July 1, 1960

electronics

Electrical explosion of fine metallic wire may be useful for spaceship propulsion and optical radar. Circuits for both detonation and instrumentation are described on p 43

A McGraw-Hill Publication 75 Cents

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Creative Microwave Technology

Published by MICROWAVE AND POWER TUBE DIVISION, RAYTHEON COMPANY, WALTHAM 54, MASS., Vol. 2, No. 1

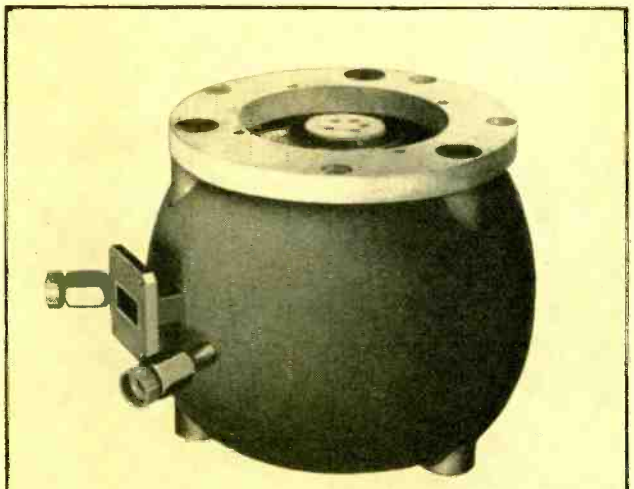
RAYTHEON "M"-TYPE BACKWARD WAVE OSCILLATORS

Electronically tunable at high power levels
for a wide range of microwave applications

Where extensive frequency mobility is required, the efficient crossed-field, "M"-type backward wave oscillator is highly versatile. Introduced more than eight years ago, it has been perfected by Raytheon and is now being economically mass produced. Hobbing of the slow-wave structure, a Raytheon-developed technique, assures precision construction necessary for consistently reproducible performance from tube to tube.

Typical of the "M"-type BWO's available from Raytheon is the QK-634A, an X-band tube which features all ceramic-and-metal construction for reliable operation under extreme environmental conditions.

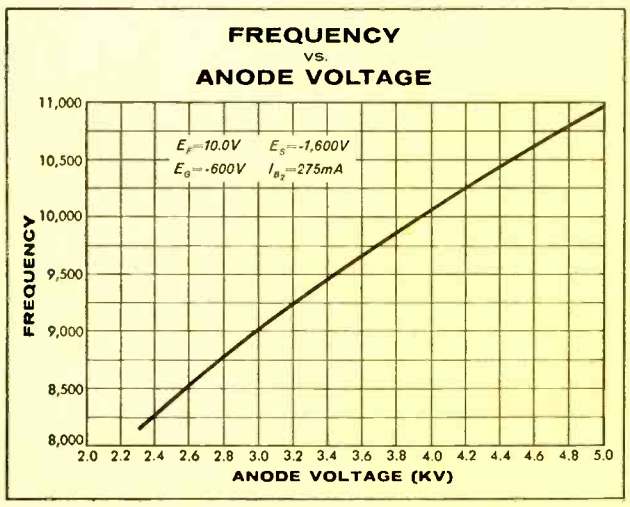
The QK-634A has a nominal power output of 200 to 250 watts and is electronically tunable over its entire frequency range. Precise determination of the radiated spectrum is accomplished by adjusting the voltage applied to either the anode or the sole. Amplitude modulation is also accomplished electronically. Small and compact, the QK-634A can be mounted in any position.

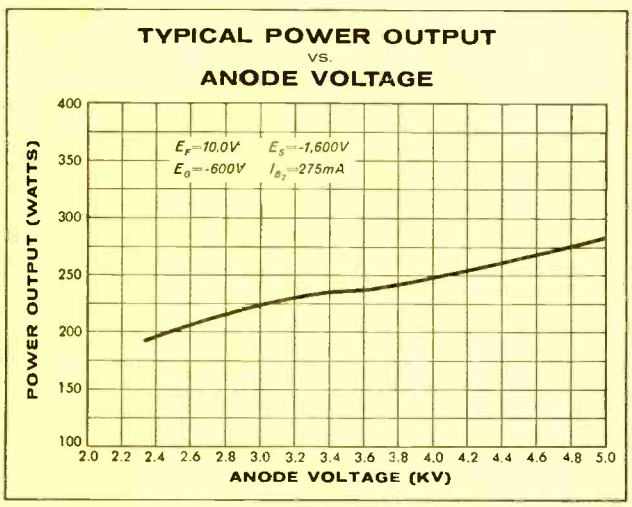


QK-634A Backward Wave Oscillator

Typical Operating Characteristics--QK-634A

Frequency Range	8,150 to 11,000 Mc
Power Output	150 watts (min.)
	200 to 250 watts (nom.)
Output Flange	Mates with UG40A/U modified for clearance holes
Tuning Sensitivity	1.0 Mc/V





Other unclassified BWO's in this series include the QK-625 and QK-659, which cover the 2,500-4,450 Mc band.

Excellence in Electronics

RAYTHEON

You can obtain detailed application information and special development services by contacting: Microwave and Power Tube Division, Raytheon Company, Waltham 54, Massachusetts

A LEADER IN CREATIVE MICROWAVE TECHNOLOGY

July 1, 1960

electronics

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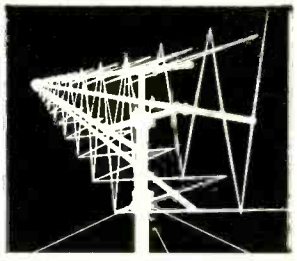
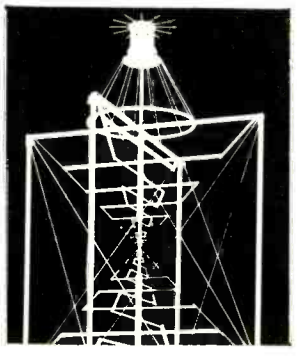
BUSINESS

ENGINEERING

DEPARTMENTS

BROAD-BAND LOG-PERIODIC ANTENNAS FROM GRANGER ASSOCIATES





Specifications for typical Granger Associates log-periodic antennas (Models 720 and 721 shown)

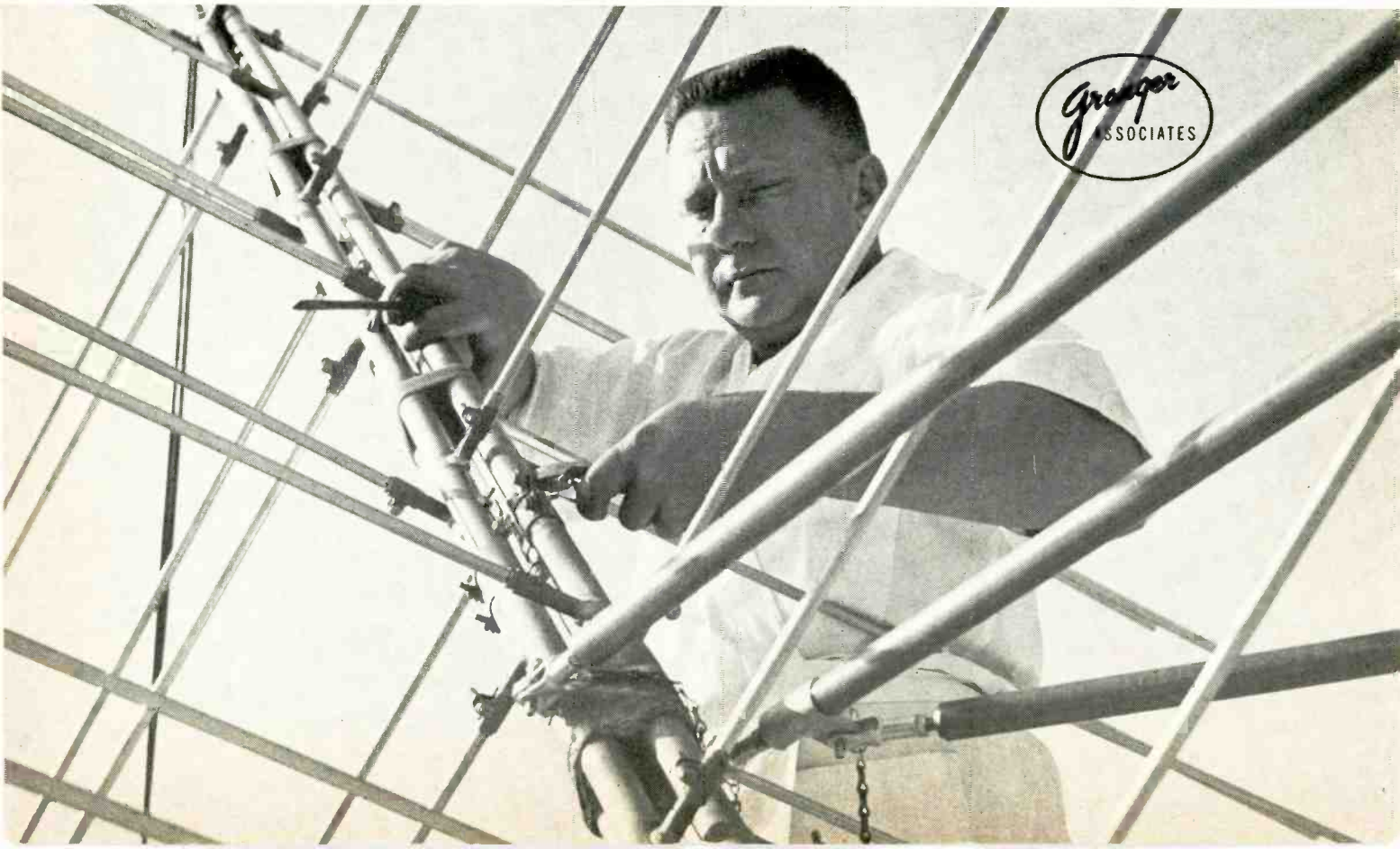
	Model 720 (uni-directional)	Model 721 (omni-azimuthal)
Frequency range	50 to 1000 megacycles	
Polarization	Linear, remotely selected vert. or horiz.	
Pattern Beamwidth		
Horizontal Polarization	Azimuth 60 deg. Elevation 60 deg.	Azimuth 360 deg. Elevation 55 deg.
Vertical Polarization	Azimuth 60 deg. Elevation 60 deg.	Typical discone patterns
VSWR	3.6:1 relative to 50 ohms over the band	
Environment	withstands 100 mph wind; ½" ice coating	
Dimensions	75" high & wide 76" long; mounted on 36" guyed mast	176" high; 92" wide & deep

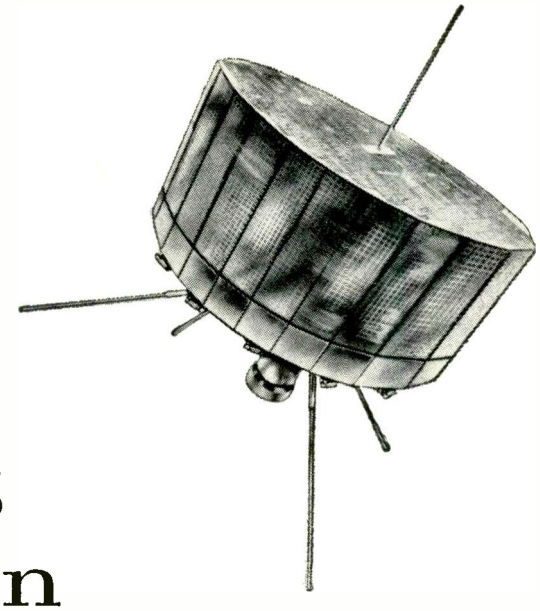
Note: Model 720 is provided with 360 deg. azimuth drive at 2 rpm with left-stop-right controls and remote position indicator.

Bandwidth of ten to one or greater independent of frequency—that's why system planners in communications, back scatter, range instrumentation, signal intercept and ECM are excited about log-periodic antennas. Translating this new theory into practical hardware is a specialty of Granger Associates; one of the few organizations that not only understands the concept, but actually builds log-periodics and delivers them to highly satisfied customers. Our accomplishments in this category include omnidirectional designs, high gain pencil beam designs, designs that permit remote selection of polarizations, feeds for reflectors, direction finders, scanning and switched beam arrays. System planners will also find G/A an excellent source for low noise preamplifiers, receiving multicouplers, wide-band baluns, special purpose transmitters. They will find more: an adroit team of specialists with a unique approach to problem solving that results in dependable equipment—the right kind at the right time.

Granger Associates / 974 Commercial Street / Palo Alto, California / DAvenport 1-4175

Circle 2 on reader service card





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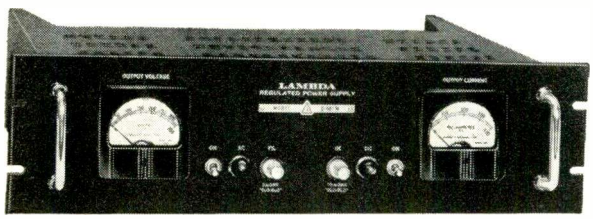
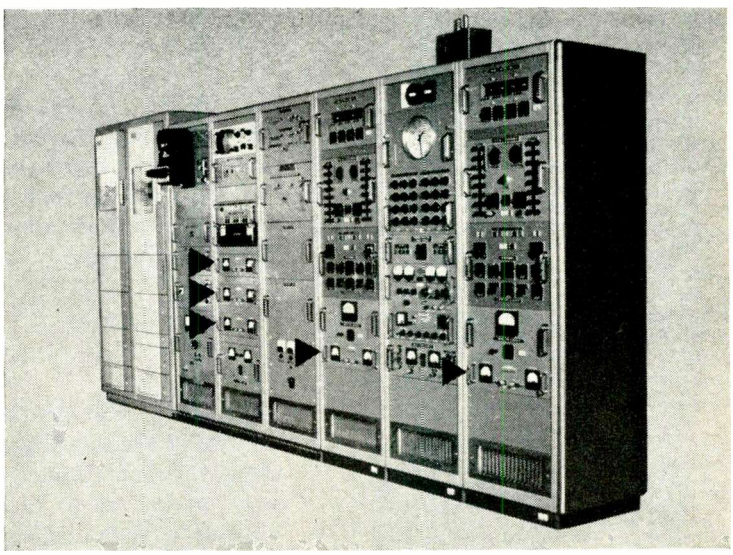
This same Lambda quality is the reason Lambda Power Supplies are consistently selected *first* by engineers in independent surveys. To find out more about Lambda Supplies, which are guaranteed for a full five years, send today for the Lambda Catalog. It gives data on Lambda's complete line of tube models ranging up to 525 VDC and transistor models up to 10 Amps.





The Tiros System
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CROSSTALK

SEMIANNUAL INDEX. With this issue we initiate a semiannual index as a new service to our readers. The switch from an annual to a semiannual index has been made feasible through use of a comparatively new offset printing technique.

Process involves Varityping each line of information onto a separate IBM card. The resulting cards (some 9,000 in all) are fed at the rate of 120 a minute through a camera with a micrometer adjustment that automatically sets the vertical spacing between lines. Resulting strip negatives are cut and made up into pages, as you may see starting on p 75.

SATURN PROJECT. When the first 180-ft-tall Saturn space vehicle is fired from Cape Canaveral next summer, the tremendous 1.5-million-lb thrust booster stage will have undergone thousands of simulated firings set up on computers at the Redstone Arsenal in Huntsville, Ala. In addition to simulated firings, the eight-engine Saturn booster stage will have undergone 11 static test firings. Eventual goal of the Saturn Project, in 1964, will be flights around the moon and into deep space with payloads up to 25,000 lb.

A few days ago, newsmen witnessed a successful full-duration static firing of all eight booster engines. Covering the Saturn story for ELECTRONICS and witnessing the dedication of a new all-solid-state computer, the IBM 7090, was Assistant Editor Lindgren. His story on p 28 takes you to the static firing and gives you a close look at the 7090, whose capabilities of nearly 14 million logical decisions per minute are speeding up the project's development.

MARKETS. When the American Marketing Association recently held its 43d national conference in Minneapolis, about 100 representatives of the electronics and missile industries were among those in attendance. Naturally, space equipment sales were a prime discussion topic. It's predicted they will reach $6 billion in 1975. For predictions on other matters—and what marketing men in our industry are talking about today—see the story on p 32.

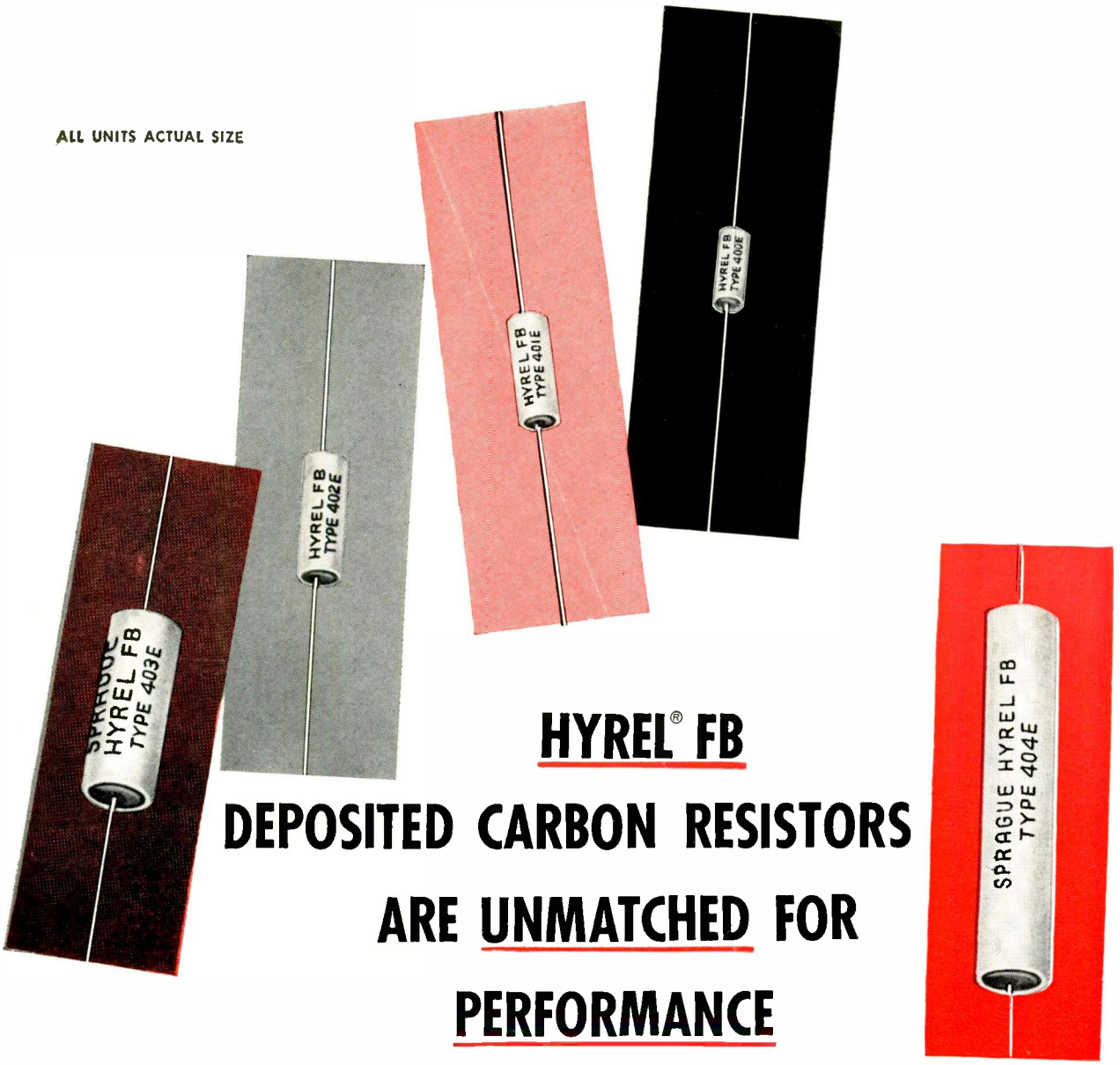
FOR MEN. If you speak the language of electronics engineers, think you would find it challenging to discuss technical articles with potential authors and also cover the industry's news, like to write occasionally yourself and are not above doing some indoor editing too . . . there may be an opportunity for you on our staff. In New York. Or Chicago. Write the Editor.

