A McGRAW-HILL PUBLICATION · PRICE ONE DOLLAR

JANUARY 31, 1958

electronics

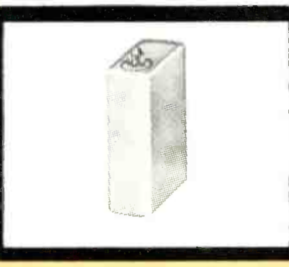
engineering edition

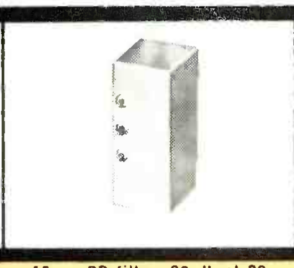
1/29/58

For Your Special Applications

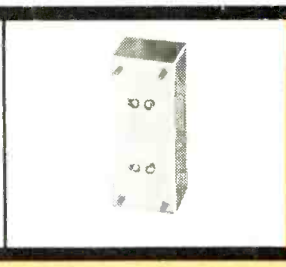
The bulk of UTC production is on special units designed to specific customers' needs. Illustrated below are some typical units and some unusual units as manufactured for special applications. We would be pleased to advise and quote to your special requirements.

FILTERS
All types for frequencies from .1 cycle to 400 MC.

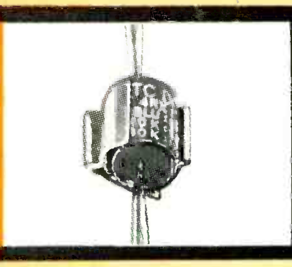

400 ~ telemetering, 3 db at ± 7.5%, 40 db at 230 and 700 ~, ⅝ x 1¼ x 2″.

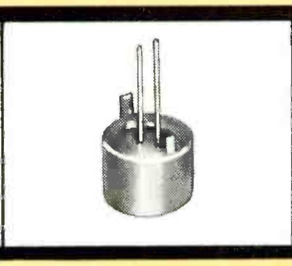

15 ~ BP filter, 20 db at 30 ~, 45 db at 100 ~, phase angle at CF less than 3° from —40 to + 100° C.


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.

HIGH Q COILS
Toroid, laminated, and cup structures from .1 cycle to 400 MC.

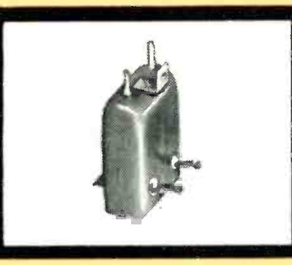

Tuned DO-T servo amplifier transformer, 400 ~ .5% distortion.


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.

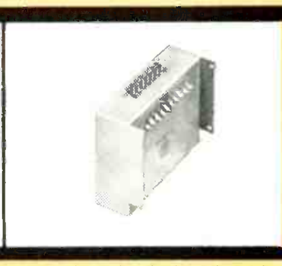

HVC tapped variable inductor for 3 KC oscillator.

SPECIALTIES
Saturable reactors, reference transformers, magnetic amplifiers, combined units.


RF saturable inductor for sweep from 17 MC to 21 MC.


Voltage reference transformer .05% accuracy.


Multi-control magnetic amplifier for airborne servo.

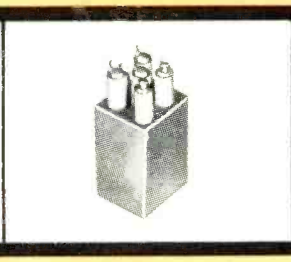

Input, output, two tuned interstages, peaking network, and BP filter, all in one case.

PULSE TRANSFORMERS
From miniature blocking oscillator to 10 megawatt.


Wound core unit .01 microsecond rise time.

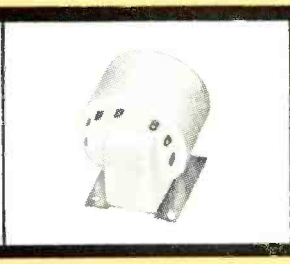

Pulse current tansformer 100 Amp.


Pulse output to magnatron, bifilar filament.

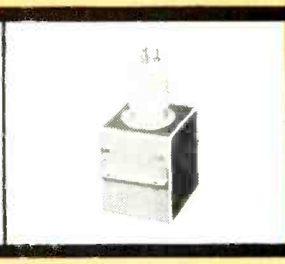

Precise wave shape pulse output, 2500 V. 3 Amps.

POWER COMPONENTS
Standard and high temperature . . . hermetic, molded, and encapsulated.


Multi-winding 140 VA, 6 KC power transformer 1¼ x 1¼ x 1″


200° C. power transformer, 400 ~, 150 VA.


400 ~ scope transformer, 20 KV output.


60 ~ current limiting filament transformer, Sec. 25 Mmfd., 30 KV hipot.

UNITED TRANSFORMER CORPORATION

150 Varick Street, New York 13, N. Y. • EXPORT DIVISION: 13 E. 40th St., New York 16, N. Y., CABLES: "ARLAB"

PACIFIC MFG. DIVISION, 4008 W. Jefferson Blvd., Los Angeles, Cal.

electronics engineering edition

A McGRAW-HILL PUBLICATION • VOL. 31 • NO. 5 • JANUARY 31, 1958

ISSUE AT A GLANCE

DIGEST CONTINUED ON NEXT PAGE

DIGEST (continued)

electronics

January 31, 1958 Vol. 31, No.5

Published weekly, with alternating engineering and business editions, and with a BUYERS' GUIDE issue in mid-June, by McGraw-Hill Publishing Company, Inc., James H. McGraw (1860-1948) Founder.

Executive, Editorial, Circulation and Advertising Offices: McGraw-Hill Building, 330 W. 42 St., New York 36, N. Y.

Longacre-4-3000. Publication Office 99-129 North Broadway, Albany 1, N. Y. See panel below for directions regarding subscription on change of address. Donald C. McGraw, President; Joseph A. Gerardi, Executive Vice President; L. Keith Goodrich, Vice President and Treasurer; John J. Cooke, Secretary; Nelson Bond, Executive Vice President, Publications Division; Ralph B. Smith, Vice President and Editorial Director; Joseph H. Allen, Vice President and Director of Advertising Sales; A. R. Venezian, Vice President and Circulation Coordinator.

Single copies $1.00 for Engineering Edition and 50¢ for Business Edition in United States and possessions, and Canada; $2.00 and $1.00 for all other foreign countries. Buyers' Guide $3.00. Subscription rates—United States and possessions, $6.00 a year; $9.00 for two years. Canada, $10.00 a year, $16 for two years. All other countries $20.00 a year, $30.00 for two years. Three year rates, accepted on renewals only, are double the one-year rate. Second class mail privileges authorized at Albany, N. Y. Printed in U.S.A.

BRANCH OFFICES: 520 North Michigan Avenue, Chicago 11; 68 Post Street, San Francisco 4; McGraw-Hill House, London E. C. 4; National Press Bldg., Washington, D. C. 4; Architects Bldg., 17th & Sansom Sts., Philadelphia 3; 1111 Henry W. Oliver Bldg., Pittsburgh 22; 1510 Hanna Bldg., Cleveland 15; 856 Penobscot Bldg., Detroit 26; 3615 Olive St., St. Louis 8; 350 Park Square Bldg., Boston 16; 1321 Rhodes Haverty Bldg., Atlanta 3; 1125 West Sixth St., Los Angeles 17; 1740 Broadway, Denver 2. ELECTRONICS is indexed regularly in The Engineering Index.

Subscriptions: Address correspondence to Subscription Manager, Electronics, 330 W. 42nd St., New York 36, N. Y. Allow one month for changes of address, stating old as well as new address. Subscriptions are solicited only from persons engaged in theory, research, design, production, management, maintenance and use of electronics and industrial control components, parts and products. Position and company connection must be indicated on subscription orders.

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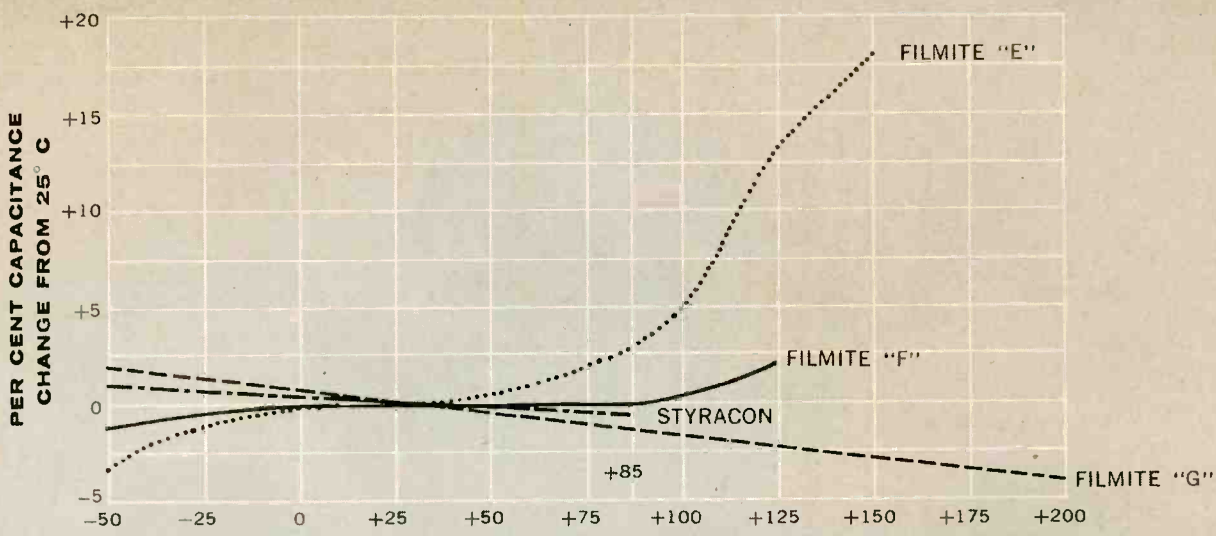
TYPICAL CAPACITANCE vs TEMPERATURE CHARACTERISTICS at 1000~



	STYRACON (85°C)	FILMITE "E" (150°C)	FILMITE "F" (125°C)	FILMITE "G" (200°C)
RATINGS	.001 to 1.00 µF 50 to 600 WVDC	.001 to 1.00 µF 200 to 2500 WVDC	.001 to 1.00 µF 200 to 600 WVDC	.001 to 1.00 µF 200 to 600 WVDC
STYLES	tubular metal cases screw-neck cases drawn metal cases	tubular metal cases screw-neck cases	tubular metal cases screw-neck cases "bathtub" cases	tubular metal cases screw-neck cases drawn oval cases
WRITE FOR TECHNICAL DATA	Engineering Bulletin No. 2510	Engineering Bulletin No. 2410	Engineering Bulletin No. 2560	Engineering Bulletin No. 2610

4 kinds of film dielectric capacitors

for specialized applications

Here are four plastic-film dielectric capacitors now in regular production at Sprague:

STYRACON CAPACITORS find wide application in laboratory equipment and in industrial controls where their low dielectric hysteresis (low "soak"), high insulation resistance, high "Q", low and linear temperature coefficient of capacitance are of great value.

FILMITE "E" CAPACITORS are general-purpose capacitors for use up to 150°C where capacitance stability with temperature is of secondary importance. They are also used at lower temperatures where very high insulation resistance is a prime requirement.

FILMITE "F" CAPACITORS are intended for use in circuits where the absolute minimum in capacitance change with temperature is a must and relatively large capacitance values are used. These capacitors typically will be within .05% of their 25°C value from −10°C to +85°C. They may be used up to 125°C where greater capacitance excursion is tolerable.

FILMITE "G" CAPACITORS have the highest temperature rating of any organic dielectric. They may be used up to 200°C! All units are nickel-plated to withstand high temperature corrosion. They also have the highest insulation resistance, the lowest dielectric hysteresis, and the lowest dissipation factor of any capacitor made so that they are often used at lower temperatures which are above the 85°C limit of the lower-cost Styracon Capacitors.

CAPACITANCE VS. TEMPERATURE CHARACTERISTICS of all four types of film capacitors are compared in the chart above for the benefit of the circuit designer.

ALL SPRAGUE FILM CAPACITORS are designed to have positive electrical contact between leads and electrodes, even at low operating voltages.

WRITE FOR ENGINEERING BULLETINS on the Sprague plastic-film capacitors in which you're interested. Address your letter to Sprague Electric Co., Technical Literature Section, 35 Marshall Street, North Adams, Mass.

SPRAGUE®
the mark of reliability

SPRAGUE COMPONENTS:

CAPACITORS • RESISTORS • MAGNETIC COMPONENTS • TRANSISTORS • INTERFERENCE FILTERS • PULSE NETWORKS • HIGH TEMPERATURE MAGNET WIRE • PRINTED CIRCUITS

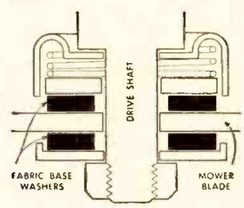
How a Taylor Laminated Plastic safety clutch protects rotary lawn mower crankshafts

Friction disc assembly permits clean cut, prevents damage to drive mechanism

Running into rocks or other solid objects with a rotary lawn mower is not a recommended practice, but it is possible to strike these objects without damaging the drive mechanism.

A laminated plastic safety clutch assembly does the job. Two Taylor Laminated Plastic friction discs, mounted as shown in the drawing, drive the cutting blade with positive force until a solid object is struck. When this occurs, the clutch assembly absorbs the shock, the discs slip, and the blade stops without impeding the operation of the driving mechanism—all parts are protected from serious damage.

Perhaps you have a similar problem—or others that can be solved by using either laminated plastic or vulcanized fibre parts. Our application engineers will be glad to help with your specific needs and recommend the material best suited to your application. Get their assistance by contacting the Taylor sales office nearest you.



CROSS SECTION of slip clutch assembly showing arrangement of components on crankshaft of rotary lawn mower. For properties of Taylor Laminated Plastic parts, see tables below.

PHYSICAL PROPERTIES

Taylor grade	Water Absorption 24 hr. immersion (% max.)				Specific Gravity	Cu. in. per lb.	Rockwell Hardness	Heat Resistance (max.)	
	1/32 in.	1/16 in.	1/8 in.	1/2 in.				Continuous use (°F)	Intermittent use (°F)
X	8.0	6.0	3.3	1.1	1.38	20	M-110	225-250	250-275
C	8.0	4.4	2.5	1.2	1.35	20.5	M-103	200-225	225-250
AA	—	3.0	2.5	1.25	1.65	16.8	M-110	300-325	325-350

MECHANICAL PROPERTIES

Taylor grade	Flexural Strength Flatwise (psi min.)		Tensile Strength (psi min.)		Compressive Strength (psi min.)	Izod Impact Strength Edgewise (ft./in. Notch min.)	
	Lengthwise	Crosswise	Lengthwise	Crosswise	Flatwise	Lengthwise	Crosswise
X	25,000	22,000	20,000	16,000	36,000	0.55	0.50
C	17,000	16,000	10,000	8,500	37,000	2.10	1.90
AA	16,000	14,000	10,000	8,000	38,000	3.60	3.00

TAYLOR

Laminated Plastics
Vulcanized Fibre

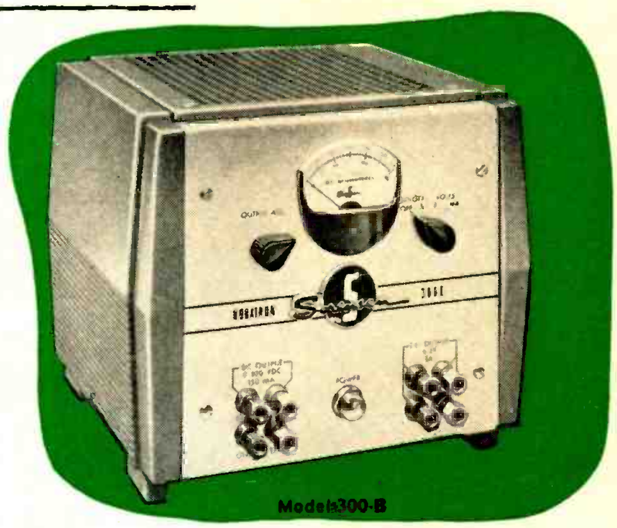
First and largest volume producer of Rolled Copper-Clad Laminates for printed circuits

TAYLOR FIBRE CO., Plants in Norristown, Pa., and La Verne, Calif.

PHENOLIC-MELAMINE-SILICONE-EPOXY LAMINATES • COMBINATION LAMINATES • COPPER-CLAD LAMINATES • VULCANIZED FIBRE

Model 610-B

new
B Power Supplies



Model 300-B

Model 300-B
Output—0 to ±300 VDC; Output Current—0 to 150 ma; Regulation Accuracy—±0.15%, or 0.3 volt if greater; Ripple (MV-RMS)—5 maximum. Series or parallel operation. Cabinet model—$225.

Model 610-B
Output 0 to ±600 VDC; Output current—0 to 1.0 amp; Regulation Accuracy—Fixed Line: ±0.15 volt for 0 to full load change, or for Fixed Load: ±0.15% or 0.3 volt if greater for 105-125 volt input change; Ripple (MV-RMS)—4 maximum. Silicon power rectifier. Independent bias supply in addition to filament currents (6.3 and 12.6 VAC). In cabinet model—$670.

HIGHER CURRENT—GREATER FLEXIBILITY—CLOSER REGULATION
All at LOWER COST in these* new *POWER SUPPLIES

These two new Sorensen "B NOBATRONS" bring a new plateau of performance to DC power supplies. They provide full range *continuous* voltage selection, from zero to maximum rating at full current . . . and the floating ground permits choice of positive or negative polarity output, extending the versatility of these improved B supplies even further. Sorensen's external sensing provision assures close control *at the load.* The current ranges of these two models are: 0 to 150 milliamps, and 0 to 1.0 ampere. Both models provide isolated filament current at 6.3 and 12.6 VAC. Printed circuit design brings all this in *light weight,* compact packages, either cabinet or rack mount—and at gratifyingly low costs too! Call your Sorensen representative for details . . . or write directly for technical data.

Sorensen

CONTROLLED POWER FOR RESEARCH AND INDUSTRY

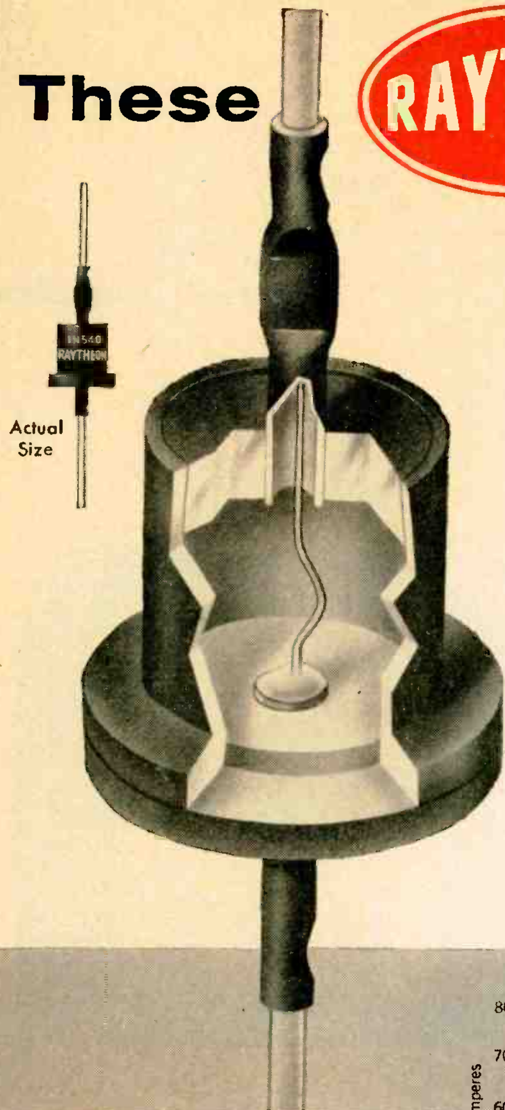
SORENSEN & COMPANY, Inc. Richards Avenue, South Norwalk, Connecticut.

CIRCLE 49 READERS SERVICE CARD

These **RAYTHEON** Reliable

SILICON RECTIFIERS

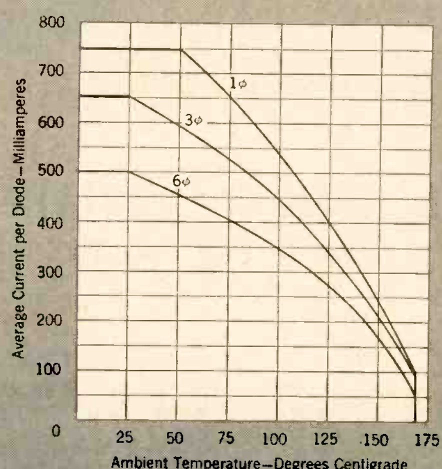
have won the confidence of users throughout the industry



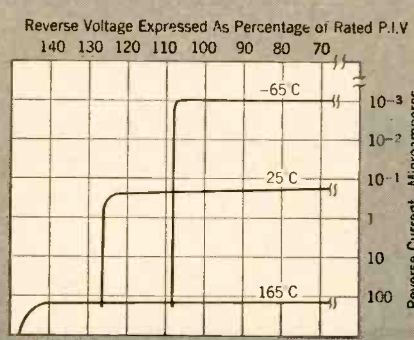
SPECIFY THEM for all missile and other highly critical applications calling for uniformly dependable performance.

Raytheon Solid State *Diffused Junction* Silicon Rectifiers provide the precise junction gradient for specific applications. They have *flat* junctions for uniform control of characteristics. Look at the charts and the tests. See for yourself why so many users have standardized on these reliable Rectifiers.

Type	Peak Inverse Volts	Average Rectified Current Amps. (150°C)	Reverse Current (max.) at PIV μA
1N537	100	0.25	2
1N538	200	0.25	2
1N539	300	0.25	2
1N540	400	0.25	2
CK844	500	0.25	2
CK845	600	0.25	2



AVERAGE CURRENT vs. AMBIENT TEMPERATURE



REVERSE CURRENT vs. REVERSE VOLTAGE

Raytheon Silicon Rectifiers easily pass these important environmental tests:

Temperature: every rectifier is cycled 8 times from −55°C to +150°C

Samples are tested for:

Mechanical Shock: 500G, 1 millisecond

Thermal Shock: −65°C to +100°C

Storage Life: 500 hours at 175°C; 500 hours at −65°C

Operating Life: 1000 hour and 4000 hour tests at 250mA, 150°C and rated PIV. 1000 hour and 4000 hour tests at 750mA, 25°C and rated PIV.

Moisture Resistance: per MIL standard 202, method 106

Salt Spray: 96 hours

Centrifugal Force: 20,000G

Vibration Fatigue: 10G

Drop: 30″ on maple block, per MIL, 19500A

Readily available in production quantities. Write for Data Sheets.

RAYTHEON SEMICONDUCTOR DIVISION

Silicon and Germanium Diodes and Transistors • Silicon Rectifiers

Newton, Mass.: 55 Chapel St., Bigelow 4-7500
New York: 589 Fifth Ave., PLaza 9-3900
Chicago: 9501 Grand Ave., Franklin Park, NAtional 5-6130
Los Angeles: 5236 Santa Monica Blvd., NOrmandy 5-4221

BUSINESS BRIEFS

ELECTRONICS NEWSLETTER

● **The Air Force** has revealed it hopes to launch a military reconnaissance satellite with a recoverable capsule by the spring of 1959. By October of this year, it is planned to put into orbit a test vehicle using the Thor IRBM.

Maj. Gen. Bernard A. Schriever, commander of the AF ballistic missiles division, told the Senate Preparedness subcommittee that the reconnaissance satellite project originated in 1946 with a contract to the Rand Corp. Although recommendations were made in 1953 to enter the systems phase of the program, he testified, this was not done until a few months ago for want of sufficient funds.

● **Russia** is still thinking big in terms of the propaganda value of satellites. **A Soviet earth satellite that can broadcast television from Moscow over a vast area of the earth looms as a strong possibility this year.**

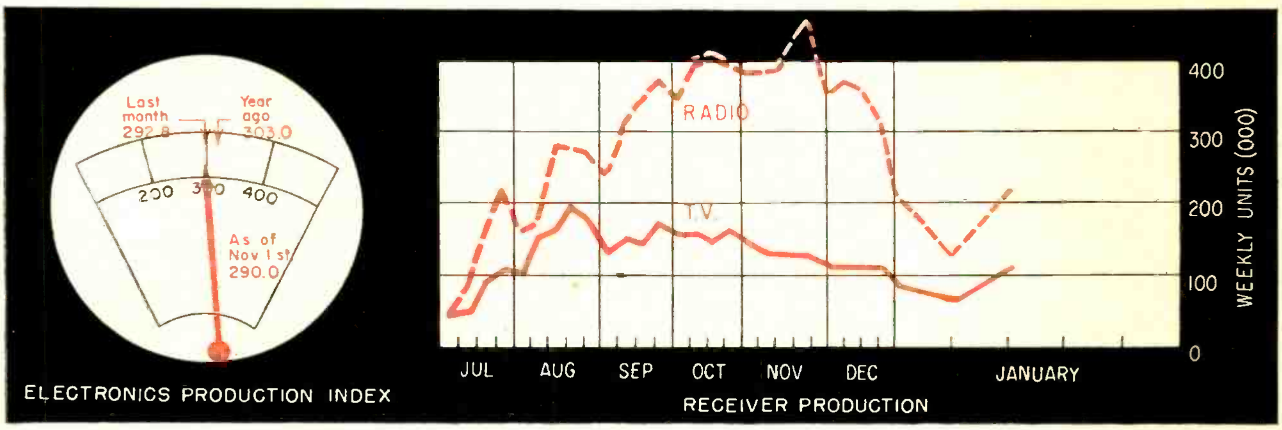
Izvestia recently quoted Prof. Katayev as stating that this year "it will be possible to receive Moscow television broadcasts not only everywhere in the Soviet Union, but also far beyond its boundaries and, in particular, in China and in the Antarctic." Katayev said the project was discussed as early as 1953.

According to the report, the Soviets will probably attempt to put their newest sputnik in orbit along the equator at or near 22,500-mi up. If it stays there, the satellite would move at the same speed as the earth's surface, and thus be "suspended" over one spot. Its tv signals would then be received all over the hemisphere facing it.

● **Aircraft and missile electronic firms** hit by contract cutbacks and stretchouts in the final quarter of 1957 can breathe a little easier. Military production orders to be placed in the first six months of 1958 are estimated at \$13.4 billion, compared to \$7.6 billion in the second half of 1957.

Production contracts for the 1958 calendar year are expected to total \$23.2 billion, up from \$17.5 billion in 1957.

● **Missile spending** alone in fiscal 1959 will add up to \$5.3 billion the President said in his budget message. With latest estimates putting electronics' share of the new ballistic missiles at roughly one-half the cost of each missile, spending for missile electronics may top \$2.5 billion in the 1959 fiscal year. Other fiscal item: \$2,075,000,000 for military research, up \$274 million.



FIGURES OF THE WEEK

RECEIVER PRODUCTION

(Source: EIA)	Jan. 10, '58	Jan. 3, '58	Jan. 11, '57
Television sets, total	114,392	61,824	118,471
Radio sets, total	216,924	127,890	268,052
Auto sets	86,570	36,789	136,836

STOCK PRICE AVERAGES

(Source: Standard & Poor's)	Jan. 15, '58	Jan. 8, '58	Jan. 16, '57
Radio-tv & electronics	44.89	45.10	47.51
Radio broadcasters	58.58	57.49	63.26

FIGURES OF THE YEAR

	Totals for first 11 months		
	1957	1956	Percent Change
Receiving tube sales	428,688,000	429,846,000	— 0.3
Transistor production	25,965,000	11,232,000	+131.2
Cathode-ray tube sales	9,076,982	10,191,545	— 10.9
Television set production	5,825,804	6,760,045	— 13.8
Radio set production	13,634,402	12,266,591	+ 11.2

LATEST MONTHLY FIGURES

EMPLOYMENT AND PAYROLLS

(Source: Bur. Labor Statistics)	Oct. '57	Sept. '57	Oct. '56
Prod. workers, comm. equip.	412,000-p	417,900-r	413,100
Av. wkly. earnings, comm.	\$76.44 -p	\$78.40 -r	\$78.12
Av. wkly. earnings, radio	\$74.40 -p	\$76.02 -r	\$75.70
Av. wkly. hours, comm.	39.0 -p	40.0 -r	40.9
Av. wkly. hours, radio	39.0 -p	39.8 -r	40.7

TRANSISTOR SALES

(Source: EIA)	Nov. '57	Oct. '57	Nov. '56
Unit sales	3,578,700	3,544,000	1,829,000
Value	\$6,989,000	\$7,075,000	\$5,559,000

TUBE SALES

(Source: EIA)	Nov. '57	Oct. '57	Nov. '56
Receiving tubes, units	39,950,000	47,075,000	39,489,000
Receiving tubes, value	\$33,166,000	\$38,421,000	\$31,476,000
Picture tubes, units	772,801	995,629	957,765
Picture tubes, value	\$15,138,438	\$19,495,574	\$16,014,839

AF: $1½ Billion To Small Firms

FORT WAYNE, IND.—IN FISCAL 1957, small business organizations, such as abound in the electronics industry, got $1½ billion of $8¾ billion total Air Force procurement. The small-business figure includes $723 million in prime contracts.

So said Dudley C. Sharp, Assistant Secy. of the Air Force, Materiel. He spoke here recently at open-house ceremonies at the Bowmar Instrument plant.

Sharp said the $723 million in prime contracts "represents only about 8.2 percent of total, but through subcontracting, small business participates in much more." Small companies eventually received 21.5 percent of $8 billion paid 88 large contractors.

Regarding apparent slow progress in tactical air defense, Sharp said it is sometimes better to "make haste slowly" rather than push into production of incompletely developed aircraft.

As to criticism of lack of cooperation among services, Sharp said there is cooperation, especially in the materiel field. Army uses Air Force developed engines in Jupiter missiles. Sidewinder and Talos, developed by Navy, are used by Air Force. Responsibility for Talos was recently transferred to Army. In developing the B-66, Air Force received benefits from Navy-developed A-3D.

Sharp said some critics have proposed a separate service of supply. "To me, this is not the answer. A single-supply approach would make systems that are already huge and unwieldly three times as huge."

Regarding "negotiated" versus "advertised" contracts Sharp said procurement by formal advertising is preferred by law.

"We use this method as much as possible, we are trying to do even more. In many cases, however, negotiated contracts are necessary," he said. Examples are aircraft, missiles, support equipment, projects such as DEW line and SAGE. In numbers alone these items represent small percentage of total items, but comprise most of dollar value.

On inertial guidance, Sharp be-

WASHINGTON OUTLOOK

MOST of Washington's bigwigs are getting involved in the furor over the future course of U.S. research and development.

The biggest fuss is over the military programs—those in which electronics is most involved. Total military R&D spending for fiscal year 1959, beginning next July 1, will be up to about $2 billion; the electronics portion of this is figured to be about one-fourth or $500 million. The new plans call for an estimated 10-percent boost over this year.

But the size of the increase isn't enough to satisfy the Administration's critics, inside or outside the Pentagon. Hence, the so-called revolt of the generals: among them Lt. Gen. James M. Gavin, the now-resigned Army chief of research and development; Air Force Chief of Staff, Gen. Thomas D. White; Maj. Gen. Bernard Schriever, Air Force ballistic missile development chief; Maj. Gen. John Medaris, Army ballistic missile development chief; and Rear Adm. Hyman G. Rickover, the atomic submarine czar.

Here are the overall R&D budgets the services are fighting over (in millions of dollars); electronics share: about ¼

	FY 1958	FY 1959
Air Force	$730	$730
Navy	573	605
Army	450	460
Advanced Research Projects Agency	5	199
Total R&D	$1,758	$1,994

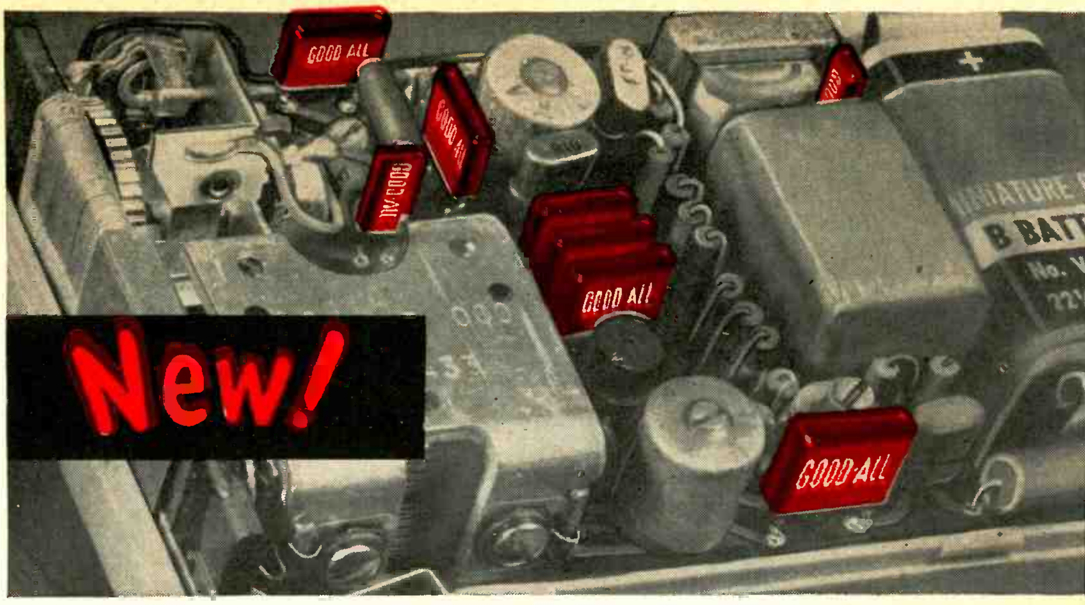
Gen. Gavin was the first to lay his feelings on the line: "I couldn't in good conscience" defend the R&D budget before Congress; it shows "No significant improvement" over "the present inadequate program."

The other generals spoke in more or less the same vein—directing their fire to both R&D programs and to what they feel are inadequate funds to get new ballistic missiles into production as quickly as possible. The new Advanced Research Projects Agency (ARPA) is the first step of Defense Secretary McElroy and Eisenhower to put the responsibility for the development of space-age weapons—the anti-missile missile, for instance—into an agency without ties to any service.

The uniformed R&D chiefs see that the administration is counting on ARPA expanding from a $5 million to a $200-million R&D shop in a single year. And they see their services getting a dwindling program each year while the new baby grows swiftly to crowd them.

Congress is going to have a say, of course, on how the squabble over money and organization of R&D is resolved.

- One powerful reorganization lever he wants isn't likely to be voted to the President. That's his request for authority to take money allocated to one service for a program and switch the money and program to another service. Eisenhower wants this authority up to a $2-billion ceiling. This means Eisenhower could put all R&D in one service—or put it all into a separate agency. This isn't likely, but this hypothetical example shows potency of the $2-billion authority to shift funds.



GOOD-ALL

TYPE

601PE

"SLIM LINE"

SPACE SAVING CAPACITOR
...tailored for transistors

SLIM LIKE A DISC... Wafer-thin shape of the Good-All 601PE makes it ideal for upright mounting in tight spaces.

EXCELLENT TEMPERATURE STABILITY... The TC of the 601PE is identical with that of a conventional tubular capacitor.

MOISTURE TIGHT EPOXY COATING... This tough, durable epoxy has exceptionally high dielectric strength and lead entries are tightly sealed.

ECONOMICAL... Competitive in price with ceramic discs in the capacity range of 0.1 MFD and above.

*DuPont's trademark for polyester film.

TYPE **601PE** DIMENSIONS
(FOR 50 VDC RATING)

CAP. (MFD.)	A	B	D	E	CAP. (MFD.)	A	B	D	E
.01	.310	.800	.187	.187	.1	.650	.850	.375	.225
.022	.359	.800	.187	.187	.15	.671	.900	.375	.260
.033	.531	.650	.312	.171	.22	.718	.900	.375	.296
.047	.531	.700	.312	.203	.33	.812	.950	.500	.312
.068	.531	.781	.312	.218					

SPECIFICATIONS

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

Capacity Tolerance—Standard tolerance is 20%.

Winding Construction—Extended foil (non-inductive) MYLAR* Dielectric.

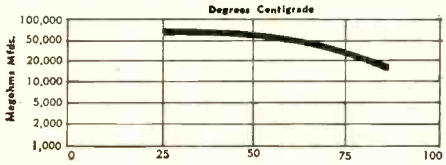
Lead Variations— Formed or straight leads.

Dissipatin Factor—Less than 1% at 1,000 cycles per second at 25° C.

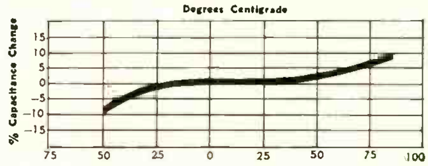
Dielectric Strength—100 volts D.C. for 1 to 5 seconds thru a minimum current limiting resistance of 20 ohms per volt.

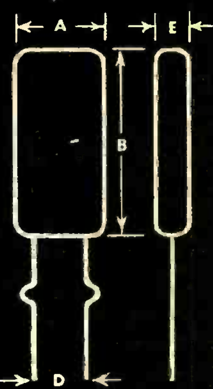
Temperature Range—May be operated at full rated voltage to 85° C. Derate to 50% when operating at 125° C.

Insulation Resistance vs. Temperature



Capacitance Change vs. Temperature



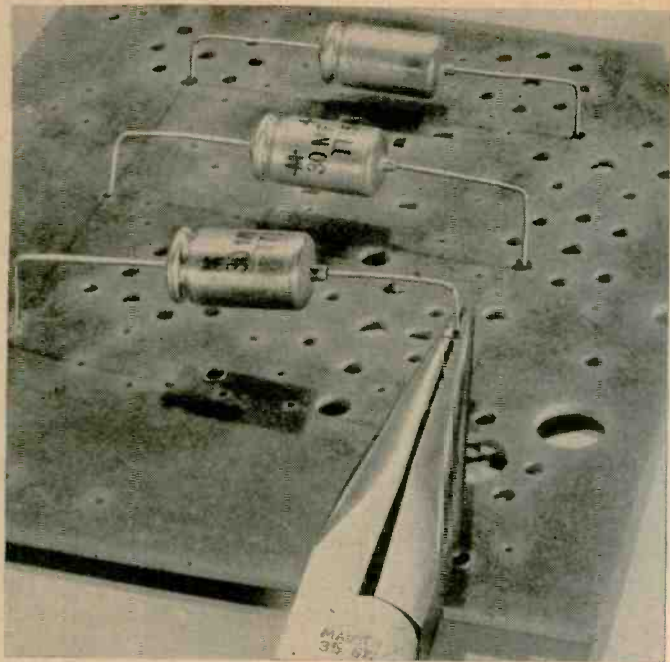


CRIMPED LEAD STYLE

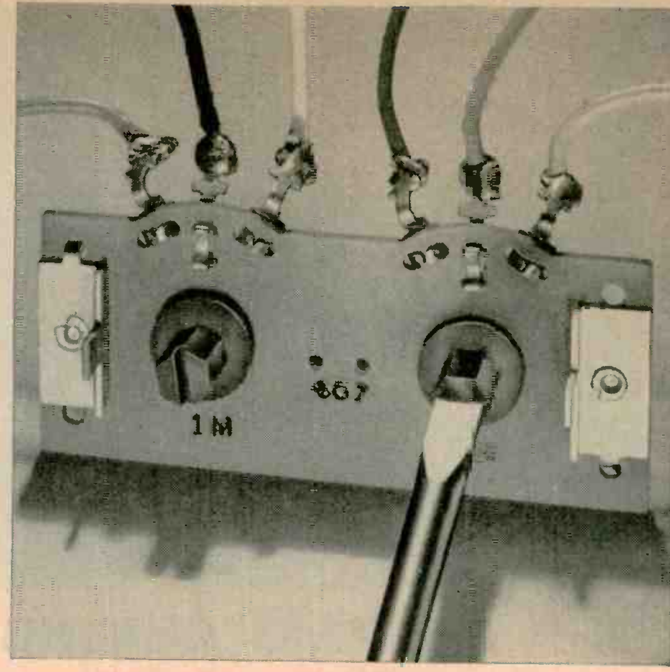
TECHNICAL BROCHURE AVAILABLE ON REQUEST

MANY GOOD-ALL CAPACITOR TYPES ARE NOW AVAILABLE AT YOUR LOCAL DISTRIBUTOR

GOOD-ALL ELECTRIC MFG. CO.
OGALLALA, NEBRASKA



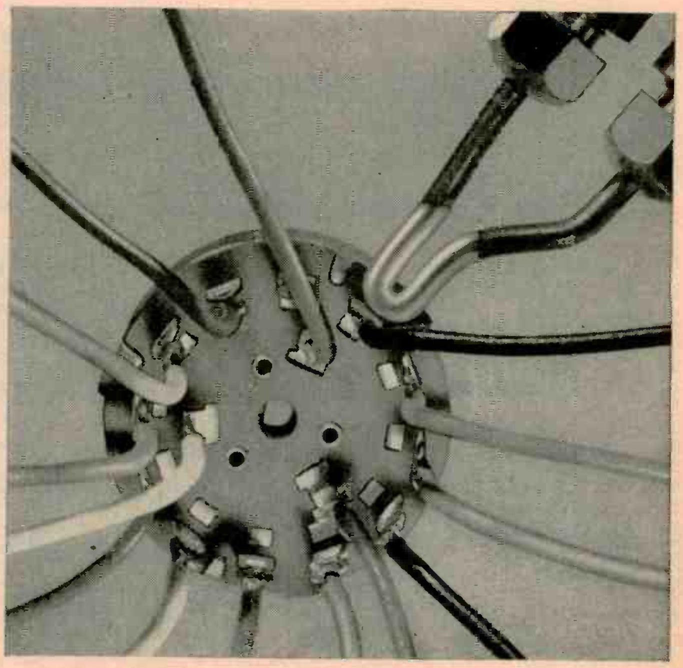
Leader in electrolytic capacitors, Mallory introduced the first electrolytics . . . the first 85° C capacitor, the Mallory FP . . . and the first high-temperature tantalum capacitor. In recent years, Mallory has been in the forefront of progress in miniature capacitors, including those shown here . . . the first miniature electrolytics economically priced for commercial use; plus a complete line of subminiature tantalum models.



Economical strip-type controls cut manufacturing costs . . . are just one of many special Mallory designs of carbon volume controls including models for use with printed circuits, with low hop-off resistance for transistor circuits, with convenient push-pull switch. Mallory precision made wire-wound resistors include a full line of controls and vitreous enamel, cement-coated and axial lead fixed resistors.

Get More From Mallory...

Pioneer in vibrators, Mallory introduced the first commercial vibrator over 25 years ago . . . has produced more than all other manufacturers combined. Latest models incorporate unique contact engineering concepts for extremely long life and dependability, and with practically zero mechanical hum. Many models for auto radio and communications service.



Special electronic components include a wide selection of wafer and push-button switches, and a series of jacks and plugs including types for communications and military uses. The famous Mallory Inductuner, a high precision variable inductance tuning element, gives superior front-end performance in VHF and UHF bands.

.... *More Precision Products . . . More Engineering Assistance*

In the Radio and Television Industry, *for example . . .*

FROM the r-f "front end" to the power supply, Mallory offers radio and television manufacturers a broad line of precision-made components . . . and skilled engineering assistance in their applications.

Batteries, capacitors, controls, resistors, switches, vibrators and tuning devices—all these products of Mallory represent the knowledge of more than thirty years of creating and manufacturing special components that have contributed greatly to electronic progress.

We at Mallory are privileged to have been among the pioneers of the radio and television industry, and to have had a part in its spectacular growth. Among our contributions have been some notable "firsts"—the first commercial vibrator, the first 85° C electrolytic capacitor, the first mercury battery. Today, you can get from Mallory the most diversified line of components, made under a tradition of precision design and workmanship unequalled in the industry.

Because the Mallory line is so varied and inclusive, you can depend on Mallory for engineering assistance that extends across the application of many related components in your specific radio or television circuit. Not merely specialists in a few components, but well experienced in many, our staff can lend valuable help to your designers in achieving peak over-all performance and economy. We'll welcome the opportunity for a consultation—just call or write Mallory today.

Serving Industry with These Products:

Electromechanical — Resistors • Switches • Tuning Devices • Vibrators
Electrochemical — Capacitors • Mercury and Zinc-Carbon Batteries
Metallurgical — Contacts • Special Metals • Welding Materials

P. R. MALLORY & CO. Inc.
MALLORY
P. R. MALLORY & CO. Inc., INDIANAPOLIS 6, INDIANA

CIRCLE 4 READERS SERVICE CARD

lieves eventually pure-IG systems will be satisfactory, but they won't be the only type used. Now some missiles use radio guidance initially, are programmed for evasive action later in flight. "We hope to get away from the radio, away from the jamming possibilities", he said.

Fast-Scan Radar Has Long Range

WATCH for a new technique in pulsed radar that permits faster scanning and faster pulse repetition rates with no loss in resolution or range. The rates far exceed those possible with conventional systems.

ELECTRONICS learns this week that the technique has been developed by the W. L. Maxson Corp. The firm did it with its own funds.

How the technique, designated Fastar, accomplishes this is proprietary information.

Certain facts concerning Fastar are, however, known. ELECTRONICS can report:

The system uses a big antenna which scans electronically in one or both dimensions. Long range and rapid scanning are both achieved with a minimum of mechanical problems. Other radars must scan at slow rates to avoid missing objects at great distances.

Rapid pulse repetition rate permits good resolution. The short pulse duration allowed by the multiplicity of signals sent out results in good range accuracy.

Other advantages Fastar has are simplified track-while-scan as well as 3-dimensional data information capabilities. Again due to Fastar's unique capability of fast pulse repetition rate that does not sacrifice range, the necessary peak power is reduced while increasing average power.

Applications of Fastar revealed by Maxson involve long range: ground control intercept, ground control approach, air traffic control, and early warning networks.

Some details of the new technique will be discussed in a paper by the inventors, Elliot L. Gruenberg and Murray Simpson of Maxson, at a classified symposium at Michigan University next week.

