures voltages of 1 mv to 1000 v full scale in 13 ranges; input resistance is 101 meg. 18 current ranges provide measurement of full scale values from 1 μ a to 300 ma; voltage drop for all ranges is 100 mv. Direct-reading resistance scales show resistances, from 10 ohms to 100 meg, center scale. Accuracy of indication is $\pm 2\%$ of full scale for voltage and current measurements, and $\pm 4\%$ mid-scale for resistance. Design features include a transistorized meter circuit, high overload capability, 1000 hour battery life, and the use of printed circuit techniques.

Belleville-Hexem Corp. Dept. ED, 638 University Ave., Los Gatos, Calif.

CIRCLE 261 ON READER-SERVICE CARD

Power Transistors

Germanium

Audio power transistors 2N350A, 2N351A, and 2N376A are germanium, pnp, alloy junction types for general industrial use. They are controlled for high power gain and low distortion at output levels to 4 w Class A and 15 w Class B. Power switching characteristics are controlled up to 3, 4, and 5 amp, respectively.

Motorola, Inc., Semiconductor Products Div., Dept. ED, 5005 E. McDowell Rd., Phoenix, Ariz.

CIRCLE 262 ON READER-SERVICE CARD

You can only stretch a spec sheet so far!



In a stereo cartridge, it's what you hear that counts. And Sonotone's ceramic cartridge gives you brilliant performance and nothing less.

More phono makers have specified Sonotone for the top of their line than any other cartridge...because only Sonotone gives true sound without distortion...high-frequency response with less record wear. Sonotone stereo gives a performance so superior you can truly hear the difference. The secret? Sonotone's four exclusive operating features listed below.

1. Extremely high compliance...also means good tracking, longer record life.
2. Amazingly clean wide-range frequency response.
3. First quality jewel styli tips—correctly cut and optically ground for minimum record wear.
4. Rumble suppressor greatly reduces vertical turntable noise.

Prices start at \$6.45 (including mounting brackets).



Get details on converting to stereo. Send for free booklet: "Stereo Simplified," Sonotone Corp., Dept. CGG-592, Elmsford, N. Y.

Sonotone PROG. P.

Electronic Applications Division, Dept. CGG-592,
ELMSFORD, NEW YORK

In Canada, contact Atlas Radio Corp., Ltd., Toronto

Leading makers of fine ceramic cartridges, speakers, microphones, electronic tubes.

CIRCLE 263 ON READER-SERVICE CARD

STANDARD MAGNETIC SHIFT REGISTERS the way you want them!



- **LOW** in Cost
- **LOW** in Weight and Size
- **LOW** in Power Consumption

Epsco is now volume-producing a complete line of magnetic Shift Registers . . . standard off-the-shelf units designed to meet an extensive application range.

Featuring extreme reliability under widely variable conditions, the units operate at rates up to 250 KC, from -55°C to $+85^{\circ}\text{C}$. The line offers very high packaging densities for signal storage and distribution in data processing systems. Each is fully compatible with the Epsco family of encapsulated Transistorized Digital Logic Circuits.

A new line of Shift Register Printed Circuit Card Assemblies is also available. Write for complete technical information.

Epsco, Incorporated, Components Division, SR, 588 Commonwealth Ave., Boston 15, Mass. Phone COpley 7-8100, TWX BS-32

Epsco 
COMPONENTS
CIRCLE 264 ON READER-SERVICE CARD

NEW PRODUCTS

Static Switch Handles up to 16 amp



Measuring 2 x 1.25 x 1 in., this silicon semiconductor switch will close 400 v circuits with steady currents to 16 amp and surge currents as high as 150 amp. Weighing 3.5 oz, the unit will stand high shock and vibration and has a 3 μsec switching time. The unit has an isolated signal and load circuit and operates in temperatures up to 125 C.

Jordan Electronics, Dept. ED, 3025 West Mission Rd., Alhambra, Calif.

CIRCLE 265 ON READER-SERVICE CARD

Vacuum Tube Electrometers

Measure low currents

Suitable for rack, panel, or console mounting, these vacuum tube electrometers are designed for measuring low currents. Models VTE-0 and VTE-1 cover a current range from 10^{-3} to 10^{-11} amp, while model VTE-2 covers 10^{-3} through 2×10^{-13} amp. The latter two instruments include a bucking current supply for observing minute fluctuations in the current source.

The Victoreen Instrument Co., Dept. ED, 5806 Hough Ave., Cleveland 3, Ohio.

CIRCLE 266 ON READER-SERVICE CARD

Coaxial Variable Attenuator

Wideband

Coaxial variable attenuator model AU 10 is designed to operate from 300 to 5000 mc with less than 0.5 db insertion loss at zero setting. Maximum attenuation values are above 40 db over most of this band, and vswr is less than 1.35. The unit is designed to permit calibration and is resettable to 0.1 db. It will dissipate up to 10 w of rf power.

Merrimac Research and Development, Inc., Dept. ED, 137-28 Northern Blvd., Flushing 54, N.Y.

CIRCLE 267 ON READER-SERVICE CARD

10 mc to 44,000 mc with ONE tuning head



PANORAMIX'S SPA-4 SPECTRUM ANALYZER

high sensitivity . . . low cost

* Better sensitivity in one compact, low cost unit than with typical multi-tuning head spectrum analyzer!

• Resolution continuously variable from 1 kc to 80 kc for analysis of wide and narrow pulsed RF signals

• 70 mc wide sweep width continuously adjustable down to 0 mc

• Careful shielding to avoid interference

• Calibrated power, voltage and log amplitude scales

• Constructed to MIL specifications

* Embodying new design techniques for high reliability the Model SPA-4 features in one compact low cost unit.

SEE THE SPA-4 AND OTHER PANORAMIX INSTRUMENTS IN ACTION AT

Booth No. 11A

1959 National Telemetering

Conference Exposition,

Cosmopolitan Hotel, Denver,

May 25-27.

Ask for new Catalog Digest and the

PANORAMIX ANALYZER



524 So. Fulton Ave., Mt. Vernon, N. Y.

OWens 9-4600

Cables: Panoramix, Mt. Vernon, N. Y. State

CIRCLE 268 ON READER-SERVICE CARD

**new rapid tests
of SSB
transmissions**
with **ONE** compact
multi-purpose
spectrum analyzer



**PANORAMIC'S
SSB-3**

**simple . . . versatile
. . . low priced**

Now, in one convenient package, all the equipment you need to set up, adjust, monitor, trouble-shoot SSB and AM transmissions!

- Sensitive spectrum analyzer with pre-set sweep widths of 150, 500, 2000, 10,000 and 30,000 cps with automatic optimum resolution
- Continuously variable sweep width up to 100 kc
- 60 db dynamic range
- 60 cps hum sidebands measurable to -60 db
- Stable tuning head with 2 mc to 40 mc range with direct reading dial
- Two-tone generator with separate audio oscillators with independent frequency and amplitude controls. Output 2 volts max. per tone into 600 ohm load
- Internal calibrating and self checking circuitry

SEE THE SSB-3 AND OTHER PANORAMIC INSTRUMENTS IN ACTION AT

Booth No. 11A

1959 National Telemetry
Conference Exposition,
Cosmopolitan Hotel, Denver,
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CIRCLE 69 ON READER-SERVICE CARD

ELECTRONIC DESIGN • May 27, 1959



**Silicon Solar
Cell Battery
Modules**

Provide 1.5 v dc
at 65 C

Designed to power transistorized equipment, type SM5-1020B silicon solar cell battery modules provide an output of 1.75 v dc at 30 C cell temperature and 1.5 v dc at 65 C. Each module directly replaces a 1.5 dry cell battery and will supply a load current of about 35 ma in direct sunlight. In applications requiring continuous day and night operation, the solar units can be combined with storage cells to provide continuous power without the need for replacement. The modules contain five series-connected 1 x 2 cm cells embedded in an epoxy mold. They may be assembled in series or in parallel.