Coming In Our July 8 Issue

SPACE PROBE. As the Pioneer V space probe hurtles through the vast reaches of the solar system, contact with our planet is maintained through use of the global Able Space Navigation Network. Designed to control deep space probes up to 70 million miles, the network consists of stations at Singapore, Hawaii, Cape Canaveral and Jodrell Bank, and a central control facility at Los Angeles.

Next week, R. C. Hansen and E. R. Spangler of Space Technology Labs describe how this network provides communication and navigation for space probes. Their informative article outlines the general requirements for space communications and the factors involved in selecting various ground stations. Also, you'll read about the equipment used at the different stations.

ALL UNITS ACTUAL SIZE



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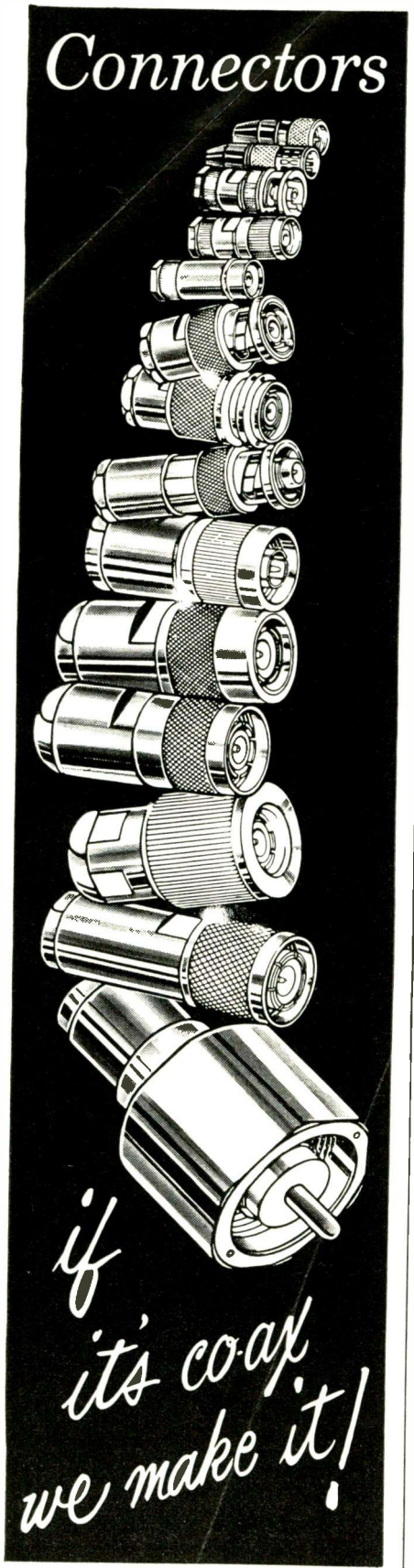

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COMMENT

Electronics in Japan

(Ref. "Electronics in Japan," p 53, May 27) . . . it is amazing how the author collected such a wealth of fundamental information in such a relatively short time. Needless to state that his impressions are very useful to us, foreign workers in this country, as they corroborate on many points our own ideas.

F. COETERIER
MATSUSHITA ELECTRONICS CORP.
OSAKA, JAPAN

Congratulations on the excellent article "Electronics in Japan." It is an outstanding piece of work. How did the author accomplish so much?. . .

JAMES F. SEARS
GENERAL ELECTRIC
SANTA BARBARA, CALIF.

Metric System

American engineers and physicists who think in terms of inch, foot, pound, gallon, mile, grain, bushel, rod and yard require conversion tables or conversion factors when they wish to express a unit in the metric system.

Modern physics makes use of the metric system all over the world (even in England and in the United States), a system which was legalized by an Act of Congress in 1886 but which has not taken root in American technical practice. The American Geophysical Union issued a circular letter on this subject, and published a "Progress Report of the Committee for the Study of the Metric System in the United States" on Nov. 1, 1959 (*Transactions, American Geophysical Union*, 40, 3) in which it was stated that 94 percent of 1,080 interviewed scientists declared themselves in favor of the urgent introduction of the metric system in the U.S. The opposition of a 6-percent minority is attributable to two causes: ignorance of the metric system; and indolence or aversion to establishing a way of thinking in terms of the metric system. . .

GEZA L. VAJDA
HALEX INC.
EL SEGUNDO, CALIF.

Reader Vajda sent along a metric conversion table showing the relationships among metric units of length (1 meter = 1,000 mm = 1,000,000 micron = 10^{10} Angstrom units). We subscribe strongly to the idea that the scientific community should use a common set of measures; but we can only record accepted practice and encourage improvements in practice. American Standards Association, National Bureau of Standards, and the Institute of Radio Engineers—these are the organizations that will have to sweep away the archaic usages.

L-F Antenna Design

In reading our paper "Antenna Design for Maximum L-F Radiation" (p 84, June 3), we note the following errors and omissions in text:

On p 84, column 2, par 2, "illustrated in Fig. 1B" should read "illustrated in Fig 1A." The equation at the bottom of column 2 on that page should read

$$Q = \frac{f_o}{2R_{loop}} \left| \frac{dX}{df} \right|_{f_o} = \frac{f_o}{R_{loop}} \left| \frac{dX_a}{df} \right|_f$$

In column 3, par 1, "net reactance $X = Q$" should read "net reactance $X = 0$."

On p 85, column 2, the equation at the end of the paragraph following equation (7) should read $dX'_a/df = a\beta K_A/hf^{a+1}$.

The value of Table I was greatly reduced when, during editing, deletion of bandwidth and center frequency was made. The efficiency values are typical for the scale model driven at 1.5 Mc with the bandwidth set at 100 Kc; and for the 150-ft antenna driven at 150 Kc with the bandwidth adjusted to 10 Kc. Under these conditions, the efficiency values are 0.15 percent, 0.53 percent, and so forth up to 0.92 percent.

We would like to thank you for the splendid presentation of the material. . .

GEORGE J. MONSER
AMERICAN ELECTRONIC LABORATORIES
LANSDALE, PENNA.

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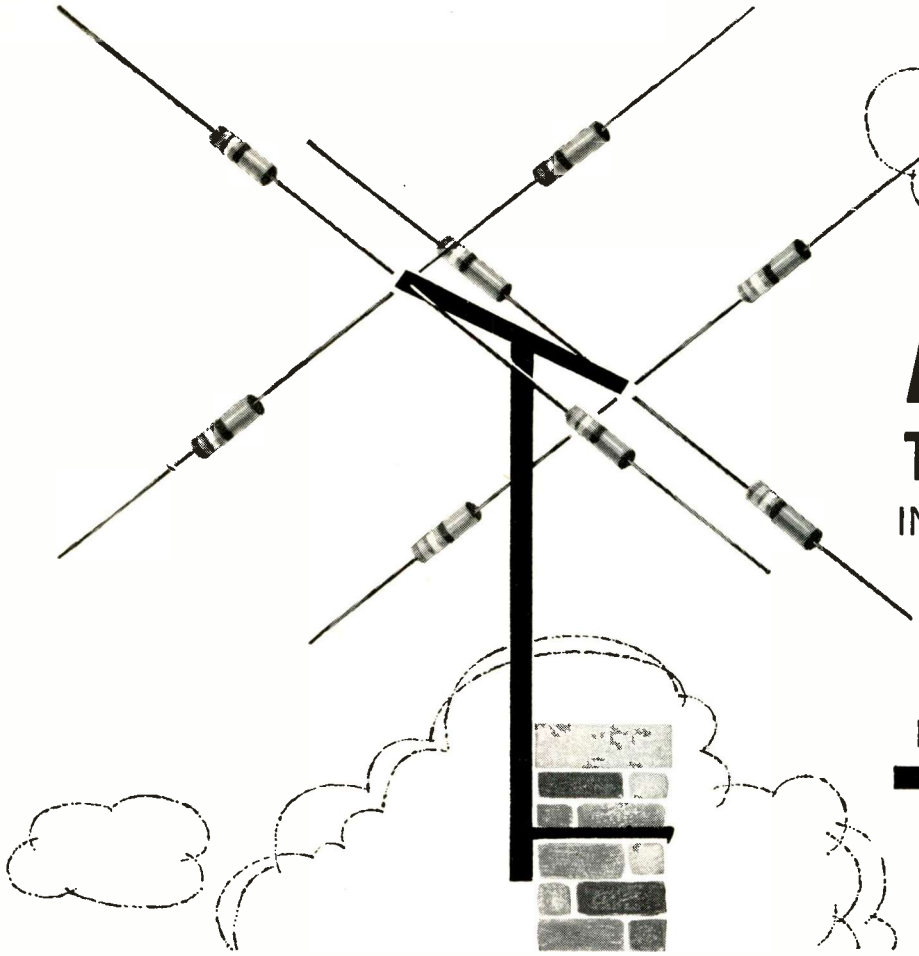

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NEW TYPES EXTEND MINI-STAB INDUCTANCE RANGE TO 10,000 MICROHENRIES!

Now, from Jeffers Electronics, pioneers in MINIature, STABle inductors, come the most recent additions to the line—MINI-STAB Inductors Types 2 and 3. Supplementing the Jeffers Type 101 and MINI-STAB Type 1 line, the two new miniatures increase the inductance values available from Jeffers to a range of 0.15 to 10,000 uh.

Miniaturization PLUS Stability

In Jeffers MINI-STAB inductors, *miniaturization* is achieved through more efficient use of coil winding space. *Stability* is made possible through the use of an open magnetic circuit as obtained with a conventional powdered iron coil form.

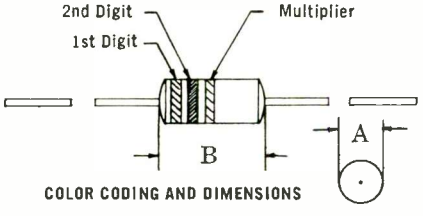
TYPICAL CHARACTERISTICS OF INDUCTOR DESIGNS BASED ON 1000 UH VALUE

INDUCTOR CHARACTERISTICS	JEFFERS MINI-STAB DESIGN	CONVENTIONAL DESIGNS	
		MINIATURIZED*	NON-MINIATURIZED
Miniaturization (wt. in grams)	1.0	0.5 to 2	2 to 10
Stability of Inductance with temp. −55 to +125°C	±2%	±10%	±2%
with applied current (zero to 90 MA)	−1%	−30%	NIL
with applied voltage (test or signal)	GOOD	POOR	GOOD

*Utilizing closed magnetic circuits such as toroids, cup-cores, etc.

A comparison of typical MINI-STAB performance with that of conventional miniaturized and non-miniaturized inductors appears above. Inductor designs of the closed magnetic circuit type such as toroids, cup cores, etc. tend to be inherently unstable.

THIS IS THE EXPANDED MINI-STAB LINE



COLOR CODING AND DIMENSIONS

TYPE	A±.015	B±.015	LEADS
1	.190	.440	AWG. #22 1 5/16 Min. Length
2	.220	.600	AWG. #21 1 5/16 Min. Length
3	.240	.740	AWG. #20 1 5/16 Min. Length

MINI-STAB TYPE 1

PART NUMBER	TYPE	INDUCTANCE (Microhenries)	MEAS. FREQ. (MC)	Q MIN.	SRF MIN. (MC)	D.C. RES. MAX. at 25°C (OHMS)	CURRENT* RATING (MA)	COLOR-CODING 1st	2nd	3rd
1311-1	1	18 ± 10%	2.5	50	25	1.8	315	BRN	GRY	BLK
1311-2	1	22 ± 10%	2.5	50	24	2.0	300	RED	RED	BLK
1311-3	1	27 ± 10%	2.5	50	20	2.8	255	RED	VLT	BLK
1321-1	1	33 ± 10%	2.5	50	19	2.5	270	ORG	ORG	BLK
1321-2	1	39 ± 10%	2.5	50	18	3.0	245	ORG	WHT	BLK
1321-3	1	47 ± 10%	2.5	50	17	3.5	225	YEL	VLT	BLK
1321-4	1	56 ± 10%	2.5	50	15	4.2	205	GRN	BLU	BLK
1321-5	1	68 ± 10%	2.5	50	14	5.0	190	BLU	GRY	BLK
1321-6	1	82 ± 10%	2.5	50	12	5.5	180	GRY	RED	BLK
1321-7	1	100 ± 10%	2.5	50	11	6.0	170	BRN	BLK	BRN
1321-8	1	120 ± 10%	0.79	50	9.0	7.0	160	BRN	RED	BRN
1321-9	1	150 ± 10%	0.79	50	8.6	8.0	150	BRN	GRN	BRN
1321-10	1	180 ± 10%	0.79	50	8.0	9.0	140	BRN	GRY	BRN
1321-11	1	220 ± 10%	0.79	50	6.6	10.0	130	RED	RED	BRN
1331-1	1	270 ± 10%	0.79	45	4.0	6.8	165	RED	VLT	BRN
1331-2	1	330 ± 10%	0.79	45	3.6	7.4	155	ORG	ORG	BRN
1331-3	1	390 ± 10%	0.79	45	3.4	10.6	130	ORG	WHT	BRN
1331-4	1	470 ± 10%	0.79	45	3.1	11.5	125	YEL	VLT	BRN
1331-5	1	560 ± 10%	0.79	55	2.9	15.2	110	GRN	BLU	BRN
1331-6	1	680 ± 10%	0.79	50	2.6	17.0	105	BLU	GRY	BRN
1331-7	1	820 ± 10%	0.79	50	2.4	19.0	100	GRY	RED	BRN
1331-8	1	1000 ± 10%	0.79	45	2.2	21.3	90	BRN	BLK	RED
NEWEST MINI-STAB TYPES 2 AND 3										
1312-1	2	1200 ± 10%	.25	60	2.2	21.0	110	BRN	RED	RED
1312-2	2	1500 ± 10%	.25	60	2.1	24.0	105	BRN	GRN	RED
1312-3	2	1800 ± 10%	.25	65	1.9	27.0	100	BRN	GRY	RED
1312-4	2	2200 ± 10%	.25	70	1.7	30.0	95	RED	RED	RED
1312-5	2	2700 ± 10%	.25	70	1.6	33.0	90	RED	VLT	RED
1312-6	2	3300 ± 10%	.25	70	1.4	37.0	85	ORG	ORG	RED
1313-1	3	3900 ± 10%	.25	75	1.5	44.0	90	ORG	WHT	RED
1313-2	3	4700 ± 10%	.25	80	1.4	49.0	85	YEL	VLT	RED
1313-3	3	5600 ± 10%	.25	80	1.2	54.0	80	GRN	BLU	RED
1313-4	3	6800 ± 10%	.25	80	1.1	60.0	75	BLU	GRY	RED
1313-5	3	8200 ± 10%	.25	80	1.0	67.0	70	GRY	RED	RED
1313-6	3	10000 ± 10%	.25	80	0.9	75.0	70	BRN	BLK	ORG

*Based on a 25° C Maximum Temperature Rise.

MINI-STAB inductors are capable of meeting the requirements of MIL-C-15305, Grade 1, Class B, as outlined in Jeffers Product Specification SK-393. Details are available on request.

JEFFERS ELECTRONICS DIVISION
SPEER CARBON COMPANY
DU BOIS, PENNSYLVANIA
Other Electronics Divisions of Speer Carbon Company—
Onondaga Electronics, Syracuse, N.Y. · Speer Resistor, Bradford, Pa.

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For more than a quarter-century, Hallicrafters has worked in close partnership with our armed forces on fast solutions to critical military electronics problems. Example: new airborne Electronic Countermeasures equipments of very advanced design, now being produced to protect our military aircraft. This kind of teamwork continues to pay off for America—in more effective, more reliable, more economical electronic warfare systems.

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U R G E N T P R O B L E M S R E L I A B L Y S O L V E D

CIRCLE 10 ON READER SERVICE CARD

ELECTRONICS NEWSLETTER

Pickaback Satellite Measures Sun's Radiation

SECOND TRANSIT experimental vehicle, which went into orbit last Wednesday, brings the Navy a step nearer an operational satellite navigation system. Last week's unique shot put two payloads into orbit on one rocket launcher. Attached pickaback to the 223-lb Transit II was a 42-lb solar radiation measurement satellite which was kicked off ahead of the larger satellite at an altitude of about 500 miles.

Navigation satellite payload was developed by Johns Hopkins University's Applied Physics Lab and built mostly by APL and the Naval Ordnance installations at China Lake, Calif., and Dahlgren, Va. The radiation-measurement satellite was developed at the Naval Research Laboratory.

Transit's payload included two ultra-stable oscillators in insulating flasks, each capable of transmitting continuously on two frequencies over a silver-painted spiral-band antenna system. An infrared scanner measures the satellite's rotation; a digital electronic clock serves as a timing standard, and a special receiver designed by Canada's Defense Research Telecommunications Establishment measures cosmic noise above the ionosphere.

Two command systems can change the satellite's position in accord with signals received from the ground. The satellite's telemetry system sends temperature and other data back to earth. Both solar cells and storage batteries power the electronic gear.

The NRL radiation-measuring satellite telemetry system includes a 108-Mc transmitter.

Compactrons Combine Tube Functions

NEW DEPARTURE in tube design sees three and four valving functions included in one envelope in General Electric's Compactron, with consequent space saving.

GE this week demonstrated a radio set equivalent to a 5-tube superhet, made with two Compactrons. One contains a power diode (equivalent to a 35W4 rectifier), a power amplifier (50C5) and a diode-triode (12AV6); the other houses a pentagrid converter (12BE6) and a pentode (12BA6). The receiver measures 2½ in. by 2½ in. by 10½ in. wide, the width being dictated by the loud-speaker size.

The company estimates that a tv receiver can be made with 10 Compactrons (compared with 15 tubes and 3 diodes, or 24 transistors and 11 diodes), and a 6-tube hi-fi amplifier could be made with 4 Compactrons.

The new valving devices are bigger than miniature tubes; they measure 1½ in. in diameter, vary in seated height from 1 in. to 2¾ in. Heaters for the individual valves are connected in series within the Compactron, so that only two heater pins are needed. Internal connections are made as in conventional tubes. The Compactron has a duodenary (12-pin) base, with a blank pin on either side of the plate connection for increased high-voltage arc rating.

Vapor-Growth Speeds Transistor Manufacture

ATOMIC BRICKLAYING technique called vapor-growth by developer International Business Machines may make semiconductor fabrication more of a production-line process. The vapor-growth process can be used to produce semiconductor components to serve multiple functions.

The vapor-growth technique uses high-temperature iodide vapor which picks up semiconductor material from a block placed in a channel through which the vapor passes. The vapor, with semiconductor material held in gaseous suspension, moves down the channel to a cooler zone where the metals deposit out on substrate pellets.

A complex multifunction device can be built up layer by layer in repeated runs through the vapor channels. Impurity introduced by the iodide vapor is negligible, about 1 part in 100 million. IBM says that diodes—including variable-capacitance and tunnel types—and transistors have been vapor-grown successfully.

Both homogeneous and heterogeneous semiconductor crystals can be formed. Germanium of either polarity can be deposited on germanium and silicon of either polarity can be deposited on silicon. Germanium can be deposited on gallium arsenide or gallium phosphide and gallium arsenide can be deposited on germanium. Silicon can be deposited on gallium arsenide and gallium phosphide.

Germanium-gallium arsenide junctions have resulted in tunnel diodes having wider voltage swing than germanium units and lower series resistance than gallium arsenide units.