MILITARY ELECTRONICS

• **Guidance system** for North American's WS-110, bomber, will be stellar-inertial auto navigation. Designated the ASQ-28, the inertial system will be oriented by a daylight star tracking device.

The intricacies of weapons systems management have arrived at an interesting situation in the case of the ASQ-28. IBM is responsible under government prime contract for the entire system. Autonetics, a div. of North American, will supply IBM under subcontract the system's N2J star tracker. The government will turn the entire system over to North American as government furnished equipment.

N2J is similar to the N2C and N2F star tracking equipment, developed by Autonetics for precision missile navigation under the Navaho and Snark programs.

• **Army** has orders to begin top priority development of a solid-fueled ballistic missile, the Pershing, to succeed the liquid-fueled Redstone. New missile will be smaller, and lighter, than Redstone. Contractual arrangements have not been announced.

• **Nike-Zeus,** anti-missile missile project, gets additional $28 million push via Army R & D contract to Western Electric.

• **Military electronics** for missiles, advanced early-warning and countermeasure systems may top $4.2 billion in 1958, says GE Defense Electronics division general manager George L. Haller.

Third and fourth quarters of the year should see the effect of military electronics expenditures on industry employment, he says, with GE's 21,000 employment level at the company's defense electronics plants expected to be maintained until the second half.

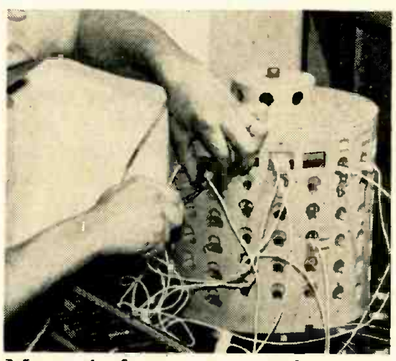
• **Propellant-loading computer** for Thor will be provided by United Control Corp. under contract with Douglas. The computer calculates the amount of fuel required for the missile's flight program and carries out the complete fueling sequence automatically.

• **Atlas, Titan, Thor, Jupiter** and Polaris will account for nearly one half of the missile program appropriations for fiscal 1959, according to President Eisenhower's budget message to Congress.

• **Improvement of Army combat** surveillance techniques will be studied over a two-year period in Washington by 35 Cornell Aeronautical Lab scientists and engineers and an equal number of personnel from Army Combat Surveillance Agency.

The contract, awarded by the Signal Corps to CAL, aims at improving battlefield surveillance systems by radar, infrared, sonic, meteorological, reconnaissance, photographic and televisional means.

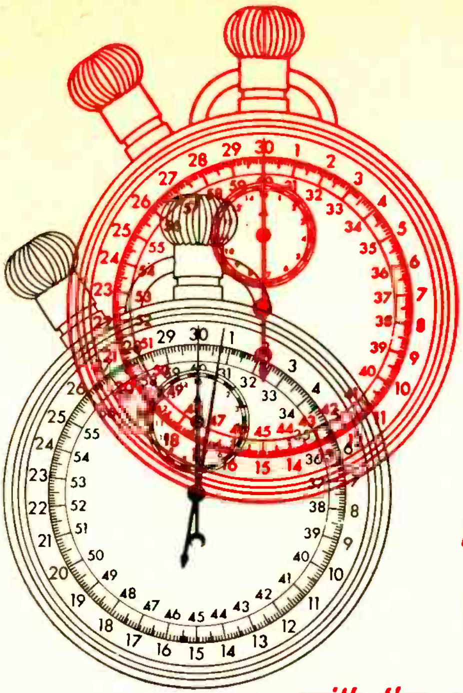
New Computers Announced



Magnetic drum memory of process-control computer has 62 tracks each capable of storing 128 words

COMPUTERS MAKING NEWS last week included a core-memory device for small-business billing operations and a transistorized unit for industrial process control. Selling price is a prominent feature of both devices.

Typing calculator—Human error and paper work inherent in invoice and order preparation may be reduced by IBM's 632 electronic typing calculator. The unit, basically an electric typewriter and small digital computer can be programmed to add, subtract, multi-



INSTANTLY...

measure and supply DC voltages to 0.02%

with the new KIN TEL DC voltage standard and null voltmeter

LABORATORY ACCURACY. The Model 301 is an extremely compact and accurate variable DC power supply and calibrated null voltmeter. It employs KIN TEL's proved chopper circuit to constantly compare the output voltage against an internal standard cell. As a DC voltage standard, it combines the stability and accuracy of the standard cell with the current capabilities and excellent dynamic characteristics of the finest electronically regulated power supplies. The self-contained null voltmeter indicates the voltage difference between the supply in the 301 and the DC source being measured, affording simple and rapid measurement of DC voltages to an accuracy of 0.02%.

PRODUCTION LINE SPEED. DC voltage measurements can be made as fast as changing ranges on a VTVM. Merely set the direct reading calibrated dials on the 301 to exactly null out the unknown DC input voltage. The reading on the dials then indicates the value of the unknown input voltage to within 0.02%. As a variable DC standard or power supply, the calibrated dials provide instant voltage selection to an accuracy normally attained only with standard cells.

VERSATILITY. The KIN TEL Model 301 is ideal for rapid and accurate production calibration of precision measuring instruments and DC power supplies . . . design of DC amplifiers and complex electronic circuitry . . . computer reference . . . versatile precision reference for calibration and measurement laboratories.

0.01% stability

0.02% accuracy

1 to 501 volts at 20 ma

4 accurate null ranges

0.002% regulation

Less than 100 μv ripple

IMPORTANT SPECIFICATIONS

Output Voltage & Current	1 to 501 volts at up to 20 ma
Full Scale Meter Ranges (Zero Center)	
DC Output Range	±500, 50 volts
DC Input Range	±500, 50 volts
DC Null Meter Range	±50, 5, 0.5, 0.05 volts
Long Time Stability	±100 parts per million
Output Voltage Calibration	±0.02% or 2 mv
Output Hum and Noise	Less than 100 μv RMS
Line and Load Regulation	0.002%
DC Output Impedance	Less than 0.01 ohm
Response Time	0.2 millisecond

Model 301 Price $625.

Representatives in all major cities. Write today for demonstration or descriptive literature.
5725 Kearny Villa Road, San Diego 11, Calif., BRowning 7-6700

KIN TEL
(KAY LAB)

CIRCLE 5 READERS SERVICE CARD

round off, position decimals carry totals. Also it will justify git numbers and type an- matically.

are prepunched on Tapes can be changed in fiftee ds by the typist.

In-field tes show a typist can learn the computer in 15 minutes. Quoted sale price is $5,600, with expected delivery in 120 days.

Expected market potential for first year is 1,000. Bulk of the market is expected to be small and medium size businesses.

One new development in the computer involves logic circuits—details were not revealed.

Process Controller—Greater yield, better plant quality control and reduced operating costs are chief selling points of the RW-300 process control computer recently demonstrated by Thompson-Ramo-Wooldridge Products, Inc. The manufacturer has a test installation at the Texas Company's Port Arthur petroleum refinery. The computer controls the refinery's polymerization unit.

The basic computer including an automatic typewriter, paper tape punch and punch tape reader will sell for $98,000. It won't be rented.

Style '58 Key In Hi-Fi, Tv

CHICAGO—RADIO, HI-FI, and tv manufacturers are still examining results of a trade show held here at the Merchandise Mart to see the directions home entertainment will take during the coming year.

Exhibitors are unanimous in their opinion that styling is the big thing for 1958. The term "planned obsolescence through styling" was heard in more than one display booth.

Portable tv sets, convertible units, and printed circuit sets, some featuring transistorization, are all subjects of attention as the market for replacements and second sets is sought after.

Color tv is expected to see about 30-35 percent increase in sales.

A-m radio receives its share of attention in such forms as fully transistorized portables, car radios, and new-style clock radios.

FINANCIAL ROUNDUP

• **Fairchild Graphic Equipment**, Plainview, Long Island, N. Y., purchases assets of **Teletypesetter Corp.** of Chicago. Fairchild Graphic is a subsidiary of **Fairchild Camera and Instrument**, while Teletypesetter is is a jointly-owned affiliate of **Western Union** and the Gannett newspaper-broadcasting organization. Teletypesetter produces automation equipment for newspapers and printing plants. Fairchild Graphic produces electronic photo-engravers. Purchase included inventory and tools of Teletypesetter as well as temporary use of its Chicago plant until operations can be integrated with Fairchild Graphic.

• **Ramo-Wooldridge** and **Thompson Products** jointly announce formation of a new subsidiary, **Thompson-Ramo-Wooldridge Products, Inc.** Its headquarters will be in the Ramo-Wooldridge center in Los Angeles and it will specialize in industrial control products. The first product is the RW-300 digital process control computer, currently being installed at Port Arthur, Tex., for the Texas Co.

• **Van Norman Industries**, New York City, acquires **Digit-Ometer** of Denver, Colo. Van Norman paid cash and stock, plus percentage of future sales; but no amounts were disclosed. Acquisition included patents, applications, inventory, tools and dies; but no employment contracts were involved. The new business will be added to **Van Norman's Electronics Division** at Manchester, N. H. Digit-Ometer makes the Cal-Ke Punch, an electro-mechanical accounting machine designed to bridge the gap between manual and automatic accounting operations.

• **Columbus Electronics Corp.**, Mount Vernon, N. Y., issues 110,000 shares of Class A common stock at $2.50 per share. The Mount Vernon firm manufactures specialized electronic components and assemblies for military and industrial users. The new money will be used for machinery, equipment and working capital required for planned expansion into semi-conductors, primarily silicon diodes and transistors. Fee of underwriters, Mortimer B. Burnside & Co. and McLaughlin, Cryan & Co. of New York City, is 45¢ per share plus option to buy 10,000 Class A shares at 10¢ per share.

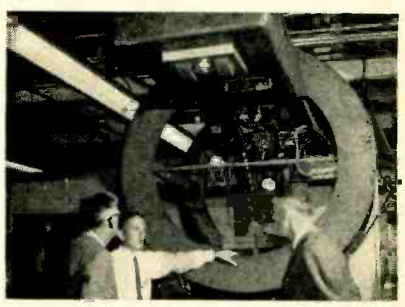
• **Controls Company of America** buys **Hetherington, Inc.** of Folcroft, Pa. CC will exchange 65,000 shares of its common stock for all of Hetherington common

Urge More Nuclear Gear

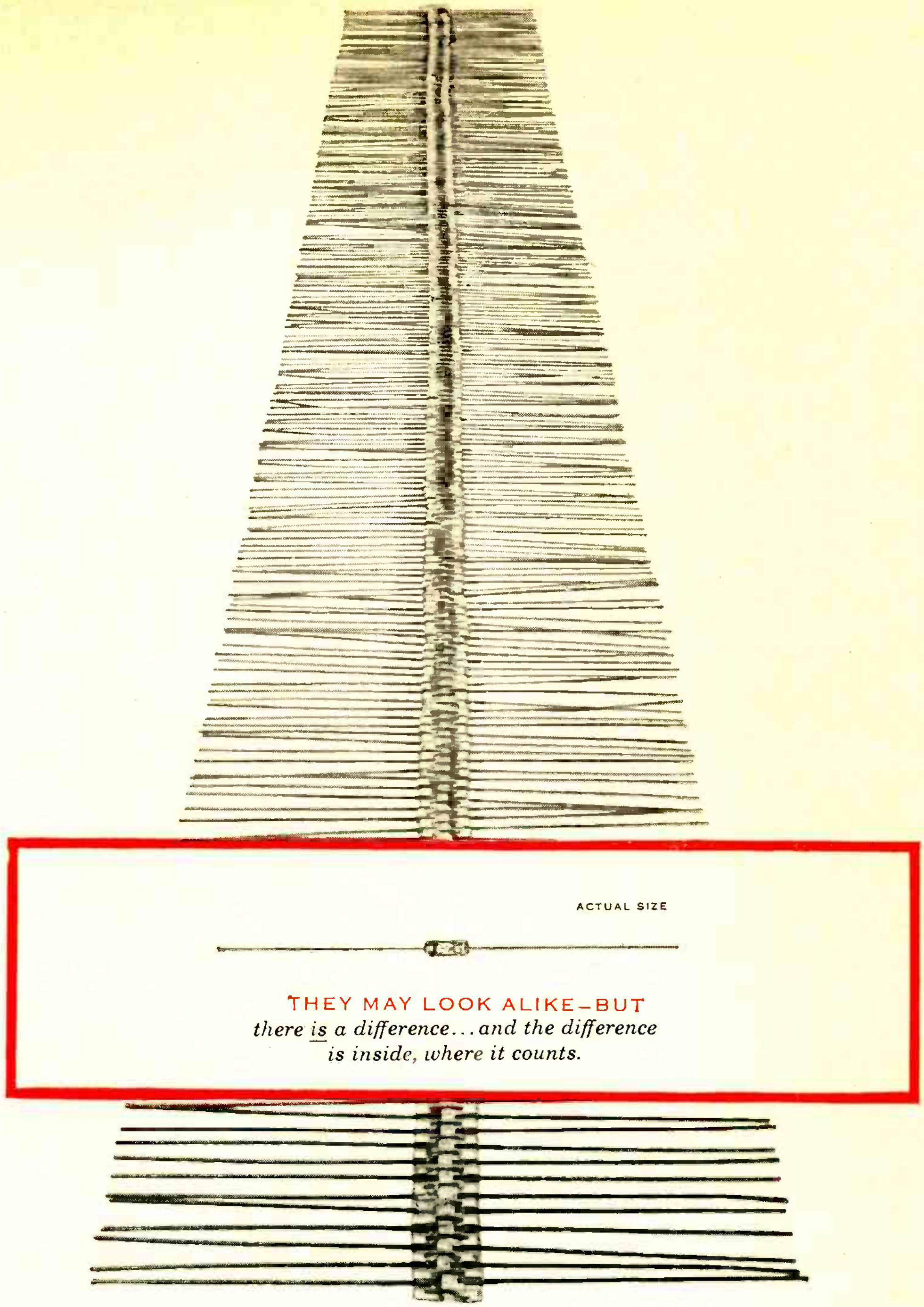
BOSTON—NUCLEAR engineers are challenging electronics designers to come up with simple, reliable instrumentation to meet the demands of high radiation fields.

"We have not been successful in procuring a reliable position indicating device for use in the MIT reactor core," Edward Profio told the Yankee Instrument Fair and Symposium in Boston in mid-January.

MIT's research reactor will be completed in March. The indicator would tell when a control rod has returned to the "down" position in the core. Sought is a device which would operate for at least two years, under heavy water and in a high radiation field, without maintenance.



Huge deflection unit magnetically bends, focuses beams from 50 million electron volt linear accelerator



All Hughes diodes resemble each other—externally. Germanium point-contact or silicon junction, they are all glass-bodied* and tiny (maximum dimensions: 0.265 by 0.107 inch). But minute, meticulously controlled variations in the manufacturing process impart individual characteristics to the diodes, make them just right for specific applications. This gives you the opportunity of selecting from a line which includes literally hundreds of diode types.

So, when your circuitry requires varying combinations of such characteristics as...high back resistance...quick recovery...high conductance...or high temperature operation, *specify Hughes.* You will get a diode with mechanical and electrical stability built in. You will get a diode which was manufactured first of all for reliability.

*Nowhere else have glass packaging techniques been developed to a comparable extent, for the Hughes process has many unique aspects. They are difficult to duplicate, yet are instrumental to the manufacture of diode bodies which are completely impervious to contamination and moisture penetration.

For descriptive literature please write: SEMICONDUCTOR DIVISION, HUGHES PRODUCTS
International Airport Station, Los Angeles 45, California

HUGHES
SEMICONDUCTORS

Creating a new world with ELECTRONICS

HUGHES PRODUCTS

Magnetic Disk Delivers 12-v

NEW DISK MEMORY with magnetic storage medium in its radial spokes promises to simplify design of small digital computers. Such a magnetic memory has been developed at Burroughs Research Center, Paoli, Pa. The storage medium is composed of a plated alloy of nickel and cobalt.

Each segment of a spoke stores one bit. Since there is no magnetic material between spokes, a signal is obtained from both a recorded ONE and a ZERO. Timing pulses can be derived from any information track instead of using a separate track for timing.

High remanance flux of the alloy, large track width, thick magnetic layer and sharp boundaries of the plating permit a readback signal of 12 v. An air guiding method for achieving small head-to-disk spacing contributes to the large signal output.

To provide a simple read-write circuit the magnetic head itself is the transformer of a blocking oscillator. The oscillator is triggered by the induced voltage in one of the head windings. Grid bias is applied as a pedestal pulse to the blocking oscillator. The oscillator is triggered by a positive pulse at the leading edges of the magnetic spokes on the disk. It ignores those at the trailing edges. Thus the oscillator is triggered by a stored ONE but not by a ZERO.

Wraps Off Thor's Guidance

MILWAUKEE—Last week, General Motors' AC Sparkplug division took the wraps off a hitherto top-secret inertial guidance system. The system recently dropped an Air Force Thor IRBM within two miles of a target 1,200 miles from its Cape Canaveral launching pad. The GM inertial guidance system is also to be used in Navy's Regulus II and an improved version of Air Force's Matador—both air-breathing subsonic missiles.

According to GM executives, the guidance for Thor costs 25 percent of the overall missile—reputed to be between \$1 and \$2 million each. Half the guidance cost is for electric circuits although electronic circuits take up $\frac{3}{4}$ of the guidance space in the missile. Biggest single cost item in guidance: machining the gyros.

Thor's guidance comes in two parts: a hemispherical gimbal containing six precision gyros, air-cooled during flight, and a four-ft- high by 24 in. square pallet containing the electronic circuits.

Heart of the system is a tuning fork or crystal-controlled frequency standard accurate to 1 part in 100,000. The frequency standard controls the power for the 12,000-rpm gyro motors. With this control, the 1-g system is accurate enough to sense rotation of a wheel moving only 1 rpm in 14 years. It is 100 times as accurate as needed to put a satellite into an orbit. It could guide a rocket to the moon and back again.

The electronic pallet is an aluminum honeycomb sandwich containing hundreds of tubes and transistors. Here are some of the units: electronic stabilizer (analog computer); inverter control, junction box; accelerator circuits (analog computer); rotating inverter; telemetry unit (used in test firings only); computer electronics; computer servo; precision power supply; and torque exciter. Accuracy of computer error-correction loop is 1/100 of 1 percent.

GM engineers stress that Thor's guidance is pure inertial. Telemetering is used only for test firings as is the radio destructor link.

MEETINGS AHEAD

JANUARY						
S	M	T	W	T	F	S
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	

FEBRUARY						
S	M	T	W	T	F	S
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2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	●	21	22
23	24	25	26	27	28	

MARCH						
S	M	T	W	T	F	S
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9	10	11	12	13	14	15
16	17	●	19	20	21	22
23/30	24/31	25	26	27	28	29

Feb. 2-7: Committee on Television and Aural Broadcast Systems, Technical Papers, Hotel Statler, New York City.

Feb. 3-7: American Institute of Electrical Engineers, Winter General Meeting, Hotel Statler, N. Y. C.

Feb. 14-15: Cleveland Electronics Conference, Fifth Annual, IRE, AIEE, ISA, CPS, Masonic Auditorium, Cleveland, Ohio.

Feb. 18: Fourteenth Annual Quality Control Clinic, Rochester Society for Quality Control, War Memorial, Rochester, N. Y.

Feb. 20-21: Conf. on Transistor and Solid State Circuits, PGCT, AIEE, Univ. of Penn., Phila., Pa.

Mar. 3-7: Pittsburgh Conference on Analytical Chemistry and Applied Spectrography, Penn-Sheraton Hotel, Pittsburgh.

Mar. 16-21: Nuclear Eng. & Science Congress, PGNS, EJC, ANS, Palmer House, Chicago, Ill.

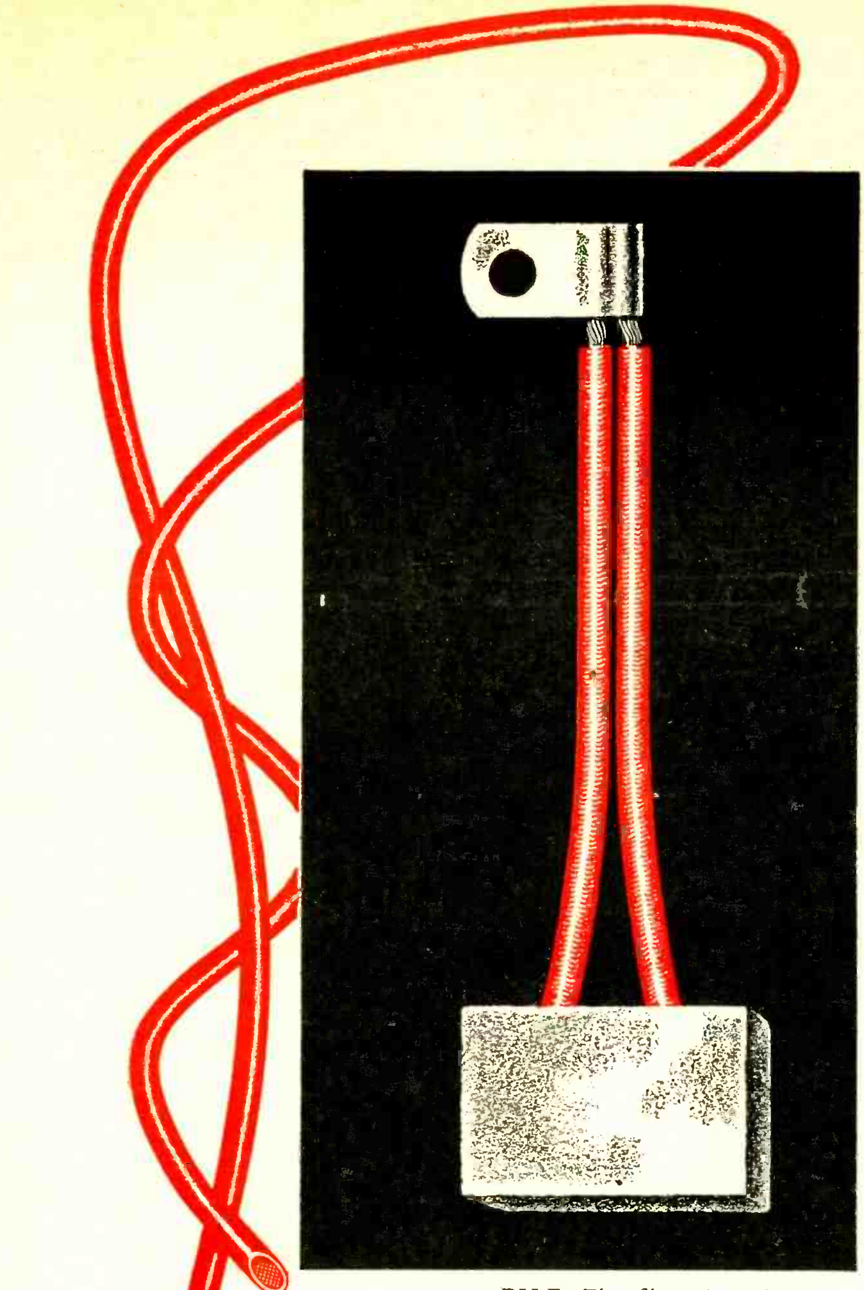
Mar. 17-21: 1958 Nuclear Congress, Engineers Joint Council, AICE and Atom fair, Atomic Industrial Forum, International Amphitheatre, Chicago, Ill.

Mar. 18-19: Conf. on Extremely High Temperatures, AFCRC, Air Force Cambridge Research Center, Bedford, Mass.

Mar. 24-27: Fourth International Instrument Show, Caxton Hall, Westminster, London, S. W. I.

Mar. 31-Apr. 2: Instruments & Regulators Conf., PGAC, ASME, ATCHE, ISA, Univ. of Delaware, Newark, Del.

Mar. 31-Apr. 2: Southwest District Meeting of AIEE, Mayo Hotel, Tulsa, Oklahoma.



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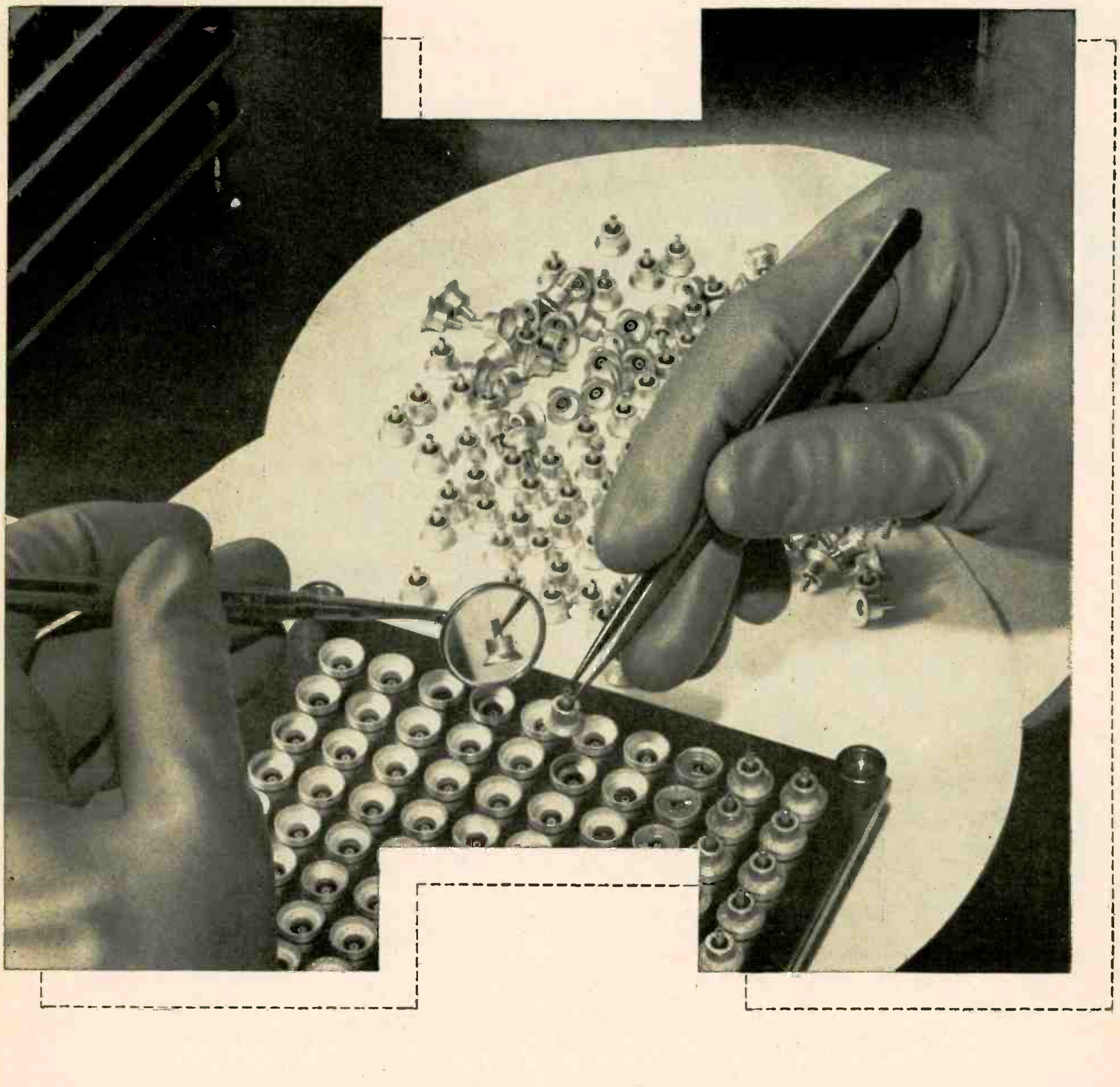
"INCUBATOR BABIES"



WITH A LONGER LIFE-SPAN

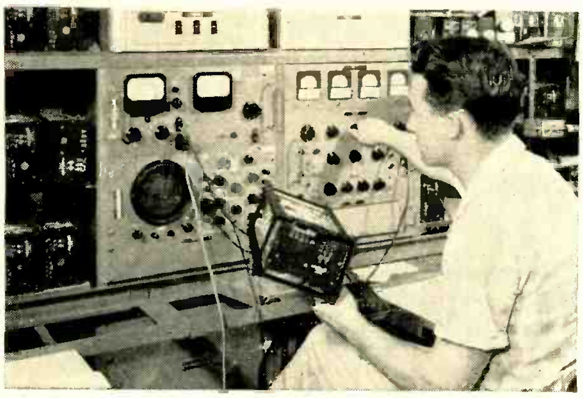
Reliability . . . one of the electronics industry's most pressing problems. Today, a system must not only work efficiently—it must often perform operations under highly adverse conditions.

Hughes Products, the commercial activity of Hughes, markets a wide variety of reliable systems and components to industry . . . ranging from semiconductor devices, electron tubes, instruments and electro-mechanical components, to control systems. In order to establish tight quality control, all functions—research and development through manufacturing—are performed by Hughes Products personnel.

One important phase in producing reliable products is careful control at each step in the manufacturing process. The assembly of the tiny Hughes transistors shown at left, for example, is carried out under glass in a dust-free, moisture-free atmosphere. The care given these "incubator babies" assures the quality needed for reliable performance.

Reliability is given high priority in *every phase* of the Hughes operation. Years of study and experiment—in research, development, and manufacturing—have given Hughes electronic armament systems, radar warning systems, guided missiles, and commercial electronics products a reputation for high standards of performance under all kinds of conditions.

The constant advance of Hughes into newer and more challenging fields benefits the present and prospective employee by assuring him an opportunity to progress with a leader in his field.



Precise evaluation of highly complex electronics armament systems requires that manufacturing engineers design and develop test equipment frequently as complex as the system being tested.

Setting the stage for new product developments, the Hughes Research & Development Laboratories delve into basic theory. Here R & D engineers work with a slot-array microwave antenna.

Highly rewarding positions are now open for experienced engineers, including the areas of:

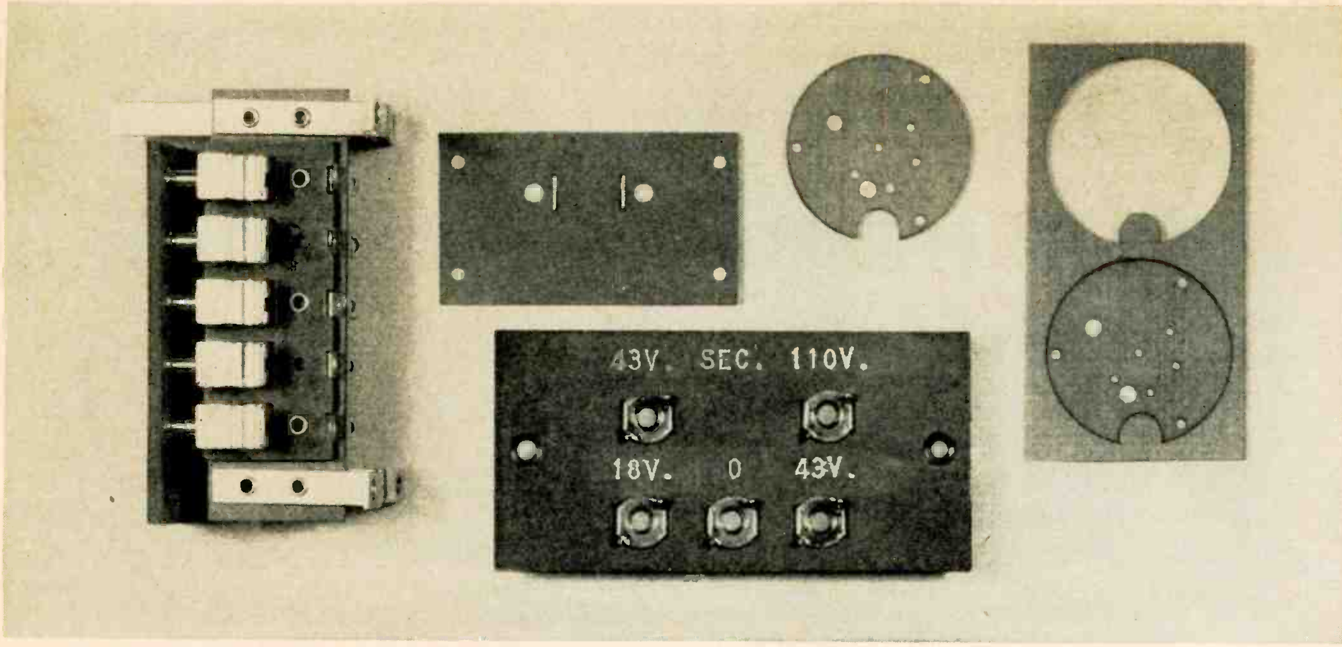
Circuit Design	Systems Analysis
Reliability	Semiconductor Applications
Microwaves	Semiconductor Sales
Computers	Solid State Physics

Write, briefly outlining your experience to Mr. Phil Scheid, Hughes Personnel, Bldg. 17B, Culver City, California.

Creating a new world with ELECTRONICS

HUGHES

HUGHES AIRCRAFT COMPANY
Culver City, El Segundo
and Fullerton, California
Tucson, Arizona



LEADING MANUFACTURERS USE VULCOID. For a punched timer-switch part that operates in oil; for arc chutes in circuit breakers; for the insulation and structural part of an auto-headlight dimmer switch; for a formed electrical switch part carrying 110-volt 60-cycle current; for a mass-produced, 110-volt light-socket part—for these and many more Underwriters-approved parts, CDF Vulcoid is an effective, economical insulation material—good where neither plain fibre nor plain phenolic laminate would suffice.

Fibre gives it high arc-resistance . . .
Aniline resin gives it moisture-resistance

CDF VULCOID

resin-impregnated vulcanized fibre

Vulcoid® is *different.* To the electrical properties of vulcanized fibre we've added the low moisture-absorption of an aniline-type resin with an unusual affinity for cellulose fibers—*all at low cost.* Excellent moisture-resistance (two to four times that of plain vulcanized fibre) helps stabilize Vulcoid's excellent electrical insulating characteristics. Its low cost makes Vulcoid a fine production material for applications of moderate electrical requirements.

Underwriters' approval. Vulcoid is approved by Underwriters' Laboratories as a material for the insulation of current-carrying parts in electrical equipment. It carries the distinctive red and blue thread marking of such materials.

Easy to work. Like vulcanized fibre, Vulcoid is readily drawn or formed into permanent shapes, punched, machined (see illustration above) at low cost. CDF fabrication facilities can give you production quantities of Vulcoid parts to your specifications.

Learn all the advantages of designing around low-cost CDF Vulcoid parts such as arc-deflector spacers, transformer and motor lead bushings, circuit-breaker and transformer barriers, knife-switch guides, transformer coil separators, instrument and contact panels, baseboard receptacles, etc. Ask your CDF man or write for new technical bulletin.

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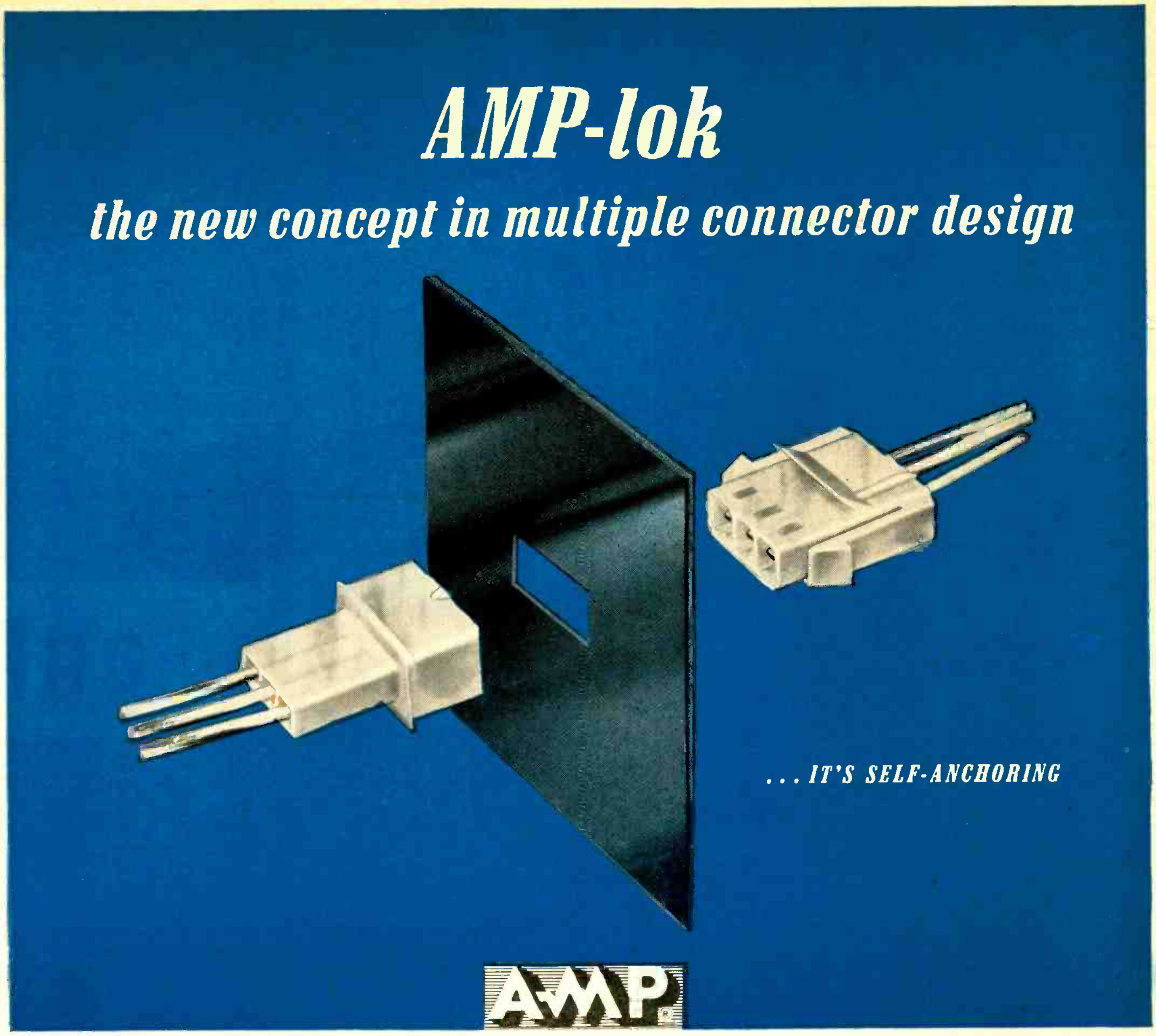
COMPARATIVE PROPERTIES

Property	Commercial Vulcanized Fibre 1/16″	Paper Base (XX) Phenolic 1/16″	VULCOID 1/16″	VULCOID 1/8″	VULCOID 1/4″	VULCOID 1/2″	VULCOID 3/4″	VULCOID 1″
Arc Resistance, seconds	140	4	110	110	110	110	110	110
Specific Gravity	1.25	1.35	1.35	1.35	1.35	1.30	1.20	1.10
Moisture Absorption, % 24 hours	60	1.4	30	15	6	4	4	4 8
Tensile Strength, thousands of psi. —MD CD	11	12 10	12.5 7.5	12 7.5	11 7	9 6.5	8.5 6	5.5 12
Flexural Strength, thousands of psi. —MD CD	16	19 17	24 19	23 17	20 16	16 13	14 11	9 60
Shearing Strength, thousands of psi. —MD CD	8.5 8	14 12	14 12	12.5 11	12 10			
Compressive Strength, flatwise thousands of psi.	25	34	36	36	36			
Izod Impact Strength (Edgewise) Ft. lbs. per inch of notch MD	2.0	0.50*	1.2	1.2	1.2	1.2		
Dielectric Strength, Perpendicular to surface VPM	175	700	475	425	275	170	100	

NOTE: ASTM test methods used for Specific Gravity, Moisture Absorption, Arc Resistance, Tensile, Flexural, Compressive, and Dielectric Strength.



AMP-lok eliminates the necessity for supplementary mounting devices in through panel multiple connector applications.

Additional literature and samples available on request.

AMP-lok obsoletes all it replaces because of the following design features:

- contacts are identical . . . self-cleaning recessed for safety
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- polarized to eliminate circuit error
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with new simplicity and

Measure frequency to 12 KMC on pulsed AM, FM, CW and noisy circuits!

Fast, simple, extremely accurate

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Eliminates expensive, complex setups

Includes self-contained oscilloscope

Two compact, portable *-hp-* instruments permit you to measure unknown frequency from zero to 12 KMC with revolutionary convenience and *electronic counter accuracy!*

Hewlett-Packard 540A Transfer Oscillator and 524B Electronic Counter (524B plus proper plug-ins, oscillo-synchroscope or detectors) are the only instruments required. Complex instrument arrangements and tedious trial-and-error "guesstimates" are eliminated.

Model 540A contains a highly stable, 100 to 220 MC oscillator generating harmonics to 12 KMC. These harmonics are provided for comparison with the unknown. The comparison device is a diode mixer, amplifier and built-in oscilloscope. In conjunction with *-hp-* 524B, the 540A extends the 524B's range to 12 KMC with no loss of accuracy or convenience.

Simple Measuring Procedure

To measure, with approximate signal frequency known, *-hp-* 540A is tuned until one of its harmonics zero beats with the unknown. The multiplying factor is noted, and the 540A's frequency measured directly on the 524B. This 524B reading, times the multiplying factor, is the frequency of the unknown.

When the signal frequency is totally unknown, a simple calculation employing two or more harmonics determines the proper multiplying factor. Frequency of the unknown is then determined as before.

Pulsed Carrier Frequency

In measuring carrier frequency of pulsed signals, an external oscillosynchroscope is used to display the detected pulse. Zero beat appears as horizontal lines across pulses when the oscillator is tuned to an exact sub-multiple. Video amplifier frequency response controls can be used to simplify this procedure.*

In working with noisy or AM signals, the *-hp-* 540A response can be narrowed to obtain more accurate indication of zero beat.*

In signals with appreciable FM, the 540A's oscilloscope presents a characteristic pattern pin-pointing upper and lower frequency deviation limits. If FM deviation is present, center frequency may also be determined.*

1/1,000,000 Accuracy

The 540A-524B system's accuracy approaches one part per million for stable CW signals. On pulsed signals,

hp Precision accuracy, utmost value;

electronic counter accuracy

accuracy is governed by carrier frequency and pulse lengths. On noisy or intense AM signals, the transfer oscillator system with *-hp-* 540A often provides the only means of accurate measurement. Over-all system accuracy is better than 10 times that of the best microwave wavemeters.

Quality Features

Each of the circuit elements of *-hp-* 540A may be used separately by shifting front panel patch cords. Controls are provided for coarse and fine tuning; there is also an electrical vernier with range approximating ± 125 parts per million. The video amplifier has both gain and bandwidth controls. Horizontal input to the internal oscilloscope is power line frequency with phase control. Input attenuation is variable from approximately 20 to 80 db to adjust signal level for optimum mixing level.

**For complete details see your -hp- representative and write -hp- for Vol. 6, No. 12, Hewlett-Packard Journal*

SPECIFICATIONS

-hp- 540A Transfer Oscillator

GENERAL:

Frequency Range: 10 MC to 5,000 MC. (10 MC to 12,000 MC or higher with external detector such as *-hp-* 440A)
Input Signal: CW, FM, AM or pulse
Input Signal Level: Varies with frequency and individual crystals. Minimum input signal approximately 0 dbm to attenuator. Maximum input 0.5 watt average (5 volts into 50 ohms)

OSCILLATOR:

Fundamental Frequency Range: 100 MC to 220 MC
Harmonic Frequency Range: Above 12,000 MC
Stability: Less than 0.002% change per minute after 30-minute warmup
Dial: Six inch diameter, calibrated in 1 MC increments. Accuracy: ± 0.5%
Output: Approximately 2 v into 50 ohms

ATTENUATOR:

Range: Approximately 20 db to 80 db
Input Impedance: 50 ohms, SWR: 1.5 max. at 1 KMC; 3 max. at 5 KMC

AMPLIFIER:

Gain: Variable. Maximum 40 db or more
Bandwidth: Variable. High Frequency: 3 db point adjustable approximately 1 KC to 2 MC. Low Frequency: 3 db point switched from 100 cycles to below 10 KC. Adjustable to above 400 KC
Output: 1 volt rms maximum into 1,000 ohms

OSCILLOSCOPE (Self-Contained):

Frequency Range: 100 cps to 200 KC
Vertical Deflection Sensitivity: 5 mv rms per inch at mixer output
Horizontal Sweep: Internal, power supply frequency with phase control, or external (connection at rear) with 1 v per inch. Sensitivity, 20 cps to 5 KC

MISCELLANEOUS:

Size: Cabinet Mount: 20½" wide, 12½" high, 15¼" deep
Power Supply: 115/230 v ± 10%, 50/1,000 cps, approximately 110 watts
Price: *-hp-* $615.00

-hp- 524B Electronic Counter

FREQUENCY MEASUREMENT: (without plug-in units)

Range: 10 cps to 10 MC
Gate Time: 0.001, 0.01, 0.1, 1, 10 seconds or manual control
Accuracy: ± 1 count ± stability
Reads In: Kilocycles. Automatic decimal.