International Rectifier Corp., Dept. ED, 1521 E. Grand Ave., El Segundo, Calif.

CIRCLE 270 ON READER-SERVICE CARD

Log Count Rate Meter

Has 1% linearity



For use with scintillation detectors, G.M. counters, BF₃ counters, and reactor instrumentation, the rack mounted model N-701C log count rate meter counts pulses resulting from nuclear disintegrations. It has a limit switch that can activate an alarm system. Ranges are 1 cps to 1 kc, 10 cps to 10 kc, 100 cps to 100 kc, and 1 cps to 100 kc; and optional input sensitivities are -50 to +100 v, -0.25 v to +1 mv, or -5 v to +1 mv. The unit has a 0 to 10 mv output for recorder, 1% linearity, and 1% per day stability.

Hamner Electronics Co., Inc., Dept. ED, Princeton, N.J.

CIRCLE 271 ON READER-SERVICE CARD

EXPANDED RESEARCH

to advance new concepts of
SPACE FLIGHT

⊕ Expanded Research programs to meet the most complex technological requirements of the Space Age are only one of the far-reaching objectives of the new multi-million-dollar Lockheed Research Center, near Los Angeles. Destined to become one of the nation's major research installations, its programs are broad in scope and designed to investigate new frontiers of space flight.

⊕ A primary consideration in planning the new Research Center was to provide environment for scientific freedom and ideal research conditions—using the most advanced equipment available. This modern, integrated research facility will touch almost every aspect of aviation and transportation—leading toward exploration into completely new or relatively undeveloped fields of science and industry.

⊕ On completion, most of Lockheed's California Division's research facilities will be located in this single area. The Center will provide complete research facilities in all fields related to both atmospheric and space flight—including propulsion, physiology, aerodynamics and space dynamics; advanced electronics in microwave propagation and infrared; acoustics; mechanical and chemical engineering and plasma/magneto-hydrodynamics; thermal electricity; optics; data communications; test and servo-mechanisms.

⊕ The first phase of the advanced research building program has already begun—with initial construction of a \$5,000,000 supersonic wind tunnel and high-altitude environmental test facilities.

⊕ Scientists and engineers of high caliber are invited to take advantage of outstanding career opportunities in this new Lockheed Research Center. Openings now exist for thoroughly qualified personnel in: Electronics; aero and thermo dynamics; propulsion; servo-mechanisms; materials and processes; structures and stress; operations research; research in optics, infrared, acoustics, magnetohydrodynamics, instrumentation, mechanics and hydraulics; mathematics and in all phases of design.

Write today to: Mr. E. W. Des Lauriers, Manager Professional Placement Staff, Dept. 13052, 1708 Empire Avenue, Burbank, California.

LOCKHEED

CALIFORNIA DIVISION

BURBANK, CALIFORNIA

NEW! DRY HI-POWER DIRECT READING CALORIMETER

For all Waveguides between
1 & 12 Kmc



This Calorimetric Power Meter consists of a Waveguide Thermopile Mount, a Microammeter and a blower to remove heat. The instrument is compact and is not much bigger than a Waveguide Waterload. It is extremely simple to operate. There are no controls, no thermometers, no flowmeters, no heat exchanger, no liquids. Reading time is approximately one minute and one minute between readings of different power levels. Accuracy is better than plus or minus 5%. The effect of ambient temperature changes between 60°F to 80°F is negligible.

Model	Frequency Range KMC	Average Power Rating	Peak Power Rating Megawatts	Maximum VSWR	Flange
DCXS	8.2 - 12.4	10 Watts	.29	1.1	UG39/U
DCXS (B)	8.2 - 12.4	300 Watts	.29	1.1	UG39/U
DCXL	7 - 10	10 Watts	.46	1.1	UG51/U
DCXL (B)	7 - 10	500 Watts	.46	1.1	UG51/U
DCM	5.85 - 8.20	50 Watts	.71	1.1	UG344/U
DCM (B)	5.85 - 8.20	500 Watts	.71	1.1	UG344/U
DCN	3.95 - 5.85	100 Watts	2.0	1.1	UG149/U
DCN (B)	3.95 - 5.85	600 Watts	2.0	1.1	UG149/U
DCS	2.4 - 3.7	100 Watts	3.	1.1	UG53/U
DCS (B)	2.4 - 3.7	1000 Watts	3.	1.1	UG53/U
DCH	1.7 - 2.6	100 Watts	3.7	1.1	UG435/U
DCH (B)	1.7 - 2.6	2000 Watts	3.7	1.1	UG435/U
DCL	1.12 - 1.70	100 Watts	7.0	1.1	UG417/U
DCL (B)	1.12 - 1.70	2000 Watts	7.0	1.1	UG417/U

WRITE FOR COMPLETE INFORMATION

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CIRCLE 272 ON READER-SERVICE CARD

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... panel-mounted ...
small-size
ELECTRONIC
VOLTMETERS



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Build accuracy into all your equipment, test and production alike, with Metronix DC and AC Electronic Voltmeters.

These Metronix instruments are no larger than conventional voltmeters, cost little more. They offer higher accuracy because they don't load the circuit. In AC applica-

tions, they respond accurately over a frequency range of 20 CPS to 100 KC.

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S.A. 1975

NEW PRODUCTS



Photorelay
Weatherproof and
shock resistant

Mounted in a Crouse-Hinds FD-1 Condulet box with a 1/2 in. threaded fitting, the model R-CH photorelay withstands the effects of dust, moisture, shock, vibration, and other adverse conditions. Using a solid state photocell it automatically triggers on-off and go no-go circuits at predetermined light levels. It is sensitive to 10 ft-c and operates on 60 cps, 115 v ac. Power consumption is 2.5 w, and the spst contacts are rated at 5 amp, 115 v ac. The unit measures 3 x 3-1/2 x 4-1/2 in. and weighs 4 lb.

Berkeley/Dynamics, Dept. ED, 2831 Seventh St., Berkeley, Calif.

CIRCLE 274 ON READER-SERVICE CARD

Portable EIR Meter

Has 39 ranges

Model MV-77A portable multimeter has 13 voltage ranges from 0 to 1 mv to 0 to 1 kv; 13 current ranges from 0 to 1 μ a to 0 to 1 amp; and 13 resistance ranges from 0 to 1 ohm to 0 to 1 meg. Accuracy is 3% on the current ranges, 1% on the others. The unit is 12 x 8 x 9 in.

Millivac Instruments, Div. of Cohu Electronics, Inc., Dept. ED, P.O. Box 997, Schenectady, N.Y.

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Low Capacitance Standard

Accurate to 0.01%

Constructed to value of 10 μ f, this capacitance bridge provides an absolute standard which eliminates substitution methods of measurement. It is accurate to 0.01%. Ratio transformers can provide multiplying factors without loss of accuracy so that a standard impedance of any value can be effectively produced from the single standard.

Wayne Kerr Corp., Dept. ED, 2920 N. Fourth St., Philadelphia 33, Pa.

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For printed circuit use

Available both copper clad and nonclad, Insurok T-525 and T-525N epoxy glass laminates meet MIL-P-18177B and NEMA G10 specifications. Type T-525 copper clad is for normal printed circuit applications, while T-525N copper clad will withstand cyanide solutions for gold plating. Standard sheet size is 36 x 42 in. and standard thicknesses are 1/32 to 1 in. for unclad, and 1/32 to 1/4 in. for copper clad sheets.