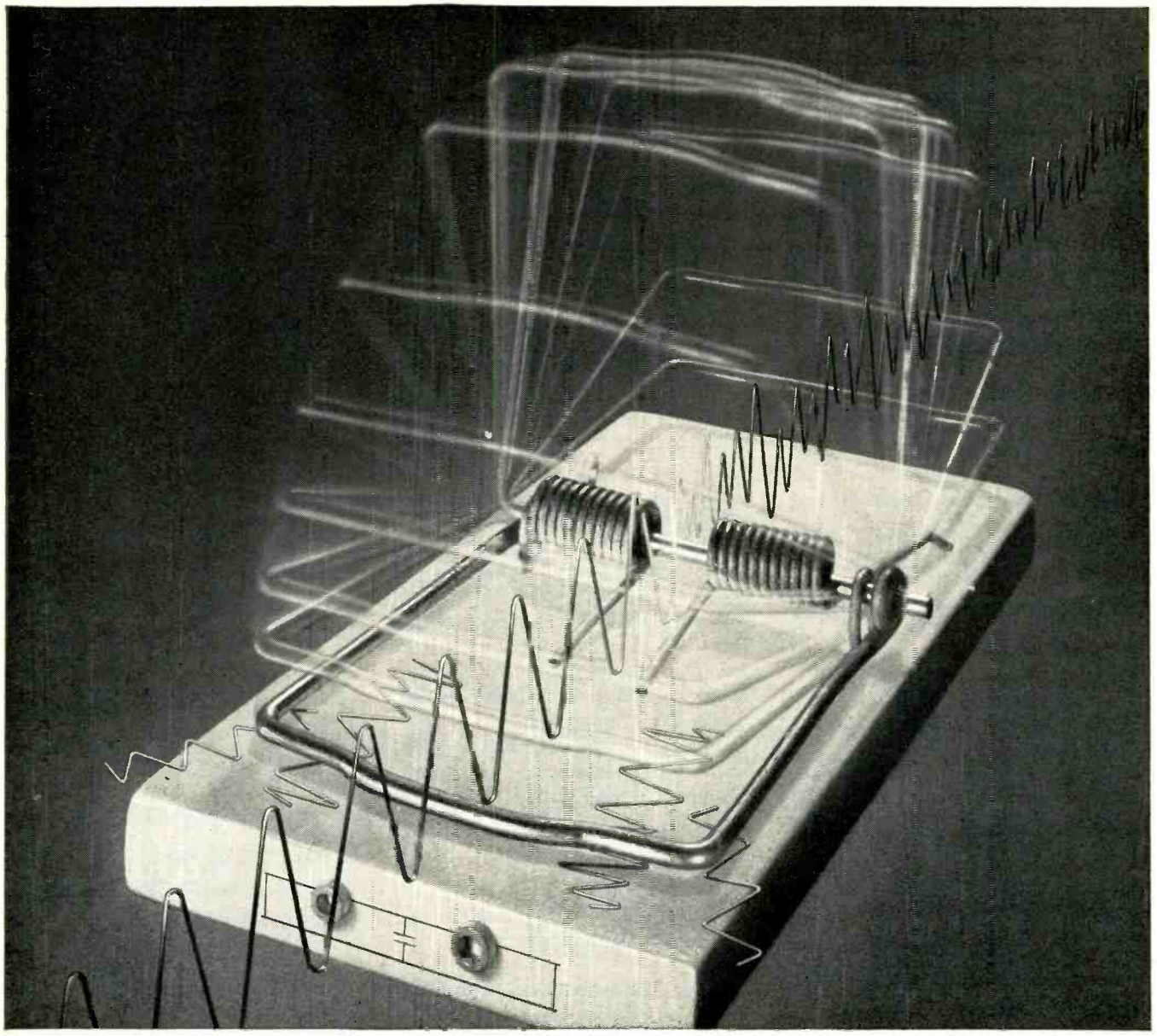
A full adder has been constructed as an *npnp* sandwich having a common three-terminal emitter and two separate collectors each on its own *p-n* mesa.

Steel-Strip Cores Ease Transformer Design

NEW FABRICATION TECHNIQUE for transformer cores, developed by Sylvania, was disclosed last week in New York. Transformers produced with the novel cores, dubbed Flexicores by the General Telephone & Electronics subsidiary, range from 2 to 30 percent lighter than conventional E-I or C transformers, can be produced in a wider variety of configurations, firm says.

Flexicores are produced from grain-oriented strip steel cut from continuous rolls. The strips are bent into staggered U-shapes and formed into nests of laminations. Each core is made up of two nests with the staggered edges interleaved for minimum resistance in the magnetic circuit; the final shape is a hollow square or rectangle.

Use of nested cores permits the magnetic lines of force to flow with the grain of the steel continuously, instead of across the grain as in parts of an E-I core. This in effect cuts the size of the core for a given value of flux. Also the fringe flux at the junctions of the core halves is less than in E-I cores, since the flux path is not changing direction at that point; hum is therefore reduced.



How to build a better (audio signal) trap!

Magnetics Inc. permalloy powder cores give filter designers new attenuation and stability standards—and miniaturization to boot!

The art of trapping unwanted frequencies has been advanced during the past year with a succession of improvements in molybdenum permalloy powder cores by Magnetics Inc. Most audio filter designers now work with smaller cores, more stable cores and cores whose attenuation characteristics are ultra-sharp. Do you?

Do you, for example, specify our 160-mu cores when space is a problem? With this higher inductance, you need at least 10 percent fewer turns for a given inductance than with the 125-mu core. What's more, you can use heavier wire, and thus cut down d-c resistance.

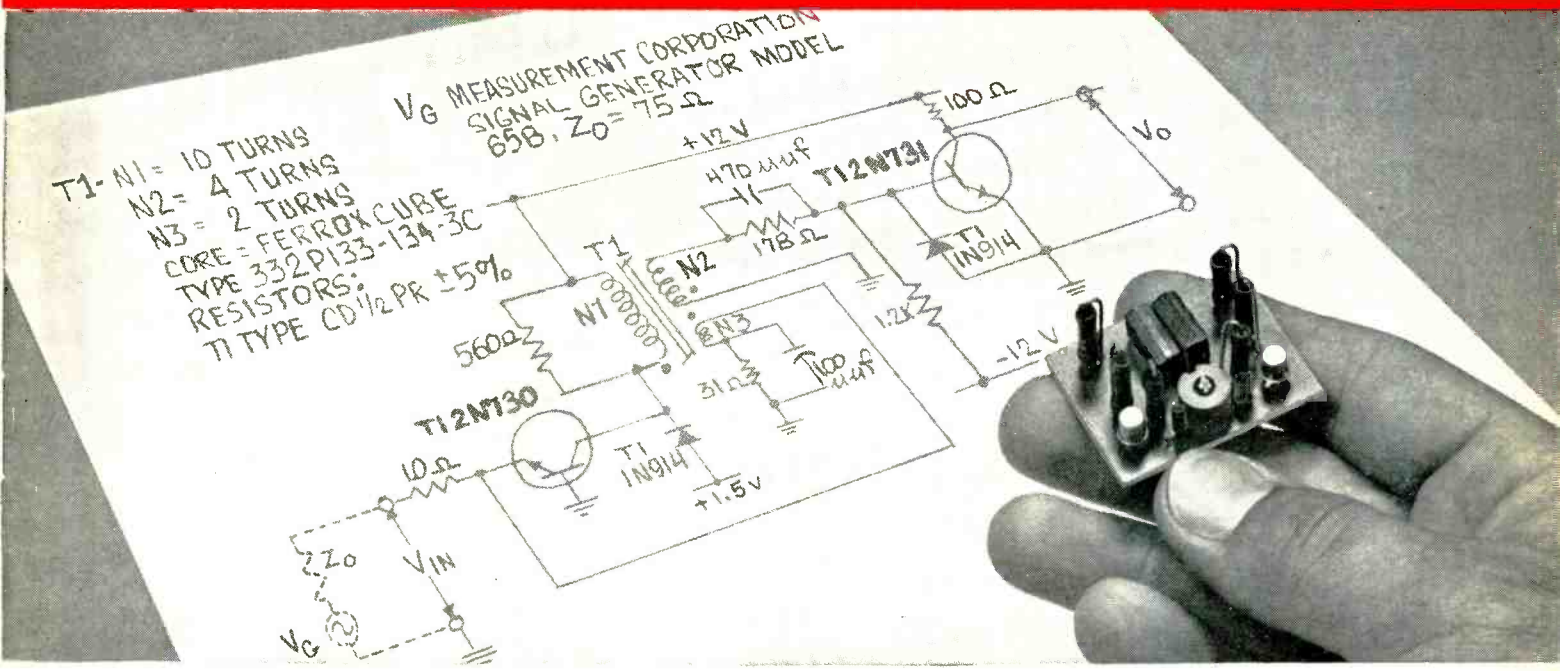
What about temperature stability? Our linear cores are used with polystyrene capacitors, cutting costs in half compared to temperature stabilized moly-permalloy cores with silvered mica capacitors. Yet frequency stability over a wide swing in ambient temperatures is increased!

And what do you specify when you must rigidly define channel cut-offs, with sharp, permanent attenuation at channel crossovers? Our moly-permalloy cores have virtually no resistive component, so there is almost no core loss. The resultant high Q means sharp attenuation of blocked frequencies in high and low band pass ranges.

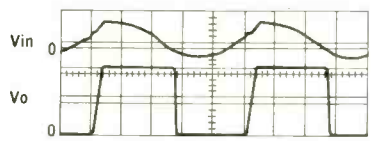
Why not write for complete information? Like all of our components, molybdenum permalloy powder cores are *performance-guaranteed* to standards unsurpassed in the industry. *Magnetics Inc., Dept. E-82, Butler, Pa.*

MAGNETICS inc. ®

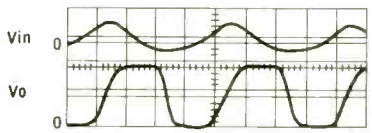
HOW TO GENERATE 100-ma PULSES AT 10 mc



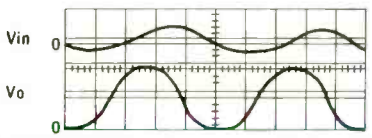
. . . WITH TI 2N730 and 2N731 SILICON MESA TRANSISTORS



1 Megacycle
VERT.—5v /cm
HORIZ.—.2 μsec /cm
T_A—25°C



5 Megacycles
VERT.—5v /cm
HORIZ.—50 mμsec /cm
T_A—25°C



10 Megacycles
VERT.—5v /cm
HORIZ.—20 mμsec /cm
T_A—25°C

See how these performance-proved characteristics apply to your high-current, high-speed switching circuits . . .

High-current loads — Switch *100 ma* at 10-mc rates using TI 2N730 and 2N731 transistors (see applications circuit) • *Fast switching* — Note *20 millimicrosecond* rise and fall times on the waveforms illustrated • *Size and weight* — Save *both* size and weight with the subminiature TO-18 packaging of the TI 2N730 and 2N731 'mesas' • *Dissipation* — Get a full *500 mw* (T_A=25°C) or *1.5w* (T_C=25°C) with beta spreads of 20-60 (2N730) and 40-120 (2N731) • *Reliability* — TI Quality Assurance *guarantees* you performance to specifications • *Applications* — Use the TI 2N730 and 2N731 guaranteed performance in your digital computer clock pulse generators and similar high-load, high-speed, high-reliability circuits. Check these specifications:

electrical characteristics at 25°C ambient (unless otherwise noted)

	PARAMETER	TEST CONDITIONS		2N730 min	2N730 max	2N731 min	2N731 max	unit
I_{CBO}	Collector Reverse Current	V_{CB}=30v	I_E=0	–	1.0	–	1.0	μa
I_{CBO}	Collector Reverse Current at 150°C	V_{CB}=30v	I_E=0	–	100	–	100	μa
BV_{CBO}	Collector-Base Breakdown Voltage	I_C=100μa	I_E=0	60	–	60	–	v
BV_{CER}	Collector-Emitter Breakdown Voltage	I_{CER}=100ma, R_{BE}=10 ohms		40	–	40	–	v
BV_{EBO}	Emitter-Base Breakdown Voltage	I_E=100 μa	I_C=0	5	–	5	–	v
h_{FE}	DC Forward Current Transfer Ratio	I_C=150ma	V_{CE}=10v	20	60	40	120	
$V_{BE(sat)}$	Base-Emitter Voltage	I_C=150ma	I_B=15ma	–	1.3	–	1.3	v
$V_{CE(sat)}$	Collector-Emitter Saturation Voltage	I_C=150ma	I_B=15ma	–	1.5	–	1.5	v
h_{fe}	AC Common Emitter Forward Current Transfer Ratio	I_C=50ma, f=20mc	V_{CE}=10v	2.0	–	2.5		
C_{ob}	Common-Base Output Capacitance	I_E=0	V_{CB}=10v	–		–		
		f=1mc		–	35	–	35	μμf

*Pulse conditions: Length = 300μs, duty cycle < 2%

Collector-Base Voltage	60v
Collector-Emitter Voltage	40v
Emitter-Base Voltage	5v
Total Device Dissipation	0.5w
Total Device Dissipation at Case Temperature 25°C	1.5w
Storage Temperature Range	−65°C to +175°C

CALL YOUR TI SALES OFFICE OR LOCAL AUTHORIZED TI DISTRIBUTOR FOR PRICE, DELIVERY AND COMPLETE TECHNICAL DATA.

the FIRST silicon transistor manufacturer

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INCORPORATED
SEMICONDUCTOR-COMPONENTS DIVISION
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CIRCLE 13 ON READER SERVICE CARD

WEINSCHEL

FIXED COAXIAL ATTENUATORS

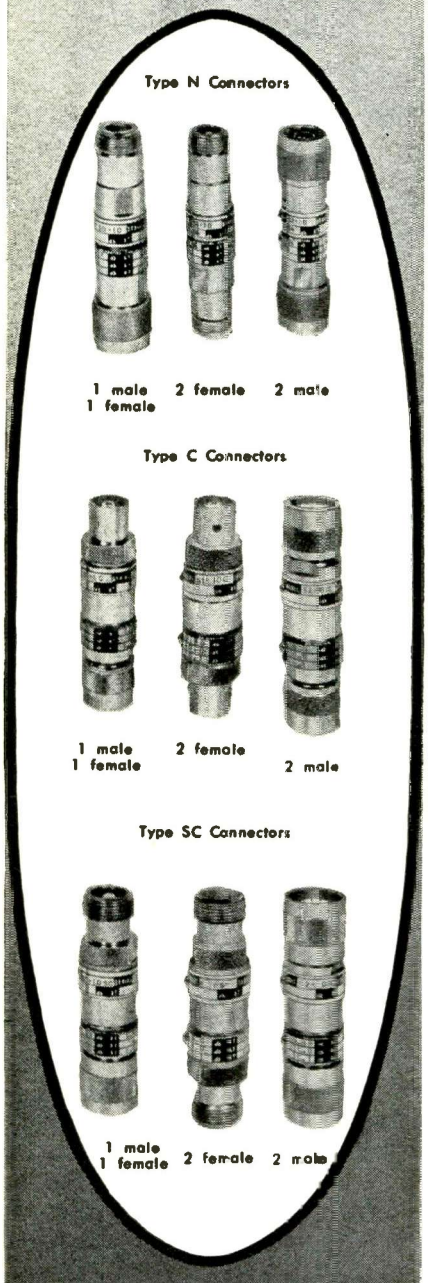
Models 50, 51, 52

DC to 1 KMC, Usable to 2 KMC

Attenuation: 1 to 50 db

High stability, low frequency sensitivity

Finish: Stainless Steel (Type N Connectors); Nickel Plated (Type C or SC Connectors)



Complete specifications upon request. Weinschel Fixed Coaxial Attenuators cover the frequency range of DC to 12.4 EMC. Write for complete catalog.

WE CO

Weinschel Engineering

KENSINGTON, MARYLAND

WASHINGTON OUTLOOK

GOVERNMENT RESEARCH AND DEVELOPMENT contracts worth $35 million are being awarded this year to foreign research institutions, universities and industrial firms. Almost half the work is supported by the armed services, the rest by at least 10 civilian agencies.

No breakdown is available by technical fields, but the Air Force, which farms out roughly 30 percent of the total amount going abroad this year for R&D work, cites electronics as one of two principal fields of interest for foreign attention (the other is geophysics).

Bulk of the work is of a basic research nature. In electronics, for instance, the University of Darmstadt is doing fundamental work on pulse-image tubes for the Air Force. A British neuropsychologist is studying for the Navy ways in which the human brain can be simulated mechanically or electronically.

Some hardware development is being done by Compagnie Generale de Telegraphie sans Fils of Paris. CSF is developing radar-jamming tubes for the Air Force and analog and digital storage tubes for the Navy.

SELF-CONTAINED and unjammable guidance systems to zero long-range missiles in on target are getting increased attention from Pentagon planners. Chance-Vought's aeronautics division, for example, is developing one such system for SLAM (supersonic low-altitude missile), a nuclear ramjet weapons system that Air Force is considering.

SLAM would operate differently from conventional ICBMs in that it would follow a ballistic trajectory out into near space and through reentry, but in terminal phase would return to controlled powered flight. At an altitude low enough to confuse radar trackers, it would turn on its ramjet and streak to its target. At intercontinental ranges, the missile could not be reliably controlled by ground command; hence the stress on self-contained terminal guidance.

Present-generation Titan ICBM may be modified to use terminal guidance to correct trajectory errors. Titan uses Bell Labs radio-command guidance on initial phase.

OVERSEAS TELEVISION STATIONS of all types have increased by almost 14 percent since the first of the year—from 1,088 to 1,237—U. S. Information Agency reports. New Free-World stations total 109, of which 98 are in Western Europe. Forty new ones went on the air in the Sino-Soviet bloc, USIA says.

The agency's report, covering the first five months of 1960, excludes the U. S. and its territories, U. S. Armed Forces stations, and Canada. Survey notes that tv receivers in use abroad now number 34,500,000, with the Free World accounting for 28,950,000, an increase of about 2,150,000. The Soviet bloc has 5,600,000 sets, up about 300,000.

PATENT RESTRICTIONS recently caused General Electric to turn down a National Aeronautics & Space Administration contract for space-vehicle guidance development, says NASA. The agency mentions GE to Congress as one of several companies that have refused agency contracts because of reluctance to get tied down by patent rules. NASA patent law requires the agency to acquire full ownership of all inventions produced under contract.

NASA is pushing for liberalization of the rule, says it has been "seriously hampered in efforts to secure research in crucial areas." The House has already passed a bill allowing NASA flexibility on the patent issue, but the outlook for Senate approval this session (see ELECTRONICS, p 14, June 17) is dim.

CONSTRUCTION WORK on the Defense Department's 1,000-ft radiotelescope near San Juan, P. R., is being delayed. Surveyors have run into subsoil difficulties on the site, a natural earth crater; they are making additional borings before permitting installation of equipment.

TAPCO ELECTRICAL POWER COMPONENTS

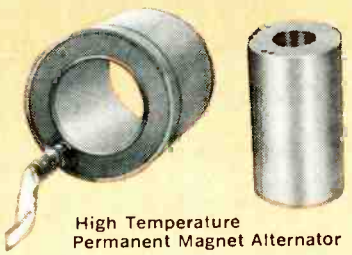
TAPCO Group primary and auxiliary electrical power systems for space, missile, aircraft and ground power applications are tried and proven. Systems performed under environmental conditions including nuclear radiation, high-temperature, liquid metal vapor, zero-G and vacuum.

Below are typical TAPCO components now available for integration into systems for such applications. Other available TAPCO electrical power components include tachometer generators, speed sensors, high temperature electromagnets and solenoids, nuclear reactor rod drive controls, static inverters, voltage regulators and electronic power conversion devices.

ALTERNATORS

Among the special purpose rotating machines designed by TAPCO is a series of high temperature alternators. These range in capacity from a few watts to 15 kw at temperatures up to 1000°F.

PERFORMANCE DATA: TYPICAL ALTERNATOR—**Power Rating:** 3 kw, 0.8 pf lagging. **Ambient Temp.:** 700°F. max. **Operating Speed:** 40,000 rpm. **Output:** 115v, 2000 cps. **Inherent Voltage Regulation:** ±5%. **Harmonic Content:** 5% total. **Efficiency:** 85%. **Weight:** 9 lbs w/o shaft and bearings. **Size:** 3⅝" OD, 5⅛" long. **Special Conditions:** Operates in mercury vapor.