PERIOD MEASUREMENT: (without plug-in units)

Range: 0 cps to 10 KC
Gate Time: 1 or 10 cycles of unknown
Accuracy: ± 0.3% (1 period) ± 0.03% (10 period average)
Standard Frequency Counted: 10 cps; 1 or 100 KC, 10 MC, or external
Reads In: Seconds, msec, μsec; automatic decimal

GENERAL:

Registration: 8 places, maximum count 99,999,999
Stability: 1/1,000,000 short term; 2/1,000,000 per week. May be standardized against WWV or external 100 KC primary standard
Display Time: Variable 0.1 to 10 seconds, or held indefinitely
Price: $2,150.00

PLUG-IN UNITS:

-hp- 525A, converts for frequency measurement, 10 cps to 100 MC. Price $250.00
-hp- 525B, converts for frequency measurement, 100 MC to 220 MC. Price $250.00
-hp- 526A, converts for high sensitivity frequency measurement, 10 cps to 10 MC. Price $150.00
-hp- 526B, converts for time interval measurement, 1 μsec to 10^7 seconds. Price $175.00
-hp- 526C, improves period measurement accuracy, 0 to 10 KC. Price $225.00

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What's more, you give your product new sales-advantages: Direct-reading digits, instead of hard-to-read dials and verniers . . . instant remote indication if needed . . . up-to-the-minute performance records that serve as a basis for production-*Count*rol, and as proof of your performance guarantee. So don't let counters take a back seat in your new-product plans. *Design them in, when you begin . . .* it pays in many ways. Do you have the newest Veeder-Root Catalog? Write

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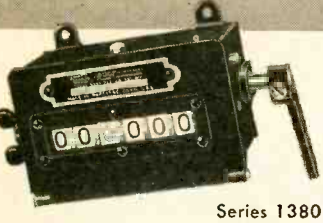

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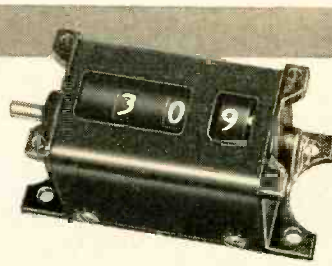

360-degree Bearing Counter

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CIRCLE 19 READERS SERVICE CARD →

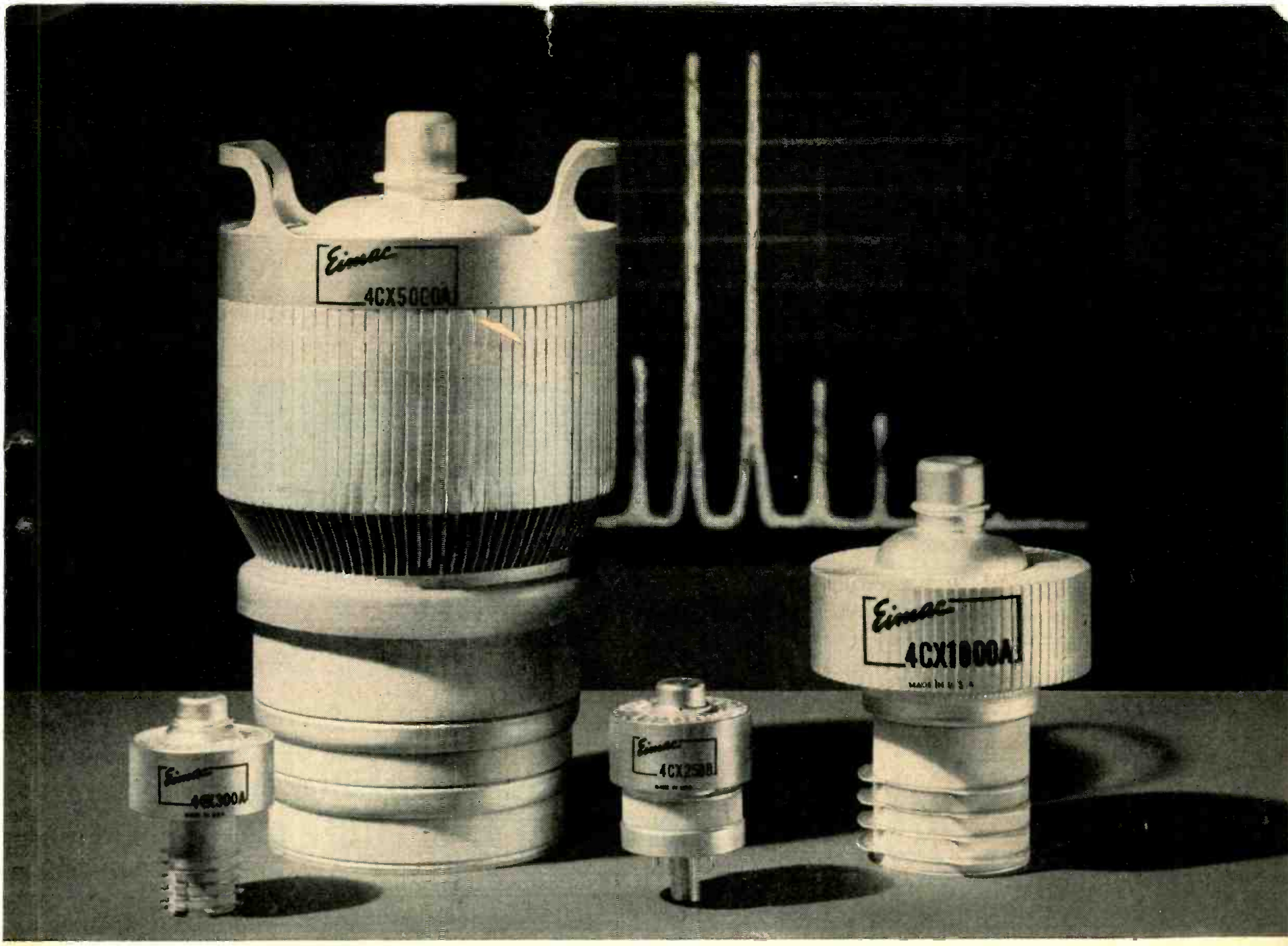

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Plate Voltage	2000 v	2500 v	3000 v	7500 v
Driving Power	0 w	0 w	0 w	0 w
Peak Envelope Power . .	325 w	400 w	1680 w	11,000 w

electronics
engineering edition

JANUARY 31, 1958

Ultrasonic Gage Speeds Field Work

SUMMARY —— Sweep-frequency sensing system and direct-reading indicator assembly measure thickness ultrasonically by determining frequency of standing wave generated within material. Pulse generated as oscillator frequency passes through resonant point of material lights lamp attached to rotating disk. Rotational position of flashes is matched with graduations on transparent harmonic scale and read out directly on thickness scale. Accuracy to 3 percent can be obtained for thicknesses of 0.027 to 4 in.

By HENRY N. NERWIN Project Engineer, Magnaflux Corporation, Chicago, Illinois

ULTRASONIC INSTRUMENTS are important tools in the field of nondestructive testing and measuring. Functionally these devices are divided into two groups: pulse-echo types and resonance types. Pulse-echo types measure thickness by determining the time interval between transmission of a pulse of energy into the subject material and reception of its echo. Resonance types measure thickness by determining the frequency of standing waves generated in the material. The ultrasonic thickness gage discussed in this article is of the resonance type.

Portability

Most resonance-type ultrasonic instruments use a crt as the indicator. Since a crt requires considerable power which must be obtained from a power line, the instruments containing them are not easily adaptable to field operations. Because of its unique dial indicator, the instrument described here can be battery operated hence is completely portable.

A block diagram of the instrument is shown in Fig. 1. The probe and the sweep capacitor are connected across a plate-tuned circuit in the oscillator. As the sweep capacitor is varied through its range by the drive motor, a quartz crystal transducer in the probe is loaded at specific frequencies depending on the thickness measured.

Frequencies are passed through which generate ultrasonic waves in the material. When they are in time phase with the crystal vibrations, the crystal impedance changes causing the oscillator to generate a series of pulses. The pulses are filtered, amplified and appear as flashes on a neon lamp attached to a rotating disk in the indicator assembly. Since the disk is driven in synchronism with the sweep capacitor, a light pattern is produced which is directly related to thickness. Special indicator dials convert the pattern to dimensional terms that enable the operator to read thickness directly.

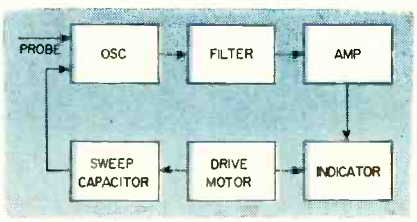


FIG. 1—Block diagram shows functional relationship of circuits in instrument

Functional Description

In operation, the probe shown in Fig. 2. is placed on the material to be measured and the crystal is loaded at a specific fundamental frequency, or at harmonics of this frequency, by the oscillator. The fundamental frequency is continuously varied by motor-driven sweep-capacitor C_1. The mechanical vibration of the crystal resulting

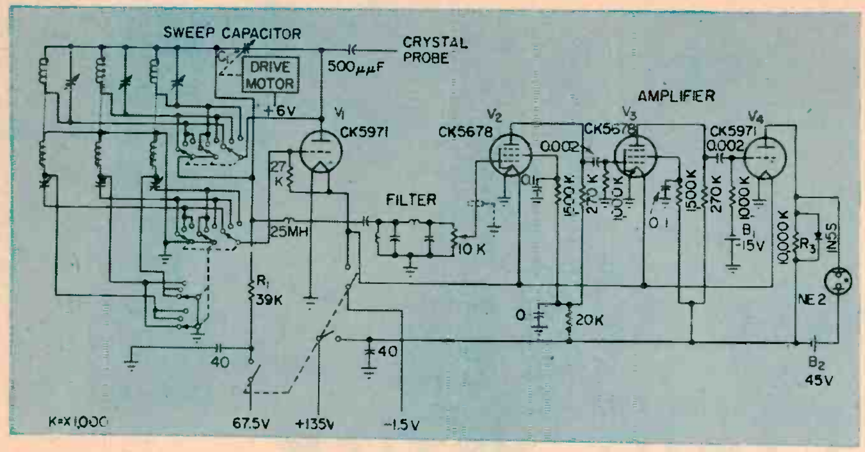


FIG. 2—Instrument employs a tuned-plate oscillator with sweep capacitor to generate the spectrum of frequencies that drive quartz crystal in probe

from the oscillator driving voltage sets up longitudinal waves within the material as shown in Fig. 3.

At some fundamental frequency, or at one of its harmonics, the ultrasonic wave is brought into time phase with the crystal vibrations. The particular fundamental frequency at which resonance occurs is determined by the thickness of the material being measured. When a resonant point is reached, the change in impedance of the quartz crystal alters the plate current drawn by V_1 which results in a voltage variation across plate load resistor R_1.

Since the oscillator is swept over a broad frequency range and since the resonant frequency spread is relatively narrow, the voltage variation across R_1 appears as a pulse each time a resonant point is passed. The number of pulses generated and their occurance relative to the rotational position of the sweep capacitor are both a function of the thickness of the material being measured.

The signal developed across R_1 is passed through a band-pass filter to eliminate the high-frequency oscillator and the low-frequency sweep components. Therefore, only the pulses developed as a result of sweeping across a resonant frequency are applied to V_2 in the amplifier.

After passing through amplifiers V_2 and V_3, the positive pulses at the output of V_3 are applied to the grid of V_4. Since V_4 is normally cut off by the bias voltages of battery B_1, no voltage drop appears across R_3; however, when a pulse is introduced, V_4 conducts. The resulting increase in voltage drop across R_3 adds to the bias voltage of B_2 ionizing the neon lamp.

Since the sweep capacitor and neon lamp are both driven by the same shaft, the disk and capacitor are always synchronized. An arc-shaped window, located immediately in front of the rotating neon lamp shown in Fig. 4 limits the view so that the lamp can be seen only while the sweep capacitor plates are meshing.

As the disk rotates, the lamp flashes at the same points along its line of travel for each revolution of the drive-motor shaft. Since the

Operator uses ultrasonic instrument to measure thickness of storage tank wall

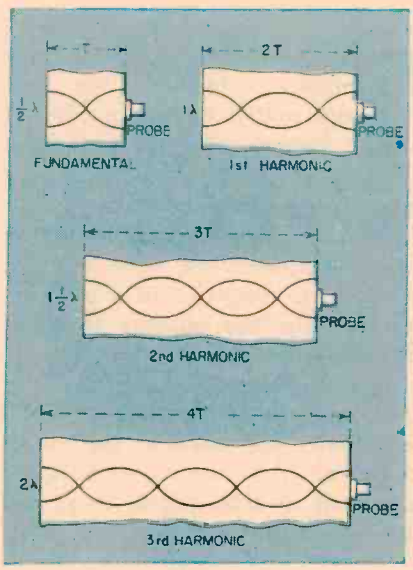


FIG. 3—Cross section of a tank wall showing resonant conditions for a fundamental frequency and for three of its harmonics

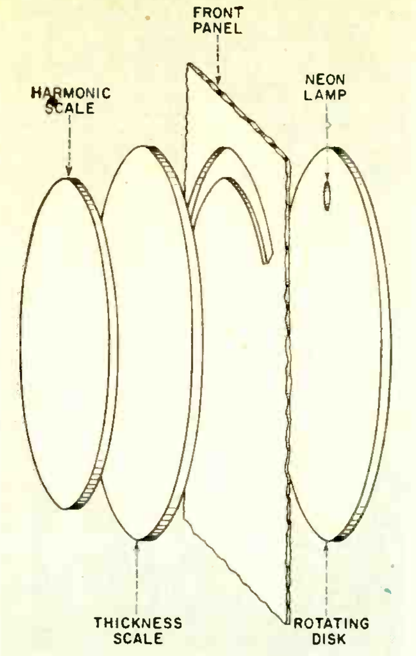


FIG. 4—Mechanical arrangement of indicator assembly. Arced slot in panel subtends an angle of 108 degrees

disk rotates at approximately 800 rpm, stroboscopic action takes place and the flashes are seen as a light pattern of individual bright spots. The number and spacing of the lights in the pattern relate directly to the thickness of the material.

Indicator Design

When the crystal vibrations and longitudinal waves within the material are in time phase, a condition exists which is analogous to the current along a short circuited transmission line of half wave length. The resonant conditions within the material for the fundamental and for its first three harmonics are shown in Fig. 3. It can be seen that the thickness, T, is related to the wave length as follows:

$$T = A/2 = V/2F$$

where V equals velocity of ultrasonic propagation in ips, F equals fundamental frequency in cps, T equals thickness in inches and A equals wave length in inches.

The fundamental frequency is expressed in terms of harmonics as

$$F = f_n/n$$

where f_n equals the harmonic frequency and n equals the order of the harmonic frequency. The harmonic frequency is expressed in terms of thickness as

$$f_n = V/2t_n$$

where t_n equals harmonic of fundamental thickness. These equations can be combined as

$$1/T = (1/n)/t_n = 1/t_1 = (1/2)/t_2 \ldots$$

Therefore, if any harmonic frequency and its order are known or if any harmonic thickness and its order are known, the fundamental thickness can be calculated. In most cases the harmonic frequency and, consequently, the harmonic thickness are known, but the order of the corresponding harmonics are not. The fundamental thickness can be determined however, by two or more adjacent harmonic thicknesses regardless of their respective positions in the spectrum.

If we know t_2, t_3 and t_4, the three adjacent orders of their harmonics can be matched to each corresponding harmonic thickness using a standard slide rule. By placing the C_1 scale graduation which corresponds to the order of the harmonic opposite the D scale graduation which corresponds to harmonic thickness, the fundamental thickness is read out under the index of the C_1 scale. This procedure may be used with any resonance type ultrasonic thickness instrument that is frequency calibrated in terms of thickness; however, the operation is cumbersome and conducive to errors.

Simplification of the calculation procedure can be effected by superimposing the harmonic indications directly on the C_1 scale. This was accomplished by converting the C_1 and D scales into circular scales as shown in Fig. 5. The scale on the large dial has all the standard numerical divisions of a D scale and is referred to as the thickness scale. The scale on the small dial has whole number divisions 1 through 30 of a C_1 scale and is referred to as the harmonic scale.

Operating Conditions

If the scales are made of transparent material and assembled as shown in Fig. 4, the divisions on the harmonic scale will lay directly over the electrodes in the neon bulb as it passes across the arc-shaped window. For the light pattern to coincide with the logarithmically spaced marks on the harmonic scale, the position of each successive flash must vary as a logarithmic function of disk rotation. This was accomplished by shaping the sweep capacitor plates to give oscillator frequencies which vary as a log function of rotation.

In use, the operator selects one of three frequency ranges, designated W, G and Y, and sets the appropriate letter on the thickness scale opposite the index mark on the panel. With the probe on the material to be measured, the instrument is turned on and the sensitivity control advanced until a clear light pattern appears. The small dial is then rotated until the division marks on the harmonic scale are aligned with the light pattern beneath. Thickness is determined by reading the indication on the thickness scale opposite the pointer on the harmonic scale.

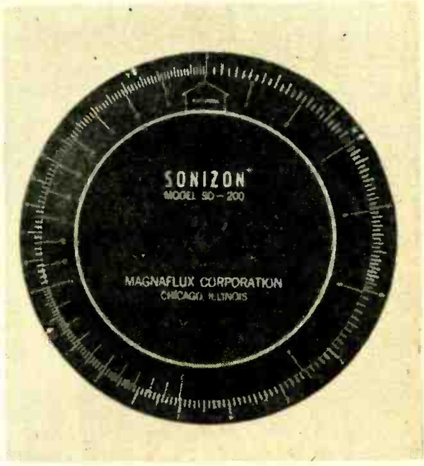
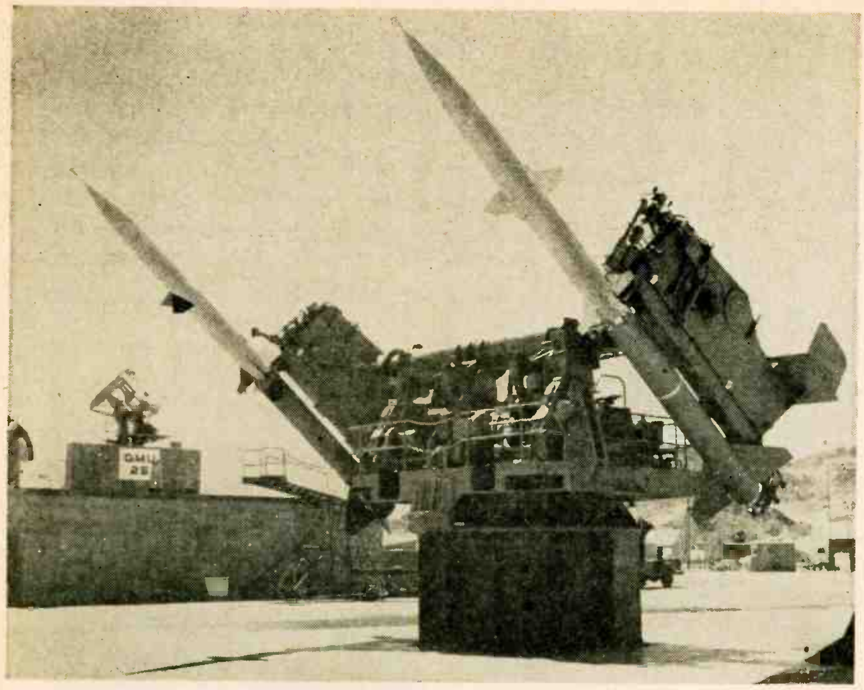


FIG. 5—Readout dials of indicator assembly. Harmonic scale is on small dial; thickness scale is on large dial

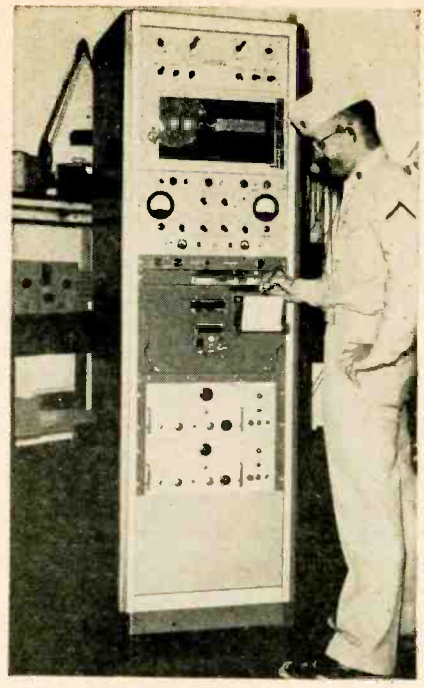
Applications

Thickness measurements can be made on practically all substances that will support ultrasonic transmission such as most metals, glass, hard insulating materials, and the like. The instrument can also be used to locate lack of bond areas between two metals, or between a metal and a non-metal without damaging material or adhesive.

The author thanks J. Farembski for his assistance on this project.



Beam-rider antiaircraft guided missiles are prepared for launching into radar beam on test range. Conditions simulate those as on board one of U. S. Navy's missile ships



Mobile version of equipment can be used with a single mobile radar

Target Simulator Tests

By G. E. HENDRIX Naval Ordnance Test Station, China Lake, California

ANTIAIRCRAFT MISSILES are usually fired at a test range during their development and evaluation. Normally, the targets are obsolete drone aircraft. Furthermore, the maintenance of drones is difficult, reliability is low and, if the missile is reasonably successful, the attrition rate is high. It is therefore desirable to be able to simulate reasonably realistic tactical conditions for antiaircraft missiles.

The simulator to be described was built for testing beam-rider missiles. In this guidance system the target is tracked by a radar in a normal fashion. A missile is launched into the beam, and guidance is accomplished by servo systems within the missile which try to keep the missile centered within the beam. The missile flies up the beam until it intercepts the target. Figure 1 illustrates the basic system.

To eliminate the target drone, the system must look the same to the missile with the exception of fuze action. This is accomplished if the radar beam moves exactly as it would if tracking a real target. The radar antenna must be slaved to a ground-based function generator. Then the simulator is concerned primarily with the drive servos.

One basic requirement of a missile system is closed-loop operation. When tracking a real target, loop closure is effected through the target, radar return and receiver. Since there is no r-f return path for the simulator, artificial loop closure is accomplished by mounting position sensing elements on the antenna to feed back antenna position to the function generator.

Noise Sources

Another system requirement is realistic simulation of tracking noise which consists of internally generated receiver and servo noise in the radar, target-scintillation angle noise and amplitude noise. Target scintillation and variations in the transmission path together cause amplitude noise.

For simplicity, it is desirable to work with the servos only and bypass the r-f sections of the radar in the simulator.

Since the servos are used in a normal fashion, their noise is present as usual. Receiver noise is assumed to be either negligible at the ranges of interest or lumped with one or the other noise sources. It was assumed that the major component of noise was target scintillation. It was further assumed that the scintillation noise could be described by band-limited white noise with a Gaussian amplitude distribution. Therefore, low-frequency random noise was injected into the system to cause antenna movement simulating the influence of target scintillation.

Simulator

The function generator consists of a pair of linear-motion potentiometers, which are moved directly by a pair of precision interchangeable cams. The cams are designed

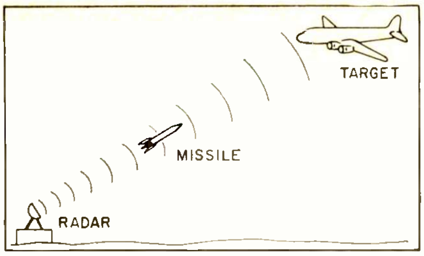


FIG. 1—Ground-based radar tracks target and beam rider missile is launched into and maintains itself in beam center

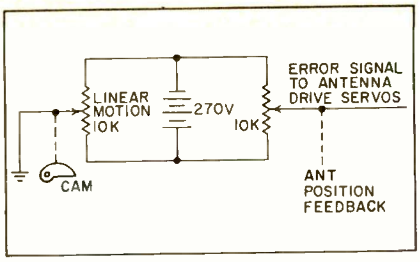


FIG. 2—Simulator uses bridge circuit to replace angle error detector to provide d-c output for antenna drive servos

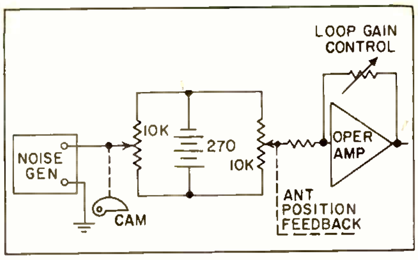


FIG. 3—Noise generator and operational amplifier are added in series with basic simulator bridge

SUMMARY —— System that eliminates expensive test drones in evaluating missile performance uses cam-actuated linear potentiometers and noise generators to provide azimuth and elevation drive signals for missile radar that approximate actual tracking conditions. Missile in beam is photographed by boresight camera and its instantaneous position with respect to beam center can be determined. System adds reliability, flexibility and economy to operational testing of antiaircraft missles

Beam-Rider Missiles

to represent the azimuth and elevation motions for a given target trajectory and can be changed in a few seconds.

Feedback of antenna position was accomplished by adding feedback potentiometers to the antenna. The feedback potentiometers are driven by rubber-tired wheels which roll on a convenient cylindrical surface on the antenna mount.

Since the available radars have d-c input to the antenna drive servos the output of the simulator is d-c.

Voltage sensitivities of the various radars were approximately one v per milliradian. Consequently the simulator, which replaces the angle error detector, uses the simple d-c bridge circuit of Fig. 2. Batteries eliminate hum problems arising in floating electronic power supplies.

To adjust voltage sensitivities for various radars, a feedback stabilized operational amplifier is inserted in series with an error signal. By varying the value of feedback resistor, the overall gain can be set at any desired value, permitting optimum adjustment of voltage sensitivity. This adjustment is essentially a control on the gain of the tracking loop.

The noise generator, the operational amplifier, and the error signal are shown in Fig. 3.

Boresight Camera

In testing beam-riding missiles, the performance of the beam and the ability of the missile to ride the beam must be monitored. For a real target this information is obtained with a boresight motion picture camera. The camera has a long focal-length lens and is colinear with the radar beam. Photographs of the target and the missile in the beam are taken. From the film, data can be extracted concerning the quality of target tracking and missile beam riding. Information concerning miss distance can also be obtained.

Since there is no target image in the boresight film for the simulator a different system must be employed to obtain information about the quality of tracking. Correlation between beam motion and beam riding can then be made.

Tracking Error

The elevation plane in the sketch of a section of a boresight film is shown in Fig. 4. Beam center position with respect to some arbitrary reference is B. Target position is T. Then the tracking error is given simply by $E_B = T - B$.

A sketch of the basic simulator bridge with added instrumentation is shown in Fig. 5. The target position T is derived from the cam and an electrical input is added to T through the noise generator. Antenna position B controls the feedback potentiometer. Since the bridge circuit is a subtractor, its electrical output is given simply by $E = (T + N) - B = E_B + N$. If N is subtracted from servo error, the resulting electrical signal is the tracking error E_B which is entered on a strip chart recorder.

When the input cam is motion-

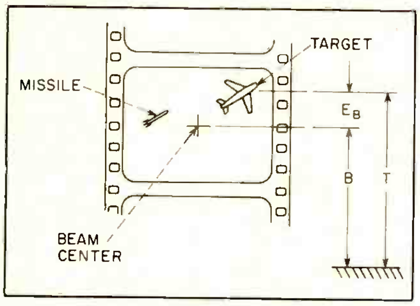


FIG. 4—Sketch of boresight-camera film frame illustrates method of computing tracting error E_B without using missile

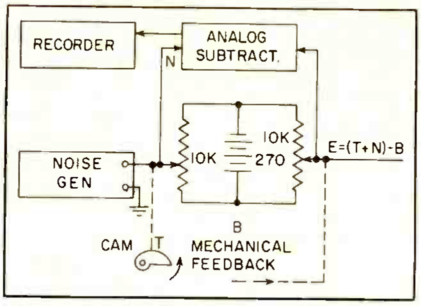


FIG. 5—Addition of instrumentation to simulator bridge circuit permis recording of tracking error on strip chart

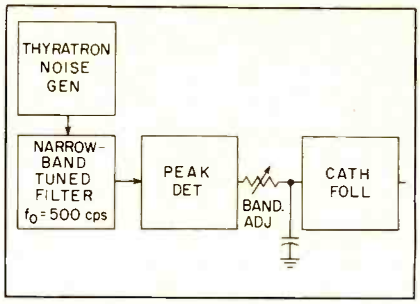


FIG. 6—Thyratron in a magnetic field is basic noise source of random-noise generator used in simulator

less T is a constant. To insure perfect tracking the antenna and its drive motors are motionless so that $T = B$. Then, the output of a perfectly balanced bridge is only the noise generator output $E = N$. If N is subtracted from the generator output the desired boresight error $E_B = O$. This method is used to check the balance of the analog subtractor.

To eliminate noise inherent in the cam surfaces and in the input and feedback potentiometers great care was taken in machining cams and in choice of potentiometers. Infinite resolution type potentiometers are used with conductive plastic as are also carbon film and slide-wire potentiometers. Linear motion potentiometers using conductive plastic elements were specially built for this application.

A computer program takes the desired target trajectory, computes azimuth and elevation angle as a function of time and from them calculates the corresponding cam radii.

The computer then prints a table of offsets specifying cam radius at each degree around the cam. Machining proceeds using this table, but final finishing of cams is a hand-honing operation.

Random Noise Generator

Figure 6 shows a block diagram of a random noise generator with a thyratron in a magnetic field as a basic noise source. The wide-band output is put through a narrow-band tuned filter with center frequency at 500 cps. Filter output is a 500-cps wave with a low-frequency random modulation. The modulation envelope has a Rayleigh distribution which is a fairly good approximation to the desired Gaussian distribution. Bandwidth of the modulation envelope is half the bandwidth of the tuned filter. A peak detector extracts the envelope and further bandwidth reduction can be obtained by low-pass filter. The unfiltered bandwidth is about 20 cps for the equipment.

Identical elevation and azimuth channels are used in the equipment. The elevation channel circuit schematic of the d-c amplifier and noise generator is shown in Fig 7.

Practical Circuits

The generated noise output of thyratron V_{11} is amplified and narrow-band filtered in stages V_1

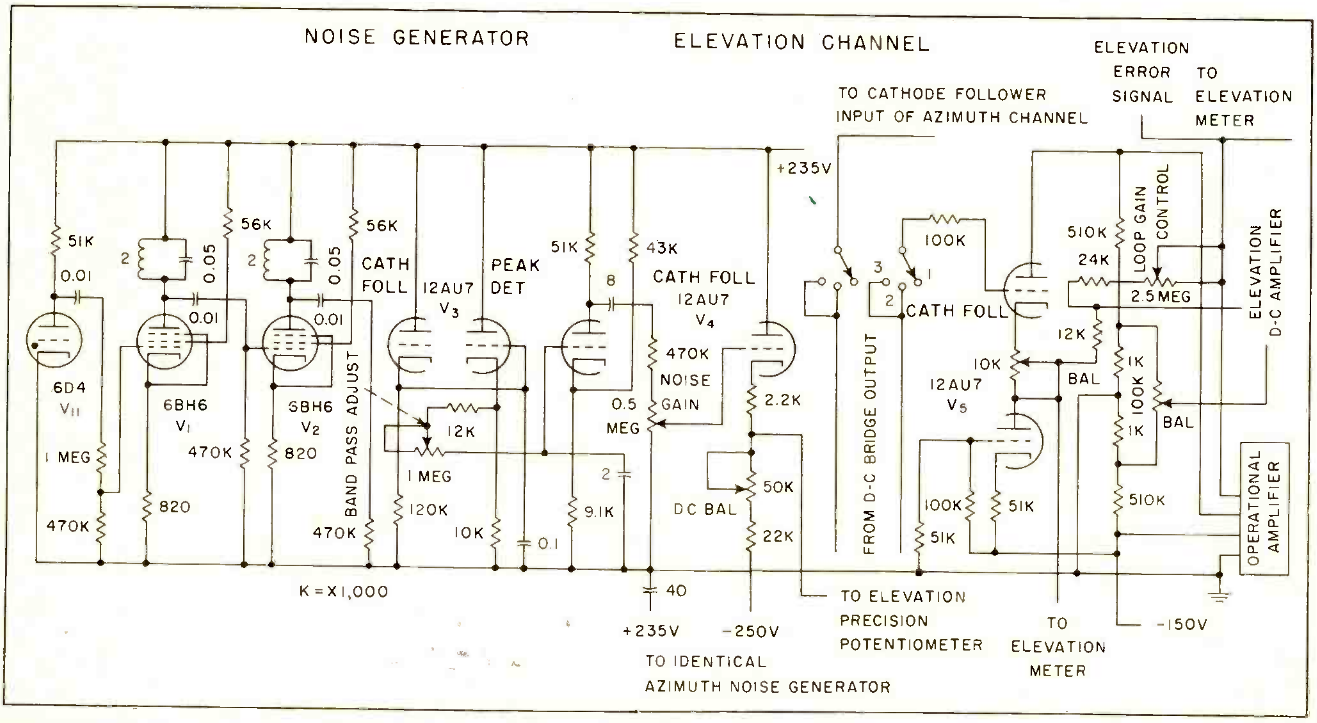


FIG. 7—Schematic of noise generator and d-c amplifier chassis. Noise components down to 0.1 cps are passed by coupling network

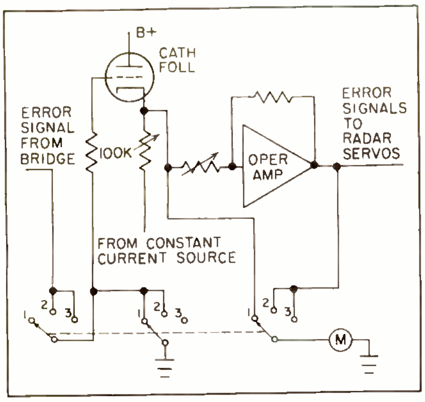


FIG. 8—Monitoring switches ground input in positions 1 and 2 while cathode follower and operational amplifier are zero adjusted. Position 3 is normal

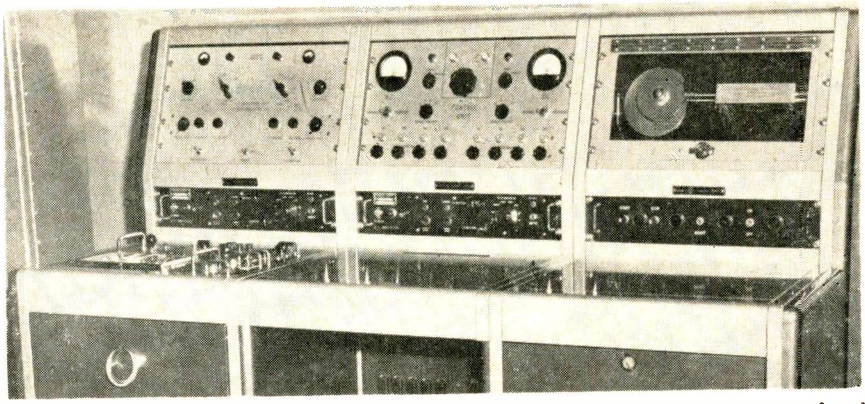
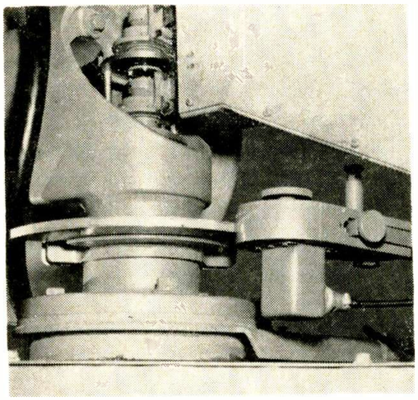
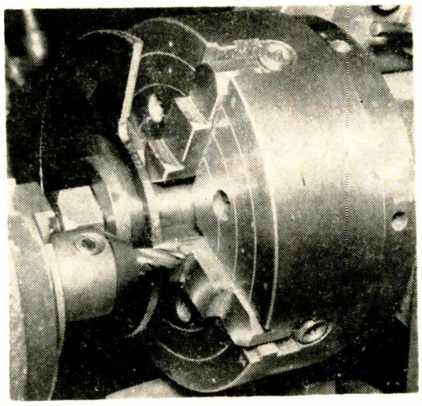


FIG. 9—Simulator consile has d-c amplifier and noise generator unit (left), control unit (center) and power unit (right). Controls are within easy reach of operator



Feedback potentiometer is mounted on radar. Rubber-tired wheel rolls on cylindrical surface and turns pot



Cams must be precision machined to 0.001 in around periphery to provide accuracy required for system

and V_2, which have resonant plate loads tuned to 500 cps. High-Q inductors are used to restrict the bandwidth to 20 to 30 cps. Filter output is coupled through a cathode follower V_{3A} to a peak detector V_{3B}. The peak detector recovers the envelope of the randomly modulated sine wave that appears at the output of the narrow-band filter.

The envelope detector is followed by a low-pass filter in which the R-C product can be varied, providing further bandwidth reduction of the low-frequency signal. The filtered signal is amplified in V_{4A} and coupled to output cathode follower V_{4B}. The time constant of the coupling network passes noise components down to 0.1 cps. In a 30-sec missile flight noise components with lower frequencies show up as bias variations and have little effect on the overall system performance.

Cathode follower V_{1B} has its cathode returned to -250 v, so the noise output can be adjusted to swing around ground level.

D-C Amplifier

The d-c amplifier portion of the circuit is built around a commercial operational amplifier. Resistive feedback is employed and overall gain is adjusted by the feedback resistor. Gain can be set to any value between 1 and 100. Because the gain of the operational amplifier is a function of the output impedance of its driving circuit, the amplifier can not be connected directly to the feedback bridge circuit, as indicated in Fig. 3. Consequently, a cathode follower is interposed between bridge and operational amplifier.

Since the bridge output may be amplified 100 times, the use of constant current tube V_5 provides better stability for the cathode follower.

Monitoring

Provision is made for adjusting the output to swing around ground and for adjusting the zero level of the operational amplifier. Adjustments are made with monitoring meters that can be switched to look at the feedback-bridge output, cathode-follower output or operational-amplifier output. These meters also obtain an initial bridge balance between cam and antenna before the radar is switched to the automatic track mode. Figure 8 shows how the meter switching arrangement permits the cathode-follower input to be grounded while the zero adjustments are made.

Figure 9 shows the completed simulator which was designed to control either of two radars interchangeably. The noise generators and operational amplifiers are in the left-hand chassis, a switching panel in the center and the cam unit on the right.

Flush mounted in the desk top is the boresight error recorder.

Meters in the center panel indicate bridge balance. Manual adjustment of the radar antenna and the cams to the proper initial coordinates prepare the simulator for automatic tracking. Antenna feedback pots are disengaged and turned until the meters indicate a bridge balance. The pots are engaged and the radar switched to the track condition. It then follows the cams.

This equipment has been in use at the Naval Ordnance Test Station for nearly three years. A total of six different service radar types in as many fire control systems have been operated using simulated targets.

Detector Plots

SUMMARY —— Sensitive measuring equipment detects 10 to 40 μv potential difference between front and rear of eyeball to indicate change of eye position while subject is reading. Scan data is recorded photographically from cathode-ray tube display and by pen on strip-chart recorder

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EMI Electronics Ltd., Hayes, Middlesex, England

VARIOUS TECHNIQUES have been studied for recording eye movements and the points on which the eyes are fixating. One of the more recent and promising techniques is electro-oculography (eog).[1] The basis of eog is a standing potential difference between the front and back of the eyeball. The field from this dipole moves as the eye rotates. Electrodes placed on the skin surface near the eye socket along the plane of rotation will detect the resulting change in d-c potential as shown in Fig. 1. These voltage changes have been found to be linearly related to the angle of eye rotation.

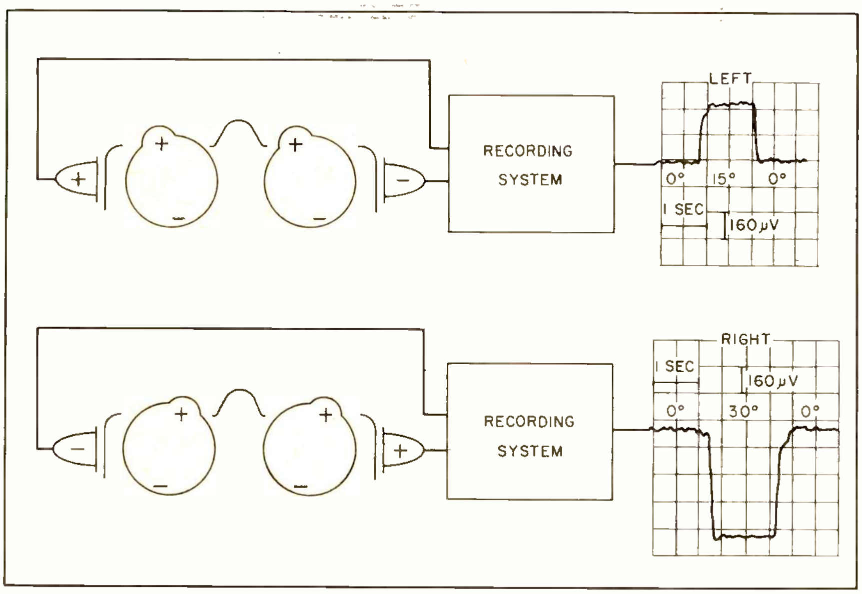


FIG. 1—Typical pen recordings obtained as eyes are moved left and right

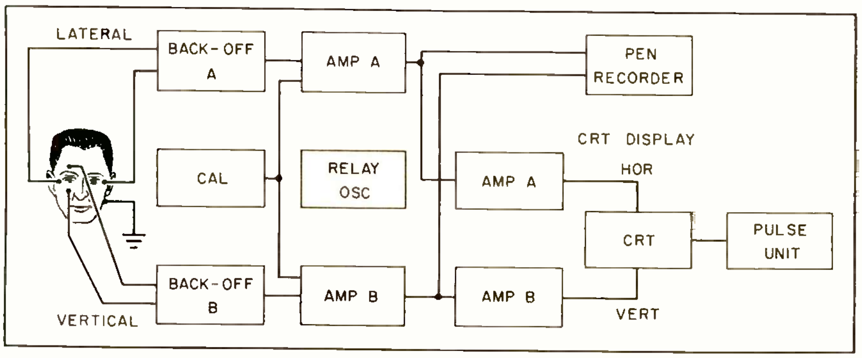


FIG. 2—Eye movement recorder uses two separate channels to indicate vertical and lateral motion of eye as it scans a sample of reading matter

A problem in employing this technique is the smallness of the eog potentials. With the average person we tested, a change of about 20 μv is detected for each degree of eye movement. Range for different people appears to be from about 10 μv to about 40 μv per deg.

For easy analysis of where the eyes are looking at any instant it is necessary to register the position component of the signal. A d-c amplifier and recording system are therefore essential.

There are two other major obstacles to successful eog recording, as listed in Table I. The skin itself may generate potentials within the same general frequency band but of considerably greater amplitude than the eog potentials. These skin potentials are also transmitted to the recording system by the electrodes.

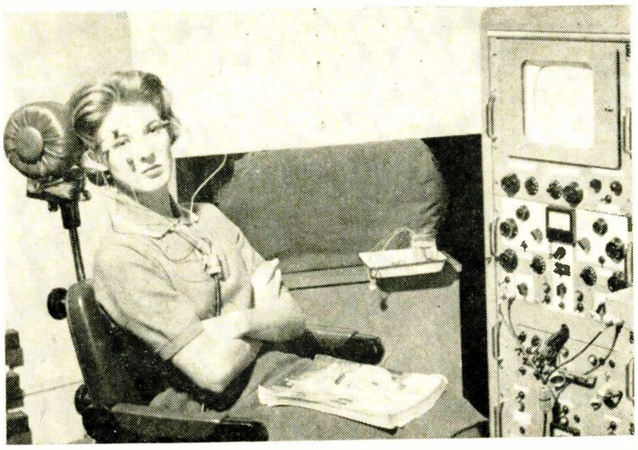
Current Transition

At the contact electrodes a transition must occur from ionic current flow in the body to electronic current flow in the amplifier input leads. The electrolyte/metal-salt/metal electrode, which must be used, is an active electro-chemical system and may produce noise, in the form of slow drift potentials, again of similar general characteristics to the eog signal.

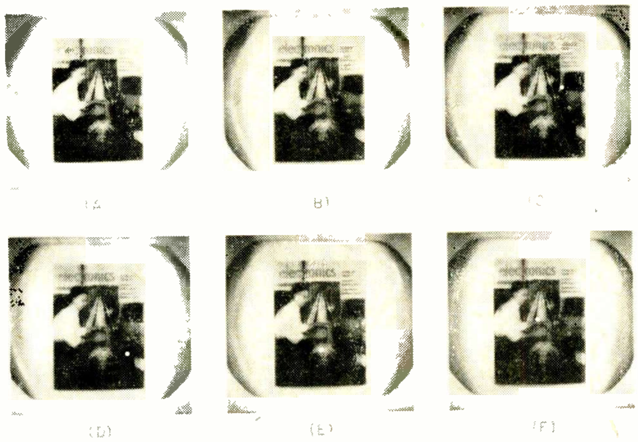
The result is that the recording pen may drift off the edge of the chart unpredictably after 20 or 30 seconds and an accurate zero level cannot be maintained.

To overcome these problems and

Eye Movements



Test subject with electrodes in place for eye motion recording is ready to make scanning test



Motion picture frames showing motion of eye in scanning magazine cover. While spot indicates point of focus in each

make eog a more reliable, routine technique, a complete eye movement measuring apparatus has been built and methods have been developed to diminish noise potentials from skin and electrodes.

Electronic System

A block diagram of the electronic system is shown in Fig. 2. Two identical channels amplify and record eye movements separately in the horizontal and vertical planes of rotation.

The backing-off circuits allow the residual standing potential difference between the pair of electrodes to be nulled to the arbitrary zero level. A zero-correcting servo[2] can also be used to do this automatically under pushbutton control. The amplifiers, with a maximum voltage gain of about 12,000, raise the signal level to that required to drive a standard pen recorder. Accurate recording for subsequent precise analysis can thus be made.

By feeding the horizontal and vertical signals separately onto the two deflection axes of a crt, successive eye movements and fixation pauses can more readily be determined as the subject views any given scene.

This may be done by placing a transparency of the subject's field of view in front of the cathode-ray tube, and by suitable initial adjustment of zero and gain, the successive items fixated can easily be seen on the screen.

Because interest here is primarily in where the eyes are looking, a rise time of 100 millisec for a step-function input signal is satisfactory. For physiological studies of the actual rapid eye movement itself a faster system response would be needed.

The advantage of the system's lower frequency response is the virtual elimination of hum and noise pick-up problems. No shielding of the subject is necessary and unshielded power leads an apparatus can be as close as five feet from the subject without causing difficulty. A single electrode behind one ear, giving rough balancing of each pair of inputs, relative to ground, has been found sufficient.

Amplifier

In the amplifier, shown in Fig. 3, the input signal is converted to 100-cps square wave by a chopper relay. Three conventional R-C coupled sections with stage by stage negative feedback form the main amplifier chain. A phase splitter enables full-wave demodulation by another relay to provide a single-ended output without loss of gain.