The Richardson Co., Dept. ED,
2700 Lake St., Melrose Park, Ill.
CIRCLE 278 ON READER-SERVICE CARD

Subcarrier Oscillators

For all standard IRIG bands

Series FO 4 solid state subcarrier oscillators are available for operation on all standard IRIG radio telemetry bands from 1 through 18 and may be obtained in various packaged system forms with silicon power supplies, signal calibration and conditioning equipment, and other telemetry apparatus. They may be used for the measurement of positive and negative dc and ac voltages. Dimensions are 2-1/16 x 2-5/16 x 9/32 or 2-1/16 x 1-3/4 x 9/32 in.

General Devices, Inc., Dept. ED,
P.O. Box 253, Princeton, N.J.

CIRCLE 279 ON READER-SERVICE CARD

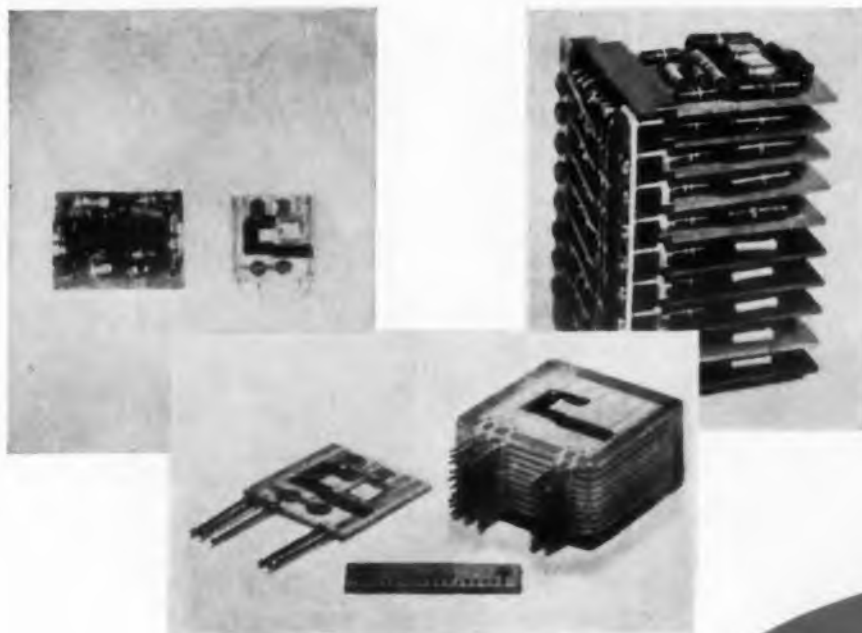
Silicon Rectifiers

Magnetic amplifier and high voltage types

These top hat silicon rectifiers are hermetically sealed with axial leads. JEDEC series 1N440B through 1N444B and 1N599A through 1N606A are magnetic amplifier types with low leakage and low forward drop. JEDEC 1N223 through 1N226 and 1N1095, 1N547, 1N1096, and 1N561 are high voltage types for power supplies, blocking applications, and clipping circuits.

Columbus Electronics Corp.,
Dept. ED, 1010 Saw Mill River Rd.,
Yonkers, N.Y.

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Section I: TECHNIQUES

- Survey of Equipment Adaptable to Microminiature Circuit Technology
- The Uses of Thin Films in Microminiaturization of Electronic Equipment
- The Application of Vacuum Evaporation Techniques to Microminiaturization
- Fine-Line Etched Wiring
- Interconnection of Microminiature Electronic Sub-assemblies

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- Two-Dimensional Transistor Packaging
- The Role of Semiconductors in the Army Micromodule Program
- The Stability of Semiconductors in Microelectronic Assemblies

Section III: COMPONENTS

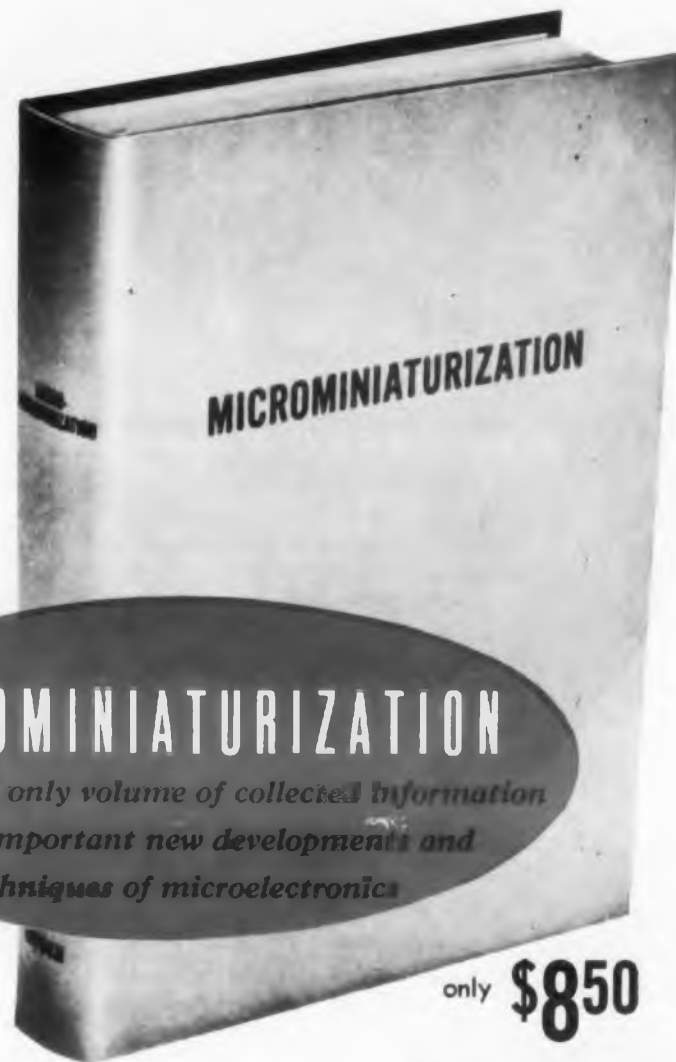
- Layerized High-Dielectric Constant Capacitors
- Miniature Incandescent Indicator Lamps
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Model IF-1 through IF-5 miniature Amplitran i-f amplifier stages are packaged in metal cases 1-1/2 in. high and 13/16 in. in diameter and provide gains from 10 to 20 db. Center frequencies range from 455 kc to 30 mc, and bandwidths are 10 to 500 kc. The transistorized units plug into 7-pin tube sockets and may be cascaded to obtain a desired gain. They have a negative feedback circuitry that permits them to be encased without danger of oscillation or instability.

Ferrotran Electronics Co., Inc., Dept. ED, 693 Broadway, New York 12, N.Y.

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For use with magnesium

For use on magnesium parts series C15-101 and C15-100 strain gages provide a low coefficient of resistance, or apparent strain, when mounted on material with a thermal expansion coefficient of 15 ppm per deg F. The first are epoxy-black types for temperatures from subzero to +200 F; the second are strippable types for use to +500 F.

Tatnall Measuring Systems Co., Dept. ED, Box 245, Phoenixville, Pa.

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Continental-Diamond Fibre Corp., Dept. ED, Newark, Del.

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Analog Computer

Has 120 amplifiers



The model 120 analog computer has 120 amplifiers, 48 of which are interchangeably summers or integrators. It also has 16 servomultipliers, each with five 10-turn potentiometers and a slip clutch which disengages the motor from the potentiometers when the input reaches ±100 v. The 240 linear scale-factor potentiometers on sliding racks facilitate storage of problems for multishift operation. Amplifier drift is 25 μv, grid current is less than 30 μma, and noise is 0.25 mv. The unit has an automatic time-scale change.

Dian Labs, Inc., Dept. ED, 611 Broadway, New York 12, N.Y.