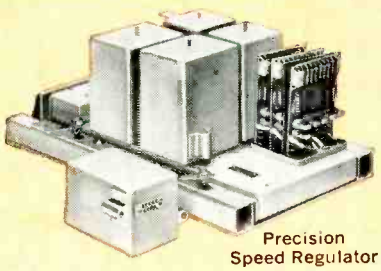


High Temperature
Permanent Magnet Alternator

VOLTAGE REGULATION AND SPEED CONTROLS

Associated with the TAPCO alternator and drive systems are system speed and voltage controls for extremely accurate frequency and voltage regulation. The unit shown is adaptable to many drive systems.

PERFORMANCE DATA: TYPICAL SPEED REGULATOR: **Frequency Stability:** 1 part in 100,000 integrated over minimum 1 hour period. **Input:** 115v, 400 cps. **Output:** 0-10v, 400 cps (phase reversing). **Feedback:** Valve position 0-57.5v, 400 cps. **Environmental Conditions:** −65 to +200°F, 50g shock for 11 millisec., vibration 0.1" double amplitude from 3 to 23 cps, 10g from 23 cps to 10 kc. **Weight:** 10 lbs. **Size:** 12" x 6" x 5".



Precision
Speed Regulator

LIQUID METAL PUMPS

A rotating permanent magnet driven by an external source induces pumping force in the liquid metal within a hermetically sealed system. This concept provides operation without friction-producing rotating seals and provides exceptional reliability and life.

PERFORMANCE DATA: TYPICAL ELECTROMAGNETIC PUMP—**Fluid:** Sodium. **Fluid Temperature:** 1000°F. **Capacity:** 20 lbs/min. **Driving Speed:** 40,000 rpm. **Pressure Rise:** 3 psi. **Weight:** 3 lbs. **Size:** 2¾" diam. flange bolt circle, ½" nominal pipe size.

Electromagnetic Sodium Pump

Tapco Group Export Representative:
American Avitron Inc. • Mamaroneck, N. Y.

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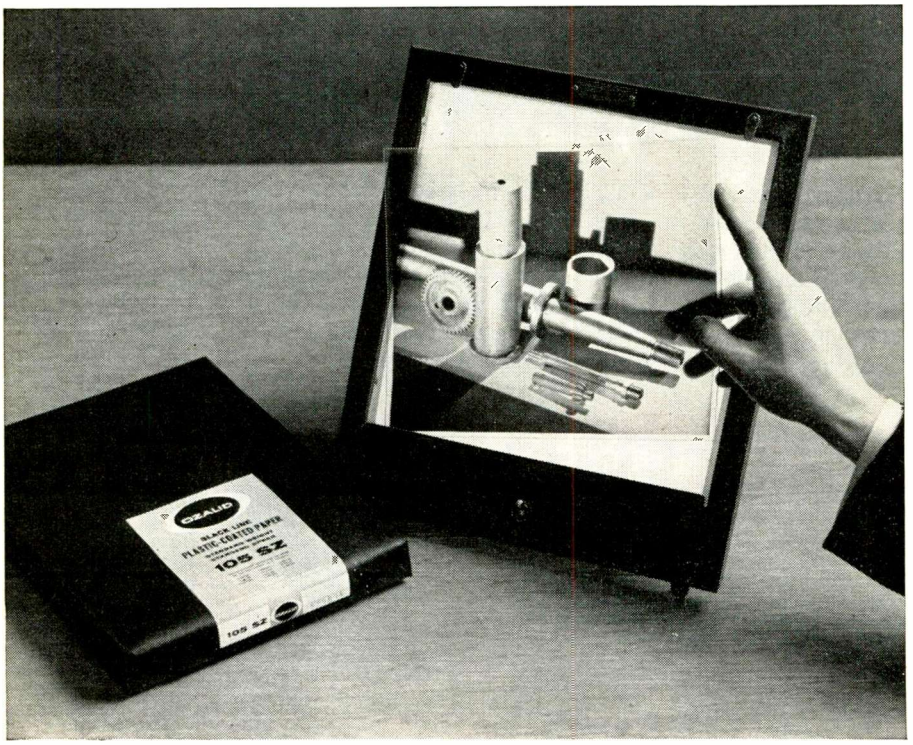
OZALID NEWSLETTER

NEW IDEAS TO HELP YOU WITH ENGINEERING REPRODUCTION AND DRAFTING



Standard materials, plus new thinking, result in big time and cost savings.

How to break the halftone costs barrier

Some of the sharper repro men looking to cut the high cost of using halftones in quantity have come up with this little timesaver that goes for pennies per halftone. Here was the problem: 200 rush copies of 16 technical photographs were needed for a service manual . . . a total of 3200 prints. This job would usually run about $2,000 and take ten days . . . that was too long and cost too much.

A bright lad thought about their Ozalid whiteprinting equipment and worked out this procedure: First an 8″ x 10″ screened film positive was made by projection from a 4″ x 5″ negative, emulsion away from emulsion. This insured proper orientation of the print in the final stage.

Next, the film positive and Ozalid black-line plastic-coated paper (105SZ) were processed in an Ozalid Printmaster 810 at a rate of 12 feet per minute. The 42-inch width of this machine permitted two operators to work simultaneously, cutting total production time virtually in half! The choice of Ozalid paper Type 105SZ was an excellent one. It gave crisp, black-line images of great density due to the paper's plastic coating. The entire project took just under a fast six hours instead of the usual ten days, and cost about $100.

Total savings: $1900 and 9½ days of production time. Pretty smart, we think. By the way, we've got sample packages available for the asking that might very well give you the same dramatic results. Why not write us at Ozalid, Box L-6, Johnson City, New York. We'll be glad to help.

Looking for a fast case of the blues?

The happy kind, we mean. The clean, rich, decisive blue image that Ozalid's new Super-Speed Blue-Line (200SS) gives. And when we say fast, that's exactly what we mean. *Poor originals are copied up to ten feet per minute faster than with regular copy papers.*

This is the first Ozalid copy paper specifically designed for copying semi-opaque originals at higher speeds . . . at no sacrifice of line density in any sense!

But what does all this mean in practical benefits, other than increased production at no loss in quality?

Well, for one thing, it means that you can now do a fine job on semi-opaque material, such as one-sided letters, documents and bulletins, at the lowest cost of any copying process . . . even if they're printed on bond papers!

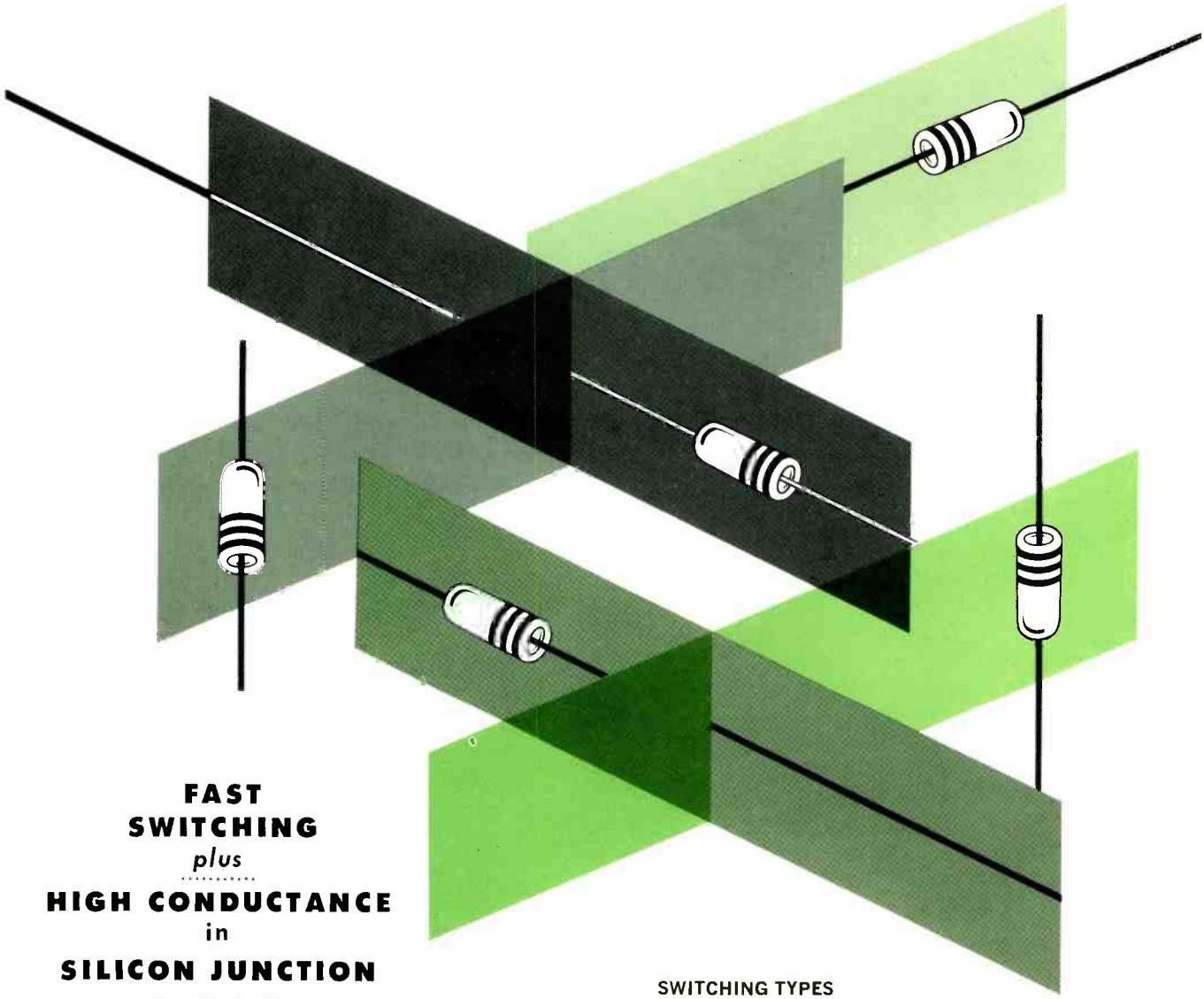
Another benefit is the clean, readable copies you can now produce from soiled, yellowed documents and low-translucency materials much faster than ever before.

Is that all? Not by a long shot. 200SS actually turns low-powered ultraviolet machines into pretty fast units. And the faster printing speeds mean faster return of the original after each cycle.

Why not try this superb, high-density blue-line paper today? It really makes sense. Just call your local Ozalid representative for a demonstration.

CIRCLE 17 ON READER SERVICE CARD→


Reliability in volume...
CLEVITE
TRANSISTOR
WALTHAM, MASSACHUSETTS



FAST SWITCHING *plus* HIGH CONDUCTANCE in SILICON JUNCTION DIODES

SWITCHING TYPES

New circuit possibilities for low impedance, high current applications are opened up by Clevite's switching diodes. Type CSD-2542, for example, switches from 30 ma to −35v. in 0.5 microseconds in a modified IBM Y circuit and has a forward conductance of 100 ma min@1 volt.

Combining high reverse voltage, high forward conductance, fast switching and high temperature operation, these diodes approach the ideal multipurpose device sought by designers.

GENERAL PURPOSE TYPES

Optimum rectification efficiency rather than rate of switching has been built into these silicon diodes. They feature very high forward conductance and low reverse current. These diodes find their principal use in various instrumentation applications where the accuracy or reproduceability of performance of the circuit requires a diode of negligible reverse current. In this line of general purpose types Clevite has available, in addition to the JAN types listed below, commercial diodes of the 1N482 series.

MILITARY TYPES

JAN		SIGNAL CORPS	
1N457 –	MIL-E-1/1026	1N662 –	MIL-E-1/1139
1N458 –	MIL-E-1/1027	1N663 –	MIL-E-1/1140
1N459 –	MIL-E-1/1028	1N658 –	MIL-E-1/1160
		1N643 –	MIL-E-1/1171

All these diodes are available for immediate delivery. Write now for Bulletins B217A-1, B217A-2 and B217-4.

Reliability In Volume . . .

A DIVISION OF CLEVITE CORPORATION

CLEVITE TRANSISTOR

254 Crescent Street Waltham 54, Mass. Tel: TWinbrook 4-9330

Telex Buys Component Firm

Telex, Inc., St. Paul, Minn., reports the purchase of **Aemco, Inc.,** of Mankato, Minn., for approximately $1½ million. The Mankato company, organized in 1918 to produce special timing switches, now also produces custom relays for electronic and electrical application. Aemco, which will continue under its present administration, will become an operating division in Telex's Components Group. Telex reports that combined annual sales total $8 million.

Hathaway Instruments, Inc., Denver, Colo., announces the proposed acquisition of **Sterling Electric Motors, Inc.,** Los Angeles, Calif., subject to the approval of Sterling stockholders. Hathaway will purchase the Sterling assets for $2½ million, which will then be distributed to the Sterling stockholders. Sterling reported sales in excess of $4 million for 1959.

Electronics Capital Corp., San Diego, Calif., reports the purchase of $250,000 worth of five-year convertible debentures issued by **Remanco, Inc.,** of Santa Monica, Calif. The debentures are convertible into 59% of Remanco's total common stock. Remanco produces microwave test equipment. The transaction is the ninth commitment ECC has made, bringing its total investments to $5,300,000.

Dorsett Electronics Laboratories, Inc., Norman, Okla., announces its merger with **Carter and Galantin,** Chicago. The merger involves an exchange of all Carter and Galantin shares for 60,000 shares of Dorsett common stock. Dorsett, producer of telemetering systems, acquired the Chicago manufacturer of industrial training and marketing aids in a step toward diversification.

Atlantic Research Corp., Alexandria, Va., reports the acquisition of **Northeastern Engineering Inc.,** Manchester, N. H., as a new subsidiary. Northeastern, producer of high-precision equipment for the medical profession and the military, reports an annual volume in excess of $2½ million. The new annual business volume of Atlantic and its subsidiaries totals $15 million.

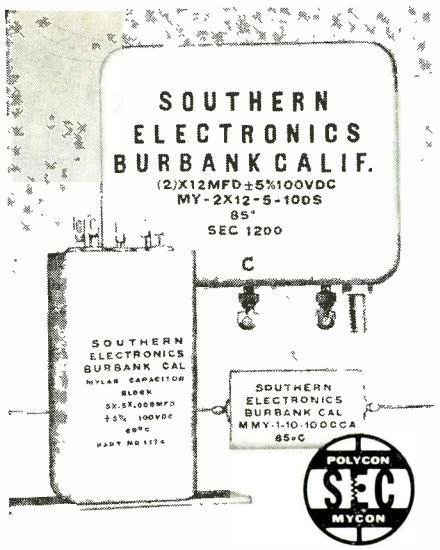
Waltham Precision Instrument Co., Waltham, Mass., announces the acquisition of **Electro-Mec Laboratory, Inc.,** Long Island City, N. Y. The Waltham producer of missile and aircraft equipment, clocks and timers, reports first quarter sales totaled $1,435,211, producing profits of $109,309, or 4 cents per share.

Textron Electronics, New York, N. Y., reports the acquisition of **Allegany Instrument Co.,** Cumberland, Md., in exchange for 140,000 shares of Textron stock. Allegany, producer of thrust and pressure measuring devices and allied electronic equipment, reports annual sales totalling $3 million.

25 MOST ACTIVE STOCKS

	WEEK ENDING JUNE 17			
	SHARES (IN 100's)	HIGH	LOW	CLOSE
Standard Kollsman	5,988	27½	19	27⅛
Univ Controls	2,788	19¼	15¼	17¼
Sterling Precis	1,837	3⅝	2¾	3⅜
Lear Inc	1,810	22⅞	18⅛	22⅝
Ampex	1,803	39¾	36	36¾
Gen Tel & Elec	1,635	31⅞	30¾	31⅛
Du Mont Labs	1,506	11¾	9⅞	11
Collins Radio	1,503	73⅜	63⅜	72⅞
Transitron	1,335	60	51⅛	58⅜
RCA	1,028	77⅝	70⅝	70⅞
Gen Inst	1,014	46¾	38¾	45⅛
Belock Inst	964	23⅞	17⅜	23⅝
Int'l Tel & Tel	912	46⅜	42¾	43
Raytheon	889	43⅝	40	43⅛
Sperry Rand	879	24⅛	22½	22⅞
Int'l Resistance	796	40¼	32¾	39
American Electronics	759	18¼	15⅛	18⅛
Amer Tel & Tel	753	90⅞	88	89¼
Emerson Radio	709	16⅞	12½	16½
Cohu Electronics	659	12⅛	10⅜	11¾
Avco Corp	654	13⅜	12½	13⅛
Varian Assoc	639	64⅞	60½	63⅛
Burroughs	581	39⅜	37½	37⅞
Gen Elec	574	96	92⅜	93¾
Beckman Inst	554	97¾	87¼	96½

The above figures represent sales of electronics stocks on the New York and American Stock Exchanges. Listings are prepared exclusively for ELECTRONICS by Ira Haupt & Co., investment bankers.



Capacitors for

NO COMPROMISE

Circuit Design

Unusual requirements in capacitance, tolerance, case size or configuration no longer need compromise your circuit designs. **SOUTHERN ELECTRONICS'** engineers are experienced in solving these problems to the extent that non-standard capacitors have become routine at **SEC.**

SEC has developed multiple block capacitors that are now saving space and weight in a production missile. Two 12mfd capacitors were designed to take less space than one, with improved electrical characteristics. In another application, **SEC** eliminated 6 tubular capacitors, utilizing a single can, 6 terminals and a common ground. **Result:** Room for additional components, easier wiring, and a less expensive component.

SEC, in addition to designing special capacitors to save weight and space, has developed dual-dielectrics to solve unusual temperature coefficient problems, and has introduced special dielectrics and oils for extreme high temperature and high voltage applications.

This engineering know-how has resulted in the use of **SEC capacitors** in twelve U.S. missiles, analog computers, and many radar and communications services.

SEC capacitors are manufactured in a wide range of capacitance to meet your needs from 100mmf to any higher value, with tolerances as low as 0.1%. They are made under unusually critical quality control standards, and meet or exceed the most rigid MIL-SPECS.

Write today for detailed technical data and general catalog.

Pioneers in custom precision capacitor engineering

POLYCON SEC MYCON

SOUTHERN ELECTRONICS *Corporation*

150 WEST CYPRESS AVENUE
BURBANK, CALIFORNIA

population - 0

Even in the most remote areas, wings aloft are guided on their way by Aerocom's new medium range N.D. Beacon Transmitter. This transmitter was designed and built to provide long, trouble-free service with no attendants...even where the total population is Zero.

NOW — FCC type accepted — single or dual automatic—for carrier powers of 10, 12, 15, 20, 25, 50 and 100 watts.

AEROCOM'S
Dual Automatic Package-Type Radio Beacon

for completely unattended service. This N.D. Beacon (illustrated) consists of two 100 watt (or 50 watt) transmitters with 2 keyers, automatic transfer and antenna tuner. (Power needed 110 or 220 volts 50/60 cycles, 465 V.A. for 50 watt, 675 V.A. for 100 watt.)

Frequency range 200-500 kcs.: available with either crystal or self excited oscillator coil. High level plate modulation of final amplifier is used, giving 97% tone modulation. Microphone P-T switch interrupts tone, permitting voice operation.

The "stand-by" transmitter is selected when the carrier or modulation level of main transmitter drops 3 db or more, in case of failure to transmit the identification signal or if carrier frequency changes 5 kcs. or more. Audible indication in monitoring receiver tells which transmitter is in operation.

Unit is ruggedly constructed and conservatively rated, providing low operating and maintenance costs.

Also available in 400 watt, 1 K.W. and 4 K.W. Models, 200-415 kcs.

AER-O-COM

3090 S. W. 37th AVENUE • MIAMI 33, FLORIDA

cool

COOL is the word for General Electric NPN silicon transistors, Series 2N332 through 2N338. At 150 mw the junction temperature is 70°C at an ambient of 25°C. Compare this with the registered derating factor which calls for a junction temperature of 175°C.

The "A" versions of these transistors dissipate 500 mw at 25°C, 83 mw at 150°C — all without a heat sink.