A low-pass feedback filter eliminates 50-cps line and 100-cps chopper frequency ripple with the minimum deterioration in rise-time response. The cathode follower provides an output impedance of 440 ohms with the signal going positive and negative about virtual ground.

Apart from a nonmicrophonic holder and shielded leads in the input stage no special precautions nor special ageing or selection of input tubes has been found necessary.

However selection of the ECC 91 for reasonable equality between the two halves is advisable to ensure linearity.

The relay drive oscillator is locked to the line frequency whenever the unit is operated from or near a power line. If this is not done, the oscillator will tend to beat with the line ripple picked up in the oscillator grid or heater leads and will produce a 0.5 to 2-cps beat at the amplifier output. The performance

Table I—Potentials Present at Pick-up Electrode

	Eyeball Potential	Skin	Electrode
Amplitude...	20 μv per deg average	Up to 1 μv	Up to 1 μv or more
Rise Time...	20 μv per sec (slow) 100 μv to 500 μv in 0.1 sec (fast)	usually between 10 μv per sec and 1 μv per sec	0 to 1 μv per sec

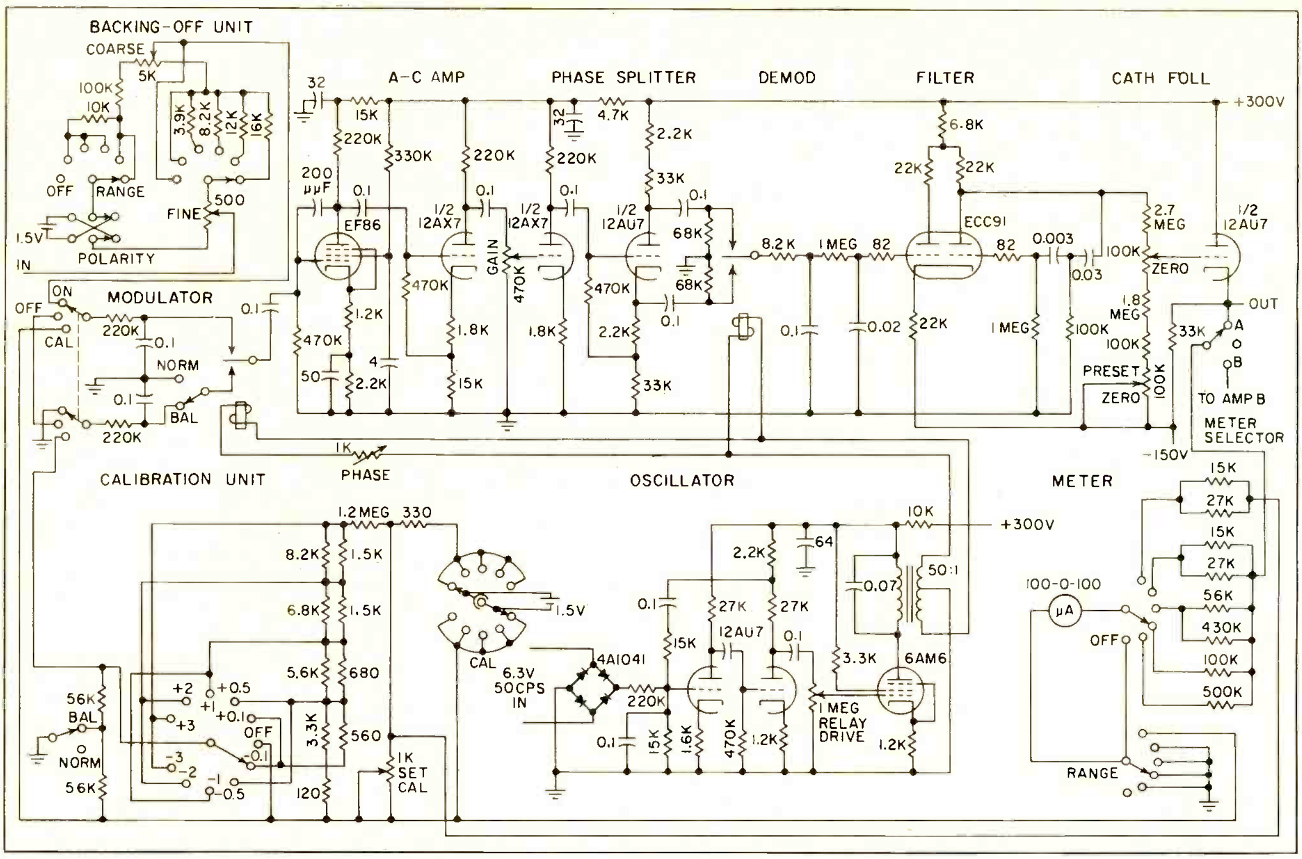


FIG. 3—Oscillator driven relays chop input and output of recorder amplifier. Drive oscillator is locked to line frequency to eliminate possible 0.5- to 2-cps beat at amplifier output. Filler stage may be replaced by R-C network

obtained from this unit may be summarized as follows: gain, maximum at least 10,000; maximum linear output at any gain setting, ±15 v; nonlinearity, less than ±3 μv per 100 μv of input signal being measured; noise and hum combined, less than 10 μv peak to peak with input shorted by a 10,000-ohm resistor; drift, less than ±20 μv in 30 minutes with input similarly shorted; rise time to step function signal, 100 millisec; input impedance, 1 megohm.

The input impedance may be raised to 5 or 10 megohms by removing the 200 μμf Miller capacitor and increasing the value of the grid leak. For applications where a longer response time is acceptable, the filter stage may be replaced by a simple R-C network, or by an equivalent parallel T network.

Network rise time then is about 500 or 300 milisec respectively, with networks attenuating chopper frequency ripple to below 10 μv referred to the amplifier input.

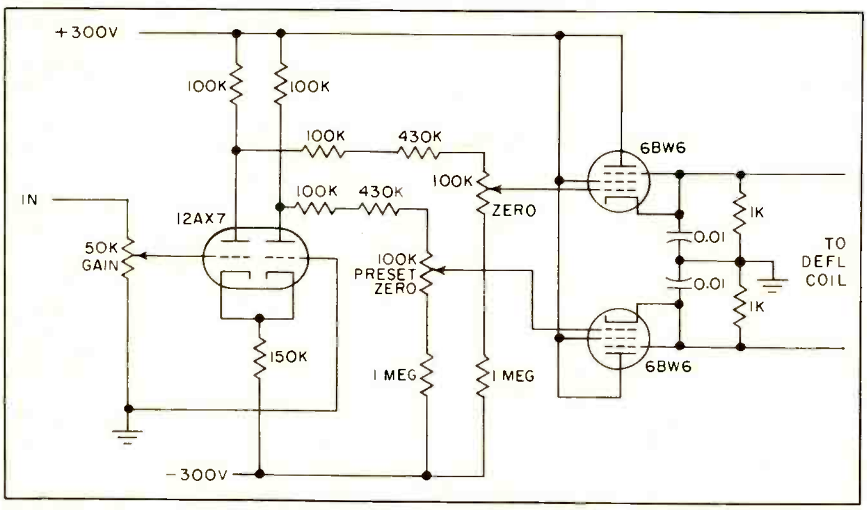


FIG. 4—Drive amplifier for crt magnetic deflection coils

CRT Display

To use a fairly large screen crt, magnetic deflection was chosen. The circuit is shown in Fig. 4. To minimize possible drift sources, a long-tailed pair combined amplifier and phase splitter is used to drive a push-pull cathode follower output stage.

A permanent magnet is used for coarse focusing with a small coil wound inside it for fine adjustment.

No time base is used. The crt is operated as a simple two-dimensional display for what is essentially a two-dimensional input function.

To avoid burning the screen and to provide time scale for film recording, the electron beam is pulsed at 100 cps or 1 kc using the circuit shown in Fig. 5.

The cathode-ray tube high-voltage supply and the regulated positive high-voltage supply are obtained from standard units. Neon regulation is adequate for the negative bias supply. Drift of this crt unit has been found to be not more than 1-mm total spot displacement in 30 minutes. Input sensitivity at full gain is 10 mv per mm.

Skin and Electrodes

Ways have been found of diminishing the drift voltages from these two sources. With a round, diamond, dental drill the horny layer of the skin can be eroded without drawing blood and without any pain at all to the subject. This reduces the skin voltage to one twentieth or less.[3]

Simple, easily attached, rubber suction cup electrodes are used (now available elsewhere[4]). Good zero stability is achieved by extreme care in preparation of the silver/silver-chloride contact pole.

Test Results

Using these techniques, recording in one minute periods, and with an average subject producing 20 μv per deg in the horizontal plane and about 15μv per deg in the vertical, records accurate to $\pm$1.5 deg horizontal at $\pm$2 deg vertical can be made for 70 percent of the testing time.

These accuracy figures assume an arbitrary zero level, but the drifts are often almost linear. Therefore, by interpolating between zero points at start and end, the record can be analyzed to better than $\pm$1 deg for a greater percentage of the total recording time. Moreover by selecting subjects with larger eog voltage, accuracy is greatly increased.

Two examples are shown of the sort of record now obtained. Fig. 6 is a record of horizontal eye movements for 62 seconds with a total zero drift of 70 μv. The subject

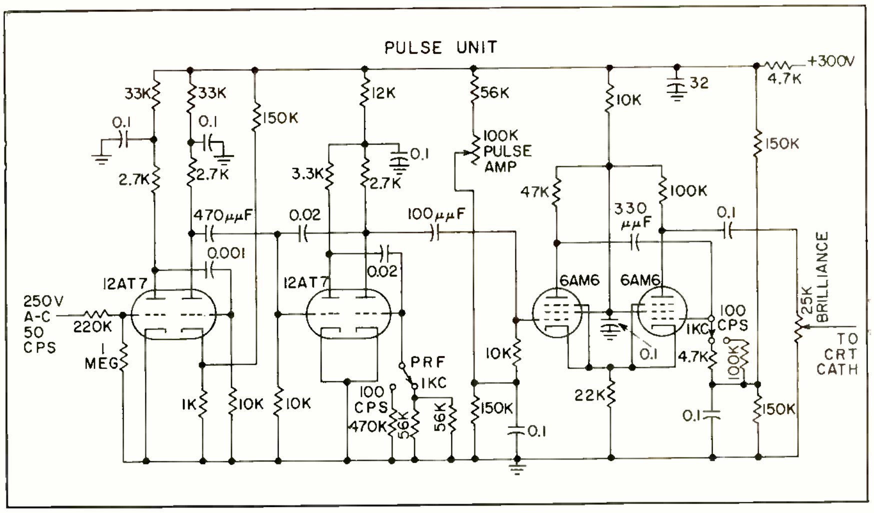


FIG. 5—Pulse unit changes spot intensity at 100 cps or 1 kc to permit time measurements on photographs

first fixated a series of dots 5-deg apart up to a distance of 30 deg to left and right of center, then he read 14 lines from a newspaper column and finally again fixated the 5-deg dots. A photo shows enlargements of single frames of a motion picture film taken when a cover page was first exposed to the subject's view. These pictures show some of the areas on which the subject fixed his eyes.

A definite limitation in any eye movement recording technique at present is how to bridge the gap between analyzing the eye movements with respect to the head and referring the successive eye positions correctly to the scene viewed by the subject. To do this successfully requires either rigid fixing of the head with respect to the visual scene or complex recording and analysis of head movements. The ideal answer to this problem in the future would seem to be a transistorized tv camera[5] fixed to the subject's head, showing his field of view wherever he moves, with his eye positioning seen as a bright spot or ring on the monitor screen onto which the field of view is transmitted.

The present applications of this technique are mainly in research studies, to help discover more about the patterns of eye movements used by people when carrying out various tasks.

There is another possible type of application of particular interest in the field of electronics. Certain types of high-speed tracking tasks are difficult for the operator to accomplish with any kind of control mechanism. It has been suggested[6] that the eye itself might provide the output signal which forms the primary input to the tracking system.

We thank the directors of E.M.I. Electronics Ltd for permission to publish.

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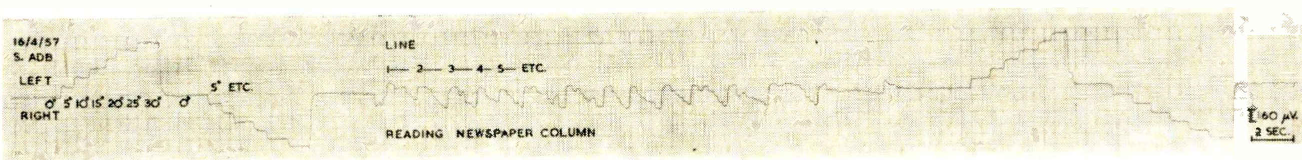
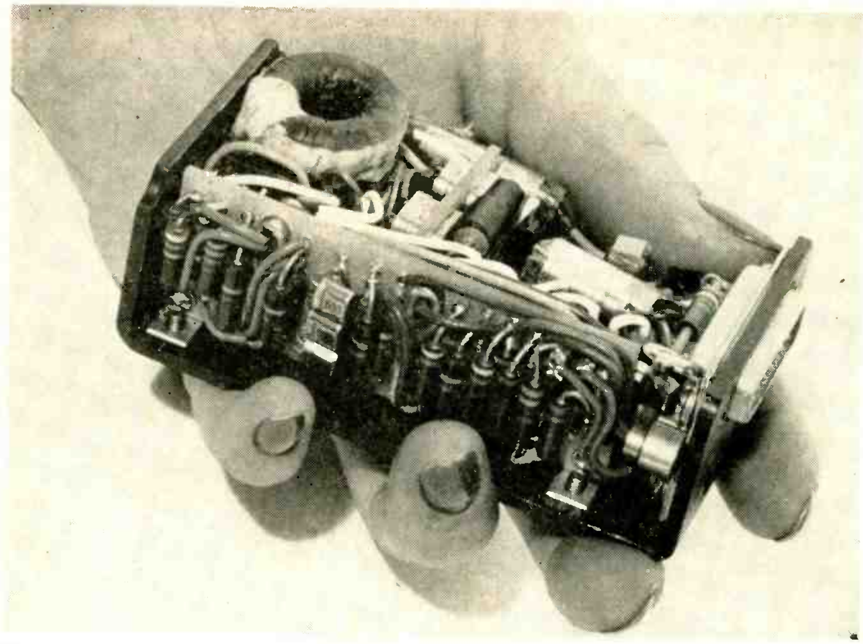


FIG. 6—Pen recording of typical eye movement looking at series of dots and reading a newspaper column



Complete strain gage oscillator weighs only 8 oz and occupies space of 6 cu in. Units have been constructed with bandwidths of 80 percent (± 40 percent frequency and an output of 5-v p-p across a 2,500-ohm load

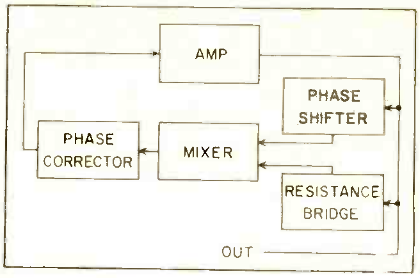


FIG. 1—Block diagram of transistorized strain-gage oscillator

Strain Gage Oscillator

SUMMARY —— Completely transistorized strain-gage oscillator for resistive-type gages produces frequency-modulated signal output that is directly proportional to applied force such as stress or pressure. Though intended for aircraft and missile flight testing, unit also has applications in spectroscopy, thermodynamics and mechanics

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ONE PROBLEM associated with flight testing of aircraft and missiles is the telemetering and/or recording of stress, pressure and other information. During flight testing such data is sometimes gathered by resistive-type strain bridge transducers that convert stress variations to voltage level changes.

Varying voltage levels are not directly compatible with f-m telemetering or magnetic tape recording. Accordingly, it is necessary to employ a converter for changing such amplitude-varying voltages to frequency-varying signals. The strain-gage oscillator to be described accomplishes this conversion with low power consumption and maximum space utilization.

System Description

The strain-gage oscillator is essentially a phase-shift oscillator used in conjunction with a four-arm resistance bridge. Unbalance of the bridge causes the oscillator frequency to vary, thus generating an f-m signal which is directly proportional to bridge unbalance or strain.

Transistors are used exclusively as the amplifying elements throughout the circuit.

Heart of the oscillator, shown in Fig. 1 and 2 is a stable high-gain a-c amplifier that operates in conjunction with the phase shifter and phase corrector to comprise a form of phase-shift oscillator when the bridge is balanced. The amplifier output signal is applied directly to the phase shifter where it undergoes 90-deg phase shift and attenuation. The phase shifter output signal is then fed through the mixer to the input of the phase corrector, the bridge being balanced and furnishing zero signal for mixing. The phase corrector shifts the signal another 90-deg and attenuates it, making the signal of the proper phase and amplitude to

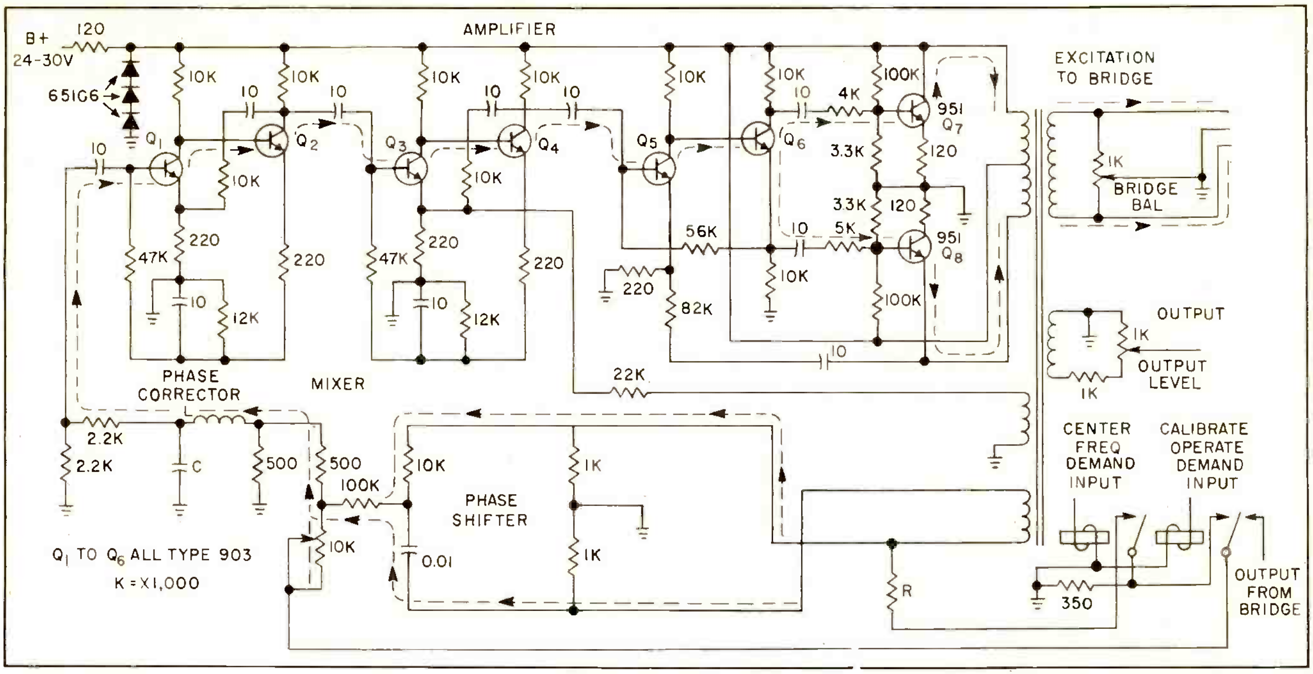


FIG 2—Operating and band-edge frequencies of strain gage oscillator are determined by values of R, L and C

for Flight Testing

satisfy the Nyquist criterion for oscillation ($K_\beta = 1$).

When the resistance bridge is unbalanced, as a result of applied stress or pressure for instance, the resulting bridge output voltage is resistively mixed with the local feedback signal (from the phase shifter) in the mixer. The sum of the two signals yields a voltage of the same relative amplitude as in the case of the balanced bridge, but of differing phase; this new signal is then applied to the phase corrector.

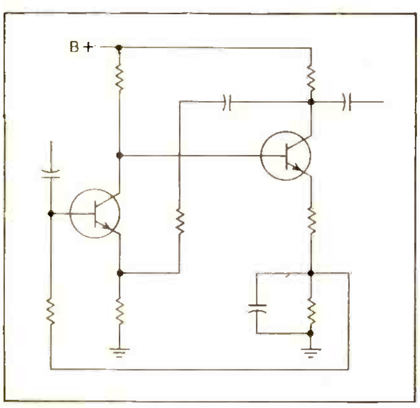


FIG. 3—Basic transistor amplifier pair used in amplifier portion of oscillator for best a-c and d-c stability

Consequently, the Nyquist criterion for oscillation is satisfied at a different frequency which is directly related to the new mixer output signal. The mixer output signal is in turn proportional to the bridge output voltage which is a direct function of the applied excitation phenomenon such as stress or pressure.

Amplifier

Referring to Fig. 2, the amplifier consists of eight transistor stages connected in the common-emitter configuration to provide a minimum open-loop gain of 10^6 and 180-deg phase reversal of the input signal at low frequencies.

The transistor amplifier pair shown in Fig. 3 was employed as the most satisfactory compromise between a-c and d-c stability. It tends to be self-compensating for d-c drift due to ambient temperature variations. Additional d-c temperature stability is obtained by supplying the first transistor bias current from the second transistor emitter circuit.

This configuration has practically no loss in theoretical gain and has the additional advantages of offering good operation with transistors of widely differing parameters and being practically unaffected by replacement of transistors.

For a-c temperature stability and high input impedance, negative feedback is applied around the common-emitter-pair amplifier.

From Fig. 2, it is seen that the first four transistors comprise two common-emitter-pair amplifiers The fifth and sixth transistors comprise a third common-emitter-pair amplifier with the sixth transistor connected as a paraphase amplifier capable of driving a push-pull pair of class AB common-emitter output transistors.

In addition to the extreme a-c and d-c temperature stability characteristics, the amplifier exhibits specific low and high-frequency roll-off and linear phase response as a function of frequency.

Low- and high-frequency roll-off are essential to avoid undesirable oscillations which normally occur as a result of reactive effects inherent in multiple transistor feedback amplifiers.

Linear phase response is desirable to ensure linear deviation of frequency above and below the nominal or center frequency.

Phase Shifter

When the oscillator is operating at nominal or center frequency, the output signal from the amplifier is phase shifted by 90-deg, attenuated somewhat and applied to one of the mixer input terminals.

The phase shifter shown in Fig. 2 does an efficient job. The secondary of the transformer, together with a resistance and capacitance comprise a bridge network. If a signal is applied through the transformer and the output is taken, as shown in Fig. 2, from the common point of the R-C network to the grounded center tap of the transformer, this output signal may be adjusted for any phase from about 0 to 180 deg with respect to the input, depending upon the ratio of resistance and capacitance. However, once adjusted in a given strain gage oscillator, the phase shift variation is approximately ±5 deg throughout a bandwidth of ±7.5 percent.

Mixer

The mixer circuit receives the phase shifter and bridge output signals and resistively mixes them, yielding a simple vector sum which is applied to the phase corrector.

Both the function and design of the mixer are simple. Presenting a high input impedance to the resistance bridge and the phase shifter, the mixer does not load the bridge unduly and it does not enter into the 90-deg phase shifting adjustment. Presenting a low impedance to the phase corrector circuit, it is not loaded by the phase corrector and the reactance of the phase corrector is not reflected back to the bridge or phase shifter circuit.

The phase corrector circuit is a simple low-pass L-C filter. This filter provides the additional 90-deg phase shift and attenuation necessary to sustain oscillations of the phase-shift oscillator. Since the circuit is correctly terminated and driven from the proper effective generator impedance, it provides the ideal linear phase shift versus frequency characteristic desired

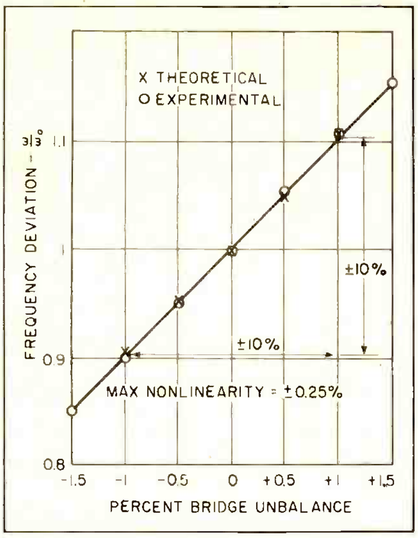


FIG. 4—Comparison of theoretical and experimental performances of oscillator

throughout the operating range of frequencies.

Calibrator

Included within the strain gage oscillator are relays and appropriate calibration resistors such that, upon demand, the oscillator presents a center-frequency signal corresponding to a balanced-bridge condition and then a band-edge frequency corresponding to a full-scale unbalanced bridge. The obvious value of these signals is in the playback system, where the calibration frequencies may be compared to standards and appropriate corrections for center-frequency drift and/or sensitivity change can be applied, if needed, to the actual data obtained from the oscillator.

During the center-frequency calibration period a precision resistor is placed between the mixer bridge input and ground, replacing the bridge output. This causes the amplifier input to be solely a local feedback signal which in turn causes the oscillator to operate at its center frequency.

During the band-edge or full-scale frequency calibration period, a precise fraction of the bridge excitation signal is placed at the mixer bridge input, replacing the bridge output as in the case of center frequency calibration. This is made to correspond to a full scale unbalanced bridge output signal and causes the oscillator to oscillate at a band-edge frequency.

The oscillator is capable of precise self-calibration because the ratio, not the absolute value, of the local feedback and the bridge output signals causes the frequency of oscillation to deviate. The oscillator offers an advantage over voltage-controlled oscillators in that it requires no external transducer excitation voltages.

Performance

Laboratory models and prototypes of the transistorized oscillator have been constructed and subjected to extensive temperature testing. The test results are shown in Fig. 4. The individual units shown in the block diagram have also been tested independently of the oscillator and are now operating satisfactorily in the field.

Applications

Because of its small size and low power requirement, the transistorized strain-gage oscillator finds major application in the fields of telemetry and remote control, particularly in the flight testing of aircraft and missiles. However, other applications are numerous.

For example, the oscillator may be used in conjunction with thermistors or hot wires to yield a good instrumentation device in the field of thermodynamics. A simple modification of the oscillator, in conjunction with photo diodes or photo transistors, yields a valuable instrument in spectroscopy.

In conjunction with pressure transducers or accelerometers utilizing resistance bridge principles, the oscillator yields simple measurement of mechanical phenomena.

Variations of the oscillator have been constructed for use as low-level voltage-controlled oscillators. Measurements of d-c levels in the millivolt range are readily and accurately obtainable.

The strain-gage oscillator may be used in conjunction with resistance-bridge transducers ranging in resistance from 100 ohms to 1,000 ohms. Total power required is less than 500 mw, including the necessary resistance bridge transducer excitation voltage of 2 v rms.

Units have been constructed that operate efficiently on 50 mw. This unit was developed under USAF contract No. AF04 (611)-683.

Transistor Oscillator Supplies Stable Signal

SUMMARY —— Colpitts circuit, employing one germanium transistor and one Zener diode, operates from a laboratory regulated power supply to maintain a sine-wave voltage of precise amplitude

By Leon H. Dulberger
Project Engineer, Fischer & Porter Co., Hatboro, Pa.

OPERATING AT A FREQUENCY of 10 kc, the sine-wave oscillator to be described provides 0.5-rms output at 15-ohms impedance. Amplitude stability is 0.1 percent over the temperature range of 30 C to 50 C. Checks indicate a drift of frequency under 0.25 percent.

Circuit

The Colpitts configuration, Fig. 1, operates from a 1N429 Zener reference diode rated at 0.01 percent per degree C temperature coefficient. A laboratory power supply, regulated to 0.25 percent for line and load, provides preliminary voltage control. This can be replaced by a semiconductor regulator.

The adjustable tank coil is coarse-tuned by C_1 and C_2, which also provide impedance match to the emitter. Fine frequency adjustment is obtained by the position of the core within the coil. A low L-C ratio, which allows high emitter current, provides a large voltage across R_2.

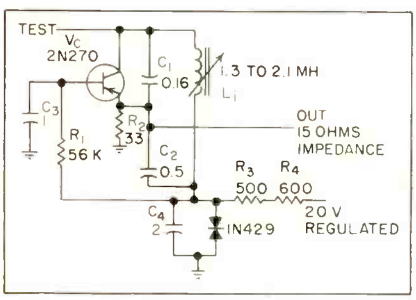


FIG. 1—Constant amplitude transistor oscillator, used as a stable amplitude carrier for a data-reduction system, replaces equipment using several electron tubes operated from a regulated power supply

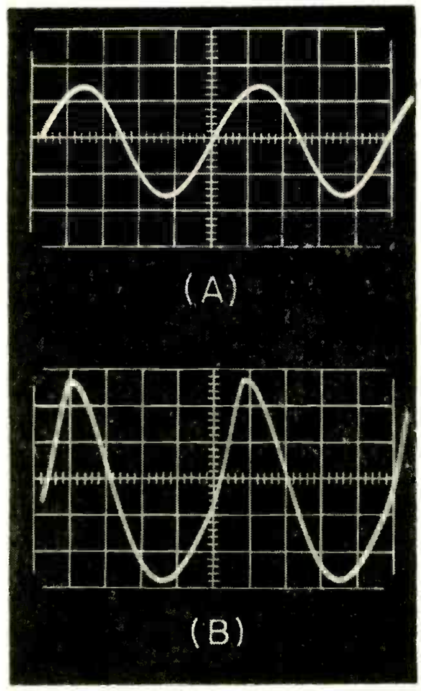
Some distortion is generated in the collector circuit, in addition to the desired positive peak clipping when providing a high signal level to the load. The output signal, taken from the emitter, is an undistorted sine wave as shown in the photograph. For a fixed supply voltage, R_1 and R_2 are adjusted for peak-to-peak collector swing just under twice the supply voltage. The final base-to-emitter bias current produces about 2 percent limiting of the peak collector swing. Final adjustment produces the collector waveform shown.

Capacitor C_3 grounds the base at the operating frequency. Under these conditions, the collector to base voltage varies directly with the collector supply voltage.

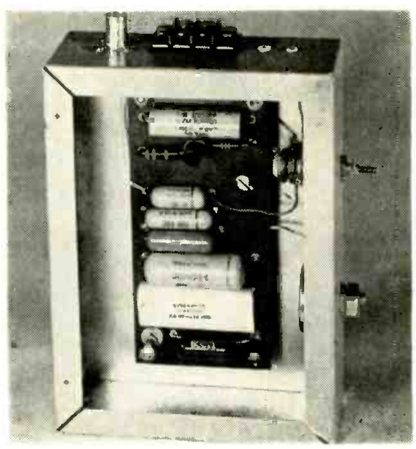
Transistor Operation

The 2N270 transistor operates at 7.6-ma collector current and 6.3-v d c supply. Best amplitude stability is obtained with 11.6 v peak-to-peak measured at the collector. At this point, output impedance is high and unsuited to driving a load. However, a 10,000-ohm load is easily driven from the emitter at 0.5-v rms without sacrificing performance.

Current-adjustment resistor R_3 with R_1, sets the idling current through the diode. For the 1N429 used, optimum regulation is obtained at 7.5 ma. Capacitor C_4 bypasses the a-c signal around the diode to provide low signal impedance.



Emitter waveform (A) vertical scale: 0.5-v per cm; horizontal scale: 20-μsec per cm and Collector waveform (B) vertical scale: 2-v per cm; horizontal scale; 20-μsec per cm. Output is undistorted



Compact design of packaged oscillator is suited for minimum-space requirements

Bearing Memory

SUMMARY — Four independent receiver-bearing indicator units operate from single antenna array in Doppler system. Memory fills in time space between code pulses and presents continuous bearing at all code speeds. Bearings are retained after transmitter leaves air and system is insensitive to antenna array misadjustments

By ROY E. ANDERSON General Engineering Laboratory, General Electric Company, Schenectady, New York

ROTATING ANTENNA SYSTEMS of idealized Doppler direction finders would have to travel impossibly fast to generate sinusoidal f-m signals. But a Doppler direction finder system has been developed in which the action of a rotating antenna is simulated by a 150-ft diameter circular array of 31 antennas, scanned 42 times each second by a capacitively coupled rotating scanner. A block diagram of the system is shown in Fig. 1.

A unique memory unit presents continuous bearings. A bearing indicator compares the envelope phase with a reference phase and presents the bearing indication on a crt.

Choice of Antenna Array

Although large antenna-array diameters reduce bearing errors from propagation disturbances and reradiation from objects near the array, economic and scanner design considerations limit the number of antennas to about 30. An upper design frequency of 30 mc requires that the spacing between adjacent antennas be no greater than 15 ft. Therefore the antenna array has 31 antennas in a circle 150 ft in diam. An odd number of antennas is required for the double takeoff system used in the scanner.

A signal from a distant transmitter induces equal voltages in all antennas of the array. The phase difference between the signals in adjacent antennas is a function of the frequency and the direction of signal arrival. For example, if the frequency were 7 mc and the direction of arrival were approximately 5 deg east of north, the signals in the various antennas of the 150-ft diam array would have the instantaneous phase relationship shown in Fig. 1.

Antenna Phasing

The vectors shown in Fig. 1 are each revolving at the frequency of the distant transmitter. However, at any one instant, the relative phase relationships between the signals in the various antennas are as shown, where the numbered vectors represent the signals in the corresponding antennas. The magnitudes of the phase differences are determined by the physical spacing of the antennas in the direction of wave travel. The relative phase relationship between the various antennas remains as shown regardless of viewing moment, motion of the scanner, or any other time event.

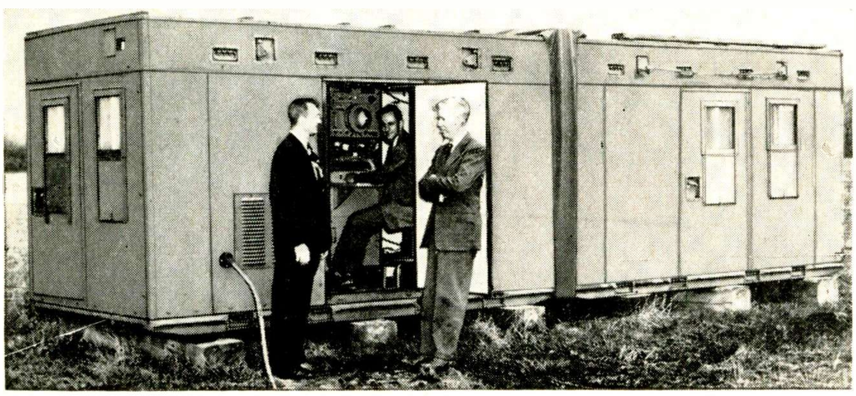
Antennas are scanned in sequence so that signals from adjacent antennas are combined during the scan to produce an f-m signal. Instantaneous frequency deviation is proportional to the phase step between adjacent antennas. The envelope phase of the f-m modulation produced during a complete scan cycle is dependent only upon the arrival direction of the signal.

Blended Switching

Signals are combined during the scan by linear-blended switching. A single signal E is incident on the doppler system antennas. The slope magnitude of the amplitude change as one antenna is scanned is represented by S and therefore, $e_n = (E - St) \angle\sigma_1$, for $t_o < t < t'$.

Simultaneously, the adjacent antenna is also scanned so that $e_{n+1} = St \angle\sigma_2$, for $t_o < t < t'$.

The voltage induced in each antenna has an amplitude of E and the difference in phase between the voltages in adjacent antennas is $\psi = \sigma_2 - \sigma_1$.



Direction finder equipment, mounted in transportable housing, is comparatively insentive to misadjustment of antenna array or to site errors

Improves Direction Finder

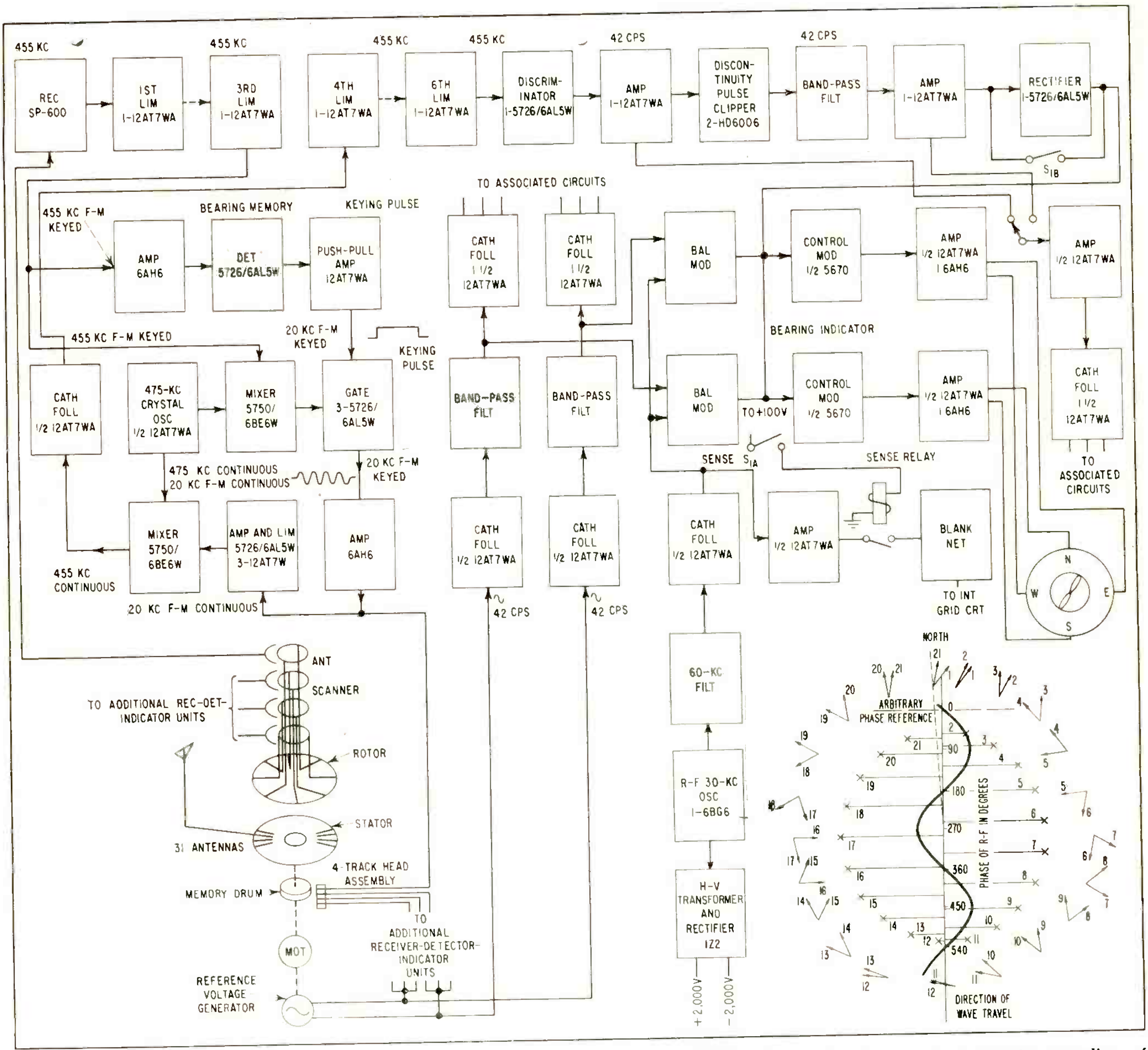


FIG. 1—Antenna scanner feeds single receiver-indicator cabinet of AN/TRD-8 (XE-2). System bearing memory permits sampling of fading or swinging bearings. Numbered vectors in phase diagram indicate phase difference variation between antennas

The vector diagram of Fig. 2A represents the voltage induced in two adjacent antennas when $\sigma_1 = 0$. Sum of voltages e_{n+1} and e_n combined in polar form is $a \angle \theta$. Phase angle $\theta = \tan^{-1} (St \sin \psi)/(E - MSt)$ when $M = 1\text{-}\cos \psi$.

The rate of change of phase, which is the frequency deviation considered during any scanning interval between two adjacent antennas, may be expressed as $d\theta/dt = t' \sin \psi/(2Mt^2 - 2\,mtt' + t'^2)$ in the interval $t_o < t < t'$ where t' equals E/S. To convert $d\theta/dt$ into cps it must be divided by 2π.

Frequency deviation is plotted in Fig. 2B for a single signal at 15 mc arriving along a line of antenna-array symmetry. Phase difference ψ is a different constant for each segment of the curve.

Phase Steps

Large phase steps are undesirable for then the spikes in Fig. 2B become large. A phase step of 180 deg gives an infinite frequency deviation and an instantaneous reduction of amplitude to zero.

Figure 3 illustrates the method by which the scanner accomplishes the linear blended switching. The antennas are numbered consecutively around the array, but they are connected to conducting segments on the stator in the order shown in Fig. 3A. When rotor 1_A is fully coupled to stator plate 1, rotor plate 1_B is between stator plates 31 and 2.

As the rotor of the scanner turns at constant speed, plate 1_A is decoupled from 1, while 1_B couples to plate 2 with both changes in coupling taking place linearly with time. When the shaft has completed one-half a revolution, rotor 1_A has scanned from stator 1 through 31, and 1_B has scanned from 2 through 30 so that two scans of the antenna array are accomplished for one rotation of the shaft.

Rotor plates 1_A and 1_B are connected to a conducting coating on the outer surface of a drum attached to the scanner shaft for signal output coupling as shown in Fig. 3B. The drum is capacitively coupled to a conducting coating on the inside surface of a stationary cylinder. The vector sum of signals on rotor plates 1_A and 1_B thus appears on the output coupling cylinder. The cylinder is connected to the receiver through an appropriate impedance matching transformer.

Since the action of the other pairs of rotor plates is the same as that of plates 1_A and 1_B, four independent outputs from the scanner provide four independent direction finders operating from one antenna array and scanner.

Noise

Peak f-m deviation of the bearing waveform increases linearly with scanning rate. A large deviation reduces the effects of f-m noise on the transmitted carrier or receiver local oscillator, but all important frequency components of the signal must be within three kc to avoid interference from adjacent communication channels. A scanning rate of 42 cps is a good compromise.

The equipment operates well up to 30 mc where the spacing between antennas is one-half wavelength and the phase-step 180 deg, but its performance falls off rapidly above this frequency.

The only degradation in observed performance is in the 25 to 30-mc range where tuning is critical.

Large peaks of frequency deviation caused by large phase steps in this region require the full bandwidth of the receiver i-f stages for passage without distortion. Therefore the wave must be accurately centered in the i-f pass band.

The signal into the receiver contains its original modulation as imposed at the transmitter plus the f-m shown in Fig. 2B. The frequency deviation of the fundamental component of f-m resulting from the scanning action ranges from 20 cps at 1 mc to 600 cps at 30 mc. Amplitude modulation ranges from negligible at 1 mc to nearly 100 percent at 30 mc.

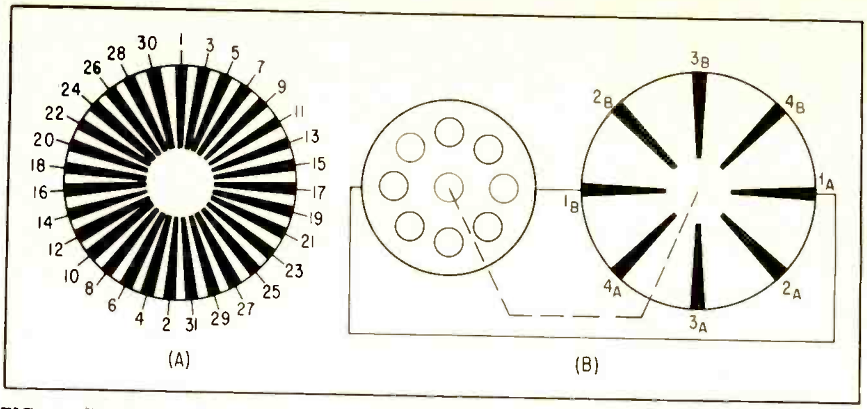


FIG. 3—For linear blending the antennas are connected to the stator conducting segments in (A). Rotor plates 1_A and 1_B are connected to conducting coating on drum surface attached to scanner shaft in (B)

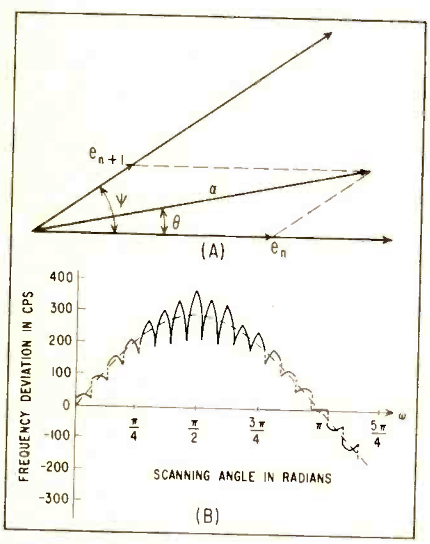


FIG. 2—Linear-blended switching uses vector voltage relationships of adjacent antennas (A). Frequency deviation derived from relationship (A) is plotted in graph (B) for single 15-mc signal

Receiver

A Hammarlund SP-600JX receiver converts the received signal to 455 kc while preserving both the amplitude and frequency modulations. When the direction of arrival is not along a line of antenna-array symmetry the spikes contain bearing information. The fundamental component of the spikes on the f-m envelope must be passed through the system. Consequently, the receiver is always operated in its 3-kc bandwidth position.

The 455-kc i-f output of the receiver is applied to a series of cathode-coupled limiter stages that remove all amplitude modulation and then to a Foster-Seely discriminator.

The discriminator output is an a-f signal having a waveform similar to the spiked pattern of frequency deviation shown in Fig. 2B. The fundamental component equals the scan rate of 42 cps and has an amplitude and phase dependent upon the frequency of the received signal and the direction of arrival respectively.

Low-frequency circuits amplify and filter the 42-cps signal and remove its harmonics. It is converted to a cusp-shaped wave by a full-wave rectifier.