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Sine Wave Oscillator

Holds voltage amplitude from —55 to +105 C



This transistorized sine wave oscillator has a high voltage stability from —55 to +105 C. Its voltage output is 3 v, its power output is 30 mw, its power input is 2.5 w, and its output impedance is less than 30 ohms at an output level of 3 v rms. Frequencies can be set from 20 cps to 50 kc. Harmonic distortion is under 1%; frequency stability, ±0.25%; and variation in output voltage amplitude, under 0.2% for ±10% variation in input voltage. The unit is potted in a MIL-T-27 size FA can and weighs 12 oz.

General Controls Co., Dept. ED, 801 Allen Ave., Glendale 1, Calif.

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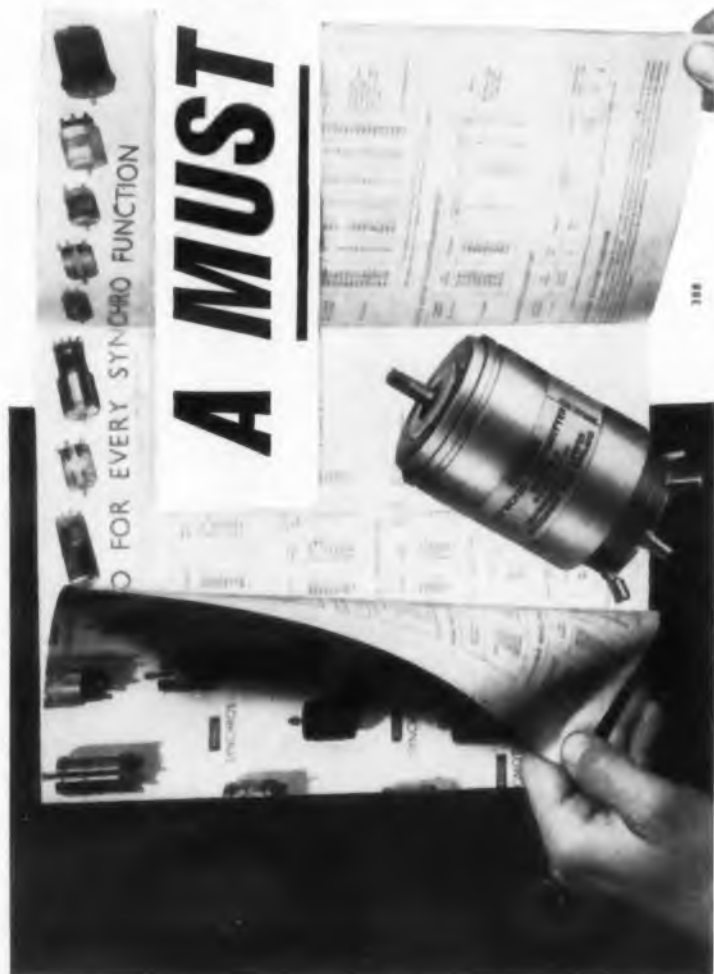
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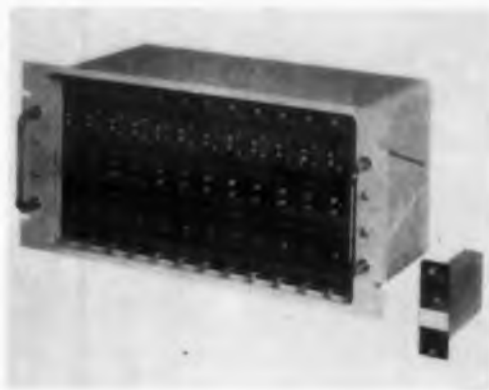


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NEW PRODUCTS

Modular Normalizing Network System

Accepts variety of transducer signals



This modular normalizing network system accepts a wide variety of transducer signals. Each of the eight different types of plug-in networks contains circuitry applicable to a particular transducer type and provides means for a normalized output acceptable by a wide variety of multiplexing and encoding systems. Each plug-in contains means for setting transducer excitation; balancing or completion of a bridge; attenuation of transducer output; automatic calibration; and a low pass filter. The system enclosure holds up to 24 modules and can be supplied for airborne or rack and panel mounting.

Kauke and Co., Dept. ED, 1632 Euclid St., Santa Monica, Calif.

CIRCLE 290 ON READER-SERVICE CARD

Tantalum Wire Capacitors

0.01 to 8 μ f

In case size H, these capacitors have dimensions of .075 in. in diameter by .255 in. in length. Their capacitance range is 0.01 to 8 μ f. All units are insulated with Mylar plastic, have axial leads, and are a part of the TW series. Polar type units, they have an effective operation at temperature extremes of -55 to $+85$ C.

Ohmite Mfg. Co., Dept. ED, 3672 Howard St., Skokie, Ill.

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Sweep Generator

Wide band

Model 900-A sweep generator supplies a sweep signal in vhf and uhf ranges with center at any frequency from 500 kc to 1000 mc and sweep widths from 100 kc to 400 mc. The rf output is flat within ± 0.5 db up to 800 mc.

Jerrold Electronics Corp., Dept. ED, 15th and Lehigh Ave., Philadelphia 32, Pa.

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Rochester 4, N. Y.

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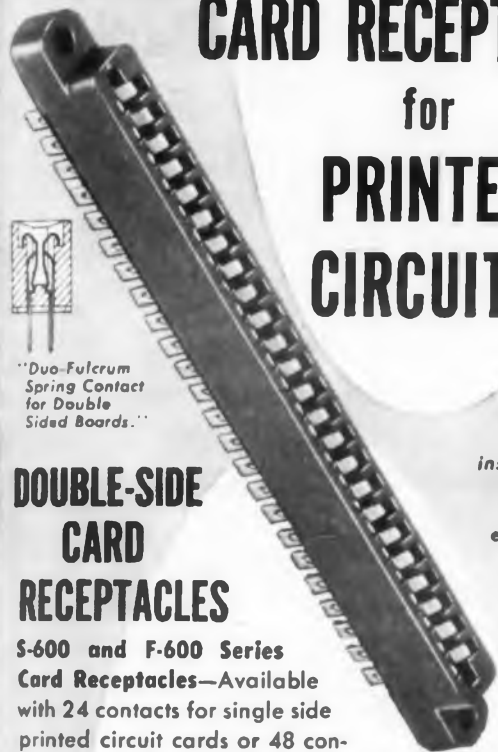
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band pass

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2 to 1 gain in vacuum tube circuits with 10 K in-
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output in transistor applications. Attenuation is
about 2 db within 3% of center frequency, then
35 db per octave. The units are 3/4 x 3/4 x 1-1/8
in. and weigh 1 oz. High and low pass type HPM
and LPM units are for 10 K in and out. They have
a loss of under 6 db at cutoff frequency and an
attenuation of 30 db at 0.67 and 1.5 cutoff fre-
quency, respectively. Dimensions are 1 x 1 x 1-3/8
in.; weight, 2-1/4 oz.

United Transformer Corp., Dept. ED, 150
Varick St., New York 13, N.Y.

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Pushbutton Switch

Operates in adverse environments



This pushbutton switch has an O ring in the
stem and potting around the leads to seal out
dirt, moisture, and oil and permit it to operate de-
pendably in adverse environments. It is corrosion
resistant and has a scraper built into the stem to
keep ice and dirt from fouling the plunger. The
unit is 3/4 in. in diameter and 1-1/2 in. high and
has ratings of 6 amp at 125 v ac or 30 v dc re-
sistive, or 2.5 amp at 30 v dc inductive. Contact
arrangement is spdt.

Electrosnap Corp., Dept. ED, 4220 W. Lake St.,
Chicago 24, Ill.

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Digital



MODEL
400B

VTVM

±0.1% comparative accuracy
0 to 1000 V ac or dc
0 to 1 megohm

Franklin's all-electronic Model 400B pro-
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Available for rack or table mounting.