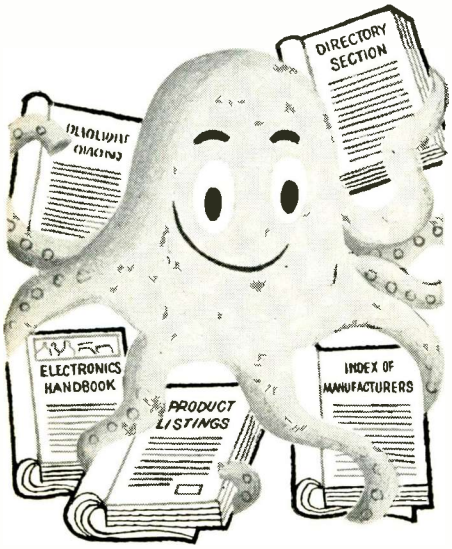
When junction temperatures go down, reliability goes up. The wide safety factor you enjoy with General Electric silicon transistors means better performance and longer life than you may ever have seen achieved before in a similar device. See your G-E Semiconductor Sales Representative for complete details.

On the shelf at your General Electric Distributor.

GENERAL ELECTRIC

CIRCLE 21 ON READER SERVICE CARD

Get the facts together quickly

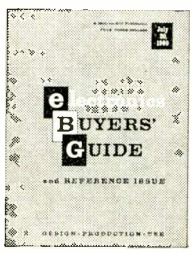


Buying is easier when you've got all the facts in *one* place.

The BUYERS' GUIDE tells who makes it. Gives detailed catalog-type product information and specs. Gives choices in mechanical and electrical characteristics. Gives more choices in terms of materials and design. Also objective and authoritative facts about markets . . . materials . . . design . . . in an exclusive 64-page reference section.

That's why the GUIDE will put you in the *strongest* position to make the best buying choice for yourself and your company.

It's *all* between the covers of one volume. The accurate, complete and authoritative **electronics** BUYERS' GUIDE and Reference Issue. O.8E



FIND WHAT YOU NEED IN THE **electronics BUYERS' GUIDE**

Defense Spending to Move Up

DIRECTION of federal spending is expected to turn around this month, the beginning of the new fiscal year, McGraw-Hill's Department of Economics reports.

Because of national defense program cuts initiated more than a year ago, government spending during the first six months of 1960 declined to its lowest level since early 1958. But the outlook from here on out is for slightly rising defense expenditures.

There is good news also for manufacturers of entertainment and other consumer electronic products. Latest surveys of consumer intentions indicate consumers expect to increase their spending for durable goods and housing during remaining months of 1960.

For every dollar the United States spends in purchasing existing types of military weapons and equipment, 40 cents is spent developing and testing new types to replace those already in hand, said Dr. Herbert York, director of research and engineering for the U. S. Department of Defense, in a commencement address at Case Institute in Cleveland. Aerospace Industries Associations says that research and development accounts for 60 percent of the intercontinental ballistic missile weapon dollar.

Solar cell sales are rising at a lively pace under impact of increasing activity in space. Major use of the device is as primary source of power for satellites. Market investigators estimate sales this year will total $9 million, twice 1959 sales.

EIA monthly count of transistors shows sales of $78,246,279 and 31,155,798 units in the first quarter of 1959 are running ahead of the 1958 quarter by 70 percent for dollar sales and 84 percent for unit sales. Number of units sold in March increased by 2½ million over units sold during February while revenue rose nearly $4 million. But average prices dropped from $2.61 in February to $2.39 in March.

During 1959 manufacturers' shipments of home-type television receivers totalled 6.0 million sets with a factory value of $815 million, a 13-percent unit increase and an 18-percent dollar increase over 1958 shipments, Bureau of Census states in recent issue of its Current Industrial Reports series.

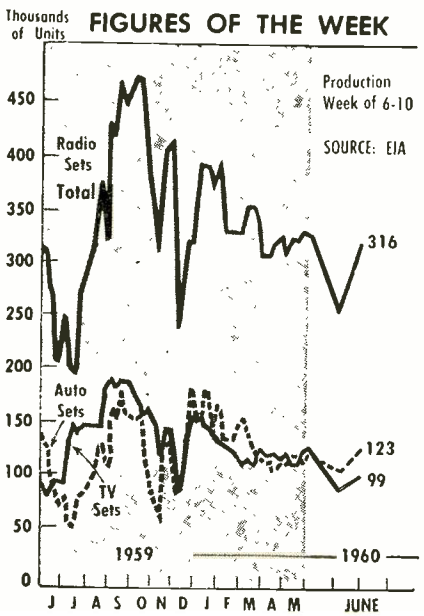
Shipments in 1959 of radios and radio-phono combinations, excluding auto radios, totaled 10.3 million sets worth $289 million, as against 8.8 million sets worth $242 million in 1958.

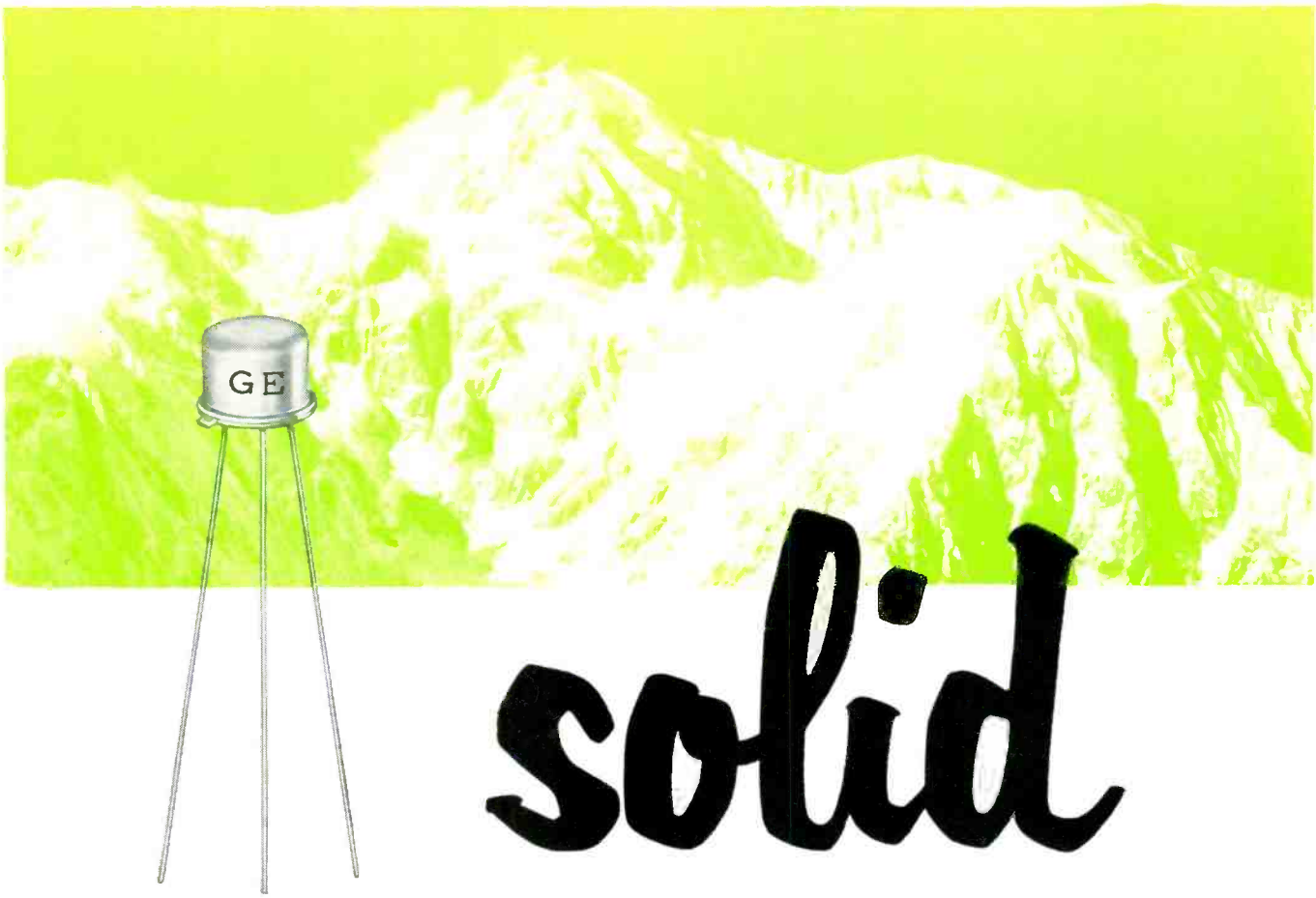
Auto radio shipments rose from 3.9 million units ($102 million) in 1958 to 5.7 million units ($133 million) in 1959.

Transistor portable radios represented 90 percent of the 4,034,000 portable radio sets sold in 1959. In the preceding year a total of 3,342,000 portable sets were sold and 70 percent were transistorized.

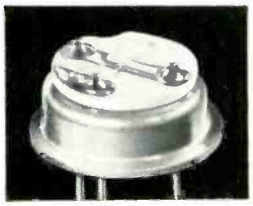
Business and Defense Services Administration is planning annual reports on electronic components sales. First will cover 1952-59.

FIGURES OF THE WEEK





solid



General Electric silicon transistors are manufactured by the Fixed Bed Mounting process. All parts are firmly fastened to a ceramic disk, with no suspended parts. The transistor reacts as a solid block in resisting shock and vibration.

G-E type 2N332 through 2N338 transistors (including "A" versions and USN versions) have been struck with a golf club, rattled 700 miles in a hub-cap, fired from a shotgun and shot from an artillery piece (40,000 G's) — and still survived to operate! Call your G-E Semiconductor Sales Representative for full details.

Absolute Maximum Ratings	2N332-6*	2N337-8†	2N332A-6A
Collector to base voltage	45 V_{CBO}	45 V_{CBO}	45 V_{CB}
Emitter to base voltage	1 V_{EBO}	1 V_{EBO}	4 V_{EB}
Collector current (I_C)	25 ma	20 ma	25 ma
Collector dissipation @ 25°C (P_C)	150 mw	125 mw	500 mw
Operating temperature (T_J)	—65 to 175°C	—65 to 150°C	—65 to 175°C

*USN versions of all units except 2N332 have QA per MIL-T-19500/37A.
†USN versions have QA per MIL-T-19500/69B.

Immediate delivery from your General Electric Distributor

GENERAL ELECTRIC

One kilowatt power in a compact ceramic package is now available to 400Mc., with the Eimac 4CX1000A radial-beam power tetrode.

The new, expanded frequency range coverage of the versatile 4CX1000A makes it ideal for AM, FM and SSB operation in the important government communication band, 225-400Mc., and for FM and VHF-TV broadcasting.

An excellent linear amplifier tube, the 4CX1000A has low voltage, high current, high gain characteristics. It achieves maximum rated power output in Class AB_1, SSB service without grid current.

Illustrated here, actual size, it is easy to see why this compact, rugged ceramic tetrode is ideal for tight space, high power situations.

A companion air-system socket to meet your specific requirement is available with the 4CX1000A.

TYPICAL OPERATION 4CX1000A (400Mc FM Amplifier)

DC Plate Voltage	3000 volts
DC Screen Voltage	250 volts
DC Plate Current	750 ma
DC Screen Current	45 ma
Driver Power Output	15 watts
Useful Output Power	1100 watts

EITEL-McCULLOUGH, INC.

Eimac

San Carlos, California

proved

Before any lot of G-E silicon transistors may be delivered, a representative number of units are selected for each of the four restrictive life tests. These tests include operation at maximum power at 25°C ambient, operation at high temperatures and peak ratings, storage at 200°C, and shelf life at 25°C—all tests for 1000 hours. If the sample fails any one of these tests, the lot cannot be shipped.

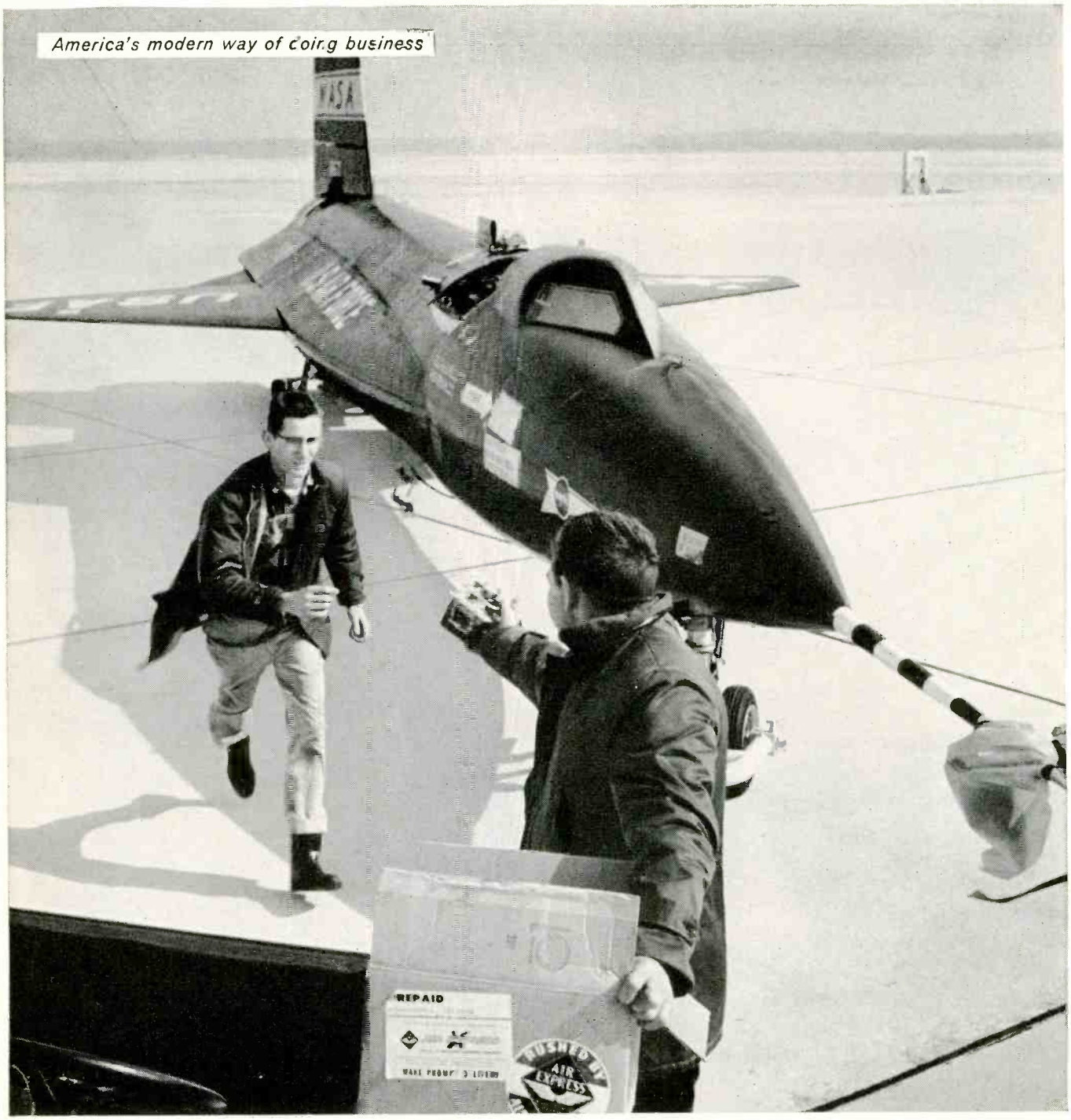
Only General Electric silicon transistors (Series 2N332-2N338, including "A" and USN versions) are subjected to such rigorous restrictive testing. *And* we keep them pure inside — no grease or surface contaminants that degrade performance are permitted to enter. Write for a full report on the restrictive tests which G-E silicon transistors must pass *before* they're shipped to you. Section S2570, General Electric Co., Semiconductor Products Dept., Electronics Park, Syracuse, N. Y.

At factory-low prices from your General Electric Distributor.

GENERAL ELECTRIC

CIRCLE 25 ON READER SERVICE CARD

America's modern way of doing business



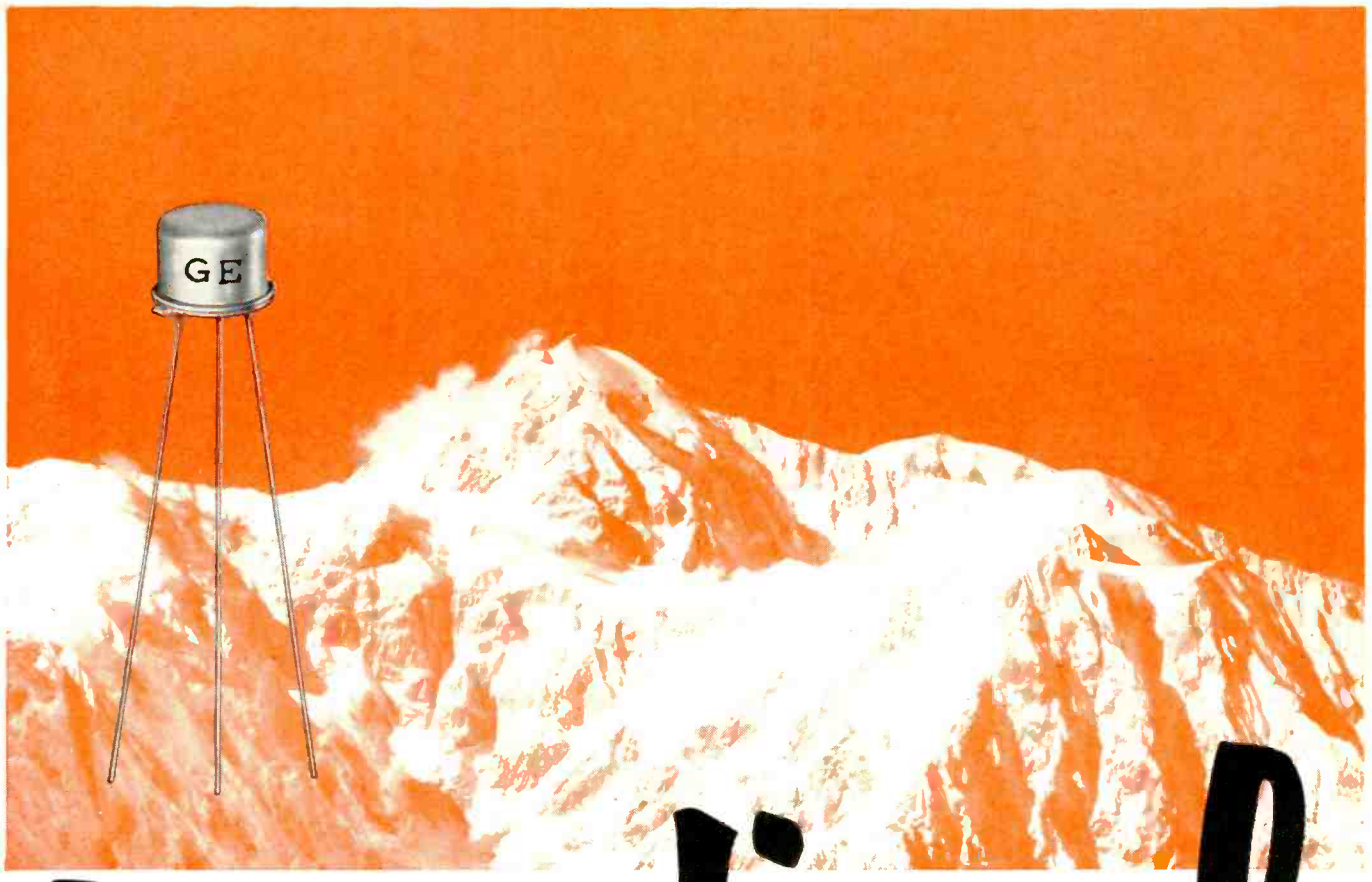
The NASA-USAF-Navy X-15 manned rocket gets a vital part . . . delivered with jet-age speed by AIR EXPRESS

X-15 part flies first 3000 miles by Air Express

The scene: Edwards Air Force Base, Calif. Crack engineers work 'round the clock to ready the X-15 for its flight to the brink of outer space. Its engine, built by Thiokol in Denville, New Jersey, packs a 400,000 HP punch—more than the power of two giant ocean liners! Because of an accelerated assembly schedule, some parts—like this turbine pump control—are installed right on the flight line. They must be shipped fast, with kid-glove handling. In short, a job for low-cost AIR EXPRESS. Give your business these advantages, too. Call AIR EXPRESS to speed your products FIRST TO MARKET . . . . FIRST TO SELL.