Bearing Indicator

The cusp-shaped wave modulates a 60-kc carrier in the bearing indicator. Two equal amplitude 42-cps voltages, 90-deg apart in phase, are derived from a small generator on the scanner shaft. These reference voltages also modulate the 60-kc carrier.

When the resulting modulated carrier is applied to a 7-in. crt, a propeller-shaped pattern appears. The pattern direction is dependent upon the relative phases of the bearing and reference signals. A direct reading of the bearing may be obtained by aligning a hairline with the propeller axis and reading the bearing on an azimuth scale. The sense ambiguity of the propeller pattern is resolved by blanking one-half of the pattern each time a bearing is taken.

The bearing signal from the discriminator is filtered to remove the spikes. These harmonics distort the bearing indicator pattern and make it unreadable.

When the system is operating, the reception of code transmissions requires that the output of the filter attain the correct phase in the short period of a dot or dash. Therefore the bandwidth of the filter should be relatively broad. On the other hand, the filter bandwidth must be so narrow that harmonics of the 42-cps scanning rate are reduced below the level at which they cause bearing errors. The best compromise limits the transmitted Morse code rate to about 25 words per minute.

Bearing Memory Circuit

The bearing memory overcomes the code reception difficulty by filling in the code gaps with previously recorded signals so that bearing information is supplied continuously to the filter even though the received signal is broken up into dots and dashes.

The circuit diagram of Fig. 4 indicates the way in which the bearing memory operates. The 455 kc signal obtained from the output of the third limiter on the detector chassis is applied to the input of the memory system. It is frequency modulated with the bearing information introduced by the action of the scanner.

The input signal to the memory system is simultaneously applied to a gate-pulse generating channel and a recording channel. The first tube in the gate-pulse channel is V_1 while the first tube in the recording channel is V_4. During signal receipt, mixer V_4 converts its center frequency to 20 kc. It is then passed through the diode gate consisting of V_5, V_6, and V_7 and then to V_8 which drives the recording head.

When no signal is received, the diode-gate circuit is in the not-pass condition and prevents noise from reaching the record head. The noise amplitude at the input to the memory must not exceed approximately 0.5 that of the signal. Otherwise noise will trigger the gate and be recorded during the signal receipt time.

Signals are recorded on the drum as they are received and are reproduced from the drum when no signals are received. The recording signal records to saturation so that during receiving and recording any signals previously recorded on that segment of the drum are erased. Only one head is used for recording and reproduction. When a received signal stops, the head no longer causes erasure but reproduces the recorded signals to fill in code-transmission gaps.

One scan of the antenna array produces one cycle of f-m receiver signal. Two scans of the array are accomplished during one scanner shaft rotation. Since the magnetic recording drum is attached to the scanner shaft, exactly two f-m cycles are recorded on the drum. The f-m envelope has a coherent phase since its phase with respect to a reference is determined by the signal arrival direction. Keying has no effect on the phase of the bearing signal modulation. There is no coherence between angular position of the drum and the start and conclusion of code pulses. Therefore, any information on the drum may be replaced by new information as it is received.

The fundamental phase of the recorded modulation envelope is determined by the direction of arrival. The time for one rotation of the drum, 0.05 second, equals

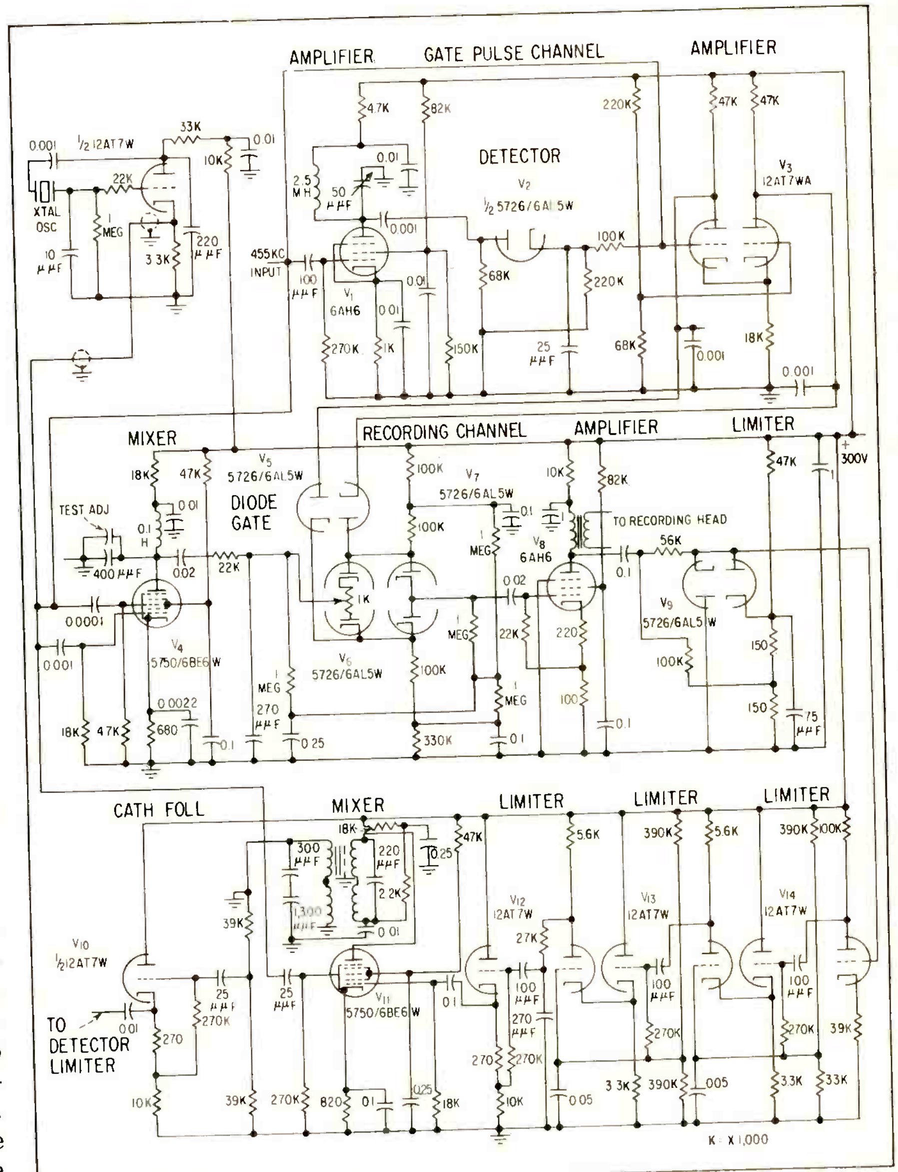


FIG. 4—Memory-unit input simultaneously feeds gate-pulse generating channel and recording channel. Diode gates keep noise off record head

the duration of a dash at 100 wpm. The drum is filled with information after the first dash even at code speeds as high as 100 wpm.

During the signal receipt time the signal is applied to the record head, diode limiter V_9 and cathode-coupled limiters V_{14}, V_{13}, and V_{12}. Its center frequency is then converted back to 455 kc by mixer V_{11}. It is then applied to the fourth limiter on the detector chassis through cathode follower V_{10} as shown on the block diagram of Fig. 1. During the time no signal is received, the reproduced signal is applied to the limiter and mixer chain starting with V_9.

Continuous Indication

Although the signal at V_9 is several hundred times larger during recording than during reproducing, the limiter action maintains a constant-amplitude mixer output. Consequently the fourth limiter on the detector chassis receives the same continuous bearing signal for a code station as for a station that transmits continuously. Audio filters located beyond the limiters and discriminators reject switching transients caused by the scanner and receive a continuous signal.

Single-Head Design

One head of the recording system provides the record, reproduce and erase functions. This design eliminates gaps in the record information and the effects of variations in drum rotation rate. Each point on the drum passes under the head during reproduction at the same linear speed as during record. Although the recorded wavelengths vary with the drum-surface speed, the reproduced frequency from each drum segment is the same as the frequency recorded on that segment.

Signal receipt to signal reproduction ratio of 500 at the memory-system limiter is a single-head system disadvantage. This fact imposes stringent design requirements on the gating circuit. To prevent noise pulse passage through the gate the attenuation of the gate must be at least 1,000 to 1 in the stop condition. If noise pulses pass through the gate, bearing indication jitter occurs during the reproduce period.

Performance Limitation

The major factor limiting the performance of the memory system is a discontinuity pulse caused by abrupt phase changes at the boundaries between recorded and newly received signals. Bearing errors, produced by discontinuity pulses during reproduction time do not exceed ± 3 deg with an average deviation of a fraction of a deg and zero average value.

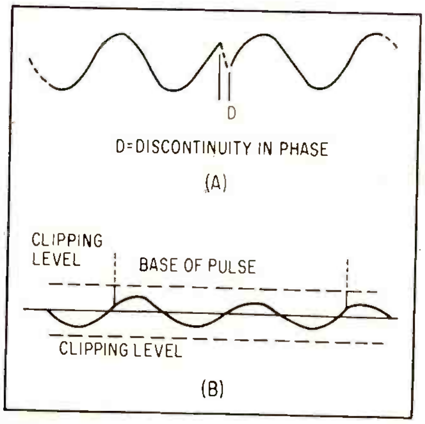


FIG. 5—Discontinuity pulse (A) caused by phase discontinuity in 20-kc carrier eliminated by biased diode clippers (B)

During code reception discontinuity pulses cause jitter at the keying rate. Since high-frequency pulse components are in the audio-filter output, large discontinuity pulses usually cause bearing pattern distortion.

Phase discontinuity in the 20-kc recorded carrier at the recording point causes the discontinuity pulse shown in Fig. 5A. The recorded frequency near the discontinuity pulse is the 20-kc carrier plus or minus the deviation appropriate for the particular portion of the scan cycle. The phase discontinuity has any random value between zero and ± 180 deg. The large rate of phase change during the period of discontinuity is equivalent to a large frequency deviation.

Discontinuity Pulse Duration

During the recording process the minimum discontinuity pulse time is determined by the maximum frequency that can be recorded to saturation with the head and drum design used. With the 0.001-in. spacing, the head design and the plated magnetic medium used on the drum, the upper frequency limit is approximately 80 kc.

The recording system will therefore set a lower limit of approximately 12 μsec on the duration of the discontinuity pulse.

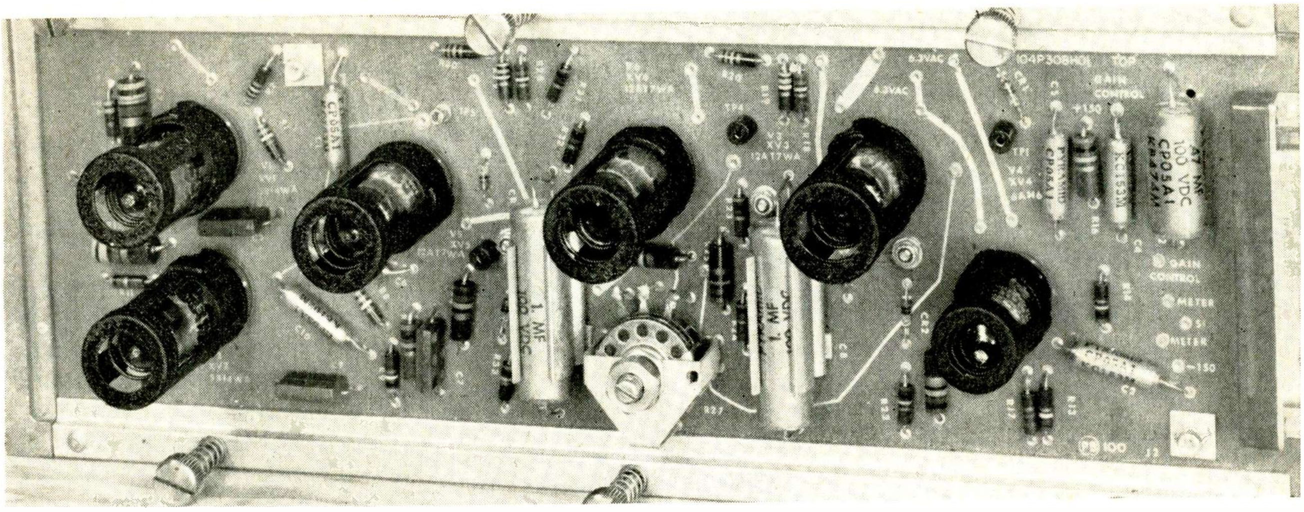
The 12-kc bandwidth of the tuned filter which separates the 455-kc and 475-kc signals at the output of the memory-system limiters determines the 80-μsec minimum duration of the discontinuity pulse. Oscillographic measurements of the discontinuity-pulse base indicate a duration of less than 100 μsec.

Peak deviation of the discontinuity pulse is determined by the filter bandwidth and the phase discontinuity magnitude in the 20-kc carrier. It may be several thousand cps.

Pulse Error

Since a dot at speeds below 30 words per min. has a duration sufficient to fill the drum there is never more than one discontinuity pulse per drum rotation at that speed. A single dash at 100 wpm fills the drum. With a single pulse on the drum the maximum pulse error could be great. The second harmonic component of a 100-μsec pulse is large compared to the deviation of the bearing signal and could occur at any phase relative to the bearing signal. In fact, the second harmonic component of the pulse waveform is equivalent to a deviation of approximately 20 cps. Since the deviation of the bearing signal ranges from approximately 30 to 600 cps the discontinuity pulse could introduce serious bearing errors.

Biased diode clippers and audio filters can greatly reduce the undesired effects of discontinuity pulse. The clipping levels are shown in Fig. 5B. The excursion of the unclipped pulse can be in either direction, of any magnitude up to approximately 200 times e, and at any phase with respect to bearing signal. The pulse duration is kept below 100 μsec by maintaining a bandwidth greater than 12 kc for all circuits from the record head through the discriminator.



Arrangement of the monitoring circuit on printed board emphasizes compactness

Monitor Displays Radar Noise Figures

SUMMARY —— Direct and continuous measurement of radar receiver noise figure is provided by comparing, in a difference amplifier, d-c signals proportional to gated monitor pulse and noise generated during receiver dead time. Since pulse and noise have passed through a logarithmic receiver, their difference represents the logarithm of their ratio. Device does not affect radar performance and a sensitivity up to 5 μa per db is obtainable

By LEO YOUNG Fellow Engineer, Radar Equipment Engineering, Electronics Division, Westinghouse Electric Corporation, Baltimore, Maryland

ACCURATE MEASUREMENT of the noise figure of a radar receiver is essential. The equipment currently in use, however, necessitates radar shutdown during measurement or else causes a deterioration in receiver noise figure.

Direct Measurement

A simple, compact circuit for measuring radar noise figure is described here which is based upon existing monitoring equipment. The unit, plugged into any one of several channels, reads the channel noise figure directly and continuously. Additional monitoring circuitry requires only six miniature tubes and a meter which is calibrated to read noise figure.

A 10-μsec r-f monitor pulse generated by a low-power oscillator occurs between the end of the maximum range time and the next transmitter pulse of the 100-μsec radar dead time. Relative position of the transmitter and monitor pulses is shown in Fig. 1. The r-f monitor pulse is coupled through 30-db directional couplers into each receiving channel.

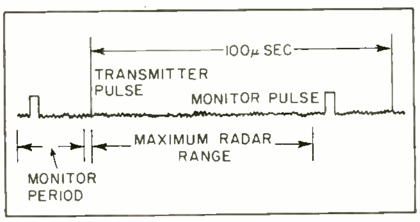
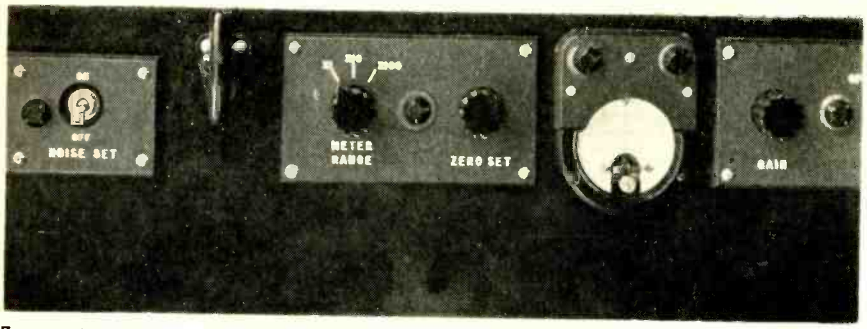


FIG. 1—Monitor pulse appears between end of maximum range time and following transmitter pulse

Signal-to-Noise Ratio

Since the receiver i-f amplifiers are logarithmic down to noise level, both the logarithm of the signal and the logarithm of receiver noise are directly available for monitoring. The signal-to-noise ratio is measured by gating moni-



Zero-center meter is mounted in panel for convenience of adjustments. Meter is calibrated in db using a known receiver noise figure as reference

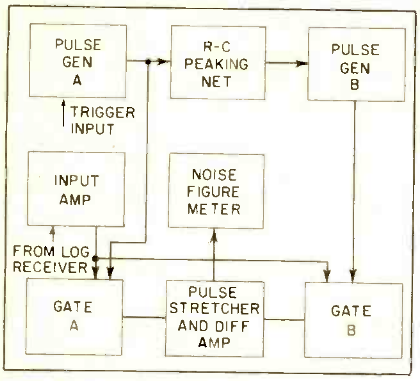


FIG. 2—Noise-figure circuit shown in block diagram uses only six tubes

tor pulse and noise signals into separate circuits, stretching each signal and comparing them in a difference amplifier. The amplifier output is proportional to the noise figure and can be calibrated against a known noise source.

Circuit Description

Operation of the two gates of the noise-figure circuit shown in Fig. 2 is initiated by a trigger pulse which determines the start of the monitor period.

The gating pulse *A* which is not much longer than the monitor pulse, permits the monitor pulse to enter one side of a difference amplifier after pulse stretching. It is thus turned into a d-c level proportional to the pulse voltage.

The trailing edge of the pulse *A*, differentiated by passing through an R-C peaking circuit, triggers pulse generator *B*. Gating-pulse *B* starts at the end of pulse *A* as shown in the timing sequence of Fig. 3 and opens a second gate. Noise between the monitor pulse and the following transmitter pulse passes into another stretching circuit and a d-c potential proportional to the noise level is therefore applied to the other input of the difference amplifier.

Since the monitor pulse and the noise pass through the same logarithmic receiver, the difference-amplifier output is proportional to their difference or the logarithm of their ratio. As both gated inputs are stretched before feeding into the difference amplifier, this ratio is displayed on a microammeter whose reading is proportional to the noise figure in db.

If a linear receiver had been used, a ratio meter could have replaced the difference amplifier.

Gating Circuits

Pulse generator *A*, the one-shot multivibrator V_1 shown in the schematic diagram of Fig. 4, is triggered by a short positive trigger pulse following the termination of maximum range time. The output, − 60-v gating pulse *A* is negative going. Pulse generator *B* is similar to multivibrator V_1 except that the pulse produced is several times longer than pulse *A*.

Gating pulse *A* feeds into a gating circuit consisting of triodes V_{3A} and V_{5A}. Although their cathodes are strapped together triode V_{3A} is normally conducting, while V_{5A} is cutoff. This is achieved by returning the grid of V_{5A} to ground, while the grid resistor of V_{3A} goes to a + 30-v point.

When the − 60-v gating pulse is applied directly to the grid of V_{3A} the tube is cutoff while V_{5A} conducts. Gate V_{5A} now becomes a cathode follower preceded by a video amplifier V_4. Adjustable negative feedback provides the gain control. The output of V_4 is also connected to V_{5B} which acts as a cathode follower for the duration of gating pulse *B*.

Gate *B* consisting of V_{3B} and V_{5B} operates similarly to gate *A*.

Pulse Stretch Circuits

Cathode-follower outputs from V_{5A} and V_{5B} are connected to two pulse-stretching circuits. Their operation depends on diodes and charging capacitors with short time constants during the charging period and long time constants during the discharge interval. Low output impedance of the cathode followers allow the charging constant to be only a few μsec, while the discharge time is several millisec. Thus two nearly d-c potentials proportional to the log of monitor-pulse voltage and noise level respectively are applied to grids 1 and 2 of the difference amplifier V_6.

Difference Amplifier

Difference amplifier inputs, proportional to the logarithm of the signal or monitor pulse and the logarithm of the noise level respectively, may differ by 40 to 60 db. To increase meter sensitivity the larger input originating on the signal side is reduced. Reduction must, because of the logarithmic amplifiers, be effected by subtraction and not division.

A 3-v d-c source in series with the difference output is adjusted to read center of the zero-center meter scale when the noise figure of the channel is equal to the normal average value. Changes of plus or minus only a few db can be made to give full-scale deflection.

To set up the circuit the difference amplifier is zeroed with no

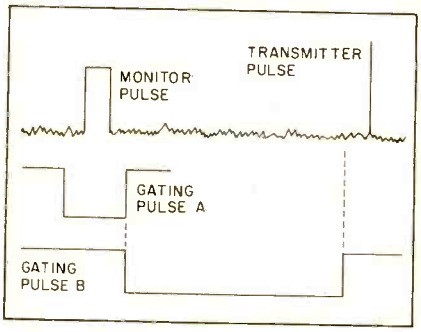
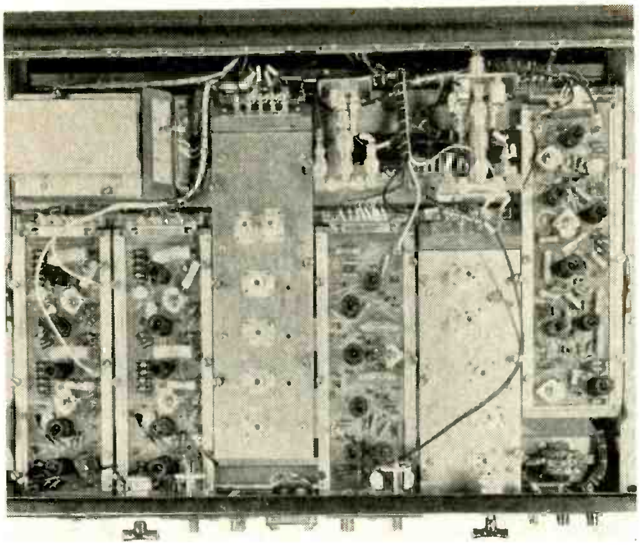
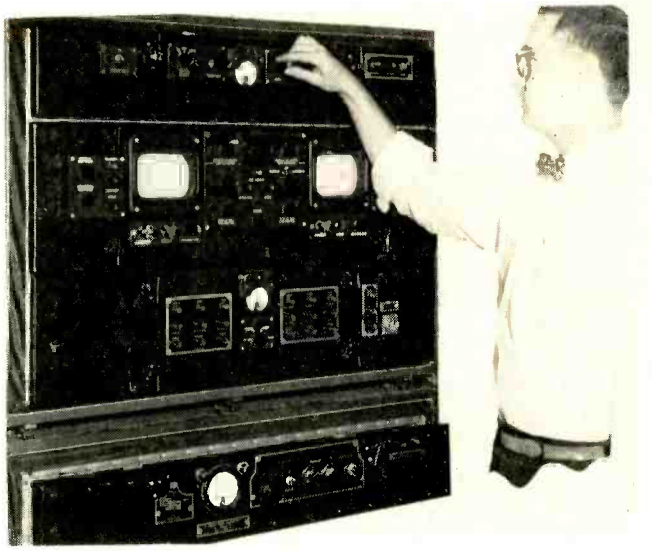


FIG. 3—Timing sequence of the two gating pulses shows relationship to the logarithmic input



Noise figure monitor is second printed board from right in the equipment drawer



Engineer adjusts monitor gain control at front of radar cabinet during calibration check of equipment

input by adjusting the potentiometer center-tap position which goes to − 150 v. Input to amplifier V_4 is then connected to a receiver whose noise figure has been calibrated against a known standard.

The pulse input is removed by shorting switch S_1. Gain of V_4 is adjusted so that the noise input of the difference amplifier produces 10 μa when 470,000 ohms is switched in series with it by S_2. This current ensures linear operation of the diodes in the stretching circuits. Switch S_1 is now opened, and pulse and noise from the receiver are passed through. Switching only the 4,700-ohm resistor in series with the meter gives maximum sensitivity.

Since the receiver noise figure is known, the potentiometer controlling the voltage from the d-c source in the difference amplifier circuit is adjusted until the microammeter db scale reads the correct noise figure.

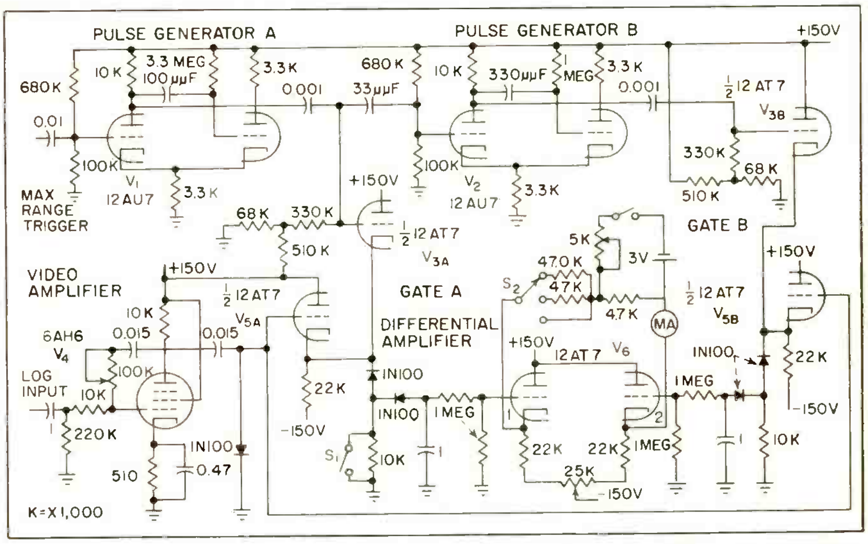


FIG. 4—Operation of the stretching circuits at the inputs to the difference amplifier depends upon charge and discharge time of the R-C networks

Characteristics

Sensitivity of the instrument is 5 μa/db on the most sensitive scale. A ± 25 μa zero-center meter is used giving a 10-db range on the most sensitive scale. The main error source over large dynamic ranges is the nonlinearity in the stretching circuits.

Accuracy over small ranges depends on the smoothness of the logarithmic characteristic and is limited by the short sampling time of the video noise in the 100-μsec monitor period. Brief sampling time causes fluctuations of the meter pointer amounting to about ± 1.5 μa on the most sensitive scale. Overall accuracy on this scale is estimated to be about 0.75 db.

Performance

The instrument provides a continuous direct reading of the noise figure of a radar receiver without interrupting or interfering with the radar operation. It is especially useful where the noise figure to be monitored does not normally vary more than a few decibels from an anticipated mean value.

It is also useful where more than one receiver has to be monitored. By providing a jack or switch, the noise-figure monitor can be connected to any receiver to immediately give a direct reading.

This project was part of a program sponsored by ARDC's Rome Air Development Center.

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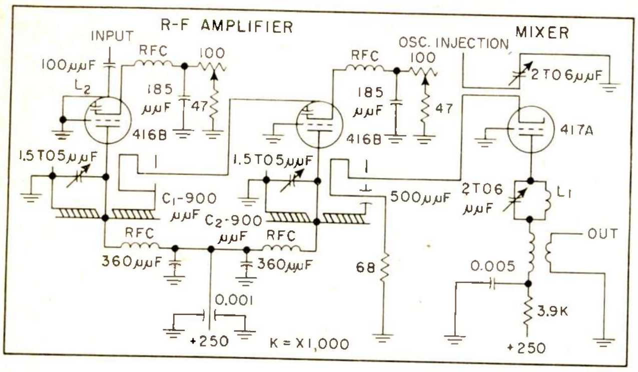


FIG. 1—Circuit of r-f amplifier and mixer. Grounded-grid amplifier stages provide low noise figure in uhf band of 400 to 500 mc. Second r-f stage further reduces noise figure

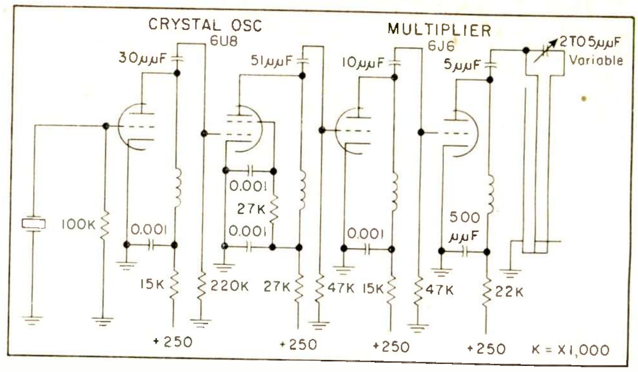


FIG. 2—Circuit of crystal oscillator and multiplier. Highly selective cavity and minimum coupling between multiplier stages prevent generation of undesirable harmonics

SUMMARY —— Converter with voltage gain of 36 db, bandwidth of 4 mc and noise figure of 2.5 db consists of two grounded-grid 416B r-f stages, 417A grounded-grid mixer, crystal oscillator and multiplier. Equipment is applicable for meteor, aurora and forward scatter propagation studies

Low Noise Converter for

By LEONARD F. GARRETT Linfield Research Institute, McMinnville, Oregon

NEED FOR LOW-NOISE receiving equipment to aid propagation studies in the 400-mc range during IGY resulted in the development of the 400-mc low-noise uhf converter described here. Since tropospheric scatter communication is mostly used in the 400-mc to 1,000-mc range, low-noise receiving equipment operating within this range is necessary for proper evaluation of signal path conditions.

The equipment is used in conjunction with the Propagation Research Project of the ARRL and the Geophysics Research Directorate, Air Force Cambridge Research Center.

Converter

Figure 1 shows the r-f amplifier and mixer stages of the converter, while Fig. 2 shows the crystal oscillator and multiplier. Employed in the amplifier are two 416B stages ahead of the 417A mixer. The 416B was chosen for the r-f stages because of its performance at vhf and uhf. It is highly suitable for grounded-grid operation in various types of coaxial structures. The second r-f stage allows a significant reduction in overall noise figure.

The converter was designed for use with a 50-ohm antenna transmission line. Frequency range of the r-f stages is 400 to 500 mc with an i-f of 30 to 35 mc. Stability is assured by the use of a 6U8 crystal oscillator and 6J6 multiplier stages.

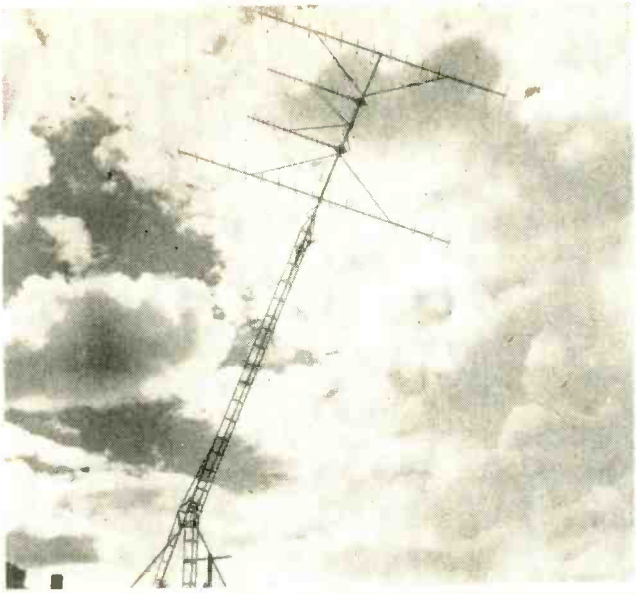
The uhf converter was designed after tests revealed the improved performance provided by the 416B in a 144-mc vhf converter. This converter has been in use two years in meteor propagation studies. It has a measured noise figure of 1.6 db and has made possible daily meteor reception of signals over airline distances exceeding 500 miles.

416B Plate Cavities

Both r-f cavities employ 0.25-wavelength modified coaxial cavities with a high ratio outer-conductor to inner-conductor diameter. This ratio is 8 to 1, which gives a surge impedance of 135 ohms and an unloaded Q of approximately 13,000. The 8-to-1 ratio was chosen to give the highest practical gain-bandwidth product.

One of the limiting factors is total circuit capacitance. A modified coaxial cavity and box construction were selected to provide compactness and ease of construction. The performance is comparable to that of the full coaxial type, providing care is used in securing a tight fit and in silver soldering of joints.

The mixer is a grounded-grid



Antenna used in conjunction with ARRL IGY Propagation Research Project. Antenna is shown tilted for meteor scatter signals from station 500 miles distant

Operator is shown adjusting plate current of uhf converter r-f amplifier to optimum level. Front panel contains 0-50 ma meter and switch that provides check for each 416B r-f amplifier

IGY Propagation Study

417A, chosen for its high g_m and low noise characteristics. This tube is superior to crystal mixers in the 400-mc range and provides additional gain, thus eliminating the need for an additional i-f stage. Oscillator injection is accomplished by a matched 50-ohm link to the cathode inductance of the 417A.

The low input impedance of the mixer provides stable loading of the second r-f stage over the desired bandwidth. A low-impedance link is inserted in the second r-f plate cavity near the cold end for coupling to the mixer. Coil L_1 and the 2- to 6-$\mu\mu$f variable capacitor in parallel form a trap to prevent the oscillator injection frequency from reaching the output of the converter.

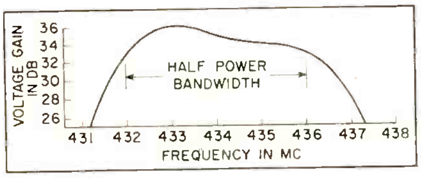


FIG. 3—Overall frequency response of uhf converter. Peak voltage gain is 36 db at 433 mc. Half-power bandwidth is 4 mc

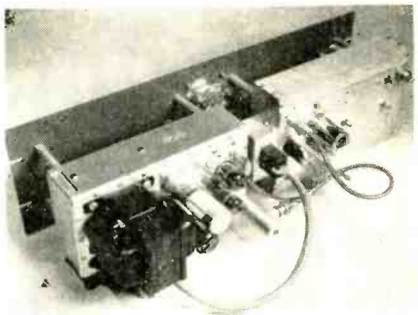
Oscillator and Multiplier

A conventional overtone crystal oscillator and suitable multiplier stages provide required stability and the necessary frequency multiplication. By reducing to a minimum the coupling between multiplier stages, and using a highly-selective cavity, unwanted harmonics of the crystal oscillator are prevented from reaching the mixer.

Construction Notes

Physical layout of the converter is shown in a photograph. The 416B's are mounted with the grid rings screwed into the partition between the input and output circuit. This partition not only serves as a mounting for the tubes, but also provides a low-impedance ground for the grid circuit of these coaxial r-f amplifiers.

Cathode inductance of the input



Rear view of complete converter showing power supply-oscillator-multiplier chassis, left, and r-f chassis, right. Visible are power cable to r-f chassis and coaxial cable between mixer and oscillator-multiplier chassis

416B is made from 0.02-in. copper and is silver plated. One end is secured to the partition between cavities and the other end makes contact with the tube body (r-f cathode) through silver-plated finger stock mounted on a small standoff insulator under the tube body.

The 416B plate cavities are 2 in. high, 2.6 in. wide and 2.5 in. long, with the center conductor 0.25-in. in diameter and 2.5 in. long. The tube end of the center conductor is slotted to form contact fingers to accept the 416B anode. Anode supply bypass capacitor is an integral part of the chassis, being formed by one side of the chassis and a 1⅝-in. silver-plated brass plate. The dielectric is 0.005-in. Mylar.

Plate Circuit

The r-f plate cavities are so arranged that the plate circuit of the first stage is opposite the input of the second, thus facilitating coupling. Perforated side covers provide necessary shielding of tube connections and protection for the exposed vacuum seal off of the 416B.

Filament and d-c cathode r-f chokes and decoupling filter network are also mounted along the side under the perforated covers. The 416B's are readily removed by lifting the socket and unscrewing the tube.

Fabricated from 0.4-in. brass plate, the r-f chassis is silver plated after all partitions are silver-soldered in place. Adequate cooling of the 416B stages is provided by two small blade-fans. Air is directed across the cavity center conductor and tube anode, as well as the tube body and glass seal, and is then exhausted through ventilating holes on the opposite side of the cavity.

Mounted on a chassis that also contains the crystal oscillator and multiplier stages is the power supply. This is mounted beside the r-f chassis on supporting pillars behind the front panel. A panel meter monitors the plate current of each 416B stage. Individual plate current controls and a meter switch are also on the front panel for easy access.

Measurements and Adjustments

Figure 3 is a curve of the overall frequency response of the converter at the half-power points. Noise-figure measurements were made with an electron tube diode noise generator, which was checked with a 50-ohm slotted line and adjusted for minimum vswr. A maximum vswr of 1.06 was obtained

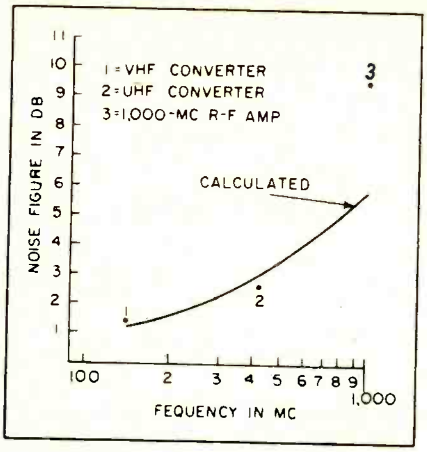


FIG. 4—Comparison of noise figure for a single 416B r-f stage (calculated), and measured values for uhf and vhf converters and 1,000-mc amplifier stage

over the 400 to 500-mc range.

In conjunction with the noise generator, a 3-db pad and 30- to 35-mc i-f amplifier followed by a detector were used in standard measurement procedure. Proper adjustment of load admittance is of prime importance in obtaining the optimum value of input impedance. It is adjusted by varying the coupling to the plate cavity of the 416B stage until minimum noise figure is obtained.

Adjusting Inductance

Value of L_1 is another important consideration in obtaining a low noise figure and can best be determined experimentally. It should be adjusted for minimum noise figure.

Figure 4 shows a curve of the calculated noise figure for a single 416B r-f stage and the measured values of the noise figure for the uhf converter described, a single stage vhf converer and a 1,000-mc amplifier stage.

Noise Figure

The following equation[1] yields the overall noise figure F_{123} of a circuit consisting of three networks in cascade:

$$F_{123} = F_1 + \frac{F_2 - 1}{G_1} + \frac{F_3 - 1}{G_1 G_2}$$

where F_1, F_2 and F_3 are the noise figures of networks 1, 2 and 3 respectively, and G_1 and G_2 are the available power gains of networks 1 and 2.

This expression shows that, while the main contribution to the overall noise figure comes from the first network, the contribution of the second stage is also significant for usual values of G_1.

This second-stage effect demonstrates the desirability of using a second low noise r-f stage ahead of the mixer to minimize the contribution of the latter to the noise figure.

More specifically, the use of two 416B r-f stages and 417A mixer reduces the noise figure by about one db over that obtained with a single 416B r-f stage and conventional crystal mixer and by several db over that yielded by other disk-seal tube r-f amplifiers and crystal mixer combinations.

Input Circuit Design

To examine the input impedance of the 416B in grounded grid service with modified coaxial cavity plate circuitry, consider the equation for the input admittance Y_{in} of a grounded-grid triode:

$$Y_{in} = Y_1 + \frac{g'_m Y_L}{g_p + Y_L}$$

where $g'_m = \frac{\mu + 1}{\mu} g_m$, $g_p = \frac{1}{r_p}$

and $Y_L = \frac{1}{QX_L}$

Substituting the values, $g_m = 0.05$ mhos, $\mu = 350$, Loaded Q $= 300$, $X_L = 80$ and $r_p = 7{,}000$ ohms into the above equation, the following is obtained:

$g_m = 500 \times 10^{-4}$ mhos, $g_p = 1.43 \times 10^{-4}$ and $Y_L = 0.417 \times 10^{-4}$ mhos

Since Y_1 is approximately equal to 2.5×10^{-4}, the input admittance of the 416B stage becomes 115×10^{-4} mhos and the input impedance Z_{in} is 88 ohms. This value is quite close to the optimum input impedance R_o for minimum noise figure in such circuits.[3]

The author thanks H. M. Swarm for encouragement and suggestions and D. Janzen for photography.

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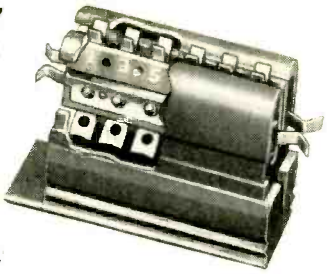
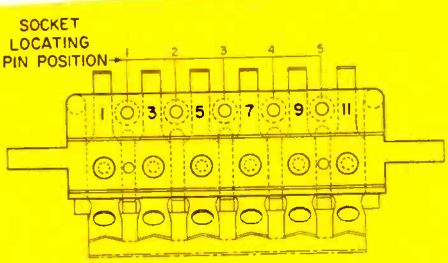
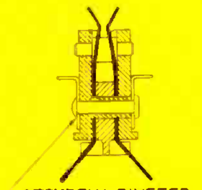


50M24054
(With Cutaway View of Hood)
12 CONTACTS

CINCH EDGE CONNECTORS





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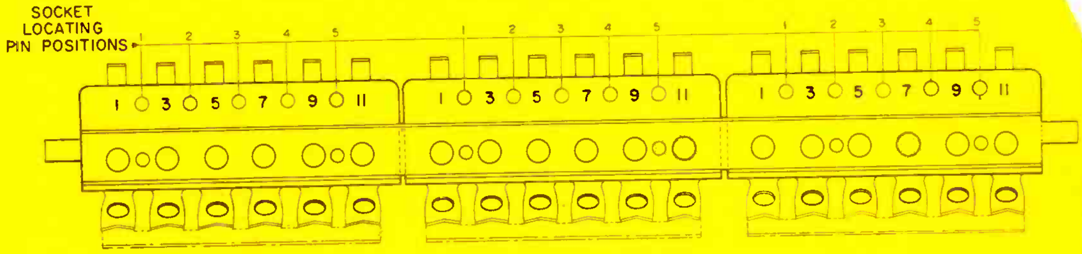

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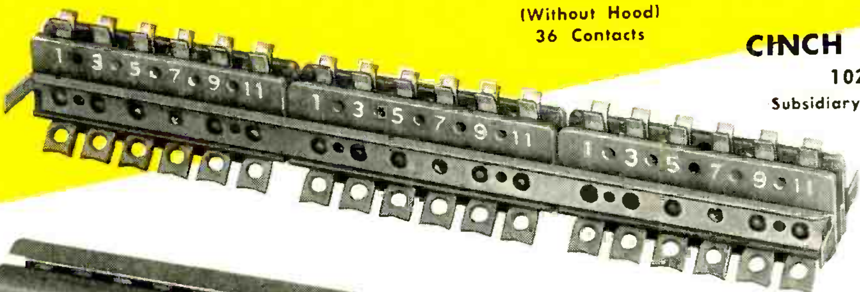

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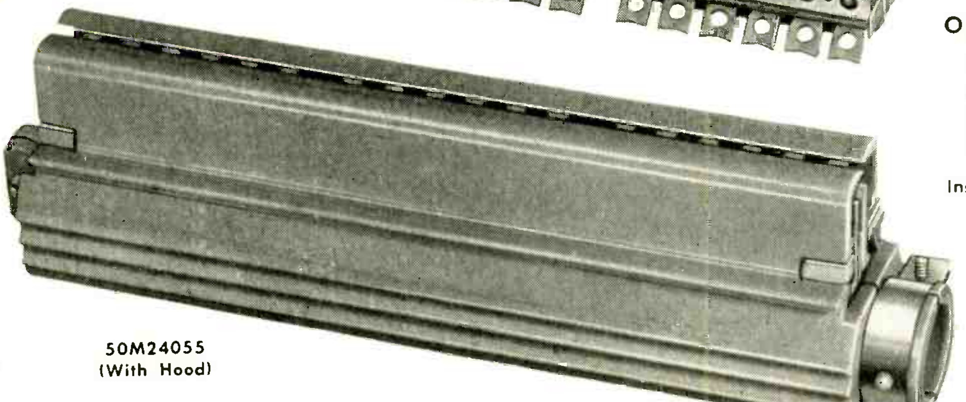

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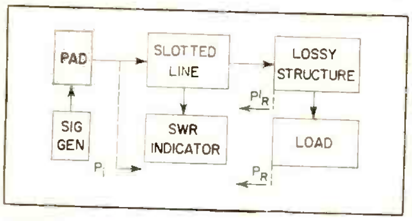

FIG. 1—System used for measuring swr shows the incident power P_i, load-reflected power P_R and slotted-line reflected power P_R'

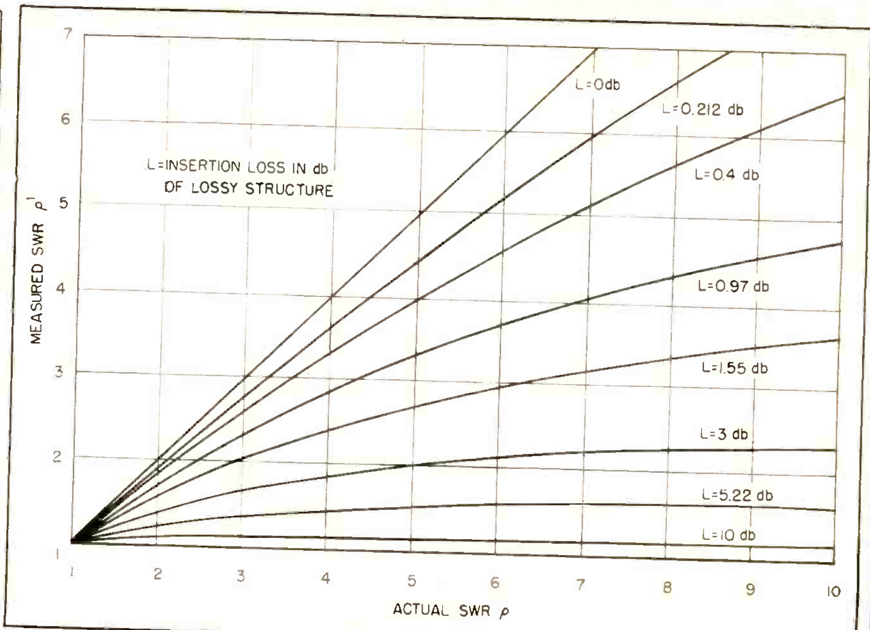

FIG. 2—Standing-wave ratio is plotted as a function of true swr. Insertion loss has been calculated in db of the lossy structure

Standing-Wave Ratio Conversion Chart

SUMMARY —— Chart provides true swr when the insertion loss of the line between the measuring point and the load together with the measured swr are known. Necessary equations for computing true swr are also presented.