Request Data Sheet 40B. OEM request Data
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D-C RANGE 0 to 10, 100, and 1000 V.	ABSOLUTE ACCURACY ±0.3%, 0 to 10 volt range; ±0.5%, all other ranges. INPUT IMPEDANCE 20 megohms.
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37 mc range



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

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Miniature Rotary Switch

Has 1 in. diameter

This miniature concentric shaft rotary tap switch, fully enclosed, is only 1 in. in diameter. Each shaft controls from one to three decks, with two to 10 shorting or non-shorting positions per deck. It is available as standard in over 6500 various combinations of decks and positions. Contacts are rated to break 1 amp 115 v ac, or to carry 5 amp.

Grayhill, Inc., Dept. ED, 561 Hillgrove Ave., La Grange, Ill.

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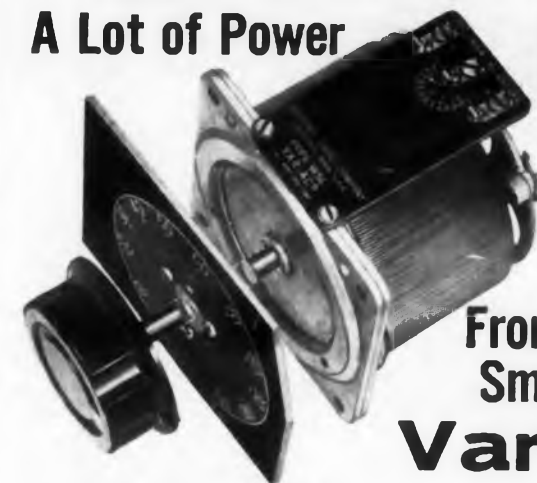
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Troy Blanket Mills, Dept. ED, 200 Madison Ave., New York, N.Y.

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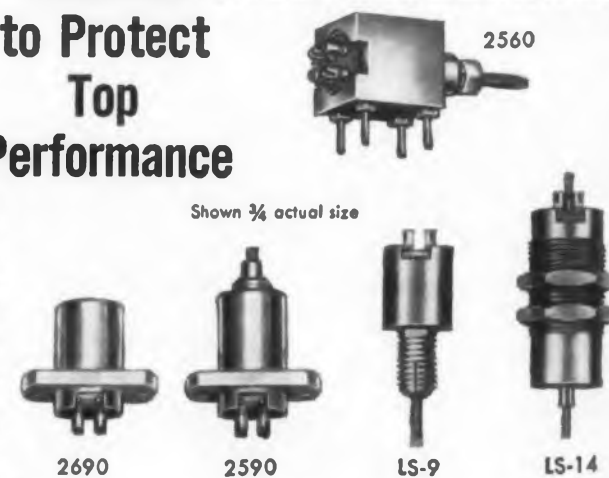
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CIRCLE 304 ON READER-SERVICE CARD

ELECTRONIC DESIGN • May 27, 1959

How Long Does It Take



to find the electronic test instrument you need?

... how can you be sure it's
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Did you know that there are 4,500 different electronic test instruments manufactured by some 400 different companies?

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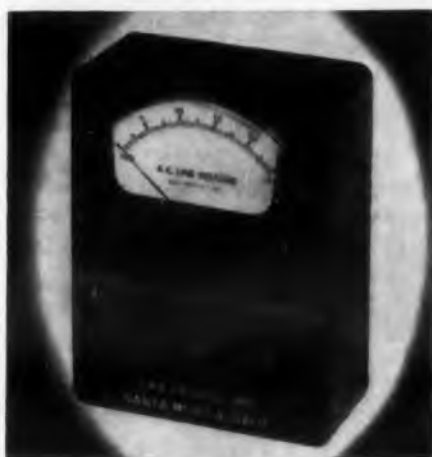
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CIRCLE 305 ON READER-SERVICE CARD

AC Voltmeter Accurate to 1%



The model SZV-125 suppressed zero ac voltmeter provides expanded scale reading accuracy without sacrificing scale space for compression at the low end. Full scale deflection is accomplished for the 100 to 125 v range, thus providing adequate coverage for the normal range of 115 v $\pm 10\%$. Reading accuracies of ± 0.2 v and meter accuracies of better than 1% are obtainable. The unit has a time constant of less than 0.5 sec and may be used on frequencies from 50 to 450 cps. It measures 2-1/4 x 5-1/4 x 6-3/4 in.

ERA Pacific, Inc., Dept. ED, 1760 Stanford St.,
Santa Monica, Calif.

CIRCLE 306 ON READER-SERVICE CARD



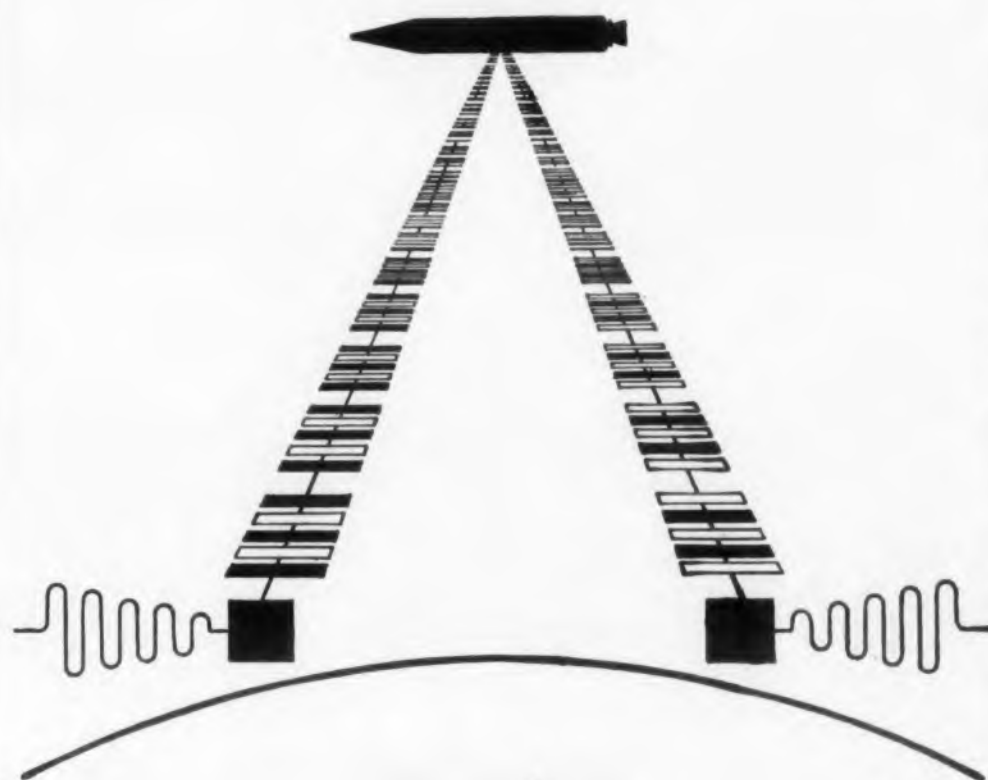
Tape Reader

For any speed to
1000 characters
per sec

Photoelectric tape reader type TR7 is a self-contained, free standing unit suitable for reading 5, 7, or 8 level tape at any speed up to 1000 characters per sec. It rewinds 1200 ft of tape in under 30 sec. The unit operates under computer or manual control and will read character by character at high speed. By means of a double row reading head, each character on the tape is read twice and the readings are compared by a built-in comparator circuit which serves as a checking facility. Dimensions are 27-3/4 x 20 x 52 in.

Ferranti Electric Inc., Electronics Div., Dept.
ED, 95 Madison Ave., Hempstead, N.Y.

CIRCLE 307 ON READER-SERVICE CARD



Probing Electronic Frontiers With MELPAR

Our mission is simply stated: advancing the state of the art in electronics to satisfy the demands of the space age and the increasingly complex problems of defense.

To the experienced engineer with an inquiring mind we extend an opportunity to blaze new technological trails and to constantly explore the parameters of his personal ability.