AIR EXPRESS

CALL AIR EXPRESS DIVISION OF RAILWAY EXPRESS AGENCY • GETS THERE FIRST VIA U. S. SCHEDULED AIRLINES



sensational

The performance of General Electric's silicon transistors is sensational:

Fixed Bed Mounting provides the most rugged construction yet developed for transistors.

By operating at a low junction temperature, reliability and stability are inherently increased.

Beta hold-up at low current is superior.

The "A" versions offer a 4V emitter-to-base breakdown and a 45V collector-to-emitter breakdown.

Every lot of transistors is subjected to four types of restrictive life tests.

USN versions are available in the Series 2N333 through 2N338.

Units tested to 5000 hours have shown an overall performance rate greater than 99 per cent.

Send for the complete specifications and test data and prove to yourself how G.E.'s silicon transistors will do a sensational job in your design. Section S2570, General Electric Company, Semiconductor Products Dept., Electronics Park, Syracuse, N. Y.

GENERAL ELECTRIC

CIRCLE 27 ON READER SERVICE CARD

Computer Installation Speeds Saturn

Army Ballistic Missile Agency in Huntsville gets a new name, a new computer and

By NILO LINDGREN
Assistant Editor

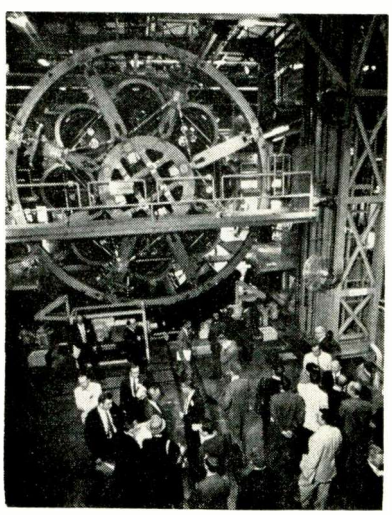
HUNTSVILLE, ALA.—Newsmen visiting Redstone Arsenal here a few days ago witnessed a spectacular show of rocket power.

The Saturn space vehicle booster stage, capable of a 1.5 million-pound thrust, was successfully static fired in a full-duration run, 122 seconds to burnout. The white columnar configuration of the Saturn booster looked like the Lincoln Memorial ready to be blasted into space. On the hill 2,000 feet away where newsmen stood watching, the 120-decibel noise drowned exclamations and the heat from the searing orange exhaust flaming out across the valley added to the hot sunlight. This test firing, the eighth of the series and the second with all eight engines, was instrumented to give Redstone scientists information on environmental and interactional effects in the booster tail region.

Working overnight, computer men had ready the next morning the correlated results on 250 different variables on the complete engine run. The massive correlation job is carried out with the aid of the newly installed IBM 7090, an all-solid-state machine that can make 13,740,000 logical decisions per minute. The system, which was officially dedicated at the National Aeronautics and Space Administration's Marshall Space Flight Center (formerly Army Ballistics Missile Agency), on the day of the static firing, will be followed by a second one next month. The two 7090's will accomplish in 8 hours what three large scale vacuum-tube machines did in twenty hours, and will provide a 25-percent saving in machine time costs.

The greatly enlarged computer capacity at the computation center will be monitored by a system called SPOOK, a master programmer. SPOOK means Supervisory Program Over Other Kinds. Developed by IBM, the system is an outgrowth of the SHARE Operating System (SOS). Containing up to 50,000 instructions, it lines up and processes data on different kinds of problems to minimize delays between jobs. More than 200 different computational problems are brought to the computation division every month.

Still another computer for the Saturn project has been under development for more than a year. This computer, being developed competitively by IBM and Librascope, will be part of the final Saturn payload. It is a microminiaturized digital computer contained in a volume probably not much larger than a filing cabinet drawer. Working from a magnetic drum storage with a capacity of a thousand digits, this computer will be used as a guidance programmer, handling up to 15 or 20 variables of flight. In moon flights and deep space probes, this computer will be continuously monitoring and recomputing Saturn's trajectory.



This great spider network at base of Saturn booster holds the eight engines, four centrally fixed, and four outer engines gimballed for steering

But long before the first live firing of the Saturn from Cape Canaveral next summer, Saturn flights will have been simulated on the computers at Huntsville thousands of times in addition to eleven static firings. Simulation of an entire Saturn circumlunar trajectory can be run off in minutes. Major points of the three-dimensional flight path come off a mechanical printer. A high-speed printer-plotter prints off data from magnetic tape for every 4-hour interval of the six- to seven-day trip around the moon and back.

Relatively few live firings of Saturn have been scheduled because of the vehicle's cost. Helmut Hoelzer, director of the Marshall Space Flight Center's Computation Division, who has worked with Wernher von Braun in rocketry and space flight for more than twenty years, said, "The V-2 rocket was developed at Peenemunde basically without automatic digital computers. As a result, there were approximately 1,000 test firings. Yet with the vastly more intricate Saturn, we have scheduled only 10 research and development firings. We now can simulate a trajectory in a few minutes for several hundred dollars. It would cost millions to stage a live flight."

According to von Braun, director of the Marshall Center, the Saturn project has been moving ahead perfectly on schedule. The objective of the program is to develop by the 1963-64 time period an efficient and reliable vehicle for lifting 25,000 lb payloads into orbit around earth and into deep space.

The long-range program calls for

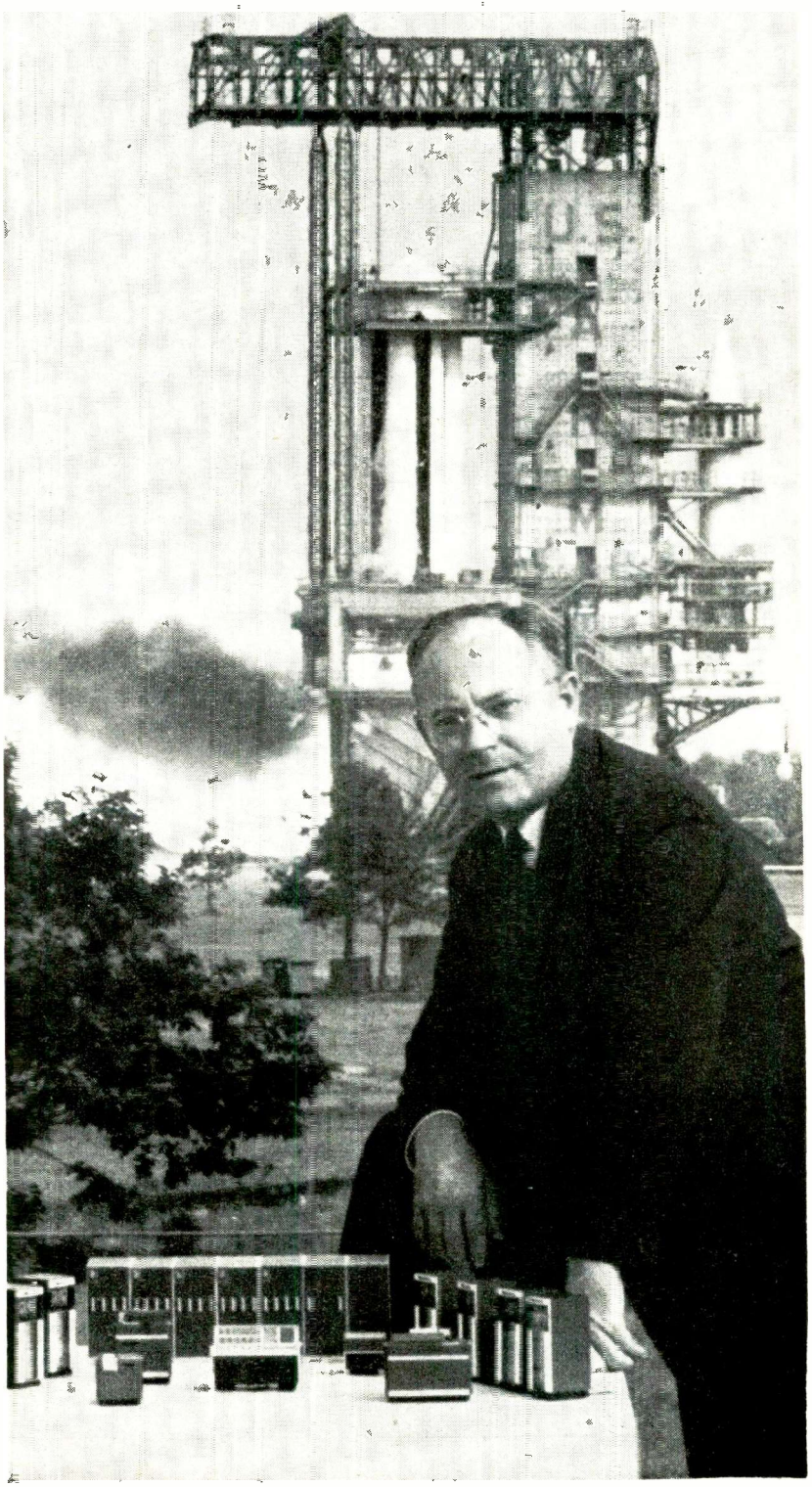
Space Project

a successful static test firing

several Saturn configurations. The first configuration is made up of the eight-engine booster under development at Huntsville, powered by liquid oxygen and kerosene; a second stage powered by four liquid hydrogen fueled engines of 20,000 pounds thrust each, being developed at Douglas Aircraft; and a third stage, powered by two liquid hydrogen fueled engines identical to those of the second stage. The entire three-stage vehicle stands 180 feet high.

Although the first Saturn shot is slated for summer, 1961, it will be late 1963 before the vehicle is fired with all three stages live. The '61 shot will carry a 500,000 pound water-filled mockup of the second and third stages. Only one shot will be made in 1961, three firings are scheduled for 1962, and five in 1963. The last three shots of the 1963 series will put the Saturn into a 300 nautical mile orbit around the earth. Possibly two shots will be made in 1964, both into deep space. According to von Braun, the final Saturn payload has not yet been frozen—several competitive payloads are under consideration. Conceivably, the Saturn could carry two men around the moon and back to earth or place instruments on Mars and Venus.

An interesting sidelight to the Saturn development is the problem of delivering the great booster to Cape Canaveral. Ordinary roads cannot sustain its weight, and it is too big for Flying Boxcars to carry. Thus, a special carrying platform and truck will carry the booster over a reinforced highway to the Tennessee River where a specially designed barge will pick it up, carry it down the Tennessee into the Ohio and the Mississippi, then along the Gulf coastline to the Florida launching pad.



Helmut Hoelzer, director of computation division at NASA's Marshall Space Flight Center, poses by model of new IBM computer installation against backdrop of a static test firing of the Saturn booster

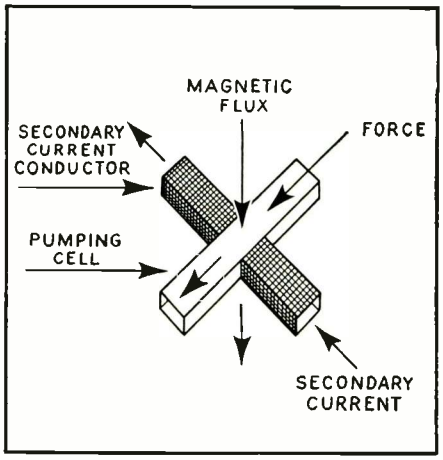
Vol. 2, No. 2

Nickelonic News

DEVELOPMENTS IN NICKEL AND NICKEL ALLOYS AND THEIR APPLICATIONS

Grade "A" Nickel bus bar keeps molten metals flowing at 1000°-1600° F

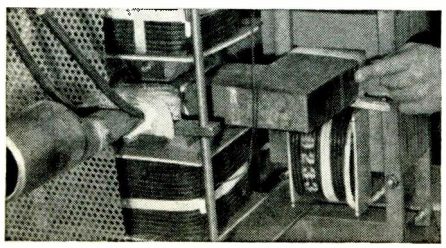
CALLERY, PA.—In nuclear reactor systems, molten metal coolants must be pumped safely and effectively. To do this, the MSA Research Corporation has developed an interesting ac conduction-type electromagnetic pump. It has no moving parts, packing glands, or throttling valves. This pump can handle molten sodium, potassium, NaK, lithium, and mercury at temperatures up to 1600°F.



WHEN A CURRENT is passed through the molten metal, perpendicular to a magnetic field, a force is produced on the liquid metal that results in motion within the pumping section. This motion is at right angles to the current and flux. (See diagram above.)

Current is conducted into the liquid metal by connecting the secondary of a current transformer in the pumping section. In the 1000°-1600°F range Grade "A" Nickel is used for the bus bar secondary because it is corrosion-resistant, and has satisfactory electrical conductivity.

A pump of this type will effectively pump fluids having a lower electrical resistance than that of the pumping section wall.



The flow rate of all MSA Research Corporation conduction type EM pumps is positively controlled from zero to maximum flow by an adjustable autotransformer. A capacitor is used for power factor correction due to the high magnetization current required.

Conduction type EM pumps may be used to pump any liquid metal which will wet the pumping section and which has a high conductivity.

Pertinent Literature: Booklet, *Nickel Alloys for Electronic Uses.*

TRANSFORMERS OPERATE AT 600°C ...ENCLOSED IN LOW CARBON NICKEL

WALTHAM, MASS. — Missiles and rockets have created environmental conditions which can destroy or seriously impair the operation of presently available electronic parts. There are two approaches to the solution of this problem. The first is to create an artificial atmosphere to support the *present* type component. The second is to create *new* components that will give reliable operation under high temperature environments.

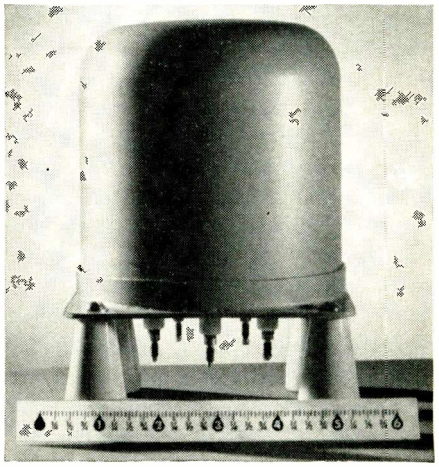
Raytheon Company has designed and tested transformers of four basic types — plate, radar pulse, audio and high-voltage plate and filament — for operation at temperatures in the vicinity of 600°C for 1000 hours.

To eliminate effects of oxidation and other environmental factors, hermetic sealing in inert dielectric gas is used. Extensive evaluation tests were undertaken on various types of materials. Included in these tests were magnet and lead wires, layer and barrier insulation, sleeving and core materials, ceramic terminals, high temperature brazing materials and container metals.

Winner of the container metal test was Low Carbon Nickel because of 1) resistance to oxidation, 2) high temperature creep strength, 3) ease of degassing, 4) general strength and 5) ease of brazing and welding.

Softer than pure Nickel, Low Carbon Nickel does not work harden as rapidly, and for this reason finds wide use in the fabrication of articles and in coining operations. Low Carbon Nickel is somewhat more ductile than Nickel, and its mechanical properties, particularly the yield strength and the elastic limit of annealed material, are lower.

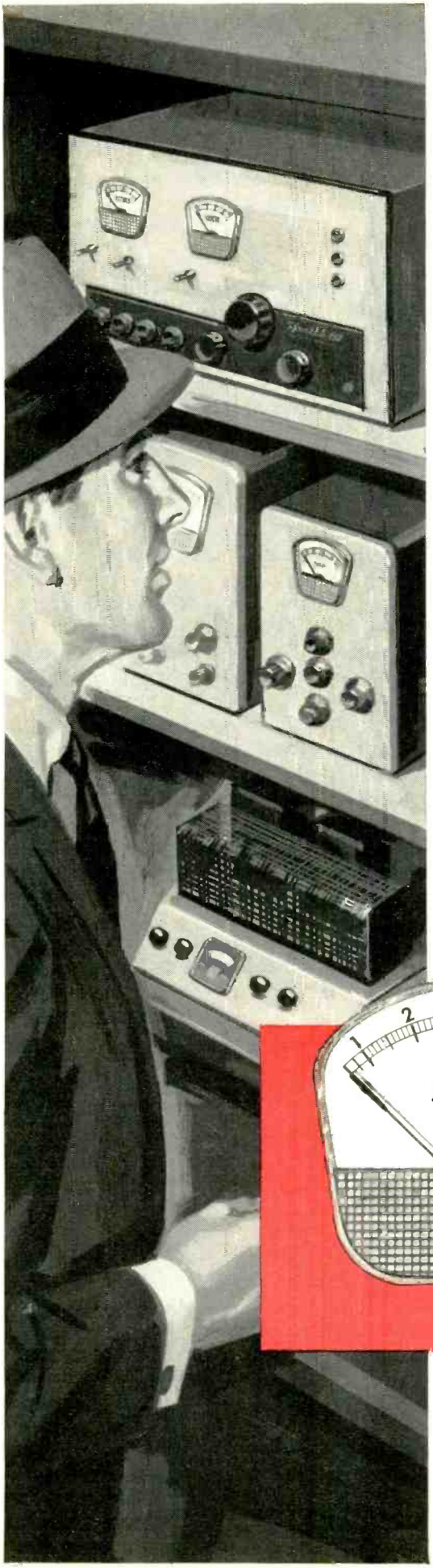
Pertinent Literature: Electronic grades of Nickel and Nickel Alloys — with their applications — are fully described in our booklet, *Nickel Alloys for Electronic Uses.* Write us for a copy.



STANDS HEAT. Some military applications call for a transformer that can operate at temperatures as high as 600°C. Raytheon's approach to this problem was to create an artificial atmosphere (such as nitrogen or argon) to support the unit. Transformer and atmosphere are then enclosed in a container of Low Carbon Nickel. This material was selected because of its resistance to oxidation, its high temperature creep strength, its general strength and ease of degassing, and the readiness with which it is brazed and welded.

HUNTINGTON ALLOY PRODUCTS DIVISION
The International Nickel Company, Inc.
Huntington 17, West Virginia

INCO TRADE MARK **ALLOY PRODUCTS**



WESTON "CROWN" METERS OFFER HIGH PERFORMANCE AT LOW COST

New AC instrument now available in economy line of matched panel meters

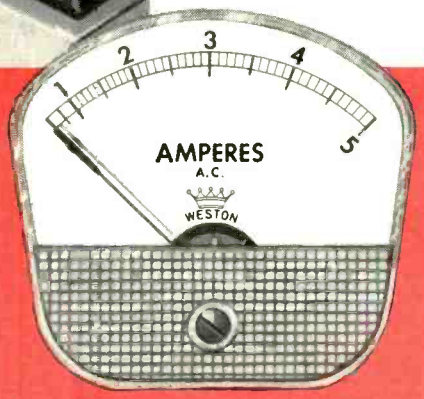
A newly-designed AC moving iron instrument with improved ballistic characteristics joins the Weston line of "Crown" meters. Instruments in this matched group combine economy with dependable accuracy, and incorporate many time-proven Weston features.

Exclusive Weston CORMAG® self-shielded mechanisms, for example, permit mounting on magnetic or non-magnetic panels without special adjustment. Instruments with this important feature may be closely grouped without intereffects, and are immune to stray field errors.

Exceptional readability is another advantage of "Crown" meters. Models 1721 and 1724 have 2.5" long scales, Model 1741 has a 4.9" scale. Clear plastic covers provide excellent, shadow-free illumination. Black lance pointers and black markings on white dial further enhance readability.

Accuracies within ± 2% full scale are available in DC and moving iron AC meters, and ± 3% in rectifier types.