By JOHN LORY Sperry Gyroscope Co., Division of Sperry Rand Corp., Great Neck, New York

IN MEASURING the standing-wave ratio of a microwave structure the length of tansmission line or waveguide connecting the structure under test and the point at which swr is measured must be lossless.

When the line is not lossless, an optimistic swr ρ' is measured. If the total loss in the lossy structure is known or can be measured, ρ' can be measured and corrected to true swr ρ.

If the losses are negligible,

$$\rho = (P_i + P_R)/(P_i - P_R) \quad (1)$$

where P_i is the incident power; P_R power reflected at the load.

If a loss occurs in the structure connecting the load and slotted line, reflected power is

$$P_R' = P_R - KP_R \quad (2)$$

where K is the fraction of power absorbed in the lossy structure.

The swr measured at the input is

$$\rho' = \frac{P_i + P_R'}{P_i - P_R'} = \frac{P_i + P_R(1-K)}{P_i - P_R(1-K)} \quad (3)$$

Solving for P_R from Eq. 1

$$P_R = P_i(\rho - 1)/(\rho + 1). \quad (4)$$

Substituting Eq. 4 in Eq. 3

$$\rho' = [\rho(2-K)+K]/[K(\rho-1)+2]. \quad (5)$$

Figure 2 is a plot of measured swr as a function of true swr.

The swr of an antenna located on top of a high pole, is to be measured. There are 31.6 ft of RG55/U cable between the antenna and slotted line. The operating frequency is 400 mc, measured swr ρ' is 1.4/1.

What is the true swr of the antenna? The cable has an attenuation at 400 mc of 9.5 db per 100 ft. Therefore, the attenuation of 31.6 ft of cable is 9.5 (31.6)/100 = 3db. Connector losses are neglected. On the swr chart a line is drawn through the 1.4/1 point, parallel to the abscissa, until it intersects the L = 3-db line. From the intersection a perpendicular is dropped to the abscissa, and the true swr of two-to-one is found.

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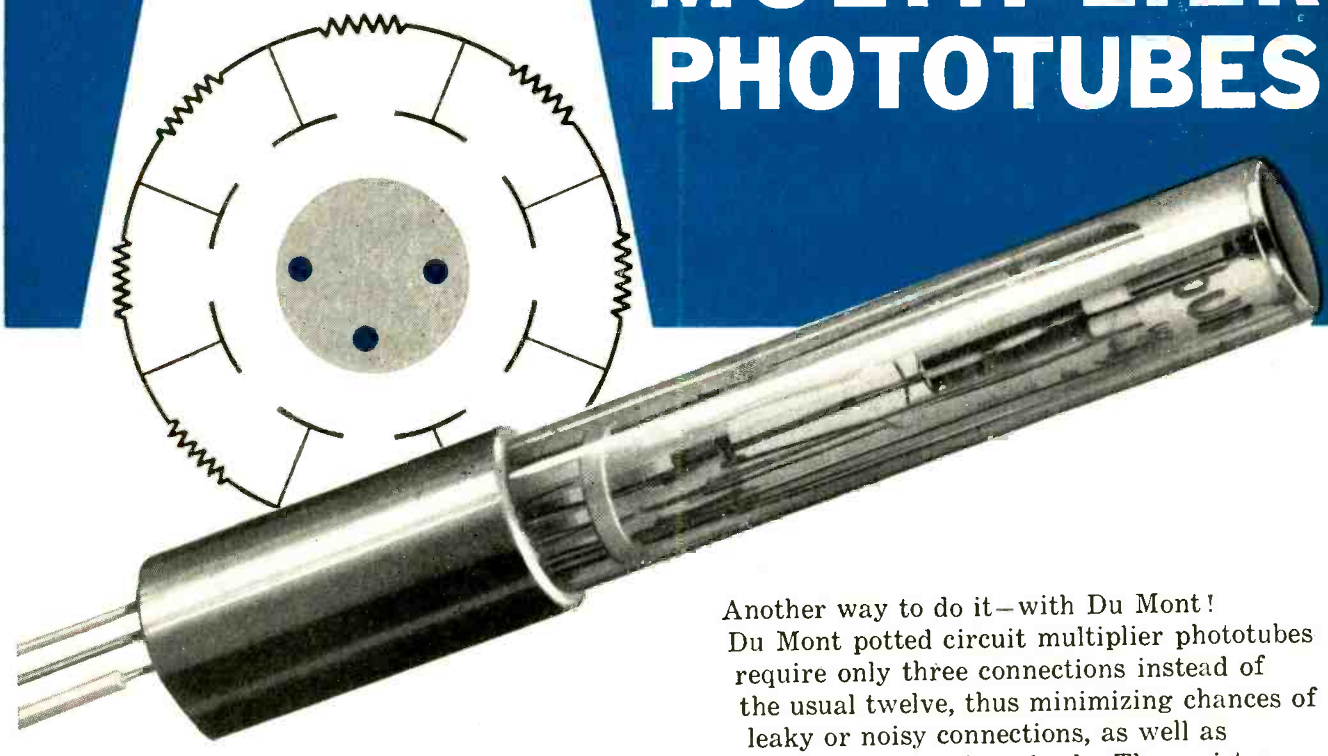

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Pulsed X-ray May Aid Cancer Fight

By R. W. TREHARNE, C. R. NOSKER, CHARLES E. JOHNSON
Charles F. Kettering Foundation, Yellow Springs, Ohio

X-RAY radiation is one of the potent therapeutic weapons used by medical researchers in the battle against cancer. At the present time, however, x-rays sometimes harm normal cell tissue in the attempt to destroy cancerous cells.

X-ray therapy is normally done with continuous x-ray radiation. The pulsed x-ray machine described here has been constructed to study the effect of x-ray bursts of radiation on normal and cancerous tissue. It is hoped that an optimum x-ray pulse repetition frequency can be found that will be most destructive to cancer cells and least destructive to normal cells. Other variables will be investigated to determine best exposure time, frequency and intensity.

The x-ray pulse generator used for biological studies on normal and malignant cell tissue culture is shown in the photograph. An auto ignition transformer is used in the system to obtain voltage pulses as high as 20,000 volts. These are applied across a dental type x-ray tube. Voltage to the auto ignition transformer primary is set by a continuously variable 0 to 20-volt d-c magnetic-amplifier type regulated power supply. Current to the auto ignition coil primary is interrupted to produce the high secondary voltage pulses by auto ignition breaker points driven by a variable speed d-c motor.

A cadmium sulphide crystal detector probe is used to detect the x-ray output. This type of probe when calibrated against a conventional roentgen meter makes an excellent continuous-reading type of x-ray detector. Cadmium sulphide when exposed to an x-ray beam exhibits a marked decrease in resistance that is linear over a wide roentgen range. In this particular application, the cadmium sulphide probe was placed in series with a

Optimum cancer-killing pulse rate, intensity, exposure time and frequency are sought for pulsed x-ray generator

200-ohm, 50-microampere meter and a 4½-volt battery. The probe was shunted by a variable resistance so that the meter could be calibrated to indicate directly roentgens per minute.

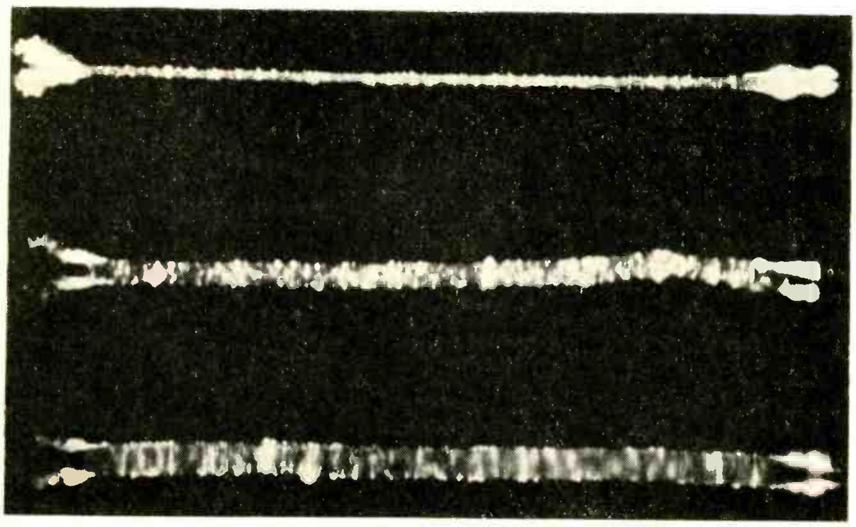
At present, the investigation of pulsed x-ray has been confined to the study of effects upon normal and malignant tissue culture grown in an incubator.

One of the numerous variables which must be investigated is the effect of x-ray spectrum. An air-cooled x-ray tube with a beryllium window is presently being used at relatively low voltage for x-ray work. The spectrum consequently is in the soft x-ray range. Even here, however, definite x-ray injury to exposed cells can be observed.

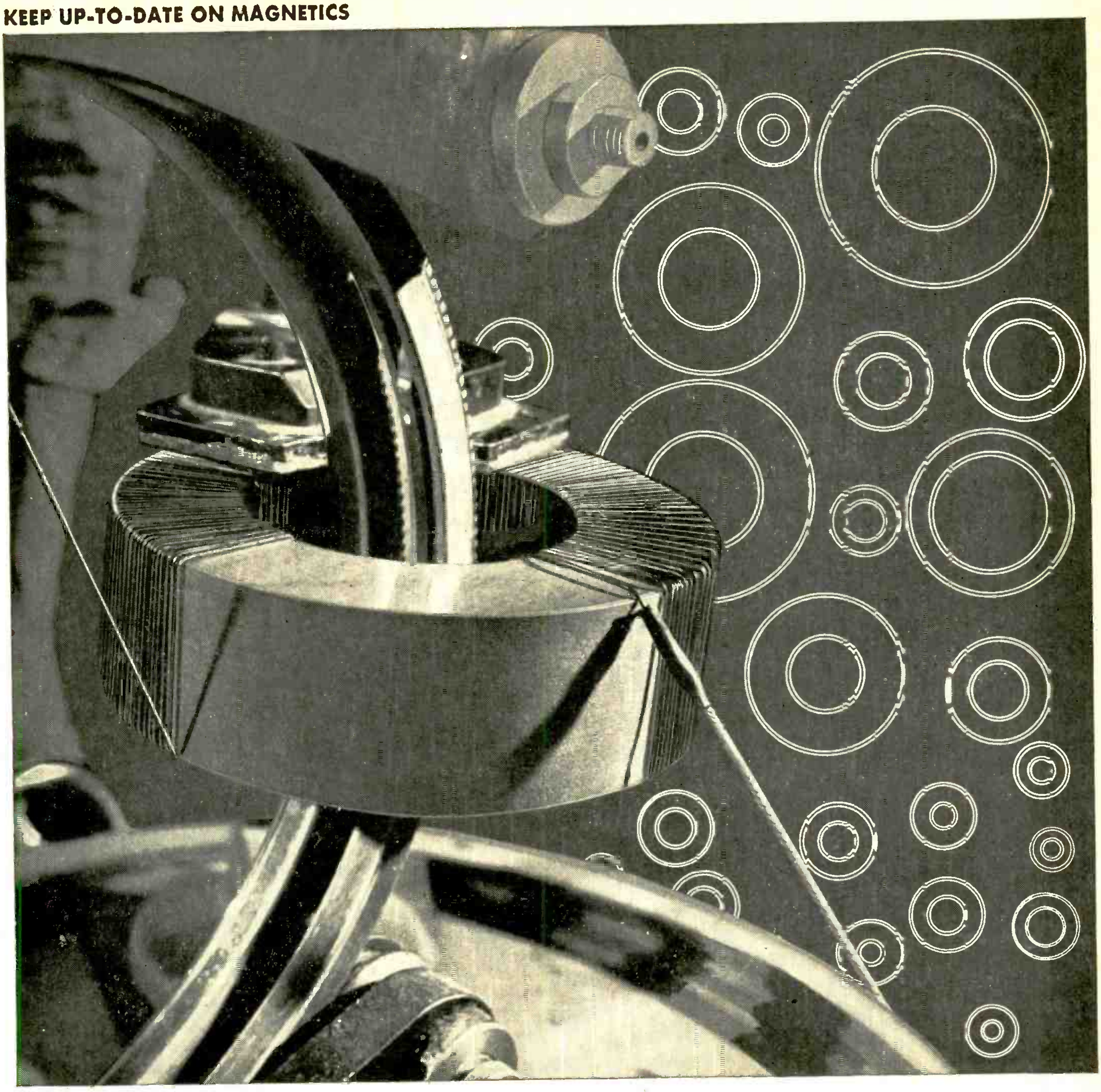
The x-ray exposure range being investigated is from 50 to 500 roentgens per minute. The pulse width is about 70 microseconds and the pulse repetition frequency can be varied from 0 to 180 per second.

Total exposure time is still another variable to be investigated. X-ray injury often can be observed

Electronics Speeds Exposures



Photographs of three aluminum wires one-thousandth inch in diameter and one-quarter inch long were taken during electrical disintegration with a new high-speed camera. Photos were taken at three phases in exploding process: 20, 30 and 40 billionths of a second after the discharge was started. Effective exposure time for each photograph was 5 billionths of a second. The camera was developed by Electro-Optical Systems under contract with U. S. Army Ordnance.



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after only a few minutes exposure.

Safety features are provided to prevent accidental irradiation of the operators. A safety interlock on a lead cover plate covering the biological specimen holder prevents high voltage from being applied to the x-ray tube until the cover is closed. Adequate shielding is provided on all sides. A lead shutter placed above the cadmium sulphide detector probe and x-ray tube and just below the specimen holder premits adjustment of the x-ray exposure level prior to exposure of the specimen.

Measuring Nonlinear Resistors

By STANLEY I. KRAMER Section Head
WILLIAM FIELDS, JR, Engineer
Fairchild Guided Missile Division, Fairchild Engine and Airplane Corporation, Wyandanch, N. Y.

ONE of the main problems in the use of nonlinear resistors is their classification and matching. A method used in the past consists of measuring the current flowing through the nonlinear resistor with the application of discrete potentials. The results are then plotted in the form of a curve or are merely tabulated. Alternately a suitable be used for selection and matching, but this technique is not sensitive. However, if the current waveform is differentiated with respect to time before it is observed, a plot is obtained of conductance as a function of voltage.

The dynamic conductance of a nonlinear resistance can be expressed as $g_e = di/de$, where g_e is

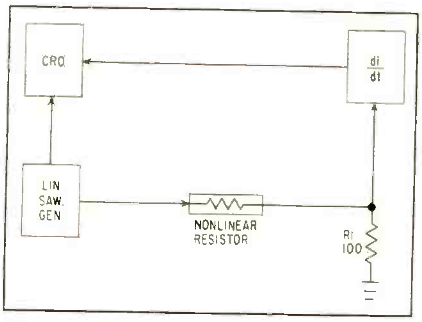


FIG. 1—Differentiating waveform through nonlinear resistor from sawtooth generator with respect to time provides oscilloscope trace of conductance as a function of voltage

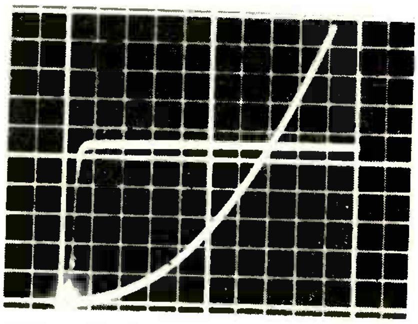


FIG. 2—Conductance curve is superimposed on calibration line produced by known linear resistor. Height of horizontal line above axis corresponds to conductance of known resistance

repetitive waveform may be applied and the resulting current waveform observed on an oscilloscope.

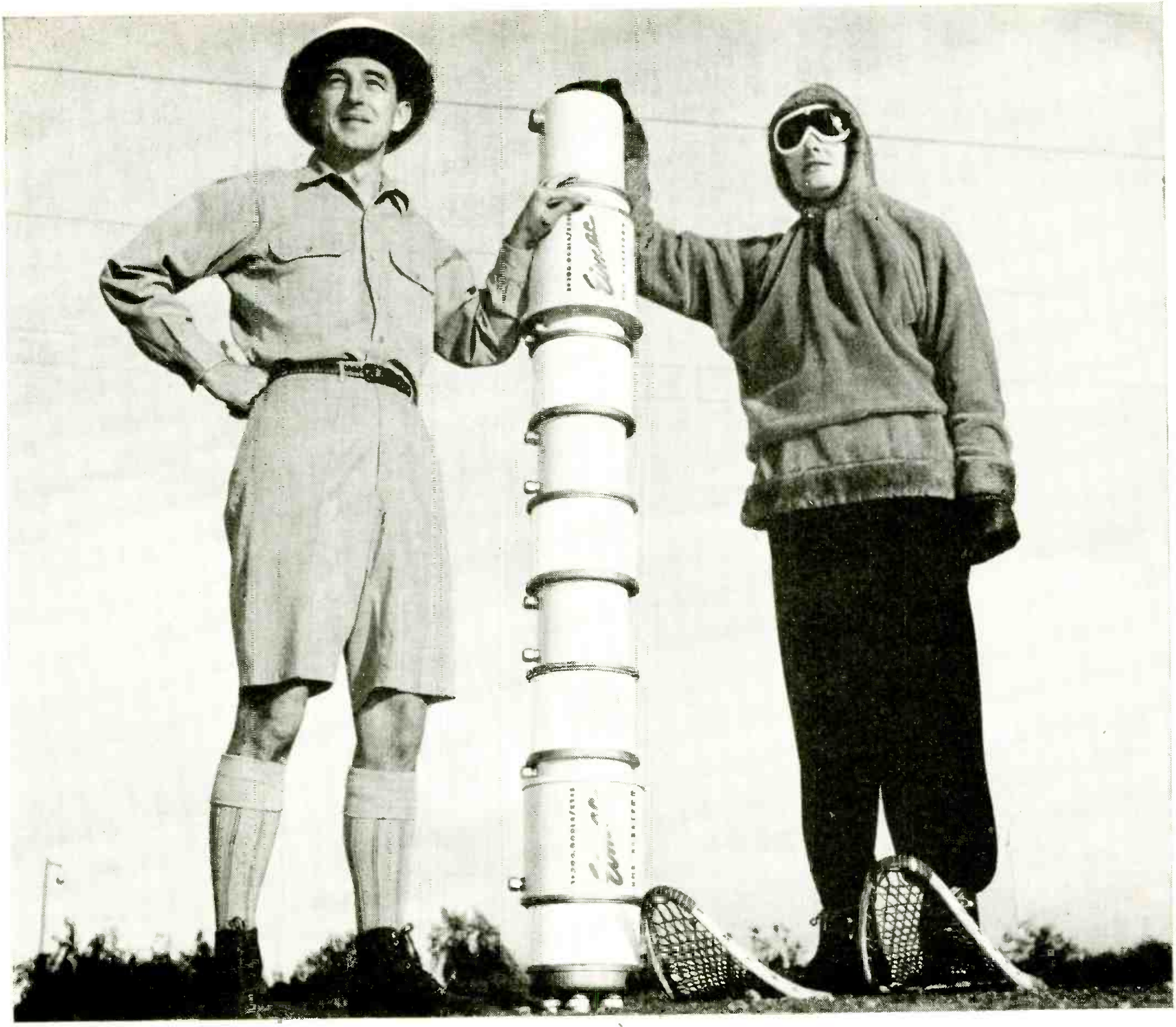
The disadvantages of the former technique are that the measurements are not continuous and are time consuming. The latter procedure is qualitative unless the applied waveform is selected very carefully.

Current Differentiation

If a linear sawtooth waveform is used as a voltage source and the current is observed on an oscilloscope, the resultant waveform can the conductance at a potential of e volts and i is the current through the resistor. If the applied potential, e, is a linear sawtooth or ramp function, then during the interval of linear rise $e = kt$ and $g_e = (1/k)\ (di/dt)$.

A resistance-voltage plot can be obtained if a sawtooth current waveform is used in place of the voltage waveform.

The complete system is shown in Fig. 1. The current is picked off from resistor R_1. This resistance must be small in comparison with the nonlinear resistor being meas-



To keep 75,000-watt Klystron tubes operating efficiently, Eitel-McCullough specifies Monsanto's OS-45 coolant-dielectric, pumpable from −65° to 400° F.

The extreme operating conditions encountered in advanced tropo-scatter communications systems, such as DEW Line and White Alice, often require special materials for cooling the Klystron transmitting tubes. A recent application of the Eimac amplifier Klystrons specified Monsanto OS-45 as the coolant-dielectric for use in these tubes.

Engineers at Eitel-McCullough, Inc., manufacturer of Eimac power Klystrons, found that OS-45 has excellent dielectric properties and that it is one of the few dielectrics that would do the job required.

When you design or miniaturize electronic equipment, consider Monsanto OS-45. You can get helpful facts from Technical Bulletin O-123. Write for it or mail in the coupon below, today.

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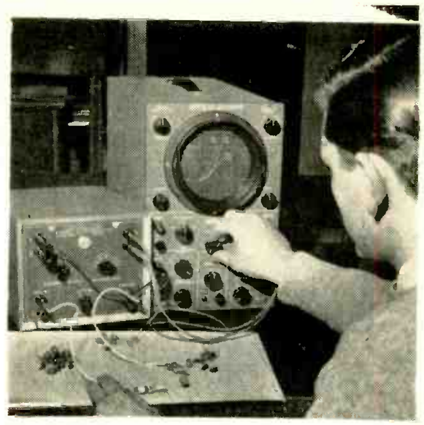
ured for proper circuit operation.

Calibration is accomplished by substituting a known linear resistance for the unknown nonlinear resistance. The height above the axis of the resulting horizontal line will then correspond to the conductance of the known resistance and can be used to calibrate the oscilloscope. This is illustrated in the oscillogram of Fig. 2.

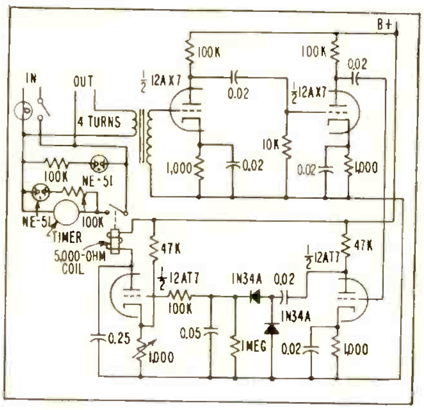
The conductance curve of a nonlinear resistor is superimposed upon a calibration line corresponding to a known linear resistor in the test circuit.



Conductance as a function of voltage shown directly on oscilloscope permits fast matching of nonlinear resistors

Circuit Times Operation of Portable Tools

By RONALD L. IVES *Palo Alto, Calif.*



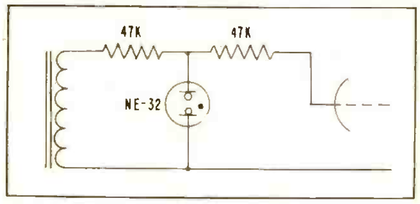


FIG. 2—Modification protects 12AX7 from loads over 1,500 watts and loads with large starting surges

FIG. 1—Loads from 25 to 1,000 watts energize timing relay

CONVENTIONAL running-time meters have drawbacks for operations timing and life testing of integrally switched devices, such as soldering guns, electric drills and hand-grinders. Special wiring between operations timer and device under test is usually necessary, unless a special auxiliary switch is used. The added wires and controls not only require a technician for their installation but have a bad effect on the operation being timed. They tend to upset the conditioned reflexes of the highly skilled workers and have an undesirable psychological effect on those less skilled. In consequence, time figures obtained with most conventional operations timers are of questionable value.

A plug-in operations timer, which times only when the device under test is operated by its own switch has been developed for this situation. It introduces no distracting special wires, controls or noises into the working environment. Load capacity is from about 25 watts to about 1,000 watts and response time is somewhat less than one second. The timer is simple enough so that semi-skilled personnel can connect, set, operate, read and disconnect it.

The series timer consists of a current transformer, amplifier, relay and running time meter. Except for some of the constants the circuit is not unconventional. All parts are standard except for the current transformer. This is made by removing the 4-ohm secondary from a Stancor A-3879 output transformer (10,000-ohm plate to 4-ohm voice coil). The winding is replaced with four turns of No. 14 insulated stranded hookup wire, firmly tied and cemented in place.

The four-turn coil becomes the primary of the current transformer

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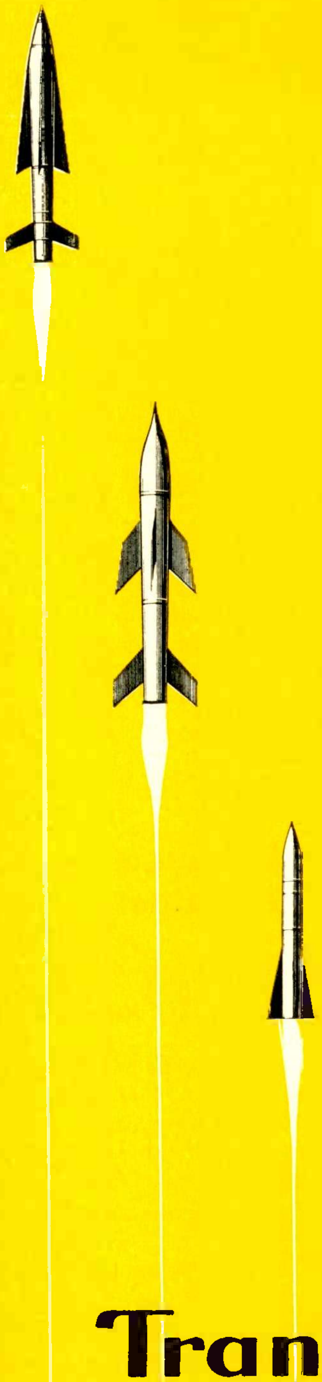

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Through close process control, these units have exceptionally low I_{co} up to their maximum voltage and temperature ratings. They can be used with confidence even with the simultaneous application of maximum ratings.

Type	Common Emitter Current Gain, β	Maximum Collector Cut-off Current At V_c Max (μa)	Maximum Collector Voltage V_c Max (Volts)
2N479A	40 to 100	0.5	30
2N474A	20 to 50	0.5	30
2N471A	10 to 25	0.5	30

ENVIRONMENTAL TESTS INCLUDE

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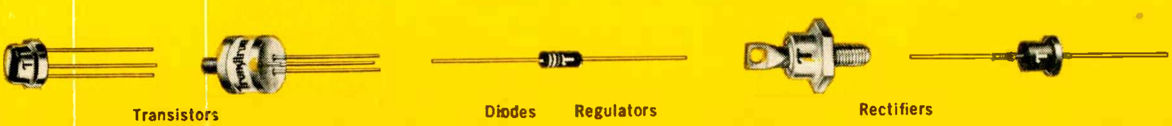


Transistors Diodes Regulators Rectifiers and the 10,000-ohm winding acts as the secondary.

Amplification of the amplifier at 60 cycles is theoretically bad. The constants used were determined by experiment, the requisite condition being a constant rectified output through as wide a range of inputs as possible. Actual measured range shows that output is substantially constant with inputs ranging from a 15-watt to a 1,500-watt series load. To obtain this range, small coupling capacitors and low value grid resistors were found essential. If conventional coupling values are used, useful operating range is variable through a ratio of only 10 to 1.

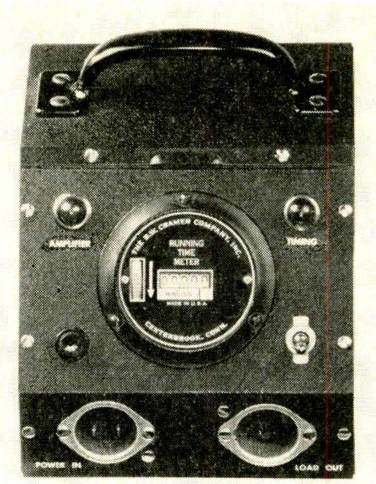
Output waveform is nonsinusoidal, and is a series of spikes, alternately positive and negative. This is because one or more of the amplifiers are driven from saturation to cutoff on each cycle. For this reason, direct drive of the counting meter from the amplifier output is not feasible, even with clean loads. With noisy loads, such as series-motor electric drills, it would give highly spurious loads.

Initial adjustment is quite simple. When the power has been turned on, the amplifier is permitted to warm up for about half a minute. Then the sensitivity control is adjusted so that the relay will pull in and drop out cleanly as a 15-watt resistive load is alternately connected and disconnected.

Operation is equally simple. The power cord is connected, the amplifier is turned on, the counter reset to zero, and the load plugged in. Thereafter, whenever the load is turned on by its own switch, the timer counts up minutes and tenths until the switch is released.

Sensitivity of the timer can be increased so that it will work dependably with loads of as little as three watts. To do this a Faraday shield is added to the current transformer, and a noise-bypass capacitor is shunted across the line immediately before it. Dependable operation with loads of less than three watts was not found practicable with this assembly.

When loads larger than 1,500 watts or loads with heavy starting surges, such as geared-down electric drills, are to be timed, input pro-



Tool is plugged into timer and no extra leads or switches are required that might bother user

tection in the form of a grid-dropping resistor and a neon flashover preventer as shown in Fig. 2 was found desirable. If such protection is not provided for highly variable loads, life of the 12AX7 will be short because of grid-cathode arcover.

Operation of the timer from a conventional clip-on current transformer is entirely feasible. The core of the transformer is clipped over one lead of the load circuit or passed through the eye of a hole-in-one connector. Coil of the clip-on transformer is connected from grid of the first amplifier tube to ground.

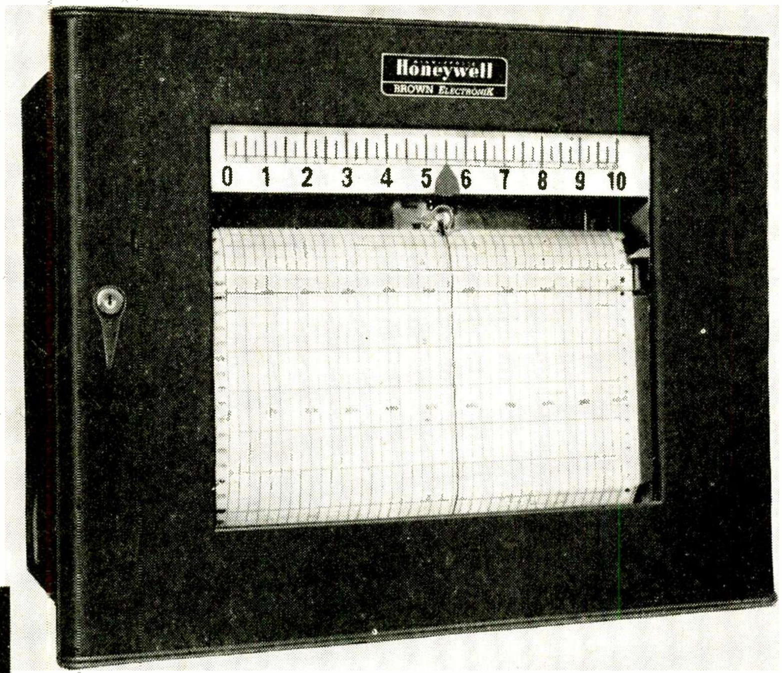
High-Dynamic-Range Differential Amplifier

By D. D. DAVIS

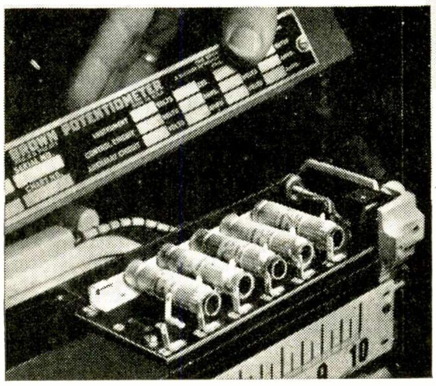
High Voltage Research
Power Transformer Department
General Electric Co. Pittsfield, Mass.

MEASURING INSTRUMENTS and control devices often require that a small difference between two large voltages be amplified, with the amplifier not responding to the average level of the input signals above ground.

A differential d-c amplifier is shown in Fig. 1 that amplifies the difference between two voltages that may be as much as 100 volts above ground. Amplification of the difference voltage is 250, but amplification of the common-mode signal (the average of the input sig-



Range resistors are easily installed in ***ElectroniK*** measuring circuits, for conversion to practically any scale.



the *ElectroniK* recorder or indicator is a thousand instruments in one

An *ElectroniK* instrument adapts easily to your changing needs, never becomes obsolete. Its remarkable versatility is made possible by the many measuring circuits . . . many types of records or indications . . . many pen or print wheel speeds . . . and the wide variety of functions that can be incorporated in the instrument.

You can convert most *ElectroniK* instruments to practically any scale, simply by soldering appropriate kit-supplied range resistors into the measuring circuits. And you have a choice of more than 575 *standard* charts and scales in strip chart instruments (similar large choice in indicators and circular chart models). You can change chart speeds from one half to four times the basic speed, with a simple gear change.

Use *ElectroniK* instruments to measure temperature, pressure, flow, pH, chemical concentration, voltage, speed—*any* variable that's translatable into a d-c signal.

Unitized construction lets you transfer complete control units from one *ElectroniK* instrument to another. Cases are designed for both surface and flush panelboard mounting. With auxiliary switches, the instrument works in conjunction with audible or visual alarms and safety cutouts.

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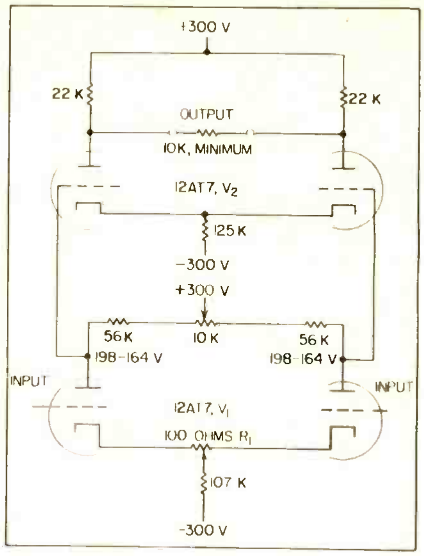


FIG. 1—Common cathode resistor keeps both cathodes at common-mode voltage

nals with respect to ground) is only 0.061.

Maximum output is 25-volts peak, and frequency response is within 3 db from d-c to 250 kc.

One input signal is applied between each grid of V_1 and ground. Because of the common cathode resistor, the cathodes of V_1 will follow the average of the two signals (the common-mode voltage) and keep V_1 in its operating range. This results in the two cathode potentials becoming almost equal. The half of V_1 with the larger input will conduct more. This raises cathode potential and causes the opposite half to conduct correspondingly less.

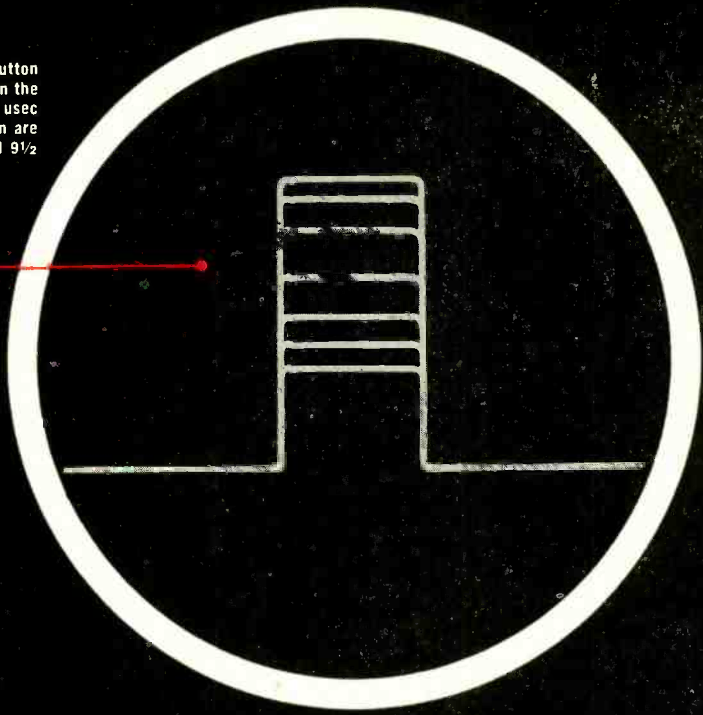
The amplified difference signal appears between the two plates. The common mode signal is attenuated because of the symmetry of the circuit and by the ratio of twice the plate resistance to the cathode resistance.

The second stage is similar to the first, providing further amplification of the differential signal and attenuation of the common mode signal.

Potentiometer R_1 is used to balance the circuit. It is set for an a-c null using an oscilloscope across the output when a test signal is applied to both inputs simultaneously.

The plate control is set for a d-c null using a voltmeter across the output with no signal applied. Tubes selected for symmetry may be required.

Fidelity of 404 push-button attenuation is shown in the multiple exposure of a 1 usec pulse. The db levels shown are ½, 1½, 3½, 5½, 7½ and 9½



0.018 usec
RISE TIME

100,000 pps
REP. RATE

Du Mont 404 Pulse Generator

- Repetition rates up to 100,000 pps, manual trigger for single pulse
- 0.018 usec maximum pulse rise and fall time
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The Du Mont 404 Pulse Generator sets new standards for stability and versatility, outmoding pulse generators employing hydrogen thyratrons. The performance of the 404 reflects the entirely new "hard-tube" circuitry concept employed.

The capabilities of the 404 provide excellent facilities for ultra-high frequency studies at moderate cost. Its hair-line firing of sharp-edged pulses, push-button stepped attenuation, high rep rate, minimum jitter, easy-to-use front panel and control layout, internal delay from 2 usec before trigger to 100 usec after—all add up to a multiple use instrument that's good for years of dependable performance.

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Rack-mounting model $690

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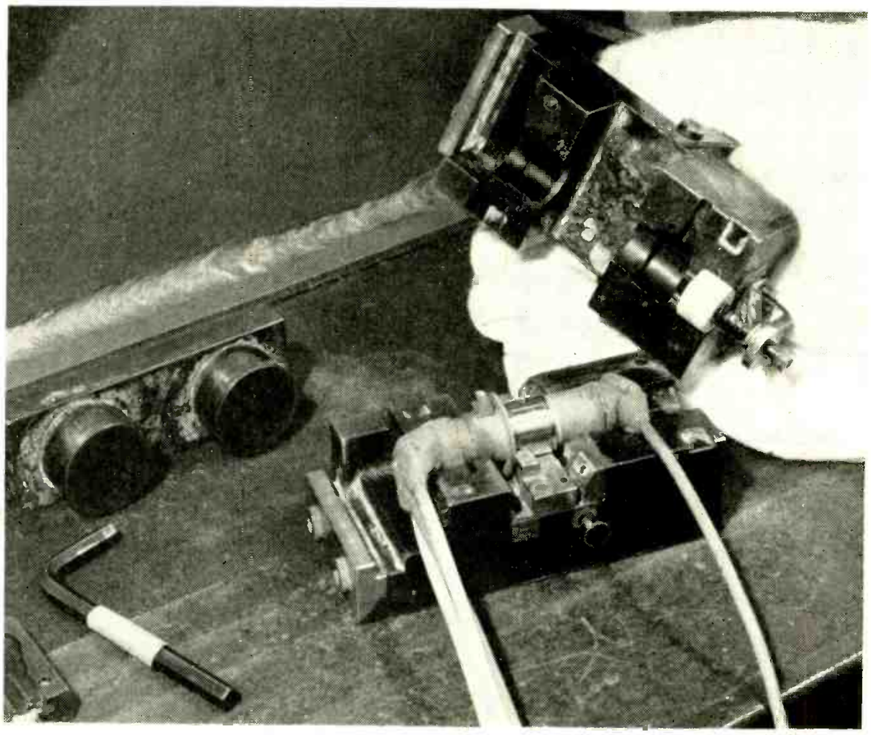
Transfer Molding Encapsulates Tube Leads

TRANSFER MOLDING quickly bonds silicone rubber to glass and metal. Encapsulating tube connections by this method, however, requires a delicate balance between forming pressure and the limiting strength of tube parts.

Techniques and molds developed at Varian Associates, Palo Alto, Calif., enable transfer molding to produce a hermetic seal on a ruggedized, moistureproof radar local oscillator klystron tube. The tube withstands extremes of temperature and high altitude without pressurization.

Single cavity transfer molds hold tubes by non-critical parts. Molds have 3 sections, to split along leads, and a plunger. Two sprue holes are at each end. Three outsized relief holes aid in reaching proper pressure. Spring loaded Teflon plug, activated by rubber from 2 of the relief holes, releases the instant the cavity is filled, maintaining minimum pressure on the tube itself.

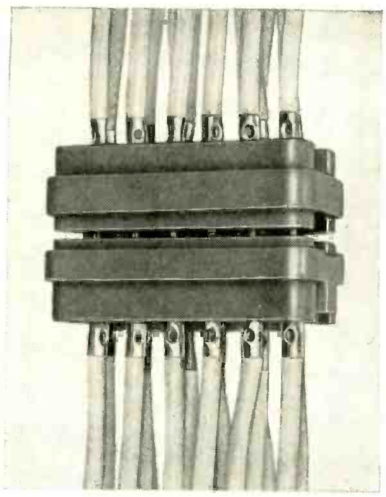


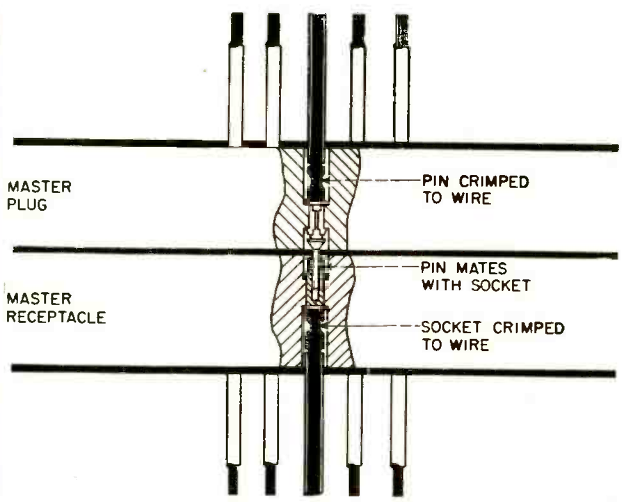
Single cavity transfer mold holds klystron by non-critical parts. White Teflon plug blocks two relief holes until cavity is filled with silicone rubber, protecting tube against presure damage

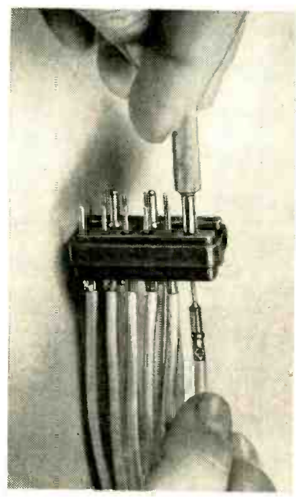
Prepacking insures good adhesion and centers leads, keeping them from being forced together in the mold. Cutouts of Silastic 80, the silicone rubber used, enable precise control over quantity of prepack.

Cutouts are made with push-out "cookie cutters". The rubber is plasticized and rolled to $\frac{1}{8}$ inch

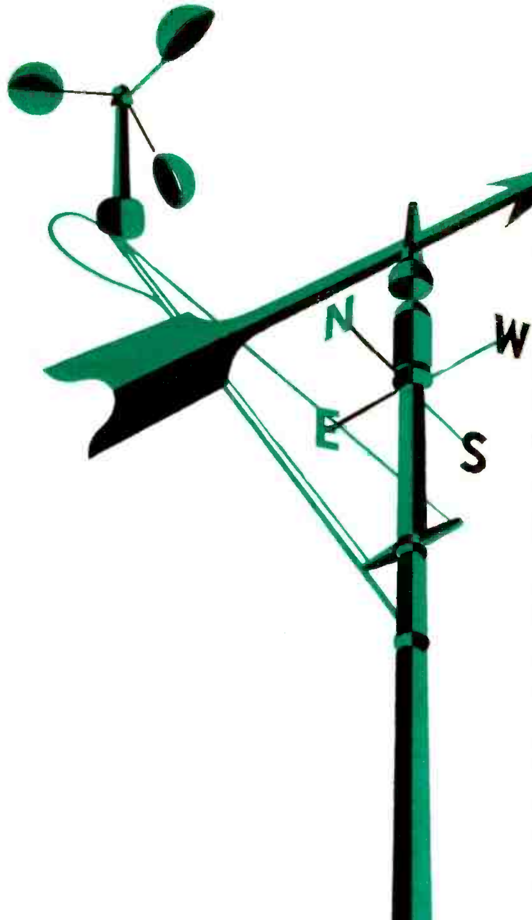
DESIGNS TRENDS: Solderless multi-lead connector







Solderless multi-lead plug and receptacle connector speeds wiring and wiring changes in harnesses. Designed by Burndy Corp., Norwalk, Conn., units have four basic parts: pins, sockets, master plugs and master receptacles. Pins and sockets are crimped to stripped wire ends by hand or automatic tools. Pins and sockets are snap-locked in master plugs and receptacles which may be mated as gang connects or disconnects. Individual circuits may be added or removed after harness is in place. Pins or sockets may be inserted by hand. Tubular hand tool shown at right depresses locking latches for withdrawal of single circuits. Cable sizes accommodated range from number 26 to 10 AWG. Pins and sockets are precious metal plated copper alloys. Thermosetting plastic plugs and receptacles are made in a variety of sizes and will mate with existing disconnects.