Opportunities are available in the following
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ing Department

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MELPAR Incorporated

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10 miles from Washington, D. C.

CIRCLE 873 ON READER-SERVICE CARD

IDEAS FOR DESIGN—ENTRY BLANK

To the *Ideas-For-Design* Editor of **ELECTRONIC DESIGN** —
830 3rd Ave., New York 22, N.Y. • PLaza 1-5530

Here is my design idea for possible publications in your *Ideas For Design* department.
I can expect \$10 for this idea if accepted for publication.

(Ideas suitable include: 1. new circuits or circuit modifications, 2. new design techniques, 3. designs for new production methods, 4. clever use of new materials or new components in design, 5. design or drafting aids, 6. new methods of packaging, 7. design short cuts, or 8. cost saving tips)

STATEMENT OF THE PROBLEM—

MY SOLUTION. AND WHY—(Please be explicit. Include sketches or photos that will help the idea across)

Signed _____
Title _____
Company _____
Address _____

(Place illustrations on separate sheet if necessary)

Fast Character 'Painter' Conventional

BY USING a "painting" technique, the Alpha-dyne Character Generator can provide readout on any oscilloscope or crt device with X-Y-Z input. Letters, numerals, or symbols can be painted on the face of the crt at any rate from 60 to 5000 per second.

Clear, crisp characters are painted in one continuous motion. A conventional gain control varies the character size.

Manufactured by Skiatron Electronics and



Typical readout on a conventional rectangular cathode ray tube.



This character generator paints characters on most scopes in one continuous motion.

er' Reads Out on al Scopes

Alpha-
headout
-Z in-
ainted
5000
e con-
control
s and

Television Corp., 180 Varick St., New York, N. Y., the Alphadyne "writes" characters on an oscilloscope as easily as one might "write" a sine wave. Thus, to display the "7" in the accompanying photograph, the X input would receive a sawtooth voltage to paint the horizontal part of the "7." Then both X and Y inputs would receive signals to complete the slanted part of the character.

An auxiliary stepping generator would be used at the X input to display several characters side-by-side. To display characters on separate lines, as well as side-by-side, one could use a stepping generator at both X and Y scope inputs.

Operation is Simple

The Alphadyne is certainly simple to operate. It requires only a switch closure for each symbol to be displayed. The switch can be a mechanical type, a relay, or a diode gate. One input line to the instrument is energized, either manually or automatically, for each character to be displayed.

Image retention is easy too. A cathode ray tube with even a very short persistence phosphor can "retain" a display indefinitely when the Alphadyne's fast writing rate is used repetitively. Of course, tubes with long persistence phosphors, or memory types tubes can be used also.

The Alphadyne's three output signals, (X deflection, Y deflection, and beam intensity) can be used to transmit characters to remote display units as far as 150 feet away.

Models of the instrument are available to generate as few as 20 characters or as many as 50. The 50-character model, for example, can generate the complete alphabet, numbers from zero to nine, and fourteen symbols.

For more information on this unusual character generator turn to the Reader-Service Card and circle 103.

HERE'S WHY MORE THAN 3,000,000



SUPERCON FILM POTS

ARE IN USE...



VIRTUALLY INFINITE RESOLUTION

Eliminates servo hunting. Improves dynamic response of feedback systems.



GREATEST ACCURACY IN A GIVEN SIZE

In a one-turn unit, Linearity to .01%! Sine-Cosine to .025%!



LONG LIFE AT HIGH SPEEDS

Typical *field* experience: 30,000,000 revolutions at 500 rpm.



ULTIMATE IN RELIABILITY

SUPERCON Film Pots are "FAIL-SAFE"; integrity of winding does *not* depend on single hair-like wire.

SUPERCON FILM POTS consist of a non-metallic resistance film permanently bonded to a high temperature plastic base with a precious metal wiper riding on its polished-finish surface. This sturdy one-piece shock, vibration and wear resistant construction has proven superior, during 10 years of field use, to the loose-wire, glued-assembly, wiper-bouncing-from-turn-to-turn construction of wire-wound pots. No longer do you have to compromise the accuracy or reliability of your system by the limitations of wire-wound pots. SUPERCON Film Pots easily meet the requirements of the space age.



A COMPLETE RANGE OF SIZES FROM 1/2" TO 5" IN DIAMETER AVAILABLE

CIC is the largest manufacturer of Precision Film Potentiometers, having pioneered in their development, with a 10-year record of supply to all branches of the Armed Services and throughout industry. Our staff of technical specialists is ready to assist you with your potentiometer needs.

Write for our catalog.



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CIRCLE 308 ON READER-SERVICE CARD

put your finger on

PROFIT



This magnified minuscule electrical part is another Advance Stamping which saved production costs.

Yes—bigger profits from smaller parts are very possible when you engineer in Stampings—especially *Advance Stampings*. As Specialists in Small Stampings, Advance has been helping metal working industries of various kinds attain higher production at lower cost for over 35 years.



Here are typical Advance Stampings which have been fabricated in different materials to meet tolerance specifications, delivery and price.

Send us your blue prints or samples for quotations. Advance engineers are available to consult on ways to improve your competitive position.

Write for Small Stamping Specialists Brochure



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CIRCLE 309 ON READER-SERVICE CARD

Full Wattage From Transistors With New Heat Exchanger

THE FIRST of a new line of heat exchangers has been built in which full wattage can be obtained from power transistors. Designed to operate in the one-to-ten cfm range, the exchanger will permit a 50 w transistor to be run at 50 w's instead of the 15 to 20 w maximum common today. The efficient use of rationed coolant air makes the device effective in airborne applications, where high pressures and small quantities of air are available.

The exchanger, a laminar-flow type called the LF-101, has been built by the Gasket Manufacturing Co. of 319 W. 17th St., Los Angeles. It is intended for use with a large family of transistors produced by Delco.

The LF-102, not yet in production, will be specifically adapted to the oblong transistor configuration commonly used by many manufacturers. All models in the LF-100 series will mate with one another, permitting the mechanical interchange of different transistor types.

Construction, as shown in Fig. 1, is of copper, styrofoam and aluminum. Cooling air passes over 15 copper fins with gentle turbulent mixing. Styrofoam filler guides air over the fin surfaces only.

When installed, the duct is sealed; maintenance and replacement of the transistor are possible without having to go into the duct. Sponge rubber gasketing takes up any mechanical mismatch. Electrical insulation is achieved by deep anodizing of the copper and aluminum. No mica washers need be installed to insulate the transistor from the mounting plate.

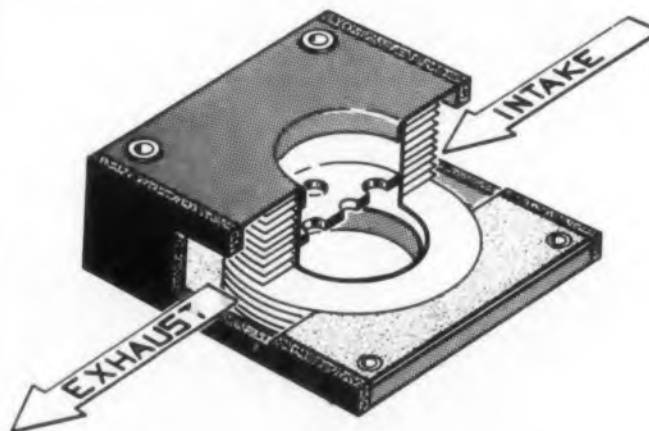


Fig. 1. Cutaway of heat exchanger. Cooling air is ducted by styrofoam filler so it passes over 30 copper surfaces. Flow has gentle turbulence.

Thermal impedance as a function of cfm and pressure drop at one atmosphere pressure is shown in Fig. 2. Not much is gained by using more than 10 cfm of cooling air because the thermal impedance approaches a limiting value.