Call your Weston representative for specifications on "Crown" instruments, or write for Catalog 01-112. Daystrom, Incorporated, Weston Instruments Division, Newark 12, New Jersey. *International Sales Division, 100 Empire St., Newark 12, N. J. In Canada: Daystrom Ltd., 840 Caledonia Rd., Toronto 19, Ontario.*



New Model 1724 AC instrument with moving iron mechanism has a 2.25" long scale. Supplied as: Voltmeters, ammeters, milliammeters. Model 1721 (2.5" scale) and Model 1741 (4.9" scale) are supplied as: DC voltmeters, ammeters, milli- and microammeters. Rectifier-type AC Model 1722 (2.5" scale) is supplied as: Voltmeters (1,000 ohms/volt), milli-and microammeters.

DAYSTROM, INCORPORATED
WESTON INSTRUMENTS DIVISION
Weston for Dependable Accuracy

Will Space Equipment Sales Reach $6 Billion in 1975?

By EDWARD DeJONGH
Market Research Editor

MINNEAPOLIS, MINN.—Military manufacturers should look to space equipment to provide growing military equipment sales totals in future years, military analysts said at the recent national conference of the American Marketing Association held here.

Electronics and missile industries responded to the increasing attention given by AMA to military and electronics problems by sending about 100 representatives to the association's 43d convention.

Annual expenditures for space equipment by National Aeronautics and Space Administration and Department of Defense will pass aircraft expenditures in 1968 at about the $3-billion level, said Edmund J. Richards, manager of market research for Thiokol Chemical Co. By 1975 total will be $6 billion.

Richards also offered an answer to a question to which military marketing men have been giving more and more thought. When will missile spending start to decrease? Missile expenditures will crest at $6½ to $7 billion about 1968, he said. They will then start to taper off, receding to $5½ to $6 billion by 1970 and $5 billion by 1975.

Behind the predicted downtrend in missile dollars is the expectation that the development phase of our family of missiles will be largely over. Consequently duplication of missile weapons systems will be almost completely eliminated. Huge expenditures for space equipment in future years will also tend to depress missile spending, he said.

Between 1960 and 1964 the number of operational missile systems in production will rise from 24 to 30, but the number will decline to 23 in 1967 and 15 in 1970. Space systems in production will rise from none in 1960 to four in 1964, six in 1967 and seven in 1970, he said.

Rapid rate at which aircraft expenditures are currently dropping will slow down and level off around the $3-billion mark in 1968, Richards said. Despite the pressure to concentrate on more advanced weapons system, there will always be a need for aircraft in surveillance, reconnaissance, transport and for some bombing-interception work, Richards added.

Net effect of the expected rise and fall among three types of systems will be a moderate overall annual increase of three percent per year, which will bring combined expenditures, up from $10½ billion in 1960 to $12 billion in 1975.

Albert Shapero, manager of systems analysis for Stanford Research Institute, spoke on government research and development markets.

He said, the federal government will spend over $8 billion dollars for R&D in fiscal 1961. Seventy percent of this total will go to DOD, 13 percent to Atomic Energy Commission and seven percent to NASA, with most of the remainder to Departments of Health, Education and Welfare and Agriculture.

National security portion of federal R&D spending (DOD and AEC) will decline to about 60 percent by 1970, Shapero said. However, expected rise in federal R&D total will compensate. Shapero looks for a total somewhere between $10 and $15 billion in 1970.

Attention was called to the dynamic government construction market by Edward J. Stockton, development planning economist for North American Aviation. Total market, including federal, state and local governments, is estimated at $16.2 billion for 1960 and is projected to around $26 billion for 1970, he said. Of particular interest to electronics and missiles firms is the portion which represents military facilities. It is currently worth $1.5 billion annually, is expected to run about $1.3 to $1.4 billion over next 10 years.

During the period there will be a shift in emphasis from items like

Helicopter Fires Bullpup Missile

Bullpup, radio-guided air-to-air missile built by Martin, is launched from helicopter in recent tests. Missile is 12½ ft long, weighs 570 lb

military barracks to test facilities, satellite and missile launching facilities, nuclear installations and radio telescopes, Stockton said.

Electronics industry was well represented at a panel on the role of market research in production planning. All three speakers were drawn from electronics firms.

David W. Day, manager of systems planning for General Electric, pointed out the need to relate new product plans to policies and goals of a business, its products, customers and capabilities.

Market researchers were lightly roasted by Hal Gordon, product planning manager for Westinghouse Electric.

Of particular interest to engineers was Gordon's suggestion that market research departments could do a better job in technical industries if they would include some engineers in their departments.

Day also recommended that less use be made of company sales forces for market survey work. "One thing you can be certain of is that surveys by salesmen will not contain any information derogatory to the sales force," he said.

He also called on market researchers to go beyond gathering facts and to make specific recommendations; to write their reports in simple English; and to remember the purpose of graphs is to reduce complicated data to simple pictures and not to make complicated pictures of simple facts.

Irving Kingsford, director of consumer product planning for RCA, pointed out the high mortality rate of suggested new product ideas. On the average, only one of every 40 suggested ideas will ever get to market. Remainder will be dropped out in the various stages of product planning—screening, specification, development, testing and commercialization.

Growing importance of industrial electronics came in for comment at the panel on industrial distribution. George Ganzenmuller, editor, McGraw-Hill's *Electrical Wholesaling*, said:

"Industrial electronics has reached a state of market demand and development where it is ready for wholesale distribution. From the distributor viewpoint, it is a products group that is up for grabs."

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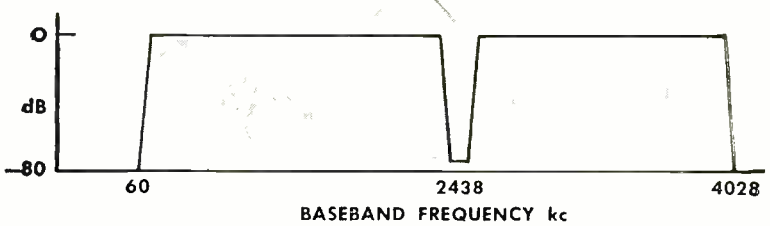

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Recent Economic Growth — The Numbers Game

If it truly portrayed recent rates of economic growth in the United States, the report on employment, growth and price levels recently issued by the staff of the Joint (Congressional) Economic Committee would point up scarcely less than a national disaster. Among other things, it would document impressively Premier Khrushchev's crack that "the capitalist steed the United States is riding . . . is worn out."

One of the major findings of the Joint Committee's staff (in the Eckstein Report, named for its staff director Otto Eckstein) is that between 1953 and 1959 the average rate of growth of physical output in the United States was only 2.4 per cent per year. This is scarcely more than half the average annual rate of growth of 4.6 per cent the staff found to have prevailed between 1947 and 1953.

Happily, however, the report does not reflect the basic economic realities. Its finding on relative rates of economic growth for the two periods is a statistical *tour de force* which, by the selection of certain figures and certain dates, distorts the record of America's long-term economic growth.

Playing The Numbers Game

By the selection of appropriate starting and terminal periods it is possible to document almost any rate of economic growth that is desired. The table at the bottom of this page shows you how this can be done. It will also show you how the Eckstein staff worked out its shocking contrast in growth rates. The table is built like a schedule of airplane fares between different cities. The postwar years 1946 through 1959 are put down on two axes. One runs down the left hand column, the other runs across the top of the table. Put your finger on the point where the two axes intersect and you have the average rate of growth for the period covered.

ANNUAL AVERAGE GROWTH RATES OF THE U.S. ECONOMY, 1946-1959*

(Percent increases, starting year to terminal year, of GNP in 1954 dollars).

Starting Year \ Terminal Year	1946	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959
1946	X	–0.1	–1.9	–1.2	3.0	3.9	3.8	3.9	3.2	3.7	3.6	3.4	2.9	3.2
1947	X	X	3.8	1.8	4.1	4.9	4.6	4.6	3.7	4.2	4.0	3.8	3.2	3.5
1948	X	X	X	–0.1	4.2	5.3	4.8	4.7	3.6	4.3	4.0	3.8	3.1	3.4
1949	X	X	X	X	8.7	8.1	6.5	6.0	4.4	5.0	4.6	4.2	3.5	3.8
1950	X	X	X	X	X	7.4	5.4	5.1	3.4	4.3	3.9	3.6	2.9	3.3
1951	X	X	X	X	X	X	3.4	3.9	2.0	3.5	3.2	3.0	2.2	2.8
1952	X	X	X	X	X	X	X	4.4	1.3	3.6	3.2	2.9	2.0	2.6
1953	X	X	X	X	X	X	X	X	–1.6	3.2	2.8	2.6	1.6	2.4
1954	X	X	X	X	X	X	X	X	X	8.1	5.1	4.0	2.4	3.2
1955	X	X	X	X	X	X	X	X	X	X	2.1	2.0	0.5	2.0
1956	X	X	X	X	X	X	X	X	X	X	X	1.8	–0.2	2.0
1957	X	X	X	X	X	X	X	X	X	X	X	X	–2.3	2.0
1958	X	X	X	X	X	X	X	X	X	X	X	X	X	7.0
1959														

*Compound rates of growth

Following this procedure, you can find growth rates ranging all the way from —2.3 per cent, between 1957 and 1958, to +8.7 per cent, between 1949 and 1950, along with almost any other rate you would choose for various years and sequences of several years over the postwar period.

For example, if you want to demonstrate that the postwar growth rate through 1953 was less than 4% per year, you take off from 1946, include a drop of 0.1 per cent between 1946 and 1947, and come up with a growth rate for the 1946-1953 period of 3.9 per cent. But if you want to show it was quite high, you take off a year later, from 1947 (which drops out that dismal —0.1 per cent for 1947) and come up with a fine growth rate of 4.6 per cent for the 1947-1953 years.

Statistical Hocus-Pocus

That's what the Eckstein staff did. It took off at one end from a year when there was just about no growth, went to the Korean War boom year of 1953 at the other end, and got that average growth rate of 4.6 per cent. Then it took off from the Korean War boom year of 1953 and ran to the year 1959, when business was recovering from a recession and suffered through a steel strike of 116 days, to come up with its 2.4 per cent growth rate for the second postwar period. As the table indicates, by taking off a year later (1954) the average growth rate would have become 3.2 per cent, and if the take off had been 1949 it would have been 3.8 per cent.

There are those who, in nontechnical terms, would characterize this as statistical hocus-pocus. There are also those who would see in it an element of political hocus-pocus, too. This is because the years 1947-53, when the Eckstein staff found there had been the healthy 4.6 per cent growth rate, were roughly years when we had a Democratic president, while the anemic growth rate of 2.4 per cent it calculated for the subsequent years was for years of a Republican presidency.

Actually it can be shown that the civilian part of our economy has had more rapid growth during the Republican administration than it had during the Democratic years. If military expenditures are subtracted from the national ouput, the resulting growth rate for 1953 to 1959 is slightly higher than for 1947 to 1953.

However, we do not question the *bona fides* of the Eckstein staff. **But we do assert that it has produced a statistical picture of the postwar growth of the American economy which is dangerously misleading both at home and abroad.**

Abroad, the report appears to give official documentation to the propaganda line that the Soviet economy is running rings around the U.S. economy in growth, and that it is Communism a country should choose if it really wants to develop rapidly. Building on a much smaller economic base than the U.S.A., the Soviet Union — as well as almost every less advanced nation in the world — is bound to show a larger percentage increase in output than the U.S.A. But the Eckstein staff calculation gives the Communists ammunition they don't deserve.

Are We Facing A Crisis?

The contrast drawn by the Joint Committee staff in postwar U.S. growth rates suggests that we are facing scarcely less than a crisis through paralysis of our economic growth which calls for drastic remedies. But this, as the full 1947 to 1959 growth record set forth in the table makes clear, is very definitely not the case. Our over-all postwar rate of growth, as measured by the gross national product in physical terms, has been 3.5 per cent per year, a rate nearly double the long-term growth rate of 2 per cent per year between 1909 and 1939. In the continuing fluctuations in the rate of growth which more or less inevitably characterize a relatively free economy, we have had some downs in recent years. **But our economy is now on the upbeat again. And at the end of this year, the U.S. economic growth rate for the postwar period can be expected to be 3.7 per cent per year.**

It is extremely important for the United States to continue to maintain this rate of economic growth or even to surpass it. Upon this effort depends our capacity to meet our defense requirements without dangerous strain, to provide an adequate margin for foreign aid, to improve our own productive facilities, and to continue to raise our own standard of living.

How not only to maintain but possibly improve upon our postwar pace of economic growth will be the subject of strenuous debate in the months ahead. However, the debate will have a much better chance of being constructive if the postwar growth record is seen in proper perspective. To this end one of the first things to do is to junk panic rousing statistical portrayals such as that in the Eckstein report.

This message is one of a series prepared by the McGraw-Hill Department of Economics to help increase public knowledge and understanding of important nation-wide developments. Permission is freely extended to newspapers, groups or individuals to quote or reprint all or parts of the text.

Donald C. McGraw

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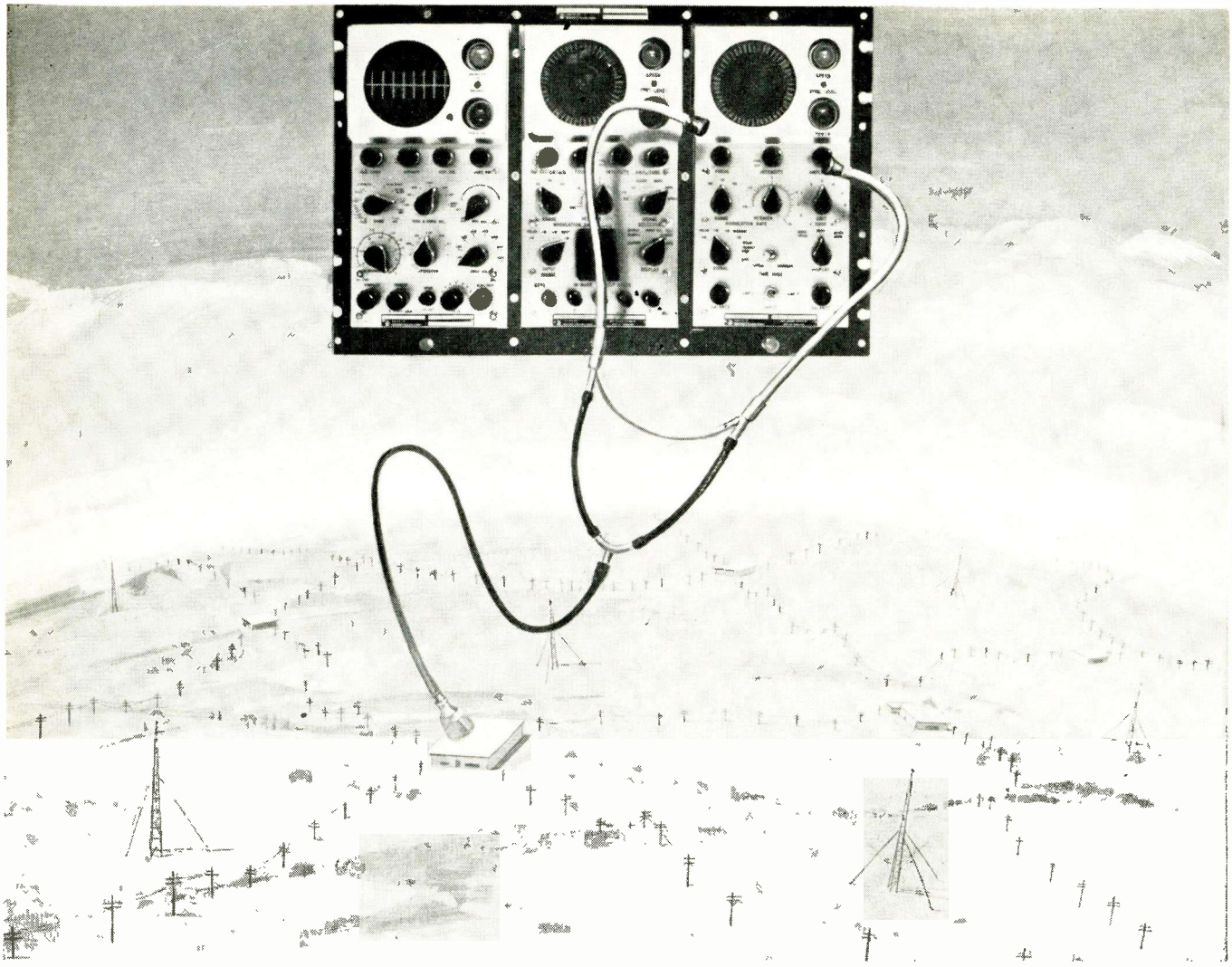

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Services Adopt Interference Standard

Symposium hears Defense plan for center to analyze r-f interference

WASHINGTON—ADVANCES in the battle with r-f interference were discussed here recently at the meeting of the second National IRE Symposium on Radio-Frequency Interference. Keynote speaker Henry Randall of the Office of Scientific Development disclosed Department of Defense plans to speed up prediction and measurement of unwanted noise in the spectrum.

Big step forward is a new military standard, "Measurement of Radio Frequency Spectrum Characteristics" (Mil-Std-449), now mandatory. It marks the first time that all three military services have agreed on such a joint standard. The purpose is to provide standard techniques for the measurement of spectrum characteristics of military electronic equipment in order to ensure the full usefulness of the data. It will be valuable, Randall said, in determining whether subsystems and systems will be compatible with their electromagnetic environments.

The new standard is not intended to provide measurement specs for near-field or conducted interference; it is strictly for measurements in the far field. The publication lists testing procedures and techniques for both transmitters and receivers. Major deviation from individual service specs is the requirement that receiver sensitivity be tested and evaluated in terms of power rather than voltage.

Plans now in the works at the Defense Department, Randall said, may see the establishment of an analysis center to use the data gathered from various sources. It will serve operational planners, those who assign frequencies, the development engineers, and users of interference-prediction information.

Of special interest to engineers from government and industry attending the Symposium was a roundtable discussion of standards and specifications. Inconsistences, ambiguities and loopholes in the military specs and Federal Communications Commission regulations were aired. Moderator Arthur Loughren of Airborne Instruments Laboratory called r-f interference one of the least understood problems today. Albert R. Kall of ARK Engineering contended that military specs provide far more stringent controls on radiated and conducted interference than on receiver susceptibility, suggested that the industry needs more accurate susceptibility tests for receivers.

Kall also suggested establishment of three categories of compliance: absolute compliance, where radiated and conducted interference are either not detectable above ambient or else remain more than 3db below specification limits; absolute noncompliance, where most of the measured values exceed specification limits and at least one measured parameter is greater than 6db above limits; and transitional compliance, where most of the measured data lie below the curve of limits, but fewer than half the readings approach or exceed the limits curve by no more than 3db. The three categories, he said, could be refined to cover all possibilities.

Kall also charged that FCC regulations are too general and do not make necessary distinction between narrow- and broad-band equipment. FCC's Edward W. Allen pointed out that the Commission's rules must be general in order to represent the needs of thousands of users with conflicting interests. The reason for putting emphasis on transmitter controls, Allen suggests, is that the law has been interpreted to mean that FCC can control only transmission, and has no jurisdiction over manufacturers.

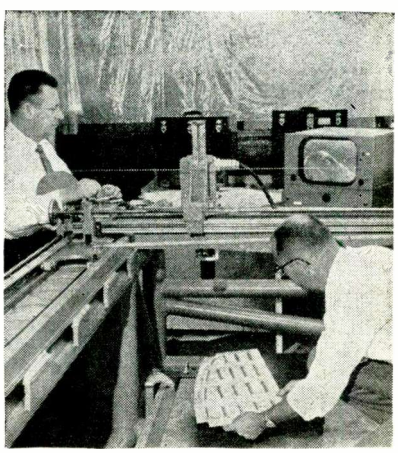
Another paper, by Herbert M. Sachs of Armour Research Foundation, discussed determining radar performance characteristics as related to the prediction of radar interference. Information contained in the paper was developed from a program for establishing techniques of measurement for radar system parameters, and cataloging pertinent radar characteristics in a form accessible for interference prediction. Radar systems under analysis were pulsed search systems; measurements were performed over the frequency range 900 Mc to 10 Gc.