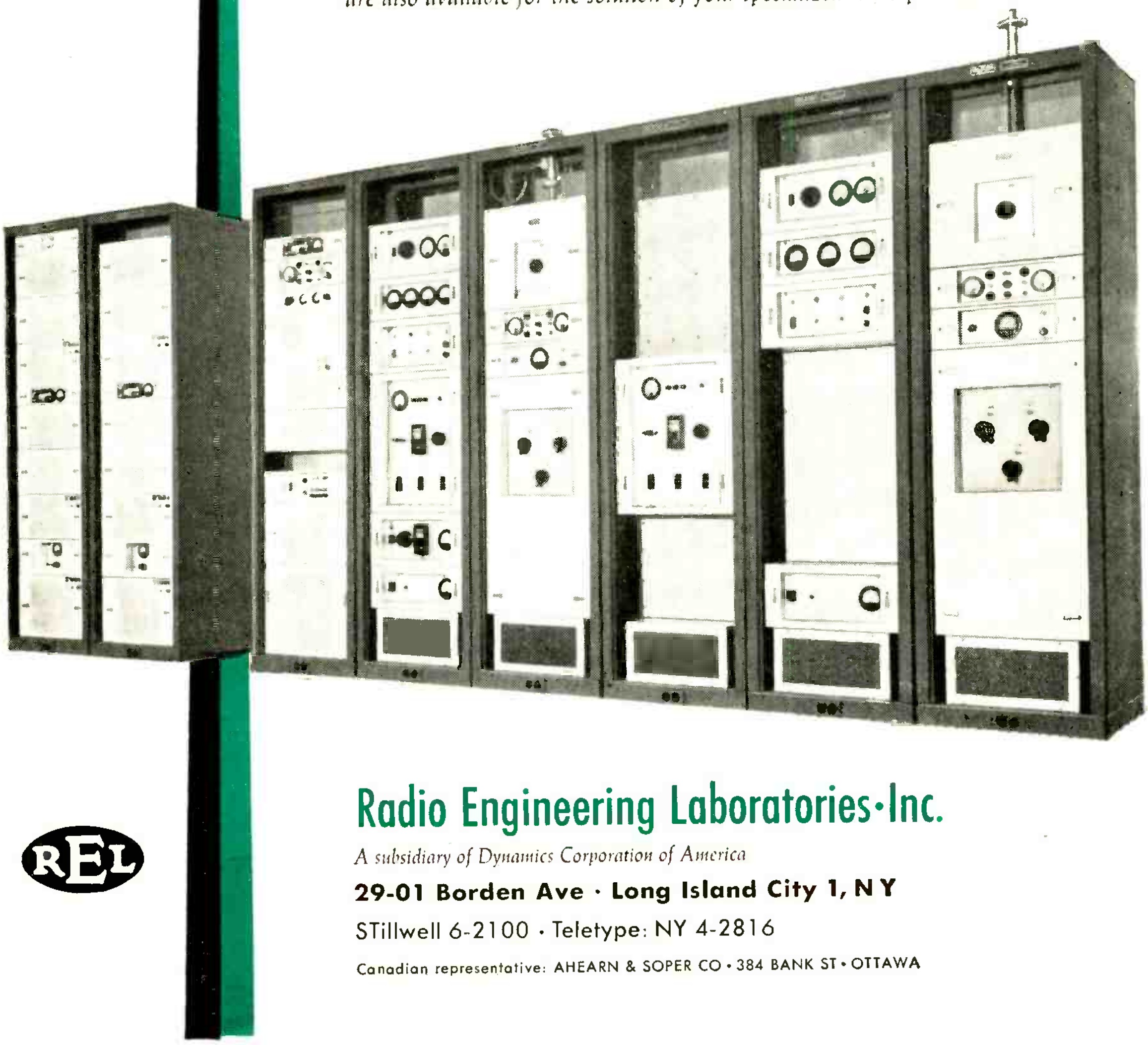
Weather links

Flying has been made safer and flights more regular by the weather information service which the Civil Aeronautics Administration is continually expanding and improving to keep pace with the growth of aviation.

An area of great meteorological importance is Alaska. Detailed observations there are of incalculable value in helping predict weather in much of the United States. To link its weather stations throughout Alaska, the CAA has commissioned REL to develop an ultra-reliable VHF communication system. It is to connect with White Alice, the giant military and civil Alaska communication system, whose tropo scatter radio equipment was also designed and manufactured by REL.

To meet—and exceed—the special requirements, REL has drawn upon its unparalleled experience in developing tropo scatter equipment. Improvements newly devised by REL for White Alice and other scatter systems are now being applied for the first time to line-of-sight communication.

The same imagination and resources which are setting new standards in this field are also available for the solution of your specialized radio problems.



Diversity receiving (left) and 5 kw transmitting station equipment

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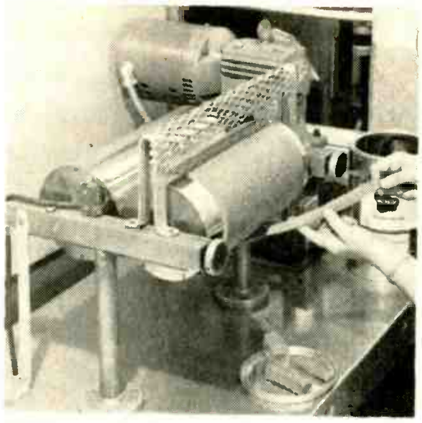


Rubber is plasticized and rolled into sheet on two-roll mill

Prepacker uses cutouts stamped from rubber sheet with "cookie cutters"

thickness in a two roll mill made by Varian. It employs a $\frac{1}{3}$ hp motor and chrome-plated steel rollers 13 inches long and 6 inches in diameter. One roll is movable to adjust tension.

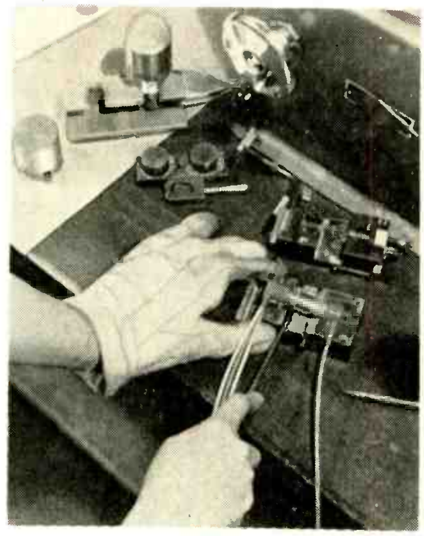
Finger cots and spatulas are used to prevent hand oils from contaminating the Silastic.

Three-ply lead wire insulation compensates for Silastic's susceptibility to abrasion. The inner layer of Silastic is covered with fiberglass overbraid which in turn is protected from fraying by color-coded Silastic.

Production Steps

The tube is sandblasted, washed with acetone and painted with Dow Corning 796 primer. A base coat of Silastic adhesive thinned with benzol is brushed on. The tube is then prepacked and the mold loaded.

In Preco hydraulic press with 4-inch ram and 40,000-pound platen pressure, the plunger forces rubber from transfer pod into mold at about 5,000 psi. Tubes are loaded in 15-minute cycles: 10 minutes in the press at a temperature of 250-260 F, 3 minutes loading and 2 minutes unloading. During cooling, weights prevent shrinking from breaking the bond between the rubber and glass or metal.



Tube is removed from mold. Weights at upper left, placed over tubes, preserve bond as cooling rubber shrinks

Nail clipper and manicure scissors are used for trimming. The curing oven is brought to 350 F over a period of 6 hours to prevent bubbles. The tubes are held at 350 F for another 6 hours and cooled for 3 hours.

Radioactive Gas Tests Components

RADIOACTIVE TRACER GAS is employed in a leak tester made by Reed-Curtis Nuclear Division of American Electronics, Culver City, Calif. The tester is designed for use by manufacturers of transistors and other sealed components.

Equipment includes pressure vessel, radioactive gas, radiation counting and monitoring equipment. Leakages as small as 10^{-12} cc. of air a second can be detected. The manufacturer estimates a test set-up will handle 3,000 transistors in 7.8 hours at labor and gas cost

Radiation count of component is made manually, as shown, or on conveyor to determine rate at which tracer gas leaks into component

of 0.68 cents a transistor.

Components are placed in a lead shielded pressure vessel and its lid is locked. The tank is evacuated. Radioactive gas is pumped into the vessel and enters any leaks in the components. Gas removal and air wash follows, generally after several hours.

Components are removed and passed before a scintillation counter. Leaky units will emit gamma radiation. The amount of radiation, when related to soak time, exposure pressure, the component's internal pressure and concentration of the gas, yields the leak rate.

Epoxy Shells Simplify Potting of Resistors

By KARL STOCK *Chief Engineer*
Resistance Products Co.
Harrisburg, Pa.

POTTING PRECISION RESISTORS with epoxy resins in molded epoxy shells eliminates the production problems associated with permanent molds. Good adhesion between potting compound and shell ensures a firmly encased resistor. The shell becomes an integral part of the resistor. No special jigs are needed.

Initially, shells were machined from epoxy rods, but wasted material made this expensive. Premolded shells were developed in cooperation with Epoxy Products, Irvington, N. J. The shells have become available for subassemblies and other electronic components.

The filling resin, Epon 828, made

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electronics engineering edition		electronics business edition		electronics engineering edition		electronics business edition	
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MAR.	28	APR.	4	APR.	11	APR.	18
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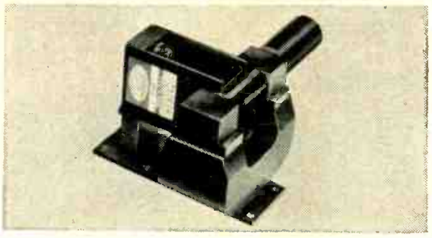
Nickelonic News

VOL. 1 — DEVELOPMENTS IN NICKEL AND NICKEL ALLOYS AND THEIR APPLICATIONS — № 2

New ultrasonic welder solves heat problem in thin gauge welding



Purity of Inco Nickel helps Raytheon stabilize emission characteristics in magnetron

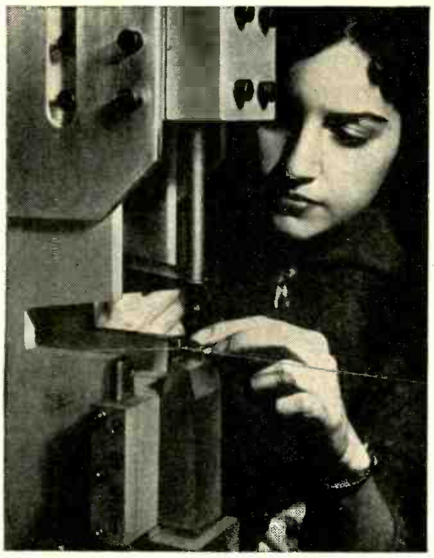
The vitality of a radar set is centered in its magnetron oscillator. This is why Raytheon chose their RK2J42 fixed-frequency magnetron to pulse their Mariners Pathfinder Radar Model 1500. This tube is designed for long-life operation at 7kw and 1500 pps.

One reason for the tube's top performance is the use of Electronic Grade "A" Nickel in the cathode. This commercially pure, wrought nickel is non-contaminating, and thus helps maintain optimum emission characteristics.

Raytheon engineers also report that it stands up against high ambient temperatures, and has good machinability.

Magnetostrictive "A" Nickel transducer provides the vibratory energy

A new welding process has caught the ear of the electronics industry: "Sonoweld", developed by Aeroprojects, Inc., West Chester, Pa. By means of high-frequency mechanical vibrations, it produces a metallurgically sound weld – and *without the application of heat.*



Thin gauge forms of metals like copper and aluminum are now being welded ultrasonically without melting and with little deformation. Photo shows "Sonoweld" unit being used to weld aluminum and copper foil conductors in American Machine & Foundry Co.'s wafer transformer project.

To maintain its high power levels, "Sonoweld" relies on a laminated stack transducer made from Electronic Grade "A" Nickel, a rugged magnetostrictive material. In a periodic electro-magnetic field, nickel undergoes alternating length-changes to vibrate at the field's frequency.

This magnetostrictive effect of "A" Nickel is relatively large, and is useful over a wide frequency range. "A" Nickel also has high resistance to fatigue, heat and corrosion, and is easily fabricated.

G. E. builds rugged PNP triode for computer use

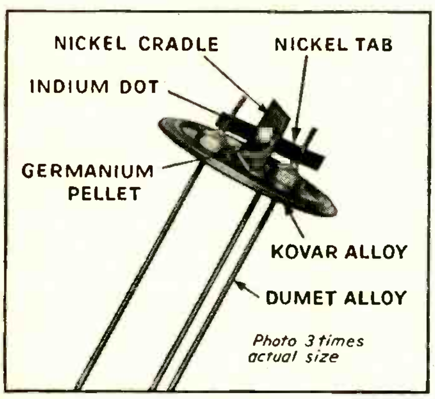


Photo 3 times actual size

Even the testing treatment (being shot out of mortars) doesn't harm the 2N123 transistor. G. E. (Syracuse) engineers build it with rugged, 99%+ pure nickel.

Non-contaminating, corrosion resistant Electronic Grade "A" Nickel has the strength to withstand shock and vibration. It also holds its shape at processing temperatures, and forms, welds and solders easily.

For sure glass-to-metal seals, G. E. uses the special purpose alloys Kovar® (29% Ni) and Dumet (42% Ni).

®Trademark, Westinghouse Electric Corp.

Reprints of useful booklet on "Inco Nickel Alloys for Electronic Uses" now available

This booklet describes the compositions and special properties of the various grades and alloys of nickel which are widely used in the industry. It also lists many important electronic applications of the Inco Nickel Alloys. For your copy, fill out the Reader Service Card, or write to The International Nickel Company, Inc., 67 Wall St., New York 5, N.Y.

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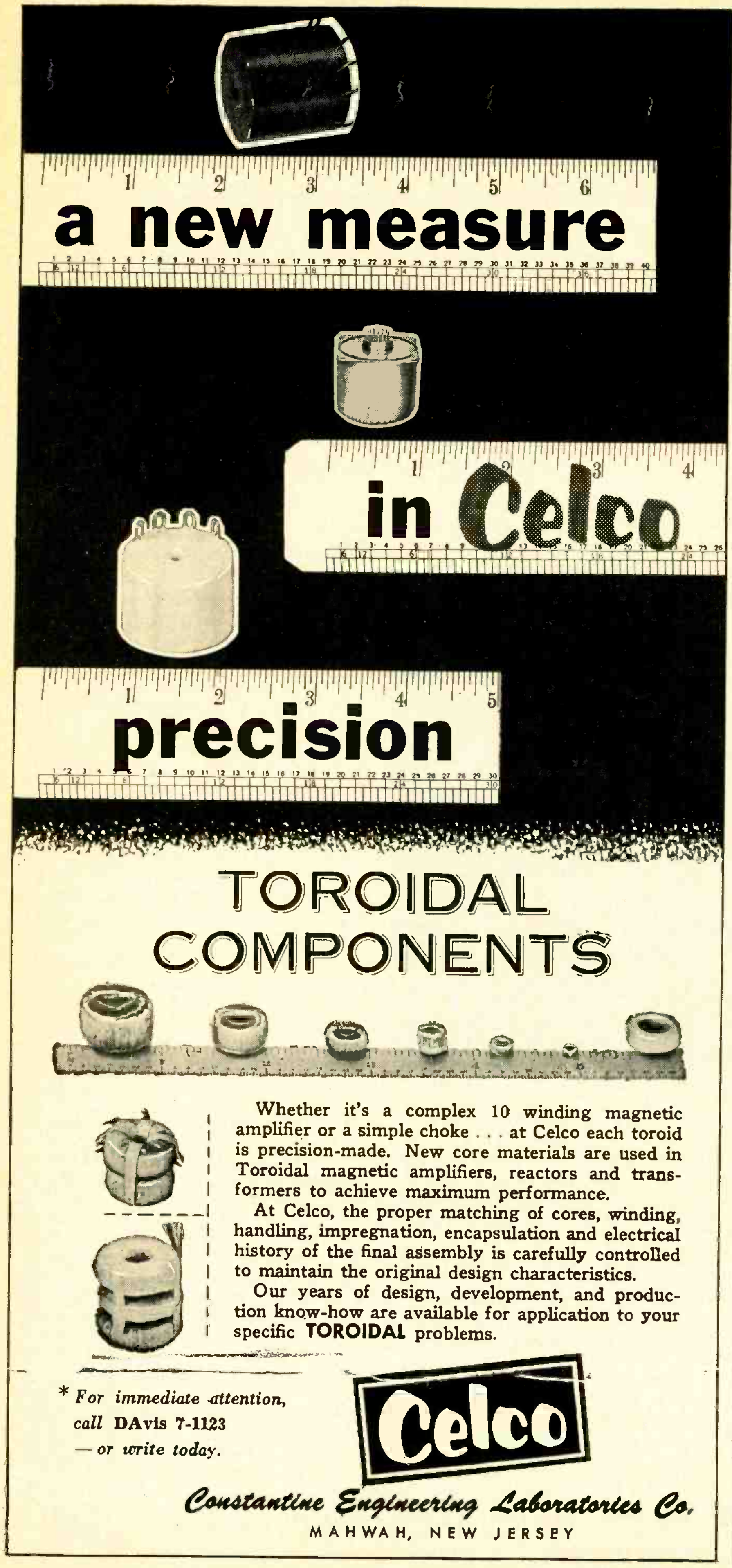
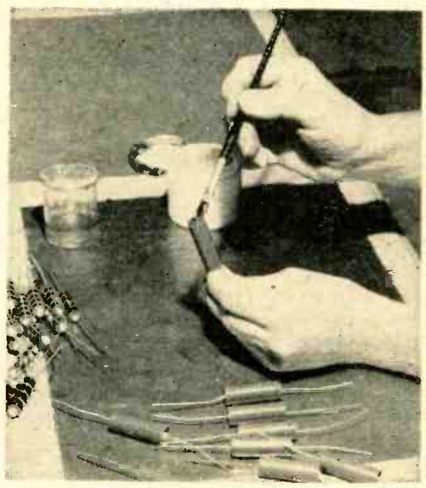
For more information on nickel alloys for electronic uses, send reader service card or write.



by Shell Chemical Corp., is prepared and held at a temperature of 50 F to 60 F in small ovens. This temperature provides even flow around the resistor without formation of air spaces. Because of its ½ hour pot life, the formulation is mixed in 25 and 50 grams lots. Paper cups are used for mixing and pouring.

Resistors are first placed part way into shell



Masking compound is placed around wire and bottom hole to prevent resin from leaking

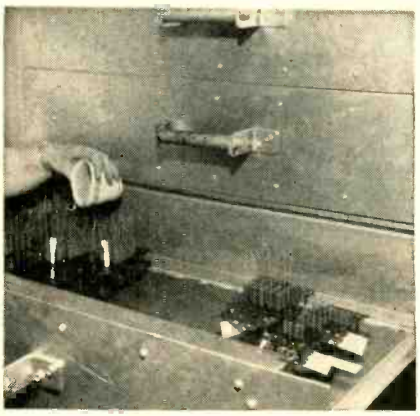
The resistor is placed part way into the epoxy shell with one wire lead extending through the bottom hole. The bottom hole is sealed with a masking compound to prevent resin leaking along the lead. Resin is poured into the shell until it is ⅓ loaded. The resistor is pushed all the way into the shell. Additional resin is poured in until the shell is full.

Filled resistors are arranged on trays and placed in a five-drawer oven. Curing is done at

185 F for $1\frac{3}{4}$ to 2 hours. After curing has begun, resin settling is checked and additional resin added where needed. After curing, masking compound is removed and resistors are checked for surface imperfections.

Bobbins on which resistance wire is wound are machined from rods of the jacket material. Porcelain

Shell is filled ⅓ with resin, then resistor is fully insert and shell is filled

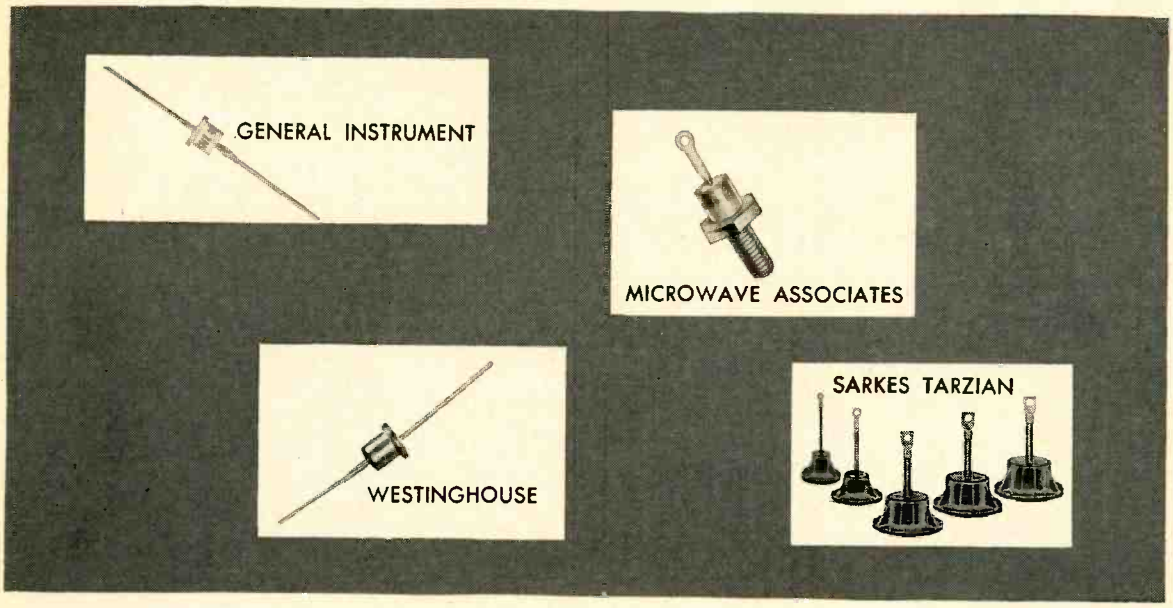


Additional resin is added where needed after resistors are in curing oven

bobbins cannot be used with epoxy encapsulation because its different coefficient of expansion results in cracking or electrical failure in thermal cycling tests.

Resistors made by the shell method withstand thermal cycling of − 72 C to 200 C. Protection from moisture, vibration and drop damage is increased. Savings in labor and rejects more than repay cost of the shells. Less potting compound is used in each resistor.

Boost Rectifier Output



Silicon Types Predominate

ON DISPLAY are a few of a wide variety of silicon rectifiers now being offered by manufacturers. All are especially designed for military applications where extreme operating conditions must be met.

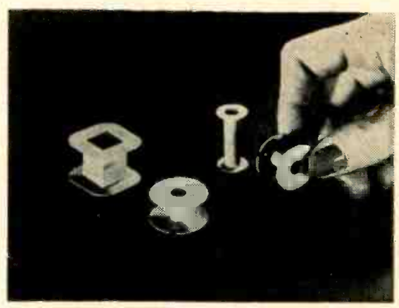
Five types of high current silicon rectifiers are being produced by **Sarkes Tarzian, Inc.**, 415 N. College Ave., Bloomington, Ind., (275), for high temperature, high efficiency applications. Current ratings range from 20 to 200 amperes d-c with piv range from 50 to 300. Features include compactness, ruggedness and positive or negative base polarity.

Westinghouse Electric Corp., P. O. Box 2099, Pittsburgh 30, Pa., (276) announces three new silicon power rectifier diodes. Particularly designed for all types of power applications, the hermetically sealed silicon rectifying cells provide d-c forward currents up to 1.6 amperes with a maximum peak inverse voltage up to 800 v. Operating junction temperature is 175C.

Three USAF types of silicon rectifiers are now available from **General Instrument Corp.**, 65 Gouverneur St., Newark 4, N. J., (277). Covering the range of 200 to 600 v peak inverse, they are rated at d-c output currents of 750 ma at 25 C ambients and 250 ma at 150 C ambients. Operating temperature is —55 C to +165C. These rectifiers are of alloyed junction construction, with all-welded hermetic seal.

Microwave Associates, Inc., Burlington, Mass. (278), has developed four new silicon power rectifiers for use in fairly high power supply and magnetic amplifier applications. Operating temperature for the stud-mounted devices is —65 C to 150 C. The rugged new rectifiers are produced to MIL-E-1/1024A, 989B, 990B and 991B specifications. The glass-metal hermetically sealed package with a solid copper base combines a high thermal conductivity with small size.

For more information use READER SERVICE CARD



Coil Bobbins molded of Alkyd

BOOKER & WALLESTAD, INC., 3336 Gorham Ave., Minneapolis 26, Minn. Inexpensive custom-molded coil forms for transformers, flash free and ready to use, are molded of Plaskon Alkyd for the electronics industry. The company molds its thermosetting forms from single cavity tooling utilizing transfer presses of its own design—now making it possible for manufacturers to incorporate coil bobbins tailored to their precise specifications into their transformers.

The use of Plaskon Alkyd enables the molder to easily produce coil forms with walls as thin as 0.018. In addition to its high strength, the alkyd possesses su-

Our reputation as the world's most Consistently Dependable producer of capacitors has been maintained for over 46 years. But *any* reputation can be lost overnight. That's why we resist the temptation to gain temporary advantage through methods that risk *our* reputation or yours. C-D's Consistently Dependable products can mean PLUS dollars to you.

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Write for catalog to Cornell-Dubilier Electric Corporation, South Plainfield, New Jersey.

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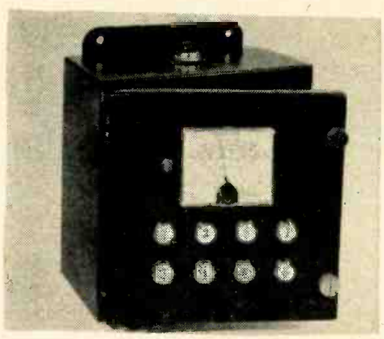
CIRCLE 11 READERS SERVICE CARD

perior arc resistance and is self extinguishing. Circle 279 on Reader Service Card.



Multipoint Scanner temperature protector

TIPPTRONIC, INC., Chagrin Falls, Ohio. This versatile multipoint temperature scanner provides over-temperature or under-temperature protection for systems where it is mechanically or economically desirable to provide one temperature alarm instrument capable of sensing several control points and providing alarm if one of these temperatures exceeds or fails to reach a preset limit.

Thermocouples, which may range from 4 to 56, are connected to a specially built stepping switch, which samples the output of each thermocouple. This signal is then delivered to the signal terminals of a contact meter.

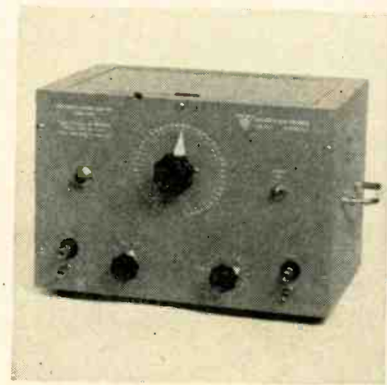
As long as each of the temperatures is below (or above) the preset limit established on the contact meter, no alarm is sounded. If any of the points scanned should happen to be beyond the set-point, an alarm is sounded and a light corresponding to the offending thermocouple is caused to remain lit and the scanner is stopped at that particular point.

The alarm mechanism can be located close to the points to be monitored, or can be placed at a more remote central location.

The scanning rate can be as rapid as ½ sec per point, but it is generally found to be more practical to use scanning rates which provide from 5 to 60 sec of dwell-time on each thermocouple. Each lamp is lit separately as its corresponding thermocouple is scanned. Circle 280 on Reader Service Card.

Multivibrator collector coupled

DYNALYSIS DEVELOPMENT LABORATORIES, INC., 11941 Wilshire Blvd., Los Angeles 25, Calif. Model 7-1201 is a collector coupled one shot multivibrator utilizing 3 *npn* transistors. The pulse width is determined by the charging of a capacitor. Positive output pulses are produced for driving flip-flops, gates and so on. Fine control of the pulse duration is controlled by a trimpot included in the package. Circle 281 on Reader Service Card.



Phase Shifter for precision measurement

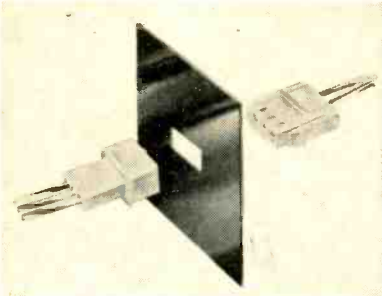
ADVANCE ELECTRONICS LAB., INC., 249 Terhune Ave., Passaic, N. J. Type 208 precision phase shifter consists of resistance-capacitance phase shifter networks, an electron-tube phase inverter, and an output cathode follower. The phase angle lag between E_{IN} and E_{OUT} can be read directly on the dials of the front panel at 400 cps.

In conjunction with a phase detector and a standard frequency signal generator, the instrument is well adapted for precision measurement of phase angle between the output and input of an amplifier, filter, transformer, servo system, and any other four-terminal networks.

Phase range is 0 to 360 deg, E_{OUT} lag E_{IN}. Maximum error is less than 0.1 deg at 400 cps. Maximum input signal is 25 v rms.

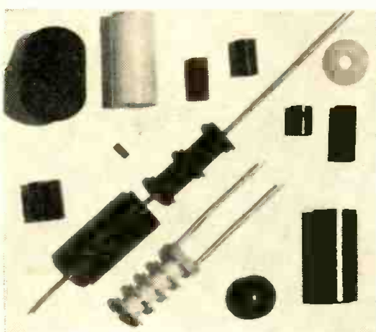
The impedance looking into the output terminals is 300 ohms nominal shunting resistance, and 2 μf series capacitor for d-c blocking.

Input impedance is about 100 K in series with 2,000 $\mu\mu$f to ground. Circle 282 on Reader Service Card.



Multiconnector features self-anchoring

AMP INC., Harrisburg 20, Pa., introduces a new type multiple connector for through-panel applications. The AMP-lok is self-anchoring and eliminates the need for supplementary mounting devices. The contacts with the mountable and disconnect units are identical, self-cleaning, and recessed for safety. The connector is polarized to eliminate circuit error. It is designed to accommodate a wide spread of panel thicknesses; one simple mounting hole in the panel is required. It permits finger-grip engagement and disengagement of mountable and disconnect units. Circle 283 on Reader Service Card.

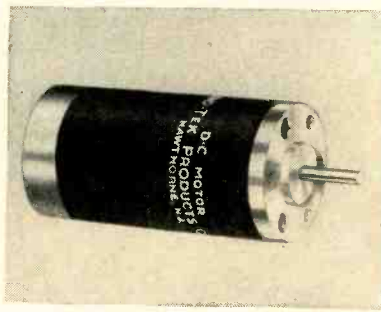


Epoxide Shells for encapsulation

NORRICH PLASTICS CORP., 107 West 18th St., New York 11, N. Y., announces exopide resin encapsulation shells and capsules for the encasing of various electronic components. These shells are machined from filled and unfilled thermosetting epoxide resin rods. This resin has been selected because of its exceptional electrical and mechanical properties.

The plotting compound used for the encapsulation of a component is composed of the same resin as the shell form. This technique insures the hermetically sealed condition of the component at extreme temperature, since the shell and encapsulation compound contract and expand to the same degree.

Precision resistors, transformers, capacitors and inductors are a few of the many components which are being epoxy encased. There are no molds or expensive tools necessary for this process. **Circle 284 on Reader Service Card.**

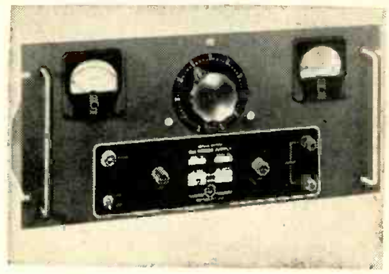


P-M Motors
miniature in size

SERVO-TEK PRODUCTS CO., 1086 Goffle Road, Hawthorne, N. J. Series B permanent-magnet motors feature increased torque ratings although they continue to measure only slightly over one inch in diameter. Stock models are available in popular voltages up to and including 115 v d-c. The new motors are of a precision construction incorporating a balanced armature revolving on shielded ball bearings. **Circle 285 on Reader Service Card.**

Vibrators
are moisture proof

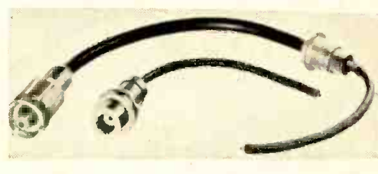
JAMES VIBRAPOWR CO., 4038 N. Rockwell St., Chicago, Ill., has announced a line of moisture-proof vibrators. To solve the "no-start" problem, the company inserts a dehydrator disk into the top of the vibrator can, where it is held in place by the rubber liner that surrounds and protects the operating assembly. The can is then sealed. The dehydrator disk absorbs the moisture present and contact-corrosion failures are virtually eliminated. **Circle 286 on Reader Service Card.**



Battery Substitutes
for aircraft use

OPAD ELECTRIC CO., 69 Murray St., New York 7, N. Y. The d-c output voltage range of models KM 75 and KM 81 aircraft battery substitutes has been extended to cover 0-32 v d-c at 5 and 10 amperes respectively. Maximum rms ripple for both ratings has been reduced to ½ of one percent at full load.

This extended output voltage range now permits marginal checking of airborne equipment as well as normal operation at 28 v. The revised designs are also available for portable or bench use and in this form are designated as model KM 75 B and KM 81 B. **Circle 287 on Reader Service Card.**

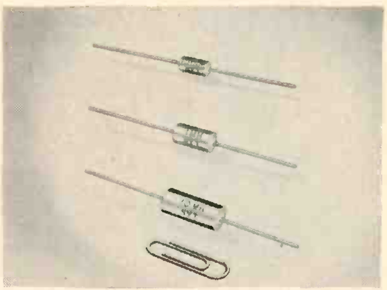


Connectors
for cable assemblies

H. H. BUGGIE, INC., Box 817, Toledo 1, Ohio. A new series of connectors for coaxial cable assemblies are now available. Designed for a wide variety of electronic, industrial and military applications, these h-v coax connectors have a rated corona level exceeding 15 kv a-c. Size-for-size they also have higher voltage handling capacities than comparable designs.

All electrical connections are accomplished by molded-on pigtails that may be ordered in varying lengths to suit assembly requirements. Thus, no soldering cup is required. Another cost-saving factor is the elimination of the usually-required potting operation. Connectors not only have higher voltage efficiency than potted types but noise radiation also has been reduced to a minimum. Each has an anti-fouling bayonet-type engagement for quick manual connect or disconnect.

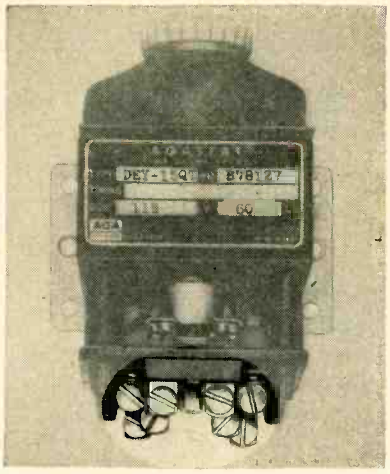
Connectors will function without impairment at −55 C under humidity and salt spray conditions and under vibration and shock conditions. The d-c breakdown level of the connectors greatly exceeds 50,000 v. Circle 288 on Reader Service Card.



R-F Chokes
epoxy encapsulated

NYT Electronics, Inc., 2979 North Ontario St., Burbank, Calif. A complete new line of Class B (125 C) epoxy encapsulated r-f chokes meeting performance requirements of MIL-C-15305A, Grade 1, Class B, has been developed.

Available from stock, units are offered in subminiature to miniature sizes, series S, M and L, with inductance values ranging from 0.1 μh to 10 mh. These are high reliability chokes, designed to conserve space (a 100 μh unit measures only 0.0122 cu in.), and provide excellent moisture and immersion resistance characteristics over the operating temperature range from −55 C to +125 C. Maximum current ratings even at 125 C are conservative, units being rated at ⅓ w for the S and M series and ½ w dissipation for the L series. Inductance values are clearly and permanently marked on each unit. Circle 289 on Reader Service Card.

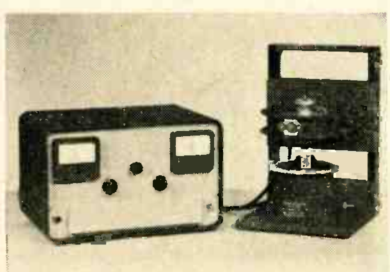


Terminal Extensions are front facing

AGA Division of Elastic Stop Nut Corp. of America, Elizabeth, N. J. Front facing terminal extensions for its line of Agastat time delay relays have been announced. Use of the extensions permits quicker and easier installation in a panel.

There are eight terminal extensions and contact screws. When installed on the contact points of an Agastat time delay relay, the spacing between the extensions allows for maximum dielectric protection.

The terminal extensions are available in combination with Agastat time delay relays or separately. Circle 290 on Reader Service Card.



Rotor Balancer direct reading instrument

M. Ten Bosch, Inc., Pleasantville, N. Y., offers a rotor balancer providing precise and direct reading in micro oz-in. of both dynamic and static unbalance in any predetermined correction plane.

Consisting of a compact, bench mounted computer and rotor mount, it permits rapid balancing of various types of rotors for gyros, motors, grinding heads, turbines, impellers, spindles and the like.

Sensitive vacuum tube transducers detect the vibrations arising from unbalance. Completely assembled units can be balanced with the spin axis in either the horizontal or vertical plane.

Rotors are brought to speed by self-contained means or accessory drives. However, indications are independent of speed from 1,000 to 200,000 rpm. Circle 291 on Reader Service Card.

Silicon Rectifiers high power devices

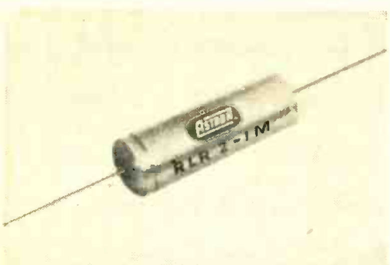
General Instrument Corp., Automatic Mfg. Division, 65 Gouverneur St., Newark 4, N. J. Silicon power rectifiers capable of handling up to 20 amperes at case temperatures of 135 C are now in large scale production. The rectifiers, which cover the range of 50 to 350 v peak inverse, are of a new type of diffused junction construction, developed for use in all types of military and commercial equipment where the basic limitations of other types of rectifiers must be overcome.

These units are designed for high reliability under the most severe environmental condition of moisture and vibration fatigue, high acceleration vibration, centrifuging, shock and temperature cycling. They have been successfully operated at ambient temperatures ranging from − 50 C to + 165 C, and they can be stored at temperatures ranging from − 65 C to + 180 C. The units are available in current ratings of 5, 10, and 20 amperes, with peak inverse voltages of 50, 100, 150, 200, 250, 300 and 350. Circle 292 on Reader Service Card.

Socket-Shield totally enclosed unit

METHODE MFG. CORP., 7447 W. Wilson Ave., Chicago 31, Ill. A new line of tube socket and shield combinations features telescoping slide construction. Since the shield is not removable from the base, hazards of shock displacement or failures to replace shields during servicing operations are eliminated.

Absolutely vibration proof and totally enclosed to reduce r-f radiation effects, variations are furnished for both conventional and printed wiring applications in seven and nine pin sizes. The units are available in usual socket materials and finishes. Circle 293 on Reader Service Card.



Capacitors metallized Mylar

ASTRON CORP., 255 Grant Ave., East Newark, N. J. A new capacitor style—metallized Mylar, type RLR

—is announced. Type RLR has a protective Mylar wrap and epoxy end seal for humidity protection. Said to be ideal for potted assemblies, military and commercial applications, type RLR provides reliable operation in spite of smaller size and lower cost. They are available in standard and continuous voltage rating at 200 wvdc, with temperature range of −55 C to +125 C. Circle 294 on Reader Service Card.

Differential hollow shaft design

REEVES INSTRUMENT CORP., 207 E. 91st St., New York 28, N. Y., is producing a double pinion hollow shaft differential. The units can operate at speeds as high as 2,500 rpm with up to 32 oz in. of torque inputs.

AGMA precision class II gearing is used throughout, in conjunction with precision, shielded ball bearings. These features, augmenting the double pinion design, assure highest accuracy. Backlash at no load is under one minute, with starting and running friction torques held to extremely low values.

Rapid installation of these units in extremely confined spaces or between cast-in supports is made possible by the hollow shaft design which accommodates $\frac{1}{8}$ in. and $\frac{3}{16}$ in. shafting and permits permanent or temporary pinning to an existing shaft. Great flexibility is provided by completely interchangeable end gears which may be easily installed in the field. The end gears are available in wide tooth ranges for 48, 64, 96 and 120 diametral pitch. Circle 295 on Reader Service Card.

New Literature of the Week

MATERIALS

Ceramic Materials. Duramic Products Div., Technion Design & Mfg. Co., Inc., 262 Mott St., New York 12, N. Y. Bulletin 109 is a one-page summary of available high temperature ceramic materials. Typical uses are described. **Circle 351 on Reader Service Card.**

Plastics and Fibre. Taylor Fibre Co., Norristown, Pa. A detailed summary of application and engineering data on laminated plastics and vulcanized fibre is furnished in a new 8-page catalog. **Circle 352 on Reader Service Card.**

COMPONENTS

Power Relay. Phillips Control Corp., 59 Washington St., Joliet, Ill. A new engineering data folder provides a comprehensive report on the type 33B general purpose power relay. Detailed descriptions of characteristics, features and technical data are included in the folder. **Circle 353 on Reader Service Card.**

Selenium Rectifiers for Power Supplies. Beta Electric Div., Sorensen & Co., Inc., 333 E. 103rd St., New York 29, N. Y., has offered a 12-page illustrated bulletin discussing the advantage of selenium rectifiers for h-v d-c power supplies. A bibliography is included. **Circle 354 on Reader Service Card.**

Transistor Manual. General Electric Co., Syracuse, N. Y., has published the second edition of the "Transistor Manual" containing basic information on transistors and their use in electronic circuits. It contains 112 pages of informational material. Price of the manual is 50 cents. **Circle 355 on Reader Service Card.**

Toggle Switches. Micro Switch, Freeport, Ill. Data sheet 142 describes a series of pull-to-unlock toggle switches which incorporate an integrally-designed lever lock and require a definite pull of approximately 0.090 in. to change lever positions. **Circle 356 on Reader Service Card.**

Wire-Wound Resistors. RCL Mfg. Co., New Jersey Ave., Riverside, N. J. Descriptions, specifications and ordering instructions for a line of precision and power wire-wound resistors are given in a 12-page booklet. **Circle 357 on Reader Service Card.**

EQUIPMENT

Coil Winders. Geo. Stevens Mfg. Co., Inc., Pulaski Road at Peterson, Chicago 30, Ill., has released a 2-page catalog sheet illustrating and giving condensed descriptions of 8 coil winding machines. **Circle 358 on Reader Service Card.**

Digital Recording Equipment. Clary Corp., 408 Junipero St., San Gabriel, Calif. Six-page brochure SA-81 describes the company's tape punch, print-punch, scanning printer, printer-perforator combinations, time data printer, printing timer, printing input keyboard and standard data printer machines. **Circle 359 on Reader Service Card.**

Thermocouple Signalling Controller. Leeds & Northrup Co., 4934 Stenton Ave., Philadelphia 44, Pa. Information about a new thermocouple Electromax signalling controller for two-position control is now available in a two-page preliminary data sheet ND 47-33 (1). **Circle 360 on Reader Service Card.**

FACILITIES

Plastics Manufacturing. The Richardson Co., 2700 Lake St., Melrose Park, Ill. The company's facilities for manufacturing plastics for industry and defense are outlined in a new 12-page booklet. Shown are pictures and descriptions of molded and laminated applications. **Circle 361 on Reader Service Card.**

Wire Firm Spreads Out

IN THE SHORT SPAN of two years, American Super-Temperature Wires, Inc., of Winooski, Vt., has developed from a bright idea into an industry with multi-million dollar sales. After a modest start in an old textile mill near the shores of Lake Champlain, Super-Temp now operates out of three large plants and is still in the process of expanding.

The story of Super-Temp goes back to the Fall of 1955 when Leroy Tourville, company president (pictured seated at center with part of the management team), predicted that the teflon insulated wire business was on the threshold of skyrocketing with the entire missile and electronic industries. As quickly as possible a team of teflon wire and cable experts was assembled and American Super-Temperature Wires, Inc., was organized. These men provided the initial "know-how" and the leadership so essential to rapid success.

Now Super-Temp's plants work as many as three daily shifts in an effort to keep ahead of the ever increasing demand for its vital products. The company produces a diversified line of wires and cables in more than 1,000 gages, varieties, conductors and colors.

The plant's quality control laboratory is equipped with the latest scientific instruments and staffed with a large group of inspection technicians. Here, every foot of Super-Temp wire and cable is subjected to all conceivable physical and environmental tests to insure the necessary wide margins of dependable performance under actual operating conditions.

Next stop in a tour is the extrusion department which the company is constantly enlarging and improving. Here teflon is extruded onto wire and cable from miniature to jumbo sizes amid a battery of electronic panels that scientifically supervise uniformity, concentricity and other critical factors.

In the magnet wire department more than twenty machines turn out millions of feet of teflon and silicone magnet wire every week with sustained production quality, using processes said to be known only to Super-Temp engineers.

The new branch plant in Winooski is devoted almost entirely to the production of teflon tape, a new venture for Super-Temp. A section of the new plant will be used for research and development on improved methods for the production of teflon insulated wires and cables. New facilities there make room for additional production equipment in the original plant.

IRE Names Fellows

SEVENTY-FIVE leading radio engineers and scientists from the U. S. and other countries were recently named Fellows of the IRE by the board of directors. This is the highest membership grade offered by the IRE and is bestowed only by invitation on those who have made outstanding contributions to radio engineering or allied fields.

Recognition of the awards will be made by the president of the Institute at the annual banquet on March 26, 1958 at the Waldorf-Astoria Hotel in New York City during the 1958 IRE National Convention.