How It Works

Prototype tests show that with any Delco transistor similar to the 2N277 (95 C junction temperature recommended), the following results are obtained:

- At 30 w (stud temperature of 70 C max. recommended)—Collector-to-emitter voltage is 25 v, 1.2 amp collector current. Input air is 25 C, cfm 3.5, pressure about 0.1 in. H₂O. Exhaust air is 40 C and the stud temperature is 56 C.
- At 40 w (stud temperature of 60 C max. recommended)—Using 25 v at 1.6 a, input air of 25 C, 13.6 cfm (comparable to a gentle breath against the hand) and a pressure of 0.75 in. H₂O, the exhaust air is 30 C, stud temperature 52 C.

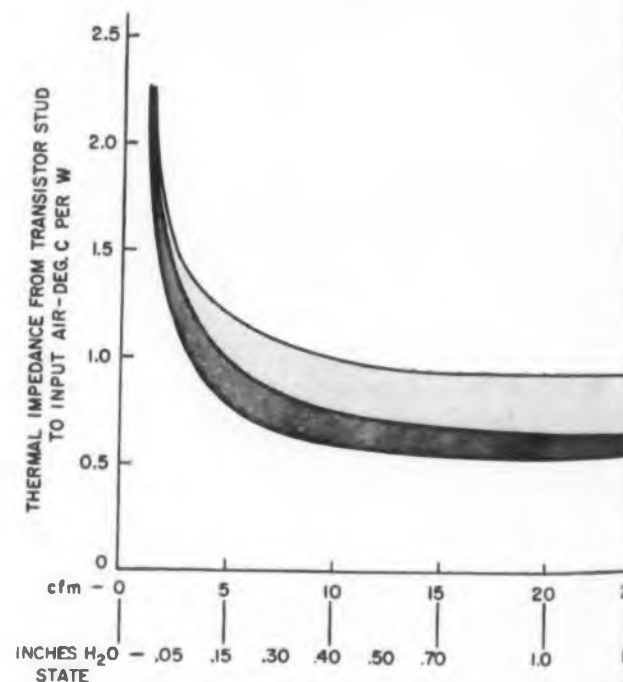


Fig. 2. Thermal impedance characteristics of LF-101 heat exchanger. Top edge of darkly shaded area represents the worst condition—50 w. Curves included in area were plotted for 10 w, 15 w, 20 w, 25 w, 30 w, 40 w and 50 w. Measurements were made at one atmospheric ambient pressure. This spread was made by testing prototype exchangers. To allow for variations in transistors, the lightly shaded area is more representative of average performance.



Fig. 3. Series (top) and parallel (bottom) mounting of exchangers. Calculation of air flow is the same as for current through resistors.

At 20 w (stud temperature of 80 C max. recommended)—This is an easy one, says the designer. With 25 v and 0.8 a, input air 25 C, 1.05 cfm, 0.01 in. H₂O, the exhaust air is 59 C and stud temperature is 69 C.

For a given temperature control problem, it is necessary to know the dissipation rate, desired stud temperature, coolant air temperature and maximum air-pressure drop that can be provided across the heat exchanger. The difference between the desired stud temperature and the coolant temperature, divided by the transistor dissipation rate, gives the maximum allowable thermal impedance. The intersection of this thermal impedance and the available air pressure on Fig. 2 will reveal the existence of excessive or insufficient cooling.

Still-Air Use Explained

If the heat exchanger is used in still air, the thermal impedance in degrees per watt can be computed by using $Z_t = 6.7 - 1.3 (Watts)$. While the LF-101 will handle 10 w safely in still air, the designer notes, it would be like hitching a race horse to a pushcart. The unit's design emphasizes the forced-air characteristic over still-air performance. The manufacturer could make a less expensive unit for still-air work.

Series and Parallel Mounting

Series mounting of two or more LF-101 exchangers as in Fig. 3 means that the total pressure drop is divided equally between them. The exhaust air from one becomes the coolant air to the next. Although expansion with heat takes place, volume flow rate can be considered identical; only the input temperature differs. Units should be positioned so the transistor having the highest dissipation rate is upstream from the rest. For further information on this full-watts transistor heat exchanger, turn to the Readers Service Card and circle 104.

FROM FAIRCHILD

MESA TRANSISTORS IN SILICON



Greatly enlarged photo of Fairchild 2N696 before capping

80 milli-micro-second rise time with 2 watts power dissipation at 25° C. This speed and power is combined with silicon's superior high-temperature reliability. The switching performance that this affords has a place in every advanced-circuit evaluation program.

Double-diffused mesa-type construction provides mechanical ruggedness and excellent heat dissipation besides being optimum for high-frequency performance (typical gain-bandwidth product 80 Mc). This type is under intense development everywhere. Fairchild has it in production.

Quantity shipments now being made give conclusive proof of the capabilities of Fairchild's staff and facilities. We can fill your orders promptly. You can start immediately on evaluation and building of complete prototype equipment. Gearing to your future production needs, Fairchild will have expanded facilities to over 80,000 square feet by early '59.

Symbol	Specification	Rating	Characteristics	Test Conditions
V _{CE}	Collector to Emitter voltage (25° C.)	40v		
P _C	Total dissipation at 25° C. Case temp.	2 watts		
h _{FE}	D. C. current gain		2N696-20-60 2N697-40-120	I _C =150ma V _C =10v
R _{CS}	Collector saturation resistance		6Ω typical	I _C =150ma I _B =15ma
h _{fe}	Small signal current gain at f=20Mc		4 typical	I _C =50ma V _C =10v

For data sheets, write Dept. B-5-27



844 CHARLESTON RD. • PALO ALTO, CALIF. • DA 6-6695

CIRCLE 310 ON READER-SERVICE CARD

Galileo Meets the Martians

One memorable day in 1633, 5 space ships suddenly materialized in the sunny Italian sky over Pisa and landed directly under the nose of Galileo's telescope. Three creatures alighted from the lead ship and made straight for Galileo.

"Good morning Signor Galilei," they chorused in unison. "We are . . ."

"Don't tell me, let me guess," interrupted the scientist. "The Mars Brothers?"

"In the flesh, more or less," leered the green one in the middle, brandishing a cigar. "I'm Sloucho. Sorry about the accident. We seem to have knocked off a Pisa the Tower."

"Good for the tourist trade," Galileo smiled. "Now for business," went on Sloucho. "The boys upstairs are fascinated with your radar.* They sent us down here to find out how you make it work without Bomac tubes."