Recipients of the award are as follows: **M. L. Almquist**, of Bell Labs, New York; **I. L. Auerbach**, of Auerbach Electronic Corp., Narberth, Pa.; **A. C. Beck**, of Bell Lab; **A. B. Bereskin**, of the U. of Cincinnati; **C. J. Breitwieser**, of Lear Inc., Santa Monica, Calif.; **F. E. Brooks, Jr.**, of Collins Radio Co., Dallas, Texas; **H. L. Brueckmann**, of Signal Corps Engineering Labs, Ft. Monmouth, N. J.; **R. L. Clark**, Research Administrator, U. S. Govt.; **R. I. Cole** of Melpar, Inc., Falls Church, Va.; **H. Costa** of the Brazilian Govt.; **C. M. Crain**, of the U. of Texas, Austin, Texas; **W. B. Davenport, Jr.**, of MIT; **H. E. Dinger**, of NRL, Washington, D. C.; **M. J. Di Toro**, of PR&D Co., Brooklyn, N. Y.; **J. B. Epperson**, of Scripps-Howard Television, Cleveland, Ohio; **G. H. Fett** of the U. of Illinois, Urbana, Ill.; **R. L. Garman**, of GPL, Inc., Pleasantville, N. Y.; **E. A. Gerber**, of Signal Corps Engineering Labs, Ft. Monmouth, N. J.; **I. H. Gerks**, of Collins Radio Co., Cedar Rapids, Iowa; **L. J. Giacoletto**, of Ford Motor Co., Dearborn, Mich.; **A. B. Giordano**, of Polytechnic Inst. of Brooklyn, Bklyn., N. Y.; **P. E. Haggerty**, of Texas Instruments, Inc., Dallas, Texas; **A. C. Hall**, of Bendix Aviation Corp., Detroit, Mich.; **J. W. Herbstreit**, of National Bureau of Standards, Boulder, Colo.; **C. H. Hoeppner**, of Radiation, Inc., Melbourne, Fla.; **Pierre M. Honnell**, of Washington U., St.

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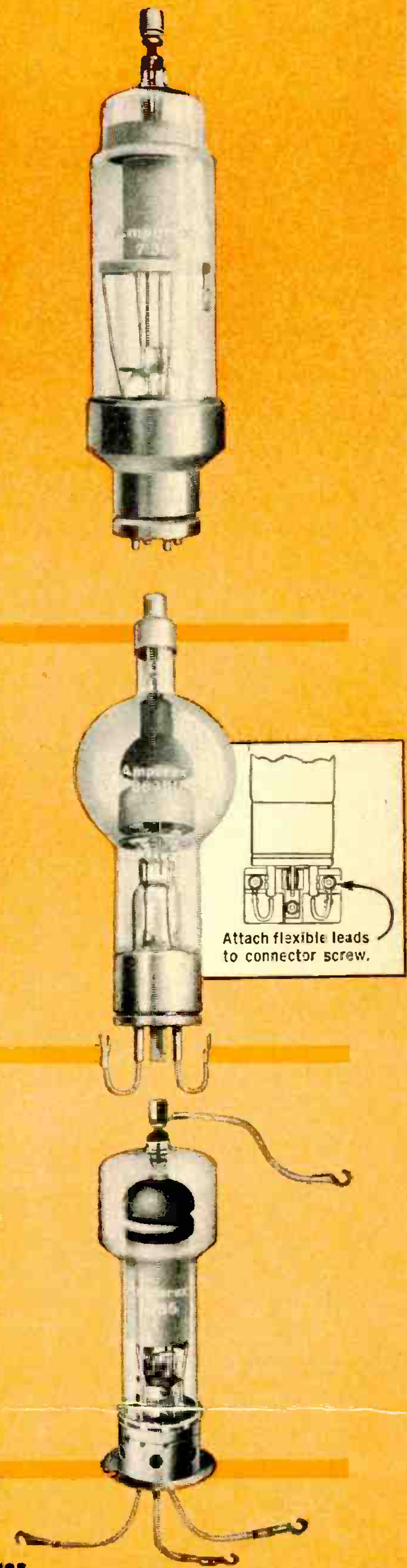

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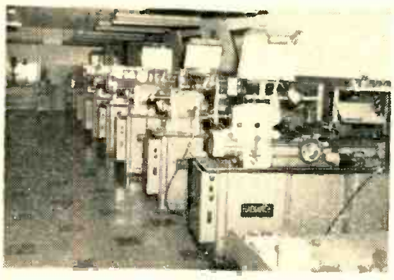


Autotronics Expands

MISSOURI firm, Autotronics, Inc., manufacturer of miniature and subminiature electromagnetic clutches and brakes, has completed an expansion program that has more than doubled its production facilities and size of staff. Plant size is increased from 3,600 to 9,600 sq ft and new production machinery units (picture) have been installed and are now in operation.

Long range expansion plans include the construction of a large new office and engineering building, scheduled to go into operation in about two years.

VRL Moves

NEW home of Vibration Research Laboratories, Inc., is a recently acquired 6,000 sq ft building at 58 Marbledale Road, Tuckahoe, N. Y.

The enlarged facilities will be used both for the manufacture of a new line of transistorized power conversion equipment including the recently introduced Vibristor, and for expanding production of vibrators and vibrator power supplies.

Packard-Bell Hires Supervisor

CALIFORNIA firm, Packard-Bell Electronics Corp., names Bernard L. Goldwasser (picture) supervisor of process engineering in the printed circuit department.

Goldwasser's background includes experience as plant manager for the Telcron Co., College Point, N. Y.; general manager at LaPointe Electronics, Rockville, Conn.; and production superintendent, Electrolab, Inc., Needham Heights, Mass.

Executive Moves

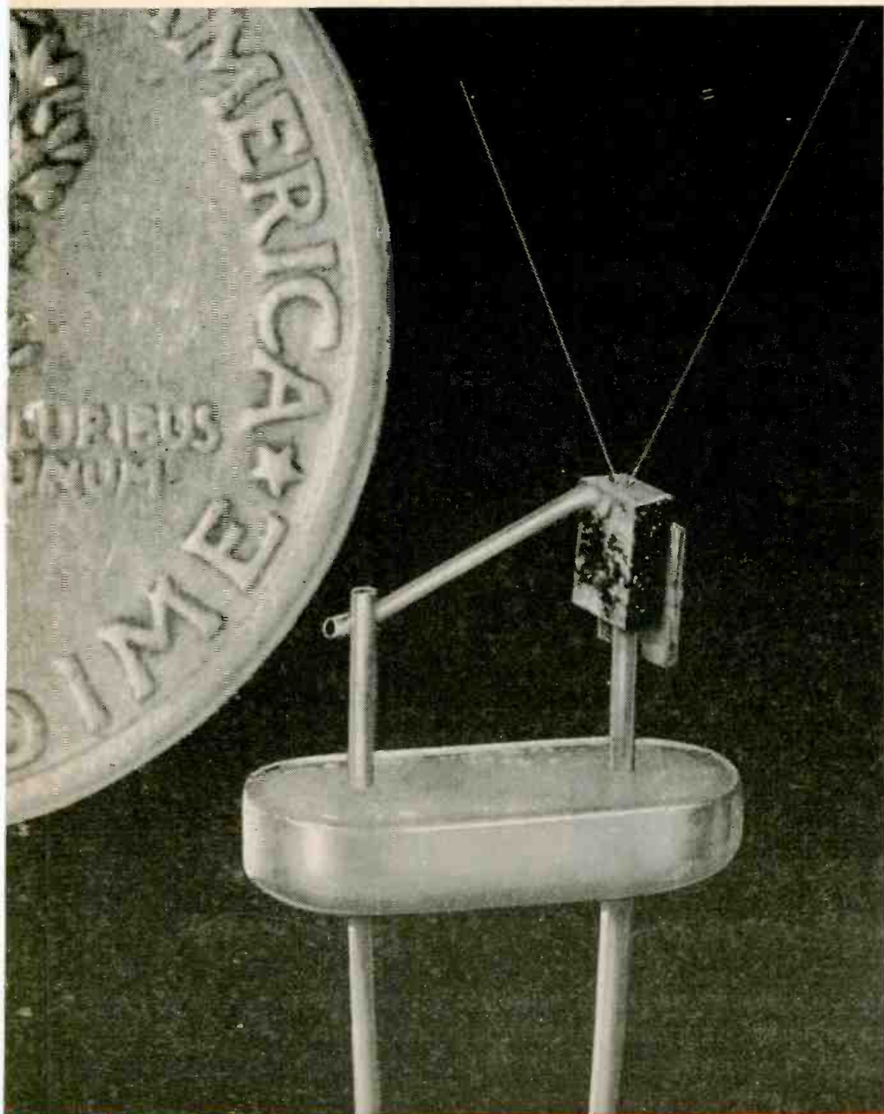
FORMERLY president of Dynalysis development Laboratories, Inc., Kenneth R. Jackson is named special assistant to the president of Waugh Engineering Co., Van Nuys, Calif.

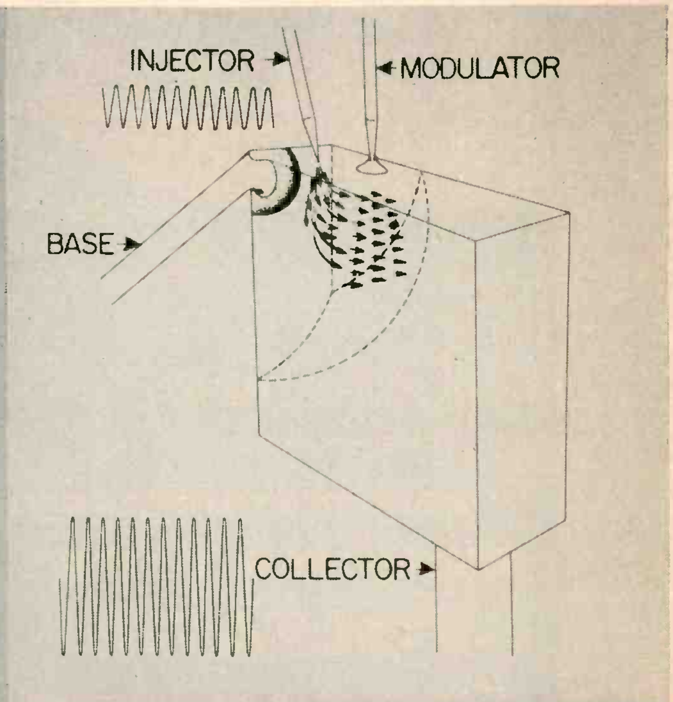
Murray C. Walker, Jr. leaves Ace Electronics Associates to become New England regional manager of the military operations department of Allen B. DuMont Laboratories, Inc.

New president of Britain's Institution of Electrical Engineers is T. E. Goldup, board member of Mullard Ltd.

Former dean of engineering at Texas Institute of Technology,

Recent Achievements by Raytheon Scientists and Engineers





THE SPACISTOR. In July 1957, Raytheon scientists announced the "spacistor", a new semiconductor device that combines the advantages of the vacuum tube with those of the transistor. In the diagram above, voltage is applied between the "base" and "collector" so as to produce a high field and virtually no current. As voltage is applied at the "injector", electrons flow rapidly to the collector contact. The injector current is modulated by applying to the "modulator" a small signal which, since it draws negligible current, is amplified.

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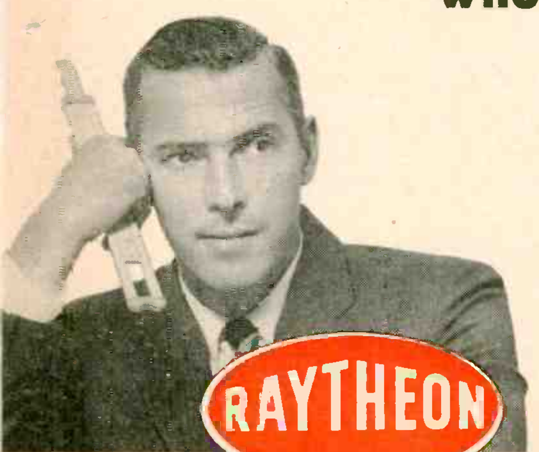

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Floyd F. Lewis, Jr., moves to Shepard Instrument Co., Phoenix, Ariz., to head up its special projects division.

Plant Briefs

DUE to product diversification, Weksler Thermometer Corp., Freeport, N. Y., changes its name to **Weksler Instruments Corp.**

Apex Electronics, E. Paterson, N. J., is a new firm set up to produce electron gun mounts. The new company expects to relocate in Passaic, N. J., early this year.

Consolidated Avionics Corp. moves to a new 20,000-sq ft plant and office facility on a 40,000-sq ft plot in Westbury, Long Island.

Marconi Instruments moves from New York City to larger quarters in Englewood, N. J.

Pacific Scientific Co. has begun construction of a two-story building in San Francisco, with completion slated for March.

News of Reps

HAMMER Electronics Co., Inc., Princeton, N. J., names **Crossley Associates, Inc.,** Chicago reps, to handle its line of nuclear and electronic instruments. The Crossley territory includes Illinois, Indiana, Iowa, Minnesota, Nebraska, North Dakota, South Dakota, southwest Ohio and Wisconsin.

Jack Kaufman leaves Lewis and Kaufman, Ltd., to set up an office in San Mateo, Calif., as manufacturers' rep.

William Logan, Daly City, Calif., is new rep firm covering northern California and northern Nevada.

Thomas L. Stevens Co., Burbank, Calif., now handles Ralph S. Thacker Co.'s line of connectors and components in southern California and Arizona.

New rep organization formed in New England: **Entis Associates,** Brookline, Mass.

NEW BOOKS

Fundamentals of Electron Devices

By Karl R. Spangenberg
McGraw-Hill Book Company, Inc. New York, 1957, 505 *p,* $10.00.

It is the purpose of this book to present the basic principles underlying electron devices and their applications, with somewhat greater emphasis on transistors than vacuum tube devices. Although planned primarily as a text to introduce undergraduate engineering students to electronic studies, the book is also of value to practicing engineers wanting basic information on new electron devices, particularly of the semiconductor type. The author of this excellent text is Professor of Electrical Engineering at Stanford University. An expert in the field of electron devices, Prof. Spangenberg has presented the text material with the same excellence which characterized his earlier text, "Vacuum Tubes."

Scope and Features—The text starts with the fundamental principles leading towards an understanding of the operation of the device and the circuit. Emphasis is placed on the similarities of transistors and vacuum tube devices rather than their differences.

Following an interesting chapter on the history of electron devices are chapters on electrons and ions, electric and magnetic fields, and ion motion in vacuum in which the author discusses the fundamental charged particles used in electron devices and their motion in electric and magnetic fields.

Important solid-state phenomena are taken up next in the chapters on the atom; conductors, insulators and semiconductors; junction effects and electron emission.

The next four chapters are devoted to the important types of electron devices and their equivalent circuits: vacuum and semiconductor diodes, control-type vacuum tubes, transistors and equivalent circuits of tubes and transistors.

Some circuit applications of

Continued

electron devices are discussed in the four chapters on small-signal amplifiers, using electron devices, small-signal oscillators, small-signal nonlinear effects in electron devices and large-signal applications of electron devices.

There are two chapters covering photoelectric devices and noise in electron devices. Thirteen appendices, a list of problems and a bibliography are also included.

The material on vacuum tubes is excellent. Much of it has been extracted from Professor Spangenberg's "Vacuum Tubes" and brought up-to-date. Undoubtedly this portion of the text will long stand the test of time. The chapter on electron emission is particularly interesting and includes material on oxide cathodes and new emitter materials, as well as pure metallic emitters.

It is to be expected, on the other hand that some of the material on transistors will be obsolete in a few years since this is a rapidly changing field. It cannot be expected that such a text could include the latest work on high-frequency transistors, for example. However, the fundamental principles discussed are well established and the student who masters them will have no difficulty in following the new developments. These principles include a detailed treatment of energy levels in semiconductors and the internal physics of the devices.

Style—The book is written in a clear, descriptive style at a level suitable for the intended readers. The use of mathematical analysis is at a minimum although no sacrifice to rigor has been made. Excellent use has been made of the appendix to discuss such important topics as the diffusion equation, the Fermi-Dirac distribution function, Richardson - Dushman emission equation, noise in resistances and several others. The development of the text is logical and appears to have been carefully prepared, containing a large number of clear illustrations, an excellent bibliography and over 200 illustrative problems.

The student will find that this is an excellent text from which to learn the fundamentals of electron devices and their application. The practicing engineer will find the text helpful in getting up-to-date on the fundamental principles of electron devices and their applications, particularly semiconductor type. Instead of increasing the gap between transistor and vacuum tube devices, the author has succeeded in closing it by presenting a unified treatment, uniquely stressing their similar features. This reviewer heartily endorses the book. —G. C. DALMAN, *School of Elec. Eng., Cornell University, Ithaca, New York.*

THUMBNAIL REVIEWS

Polyethylene. By Theodore O. J. Kresser, Reinhold Publishing Corp., New York, 1957, 217 p, $4.95. General properties, basic chemistry, manufacturing and applications of polyethylene covered in a general nontechnical way which should appeal to users of this material in the electronics industry.

Basic Mathematics for Electricity, Radio and Television. By Bertrand B. Singer, McGraw-Hill Book Co., Inc., 1957, 513 p, $7.50. Self-study book on high-school and technician level relates mathematics to elementary theory.

Human Engineering. By Ernest J. McCormick, McGraw-Hill Book Co., Inc., New York, 1957, 467 p, $8.00. Introduction to design of equipment and adaptation of work environments for optimum human use written primarily for engineers and managerial personnel.

Selection and Application of Metallic Rectifiers. By S. P. Jackson, McGraw-Hill Book Co., Inc., 1957, 326 p, $8.00. How to combine rectifier-cell characteristics and circuits for use in pulse circuits, electroplating power supplies, battery charging, magnetic amplifier power supplies and other applications. Information is given on ratings, rating methods and use of typical operating data supplied by manufacturers. Types covered include selenium, copper oxide, magnesium copper sulphide, titanium, dioxide, germanium and silicon.

COMMENT

Submarine Defenses

The insert "Military Electronics" (Dec. 1 '57, p 14) discusses "the anti-submarine rocket called ASROC." This project is of interest to all of us in the sonar engineering group at Bendix-Pacific.

It is true that ASROC "can be launched from a ship a comfortable 200 miles from its target," but the rocket will not come near the target. I do not know your source of information on range, but it is more than a factor of ten too high. Ten miles or so is an optimistic maximum for the particular weapon.

I and others who are active in sonar and torpedo design are very much concerned with the publication of information that indicates that we have an effective defense against the 400 or 500 submarines that the Russians are alleged to have. This type of false representation breeds complacency among the public and its elected representatives. We have left a door open which is as important as the air if not more so due to the vagaries of the sea.

I tried to point out some of these problems in my article on sonar (ELECTRONICS, Jan. 3, p 56). Unless the military takes a more realistic approach on underwater detection and weapons we will remain relatively unprotected on this front for many years. The basic technology is available to make a manifold increase in weapon effectiveness and detection range but it will not be achieved for a long time at our present rate.

JAMES A. RUMMELL
BENDIX AVIATION CORP.
NORTH HOLLYWOOD, CALIF.

A-c Microammeter

I am pleased to note the publication of our article "Clamp-On Microammeter Measures A-C Current" (Dec. 1, p 152).

Equation (4) in this article should read (3). The line above equation (3) should have been struck out. *I-sloped* should read *I-shaped*. The internally generated noise is not 20μs, but 20 μa.

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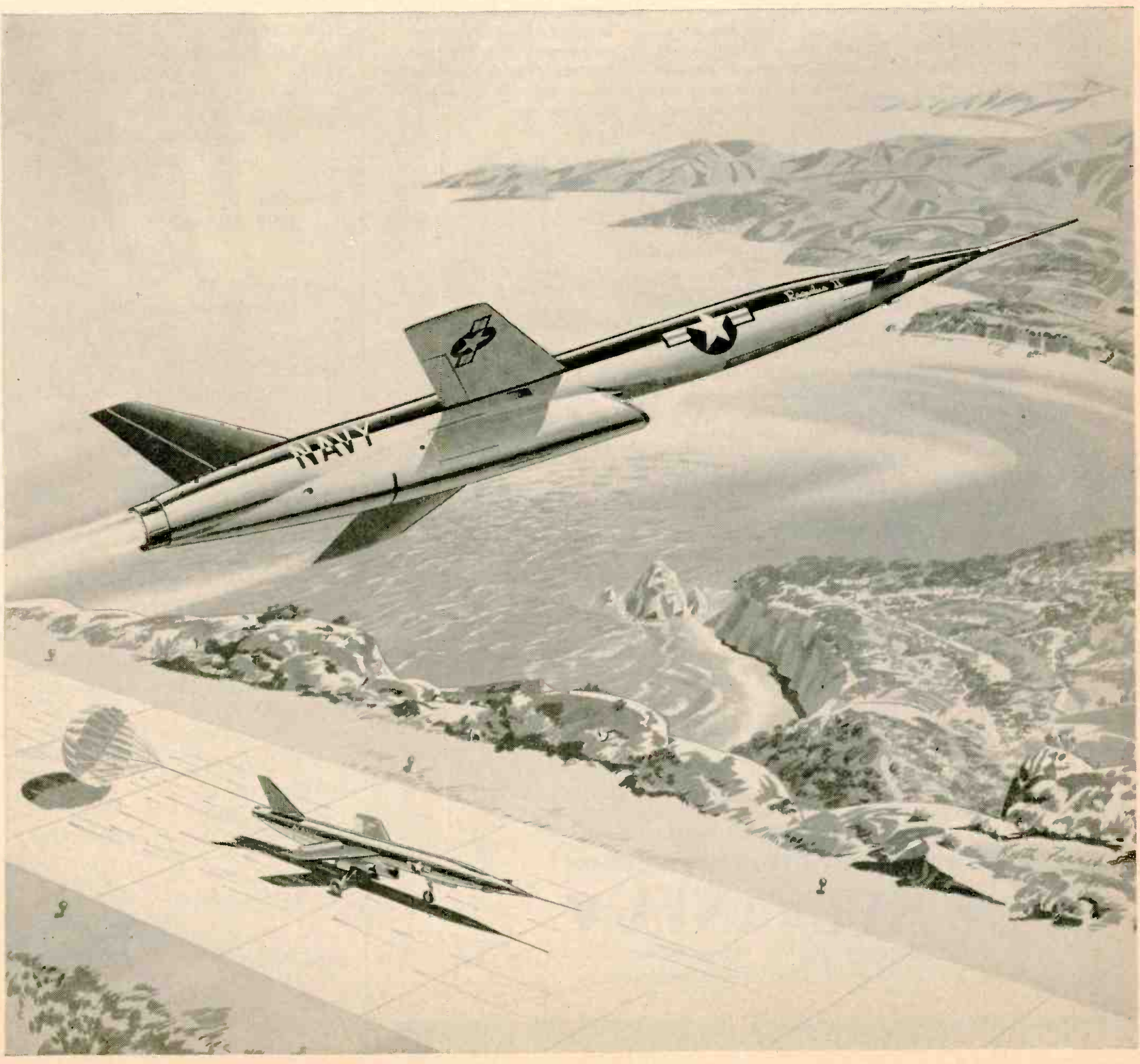

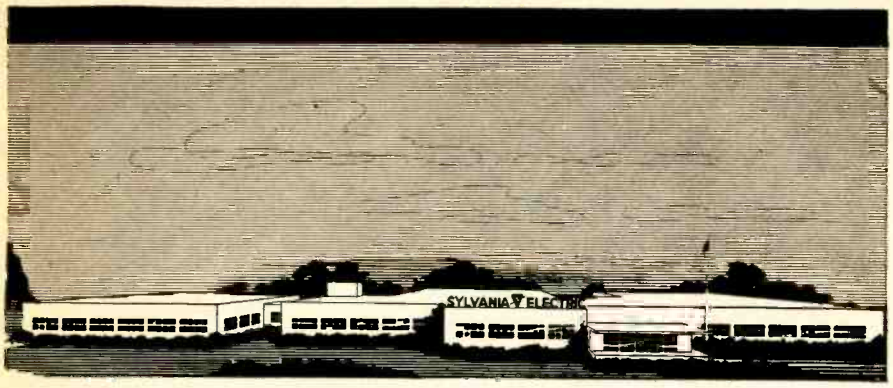

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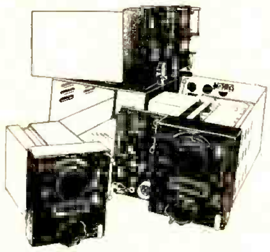

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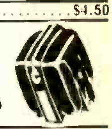

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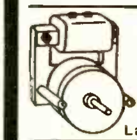

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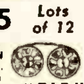

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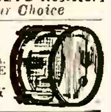

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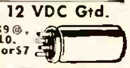

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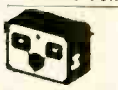

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T28V5A2CC	5 Amp 0.1% Ripple	139
T28V12A	0-28 VDC at 12 Amp	136
T28V12ACC	12 Amp (1% Ripple)	166
T28V12A2CC	12 Amp 0.1% Ripple	225
T18V24A†	0-28 VDC at 24 Amp	165
T28V24ACC†	24 Amp 1% Ripple	224
T28V24A2CC†	24 Amp 0.1% Ripple	295
T28V50A†	0-28 VDC at 50 Amp	306
T28V50ACC†	50 Amp (1% Ripple)	400
T28V100A†	0-28 VDC at 100 Amp	525
T28V100ACC†	100 Amp (1% Ripple)	729
T35V16ACC†	0 to 35V @ 16 Amp/.5% Rip	210
T35V25ACC†	0-35V @ 25 Amp (1% Rip.)	370
T35V50ACC†	0-35V @ 50 Amp (1% Rip.)	639
T60V1ACC	0-60 VDC @ 1 Amp/1% Rip	108
T60V2ACC	0-60 VDC @ 2 Amp/1% Rip	139
T60V5ACC	0-60 VDC @ 5 Amp/1% Rip	225

Variable 0-130 VDC Completely built. Includes Isolation Transformer, Selenium F.W. Bridge, Rectifier, 4" Rectangular Volt & Ammeter Specify for 115 or 230VAC/1ϕ/60cy input.

T130V5A†	0-130 VDC at 5 Amp	$225
T130V5ACC†	5 Amp (1% Ripple)	275
T130V10A	0-130 VDC at 10 Amp.	275
T130V10ACC†	10 Amp 1% Ripple	369

Includes 4" Meters 2% Acy. *2" Meters

NEW! LOW PRICED HIGH CURRENT BASIC INDUSTRIAL SUPPLIES

Consisting of Transformer & Full Wave Bridge Rectifier mtd and wired, fused, outlet, pilot light & ventilated grill & chassis or cabinet. **Ready to deliver constant DC Power. 1 yr. Gtd. Input 115VAC/60cys, 220V or 3ϕ to order!**

Stock Number	Continuous Rating	Unit Price
B23V/5A	28 WVDC at 5 Amp	$43
B28V/5ACC	5 Amp (1% Ripple)	63
B28V/12A	28VDC at 12 Amp	84
B28V/12ACC	12 Amp (1% Ripple)	129
B23V/24A	28VDC at 24 Amp	132
B28V/24ACC	24 Amp (1% Ripple)	180
B23V/50A*	28 VDC at 50 Amp	225
B23V/50ACC*	50 Amp (1% Ripple)	339
B28V/100A*	28 VDC at 100 Amp	414
B28V/100ACC*	100 Amp (1% Ripple)	570
B100V1A	100 VDC @ 1 Amp	39
B115V1.5A	115 VDC @ 1.5 Amp	52
B115V5A*	115 VDC @ 5 Amp	120
B220V5A*	220 VDC @ 5 Amp	234
B115V5ACC*	115 VDC @ 5 Amp/1% Rip	169
B115V10ACC*	115 VDC @ 10 Amp/1% Rip	275
B220V10ACC*	220 VDC @ 10 Amp/1% Rip	468

*** 115 & 230 VAC/60cy/1ϕ Input**

New 5-Way Binding "TEK-AP"® POSTS

Similar to Superior DF30*, takes plugs, tips, lugs, wire. 1/16" to 1/4" panels.
BP30*, 30 Amp, 29c@, 12/$3.25, 100/$22, 1M/$185
BP10*, 10 Amp, 18c@ ... 100/$15, 1M/$120
BP60*, 60 Amp, 75c@ ... 50/$30, $500/$250
BP100, 100 Amp, $1@ ... 27/$25, 100/$75
Mfrs. write quantity prices & Blue Prints

SINCE 1945 CERTIFIED TUBE TESTING AGEING & PRESELECT FACILITIES WRITE!

TUBES

"TAB" TESTED INSPECTED GUARANTEED!!!

WRITE FOR COMPLETE TUBE LIST | **Tubes Wanted**

OA2 ... $.70	3D23 ... $4.00	T55 ... $6.00	339A ... $29.00	708A ... $.65	954 ... $5/$1	5693 ... $4.50
OA3 ... .85	4-65 ... 15.00	RK59 ... 1.39	348A ... 3.50	709A ... .80	931A ... 3.45	5694 ... 2.50
OB2 ... .65	4-125 ... 30.00	FG67 ... 20.00	349A ... 3.50	710A ... 3.50	932 ... 6.50	5713 ... 200.00
OC3 ... .70	4-250 ... 34.00	75TL ... 9.00	350A ... 2.00	713A ... 3/$1	955 ... 3/$1	5725 ... 1.25
OD3 ... 2/$1	4X150 ... 18.00	80 ... .59	350B ... 1.85	W714 ... 24.00	956 ... 4/$1	5726 ... .60
OZ4 ... .60	4X250 ... 38.00	83 ... .99	351A ... 12.75	717A ... 5/$1	957 ... 4/$1	5732 ... 1.90
1A7 ... .90	4X500 ... 37.00	FG98 ... 14.00	354A ... 2.00	715B ... 2.00	958A ... 3/$1	5749 ... .85
1B3 ... .78	5R4 ... 1.00	VR92 ... 6/$1	355A ... 9.00	715C ... 25.00	959 ... 1.00	5751 ... 1.15
1L4 ... .82	5U4 ... .59	100TH ... 6.39	356B ... 2.50	721A ... 2/$1	973 ... 15.50	5814 ... .90
1R4 ... .88	5V4 ... .89	100TL ... 11.29	NO/C/INQ!	722A ... .90	991 ... 6/$1	5881 ... 2.65
1R5 ... .78	5Y3 ... .65	FG104 ... 28.90	368AS ... 1.00	723AB ... 6.50	C1013 ... 2.00	6146 ... 4.20
1S4 ... .79	5Z3 ... .89	FG105 ... 13.50	380A ... 1.15	724A ... 2/$1	C1027 ... 2.25	6550 ... 3.89
1S5 ... .68	5Z4 ... 1.00	VT127 ... 4.00	387A ... 3.35	725A ... 2.00	C1047 ... 2.95	1N21B ... .90
1T4 ... .85	6A7 ... 1.00	CV147 ... 5.00	388A ... .85	726B ... .85	R1100 ... 9.00	1N23A ... .95
1T5 ... .95	6A8 ... .99	150T ... 25.00	393A ... 4.00	726C ... 11.00	R1130 ... 10.00	1N23B ... 2/$1
1U4 ... 7/$1	6AC7 ... .79	152T ... 31.00	394A ... 3.00	730A ... 4.00	1608 ... 5.00	1N23C ... 1.75
1U5 ... .75	6AG5 ... .89	FG166 ... 13.50	395A ... 4.00	803 ... 1.35	1609 ... 13.00	1N25 ... 1.65
1X2 ... .75	6AG7 ... .89	FG172 ... 13.00	399A ... 3.00	807 ... 1.05	1612 ... 1.00	1N26 ... 5.00
2C39A ... 9.00	6AJ4 ... 1.69	FG190 ... 6.00	410R ... 105.00	807W ... 1.40	1613 ... 1.00	1N27 ... 2/$1
2C40 ... 6.00	6AJ5 ... 1.00	203A ... 2.00	WE417 ... 14.00	809 ... 2.45	1619 ... 4/$1	1N34 ... 3/$1
2C43 ... 7.00	6AS6 ... 1.75	215A ... 9.00	421A ... 3.50	811 ... 2.35	1620 ... 3.25	1N35 ... 1.50
2C46 ... 4.00	6AT6 ... 2/$1	217A ... 6.00	422A ... 6.00	812 ... 3.00	1621 ... 1.25	1N38A ... 2/$1
2C50 ... 5.00	6AU6 ... .59	227A ... 2.50	428A ... 29.00	813 ... 8.50	1622 ... 1.50	1N39 ... 2.25
2C51 ... 3.00	6B4G ... 1.39	242A ... 12.50	434A ... 2.00	814 ... 1.65	1623 ... 1.15	1N43 ... 2/$1
2D21 ... .68	6BG6 ... 1.49	247C ... 14.00	446A ... 2/$1	815 ... 2.75	1625 ... 4/$1	1N45 ... 1.00
2E22 ... 1.75	6C4 ... 2/$1	244A ... 12.00	451 ... 2.00	826 ... 2/$1	1626 ... 7/$1	1N46 ... 3/$1
2E24 ... 2.00	6J5 ... .50	245A ... 5.00	5BP4 ... 2.95	827R ... 90.00	1632 ... 2/$1	1N47 ... 1.20
2E25 ... 3.25	6L6 ... 1.00	249B ... 2.50	468 ... 26.00	828 ... 8.00	1633 ... 2/$1	1N48 ... 3/$1
2E26 ... 2.75	6SN7 ... .72	249C ... 3.50	9LP7 ... 2/$1	829B ... 7.00	1636 ... .65	1N51 ... 3/$1
2E30 ... 1.70	10Y ... 3/$1	252A ... 6.00	VX500 ... 6.00	833 ... 33.00	NO/C/INQ!	1N52 ... 2/$1
2E35 ... 1.60	12AT6 ... .59	254 ... 1.50	W531 ... 3.50	836 ... 1.20	1642 ... 3/$1	1N57 ... .75
2K22 ... 13.00	12AT7 ... .89	254A ... 9.00	SLP1 ... 10.00	837 ... 1.20	1649 ... 1.00	1N58 ... 1.00
2K23 ... 11.00	12AU7 ... .69	257B ... 7.00	5JP1 ... 8.00	842 ... 3.25	1654 ... 1.75	1N60 ... 2/$1
2K25 ... 13.00	12AX7 ... .79	274A ... .59	G559 ... 2/$1	843 ... 3/$1	NO/C/INQ!	1N64 ... 3/$1
2K26 ... 39.00	12AY7 ... 1.19	274B ... .59	575A ... 9.00	845 ... 2.90	1684 ... 2.00	1N69 ... 3/$1
2K30 ... 115.00	12BA6 ... .59	275A ... 2.75	W579 ... 16.00	849 ... 120.00	2050 ... .95	1N100 ... 1.25
2K33 ... 59.00	12BE6 ... .59	276A ... 27.00	H615 ... 6/$1	852 ... 3.50	2050W ... 4.00	CK705 ... 2/$1
2K34 ... 85.00	FG17 ... 3.49	282A ... 39.00	K618 ... 10.00	860 ... 2.90	2051 ... .85	CK706 ... 4/$1
2K41 ... 125.00	24G ... 2.50	300B ... 6.00	K627 ... 6.00	865 ... 4/$1	5517 ... 1.20	CK707 ... 2/$1
2K42 ... 99.00	25A6 ... 1.19	307A ... 2/$1	W652 ... 19.00	866A ... 1.15	5608 ... 2.50	CK730 ... 4/$1
2K43 ... 125.00	25A7 ... 2.19	CE309 ... 4.00	W670 ... 16.00	872A ... 1.00	5618 ... 2.50	K3 ... 4/$1
2K44 ... 108.00	25L6 ... .72	310A ... 3.00	673 ... 12.00	875A ... 18.00	5651 ... 1.00	K6 ... 2/$1
2K45 ... 34.00	25T ... 3.50	310B ... 7.00	676 ... 49.00	878 ... 3/$1	5654 ... 1.15	K63 ... 4/$1
2K48 ... 55.00	26A7 ... 2.50	313C ... 2.00	677 ... 50.00	884 ... 1.10	5663 ... .60	G7C ... 2/$1
2K50 ... 100.00	FG27 ... 8.29	BL315 ... 39.00	678 ... 40.00	R85 ... .95	5670 ... 1.20	MA408 ... 1.00
2K55 ... 15.00	28D7 ... 2/$1	316A ... 5/$1	5BP1 ... 3.00	G889A ... 45.00	5684 ... 9.00	2N156 ... 4.15
2K56 ... 50.00	EL34 ... 3.49	322A ... 48.00	702A ... .90	917 ... 1.20	5686 ... 1.00	2N158 ... 5.50
2V3 ... 2/$1	35L6 ... .59	324A ... 200.00	703A ... .80	918 ... 1.00	5787 ... 1.85	2N180 ... 3.50
3C24 ... 2.50	35TG ... 1.95	325A ... .90	Q704A ... 3/$1	919 ... 1.35	5691 ... 4.40	2N181 ... 4.20
3E29 ... 7.00	35Z5 ... .60	331A ... 15.00	707A ... 1.00	927 ... .90	WRITE FOR TUBE CAT	

TECHNICAL APPARATUS BUILDERS — Mfgrs. of Selenium & Silicon Rectifiers

Distributed by "TAB" — *NEW LOWER PRICES*

New "TESKEL"® SELENIUM RECTIFIERS* to Your Specs Any Current.
Quick Deliveries! *Write for Quantity Prices.* | *Specials in 24 hours ! ! !*

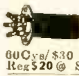
***FULL WAVE BRIDGE & †C.T. • DATED & ONE YEAR GTD.**

MAX DC AMP	Single Phase Full Wave Bridge: 18VAC 14VDC	38VAC 28VDC	54VAC 42VDC	72VAC 54VDC	130VAC 100VDC	260VAC 217VDC	3-Phase Bridge: 3-Phase 16VAC 20VDC	3-Phase 30VAC 36VDC	3-Phase 120VAC 150VDC	3-Phase 208VAC 256VDC
½	$1.00	$1.90	$2.90	$3.85	$5.00	$9.75	$1.75	$2.60	$9.45	$18.50
1	1.30	2.00	3.45	4.90	8.15	16.00	3.30	4.45	17.90	33.75
2	2.15	3.00	5.15	6.25	11.10	21.90	4.45	5.30	21.75	42.60
3	2.90	4.00	5.60	8.60	13.45	39.75	5.40	6.85	27.60	59.45
4	3.50	6.90	10.75	16.00	24.00	47.60	6.75	7.95	31.15	67.90
6	4.15	8.00	12.30	18.75	31.90	63.45	7.90	9.30	46.95	80.75
10	6.10	12.15	18.50	26.30	41.60	95.00	9.00	14.25	62.45	116.00
12	7.75	14.90	21.00	30.95	43.45	103.60	10.75	16.15	66.60	132.15
15	9.90	19.00	27.45	40.00	54.30	108.15	13.60	20.75	95.60	150.00
20	12.85	24.60	36.45	49.90	76.75	169.00	16.20	24.75	120.75	163.90
24	15.00	29.45	43.00	57.50	81.15	188.75	18.60	31.70	139.30	269.75
30	17.90	35.75	55.15	74.75	117.30	249.60	21.60	34.95	185.90	348.30
36	23.15	46.00	69.30	89.90	142.90	299.45	24.75	39.30	216.45	379.60
50	31.45	60.90	115.75	128.00	183.15	398.90	31.60	46.75	268.15	454.45

BATTERY CHARGER STACKS*† REPLACEMENT OR CONVERSION. *FAN COOLED*

Type	CR20R†	CR32D†	BR18R*	BR18C*	BN18R*
Input	10VAC/CT	16VAC/CT	18VAC	18VAC	18VAC
Output	6VDC/100A	6VDC@100Amp & 12VDC@50Amp			6V@80A & 12V@40A
	$11	$18	$23	$25	$19

STEVENS ARNOLD PRECISION DC-AC CHOPPER TYPE CH365



SPDT/COIL 26VDC800.Ω IMP 60Cys/$30 Ω 400Cys/1100 Ω. Use as Chopper Reg$20@ SPECIAL ... $2.50@, 5for$10 20for$36

New Isolation & Control Transformers

Enclosed Power Type Elec/Static-Shielded Primary 115&230V & Secondary 115/230V 1ϕ 60 cys. Also 230/460 V Same Price

TPP050/50W ... $10	TPP075/75W ... $12
TPP100/100W ... $13	TPP150/150W ... $14
TPP250/250W ... $17	TPP500/500W ... $25
TPP750/750W ... $32	TPP1000/1KW ... $39
TPP2000/2KW ... $59	TPP3000/3KW ... $81

NEW 230 TO 115 V AUTOFORMERS

For 220v/60cy Input. To 110-120V or Step up. † With Cord Plug & Receptacle.
TPA050/50W* ... $2.55
TPA075/75W† ... 3.65
TPA100/100W† ... 4.00
TPA200/200W† ... 5.75
TPA250/250W† ... 6.75
TPA500/500W† ... 8.25
TPA750/750W† ... 11.79
TPA1000/1KW† $16.95; TPA2000/2KW* $22.50
TPA2000/2KW* $34; TPA3000/3KW* $51
**Less Cord, Plug & Receptacle.*

NEW 28VDC RELAY SUPPLIES

Cased Filtered Ready to Work

B24VAR 24VDC at 1 amp Filtered ... $6
B24VER 24VDC at 2 amp Filtered ... $11
B24VJR 24VDC at 5 amp Filtered ... $21

New Variable 0 to 6 & 12 Volt D.C. Power Supplies

12 Amp Battery Eliminator, Charger, Model RR, Plater, Aircraft, Marine or any DC Reg. Extra Hvy Duty Selenium Rectifier, 2 Meters V. & A. Dsgnd for Cont. Service and up to 20 Amp. Intermittent overload. 10% ripple. **Model T612V12AC $39.00**
T612V12ACC only 0.5% Ripple at 5 Amps $45.00
6 V @ 50 AMPS & 12 V @ 25 Amps FILTERED 2% RIPPLE 115VAC/60 CY/1ϕ INPUT ONE YEAR GTD.
T612SNACC 6V/50A&12V/25A/2% Rip. ... $200

TP6000 Industrial "TABPAK" Variable Supply. Input 208-230V/3ϕ-60CYS/12KVA. Output 4X(0-8VDC) at 200amps each or 0-8V@ 800amps, or 0-16V @ 400 amps, or 0-32V at 200 amps. Filtered DC 2% Ripple. Variable transformer control TP6000 $1100

HALF-WAVE & CENTER-TAP

HALFWAVE VAC	AMP	$	CENTER-TAP VAC	AMP	$
26	2	$1.75	13/26	4	$3.60
26	3	2.00	13/26	6	3.90
26	6	2.90	13/26	12	5.00
26	10	3.95	13/26	18	7.50

"TABTRAN" Rectifier Xfmrs

Sec'd Volts (DUAL)† 0-9-15-18-&-0-9-15-18 Series Sec'ds 0-3-6-9-12-15-18-21-24-27-30-33-36 Volts

Discts. to Qty. Users

TR4001 @ 1 Amp†ea/sec/w ... $4.50
TR4002 @ 2Amp†ea/sec/w ... 6.90
TR4003 @ 5Amp†ea/sec/w ... 8.65
TR4005 @ 12Amp†ea/sec/w ... 16.70
TR4006 @ 24Amp†ea/sec/w ... 35.30
TR4007 @ 50 Amp†* per ea sec wndg. ... 57.45
TR4008 @ 100 Amp†* per ea sec wndg. ... 112.90
† Wndgs in Series at Ratings shown: Parallel 2X Current, Voltage outpt. 0-9-15-18.
***Dual Pri 115 & 230VAC/60cys INPUT**

"TABTRAN" Rectifier Chokes

CR6001/ 1 Amp/0.1 HY/1.4 Ohm ... $3.00
CR6002/ 2 Amp/0.1 HY/.67 Ohm ... 5.15
CR6003/ 5 Amp/.07 HY/.6 Ohm ... 9.45
CR6004/12 Amp/.01 HY/.1 Ohm ... 14.75
CR6005/24 Amp/.001 HY/.025 Ohm ... 27.30
CR6006/50 Amp/.001 HY/.001 Ohm ... 45.45

New Hi-Capacity Filter Condensers

CE156M 6000MFD 15V ... $2@; 2/$3; 10/$12
CE502M 2000MFD 50V ... $4 ea, 10 for $30
CE2005M 500mfd @ 200V ... $6@
CE20025M 2500mfd @ 200V ... $12@
Brackets for Capacitors @ 25c each

New Variable Voltage X-frms

SUPERIOR-GR-STACO
0-132v-1.25A ... $7.23
0-135V/3A ... 10.63
Cased 0-135V/7.5A ... 19.55
Uncased/0-135V/7.5A ... 15.30
Cased/0-270V/3A ... 22.10
Uncased/0-270V/3A ... 17.00
Cased/0-135V/15A ... 39.10
Cased/0-270/9A ... 39.10
Uncased 0-135V @ 30A ... 44.10
Uncased 0-270V @ 12A ... 44.10
Uncased 0-135V @ 60A ... 113.00
Uncased 0-270V @ 30A ... 113.00
Uncased 0-270V @ 60A ... 189.00
300BU3-3 ϕ @ 230/out 0-230/1.2KVA/3A ... $50
500BU3-3 ϕ @ 230/out 0-270/3.5KVA/7.5A ... 57
1500B3-3 ϕ @ 230/out 0-270/7KVA/15A ... 132
3000B3-3 ϕ @ 230/out 0-270/14KVA/30A ... 164
Delivery From Stock! Mfgr's We Stock For/U Qtys SIX 10% add Discount

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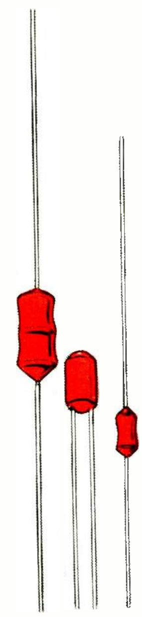

The INCREDIBLE SHRINKING RESISTOR...

Daven has always been the leader in the miniaturization of precision wire wound resistors. Now, due to further advances in resistor manufacture, Daven is able to offer higher resistance values in smaller sizes than ever before. Typical miniature units, with their new maximum values, are tabulated here.

For guided missiles, airborne radar, telemetering, and for any application where extremely small size and dependability are of prime importance, specify Daven miniature wire wounds.

TYPE	DIAM	LENGTH	MAX WATTS	MAX OHMS
1250	1/4	1/2	.33	1 Megohm
1274	3/16	3/8	.25	250 K
1284	1/4	27/64	.25	1 Megohm

THE **DAVEN** CO. LIVINGSTON, NEW JERSEY

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