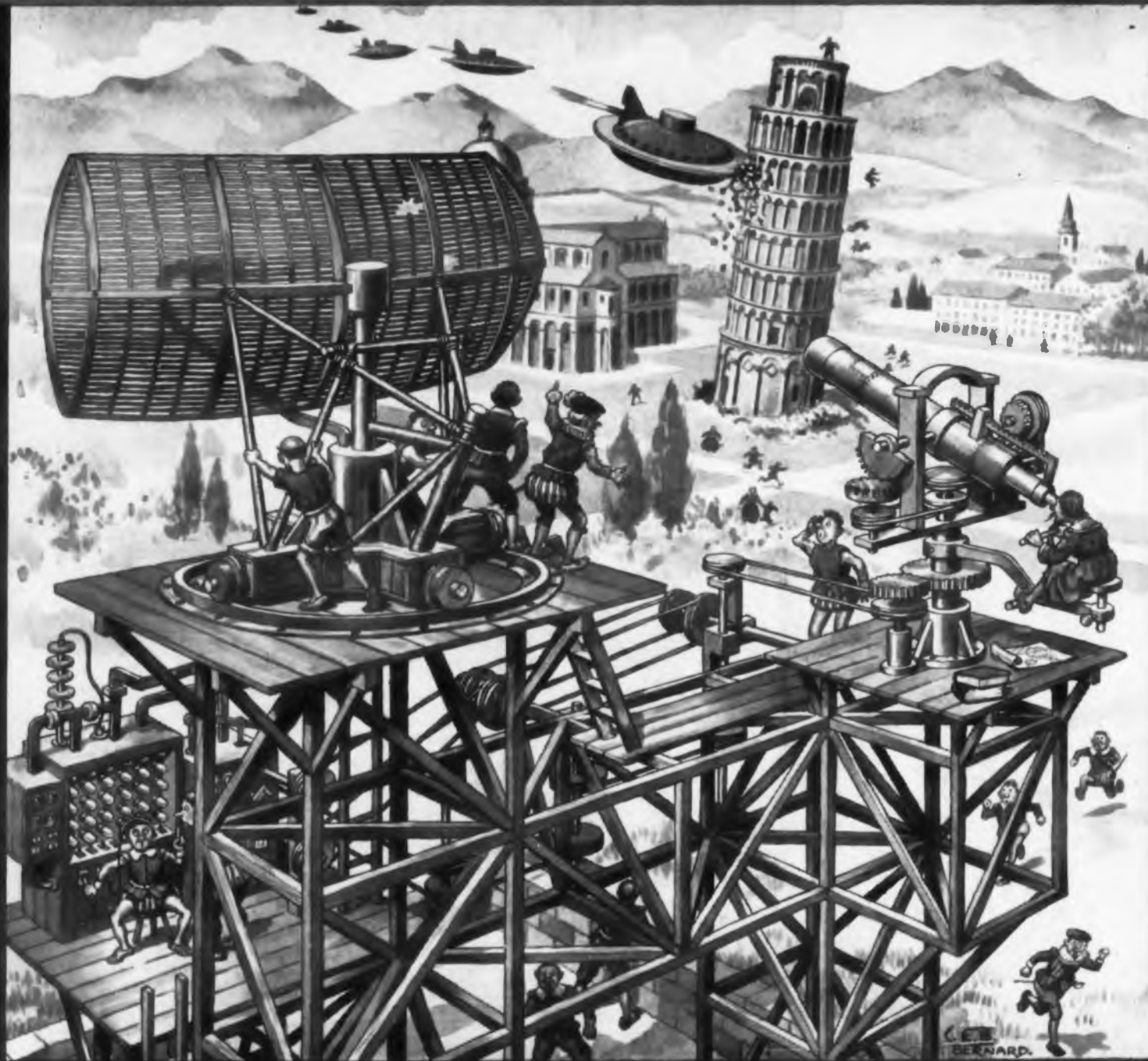
"I'm sorry to say it doesn't work at all," Galileo answered. "Or rather — it didn't, until the instant your ship hit the tower."

Sloucho's cigar was aquiver with excitement. "What happened then?" he asked.

"See for yourself," Galileo said, pointing a bony finger at the radar console. There, blinking crazily, like so many overstimulated lightning bugs, the tubes were actually spelling out a single, sure-enough word.

The word was "TILT."

No. 14 of a series . . . BOMAC LOOKS AT RADAR THROUGH THE AGES



* Bomac makes the finest microwave tubes and components this side of the leaning tower

Bomac

B

Leaders in the design, development and manufacture of TR, ATR, Pre-TR tubes; shutters; reference cavities; crystal protectors; silicon diodes; magnetrons; klystrons; duplexers; pressurizing windows; noise source tubes; high frequency triode oscillators; surge protectors.

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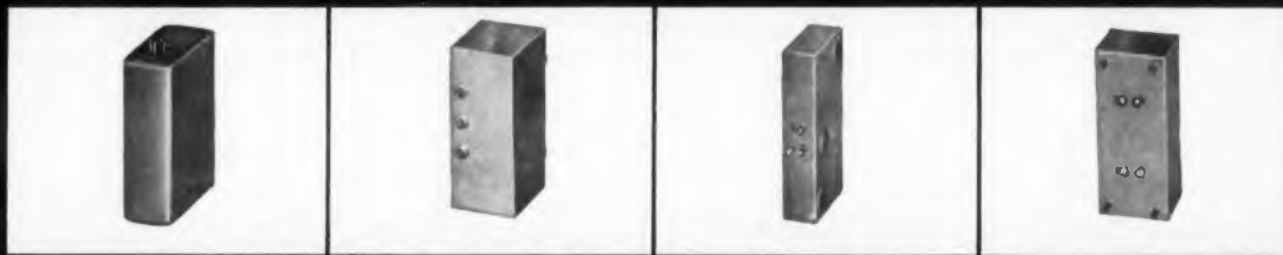


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All types for frequencies from .1 cycle to 400 MC.



400 — telemetering, 3 db at $\pm 7.5\%$, 40 db at 230 and 700 —, $\frac{1}{2} \times 1\frac{1}{4} \times 2\frac{1}{2}$ "

15 — BP filter, 20 db at 30 —, 45 db at 100 —, phase angle at CF less than 3° from -40 to $+100^\circ$ C.

LP filter within 1 db to 49 KC, stable to .1 db from 0 to 85° C., 45 db at 55 KC.

LP filter less than .1 db 0 to 2.5 KC, 50 db beyond 3 KC.



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Toroid, laminated, and cup structures from .1 cycle to 400 MC.

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Toroid for printed circuit, Q of 90 at 15 KC.

Dual toroid, Q of 75 at 10 KC, and Q of 120 at 5 KC.

HVC tapped variable inductor for 3 KC oscillator

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Saturable reactors, reference transformers, magnetic amplifiers, combined units.



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From miniature blocking oscillator to 10 megawatt.

Wound core unit .01 micro-second rise time.

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Pulse output to magnetron, bifilar filament.

Precise wave shape pulse output, 2500 V. 3 Amps.

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Standard and high temperature hermetic, molded, and encapsulated.



Multi-winding 140 VA, 6 KC power transformer $1\frac{1}{4} \times 1\frac{1}{4} \times 1\frac{1}{2}$ "

200° C. power transformer, 400 —, 150 VA.

400 — scope transformer, 20 KV output.

60 — current limiting filament transformer, Sec. 25 Mmfd., 30 KV hipot.

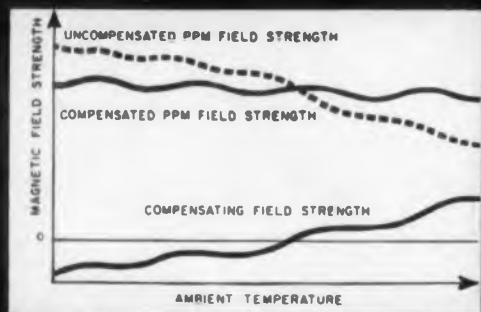
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TWT

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- Ambient temperature of -65 to $+150^{\circ}\text{C}$
- Altitudes up to 70,000 ft without pressurization
- 100% relative humidity at 25°C
- Impact shock of 30 g for 11 milliseconds
- Vibrational acceleration of 5 g over vibrating range from 10 to 2000 cps with less than 0.5 db vibration-induced modulation.



How RCA's A-1166 is temperature compensated.

"Environmentalized" to provide top performance and reliability under tough conditions, RCA's A-1166 is indicative of today's design for tomorrow's use. It utilizes PPM (periodic permanent magnet) focusing to provide substantial reduction in overall size and weight in comparison with solenoid-focused types. Like all RCA Traveling-Wave Tubes, the A-1166 represents a design for a specific application requiring long life and dependability.

RCA's Microwave-Tube Engineers will welcome the opportunity to develop Traveling-Wave Tubes for your specific-

system needs in the L, S, C, and X bands. For information as to the development of Traveling-Wave Tubes to meet your specific requirements, please call the RCA Field Office nearest you.

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RADIO CORPORATION OF AMERICA

Electron Tube Division

Harrison, N. J.

May 27, 1959
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