An interference-prediction model was described by Delmer C. Parts and Kenneth G. Heisler Jr. of Jansky & Bailey. Prediction techniques were confined to "discrete source interference," defined as a type brought about by specific identifiable sources of electromagnetic radiation from which one can trace definite propagation paths to the point of interference.

Digital-computer simulation program for the prediction of shipboard interference was described by Wilbur G. James of American Machinery & Foundry. The computer program is designed to predict the signal environment in the vicinity of each receiver under consideration and the response of each receiver to its environment.

Symposium was sponsored by the IRE's Professional Group on Radio-Frequency Interference. Sponsors plan to make it an annual meeting, figure that with recent increases in transmitter power, antenna gain, receiver sensitivity and number of r-f sources in operation, problems of interference have reached "ominous proportions."

Tv Inspects Parts



KinTel closed-circuit tv makes dimensional checks on aircraft components at Convair-San Diego

Nuclear Society Ponders Controls

Members discuss new instrument systems, computer techniques; full control years away

CHICAGO—CONSENSUS OF MEMBERS of the American Nuclear Society, which met here recently, is that completely automatic nuclear power systems are still far in the future. New instrument systems are being developed, and novel techniques for computer use are coming to the fore. But economic considerations currently block complete instrumentation of a working reactor core and put off for the present the concept of computer-controlled reactors.

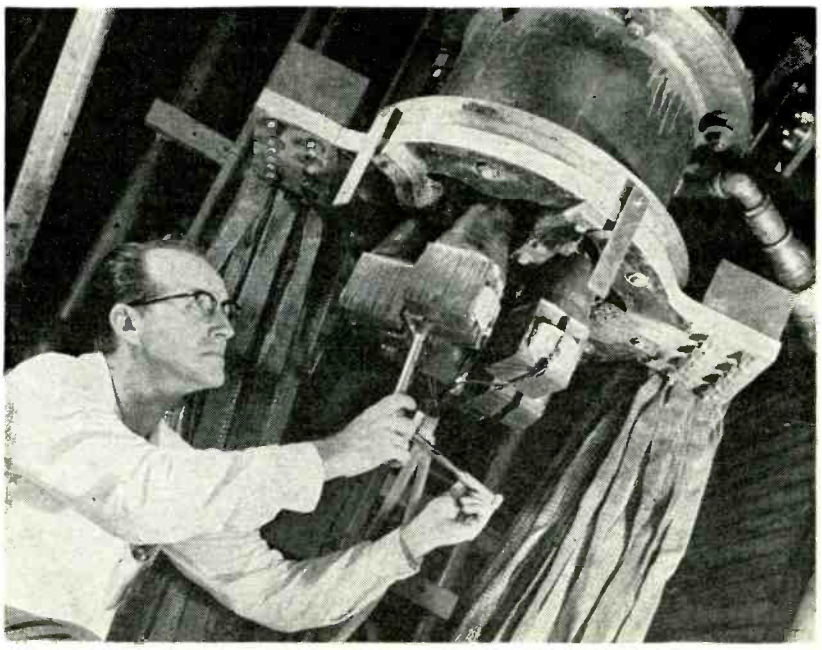
A reactor core designed for a certain job, for instance, may produce maximum practicable power. If several temperature-sensing devices are put into the core, thermal and nuclear anomalies are produced which change operating characteristics, requiring that the core be redesigned. Reactor core design, never an easy job, becomes increasingly difficult as more instrumentation is added.

Discussion sessions on computers disclosed that it may not be any more feasible to run a nuclear power system by computer than it is for a conventional power station. Sessions dealt largely with plans for computer use and with new advances in programming. Automatic coding and compiling systems such as Fortran II for IBM and Philco Transac systems, and Flame for Remington Rand Univac's Larc, were widely discussed. Navy's David Taylor Model Basin will get a Larc system next year and put it to work designing naval propulsion reactors.

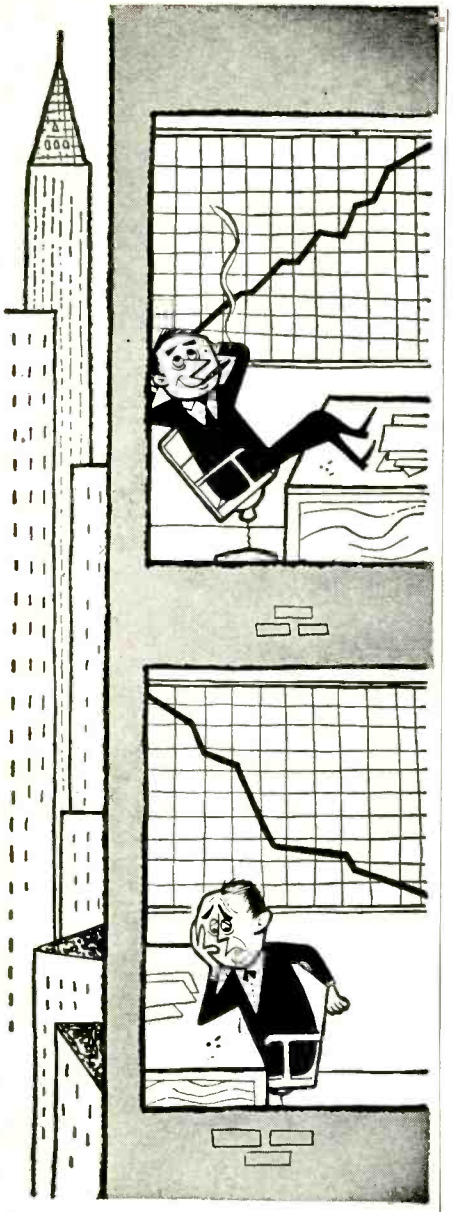
Another paper at the meeting described a device which simplifies the identification of metals. The instrument was described by R. A. Nance, J. W. Allen, and F. M. Glass, all of Oak Ridge National Laboratories. It uses the conductivity and permeability of the metals as identifying parameters.

A pickup coil is placed against the unknown metal, and the user adjusts a dial until the meter on the instrument deflects full scale. The coil is the inductive element in a tank circuit; when placed against

Ultrasonic Unit Added to Arc Furnace



Grain refining unit goes on arc-melting furnace at Westinghouse metals plant. The combination improves properties and yield of metals



WHO'S MAKING OUT BEST?

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electronics

a metal specimen, its impedance shifts and causes a shift in the oscillator frequency.

Adjusting the dial in effect measures the amount of frequency shift, giving a measure of conductivity and permeability characteristics of the unknown metal. Dial setting required for full-scale deflection is unique to many metals and alloys: phosphor bronze, for instance, requires a reading of 854; type 316 stainless steel, 712; hastelloy B, 661.

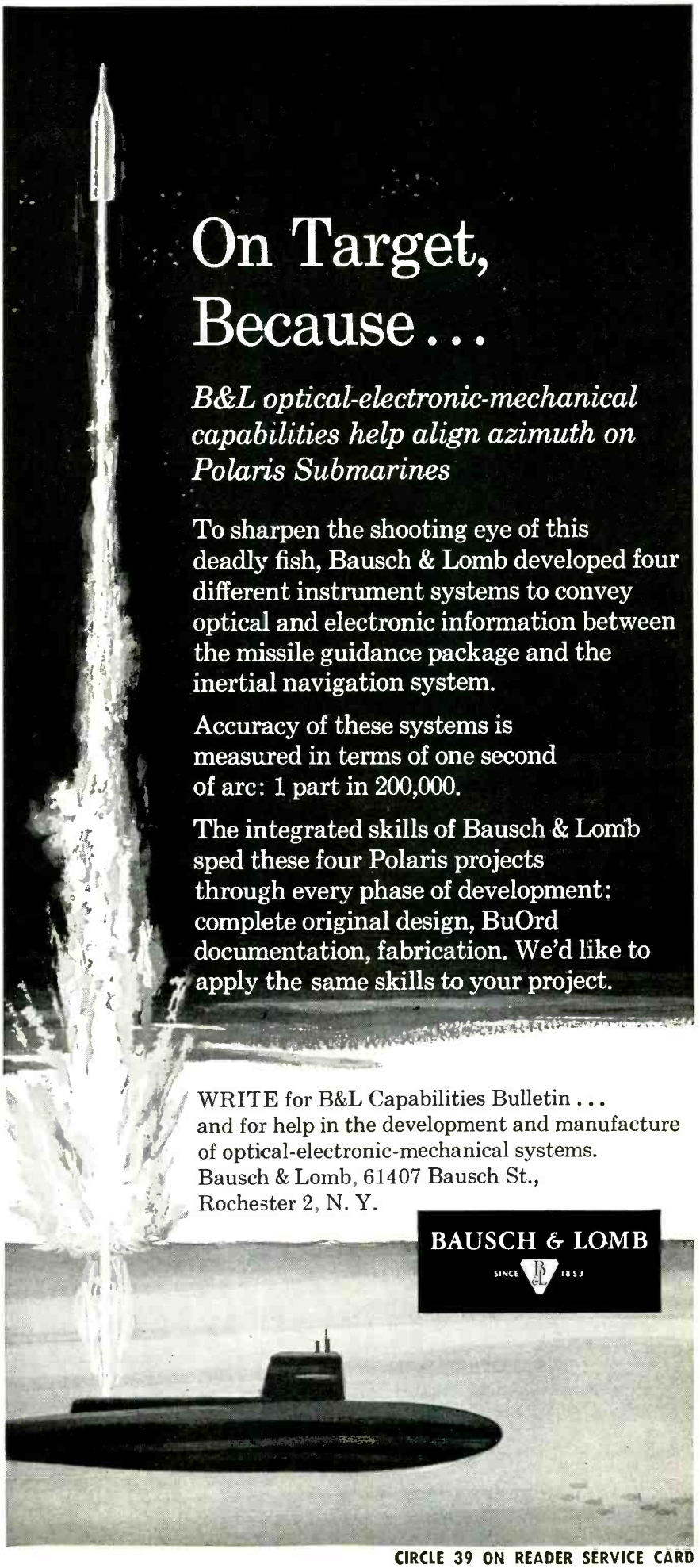
R. E. Nather, of General Atomics division of General Dynamics, described a means for converting multichannel pulse-height analyzers into time analyzers. Nather's device is an all-transistor attachment to pulse-height analyzers which have magnetic-core memories. The attachment is basically digital in nature, and makes direct use of the arithmetic, storage, display, and output circuitry of the pulse-height analyzer, obviating the necessity of converting time information into amplitude form.

Time-channel widths of 16, 32, 64, 128, 256, and 512 microseconds are provided, with an average dead time (assuming random arrival of input signals) of 8 microseconds. A zero-time, or "shutter," signal is used to start operation; random signals are stored in the proper time channel as they arrive.

Internal timing is provided by a crystal oscillator. Basic clock frequency of 1 Mc is divided by 16 or more (depending on the channel width chosen) which provides a maximum time jitter of 1/16 of a channel if the shutter pulses are not synchronized with the oscillator phase.

When compared with a secondary frequency standard, the oscillator gave an apparent frequency of 1,000,015 cps at 23 C, 1,000,012 cps at 45 C.

Only one input pulse can be accepted for each 16-microsecond interval, which means, for example, a maximum of four signals per scan can be accepted by a channel 64 microseconds wide. No channel overlap or gaps have been found in the device. The instrument is designed in modules, contains all solid-state components; it has been in service since February, 1959.



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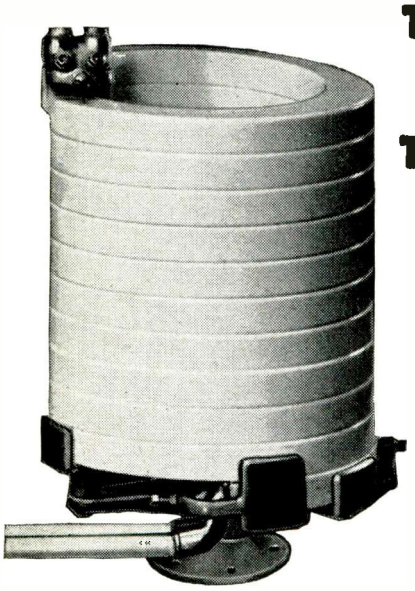

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WRITE for Bulletin 301 containing complete description and specification data. Lapp Insulator Co., Inc., 168 Sumner Street, Le Roy, New York.

Lapp

MEETINGS AHEAD

July 20-22: Forestry, Conservation Communications Assn., Annual Conf., Hotel Duluth, Duluth, Minn.

July 21-27: Medical Electronics, International Conf., Inst. of Electrical Engineers, Olympia, London.

Aug. 1-3: Global Communications Symposium, PGCS of IRE, U. S. Sig. Corps., Statler-Hilton Hotel, Wash., D. C.

Aug. 8-11: American Astronautical Society, Western National, Olympic Hotel, Seattle, Wash.

Aug. 9-12: American Institute of Electrical Engineers, Pacific General, San Diego, Calif.

Aug. 15-19: High-Speed Photography, Stroboscopic Laboratory, MIT, Cambridge, Mass.

Aug. 18-19: Electronic Circuit Packaging Symposium, Univ. of Colorado, Boulder, Colo.

Aug. 22: Scientific Apparatus Makers Assoc., Market Managers, SAMA, Statler-Hilton Hotel, San Francisco.

Aug. 22-26: Thermonuclear Plasma Physics, Symposium, Oak Ridge, U. S. Atomic Energy Commission, Gallinburg, Tenn.

Aug. 23-26: Western Electronic Show and Convention, WESCON, Memorial Sports Arena, Los Angeles.

Aug. 29-31: Metallurgy of Elemental and Compound Semiconductors, AIME, Statler Hotel, Boston.

Sept. 7-9: Automatic Control, Joint Conf., ASME, IRE, AIEE, ISA, Massachusetts Institute of Technology, Cambridge, Mass.

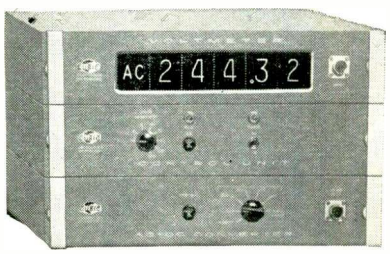
Sept. 9-10: Communications: Tomorrow's Techniques—A Survey, IRE, Roosevelt Hotel, Cedar Rapids, Ia.

Oct. 10-12: National Electronics Conf., Hotel Sherman, Chicago.

ELECTRONICALLY speaking.....

CUBIC DIGITAL SYSTEMS

speak for themselves:



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DC VOLTAGE MEASUREMENT: Models V41, V51, with Control Unit C-1

AC VOLTAGE MEASUREMENT: Models AC-1 (manual ranging), AC-2 (Automatic) AC Converters

RESISTANCE MEASUREMENT: Models 0-41, 0-51 4 and 5-digit Ohmmeters, with Control Unit C-2

VOLTAGE RATIO MEASUREMENT: Models R-41, R-51 Ratiometers, Models VR-41, VR-51 Volt-Ratiometers

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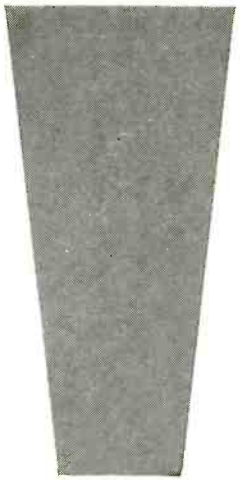

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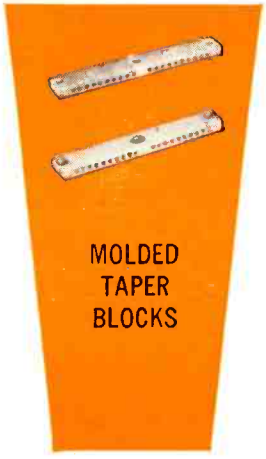

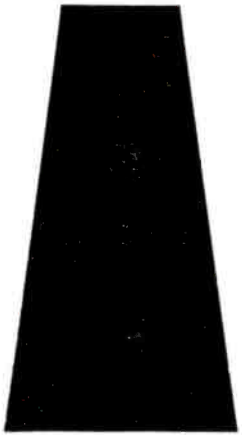

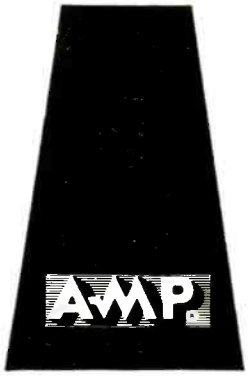

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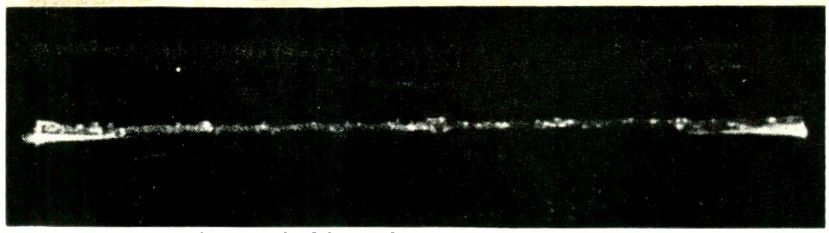
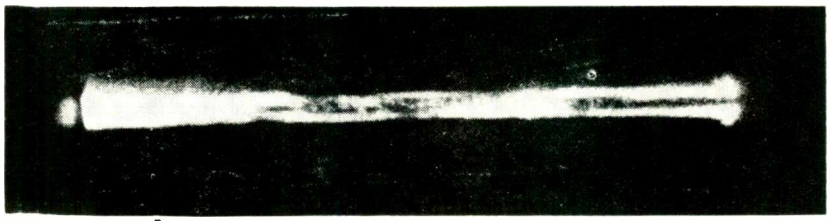
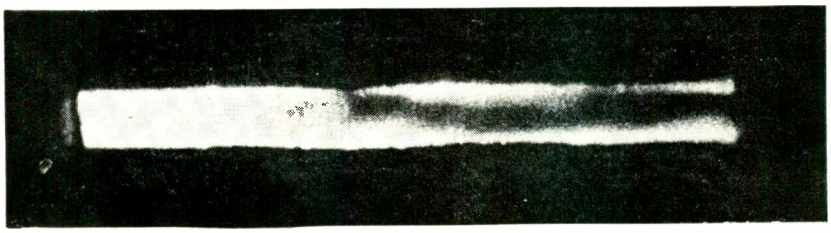


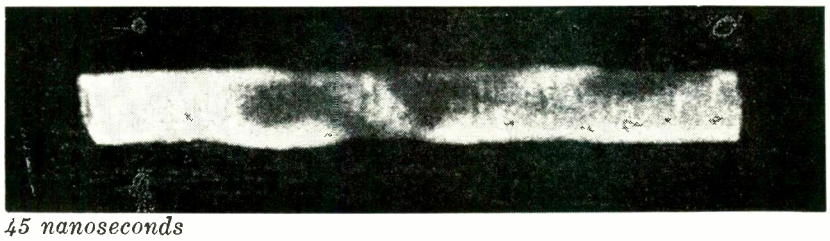
3 nanoseconds after switching of current



8 nanoseconds



32 nanoseconds



45 nanoseconds

From top to bottom, exploding aluminum wire 1 mil in diameter, 3/16 inch long and charged with 23.5 Kv. Camera exposure: 5 nanoseconds

Instrumentation for

EXPLODING WIRE RESEARCH

Electrical explosion of 1-mil wire yields high current density, pressure and temperature. Kerr cell camera photographs exploding aluminum wire

By NORMAN CHASE, NORBERT HANKIN and FRANCIS WEBB,
Electro-Optical Systems, Inc., Pasadena, California

ULTRA-HIGH-SPEED ELECTRICAL explosions of fine metallic wires, clusters or films may be applicable in space propulsion, optical radar, hypervelocity particle impact research, light sources for photochemical reactors and explosive detonators.

Current laboratory research indicates that 1,000-second specific impulses can be obtained in the explosion of clusters of metallic wires or thin films. A high degree of efficiency appears possible, thus making this an interesting possibility as a propulsive system for space vehicles. (Optimum wire size will depend upon vehicle and mission requirements.) To obtain such an impulse in a 1-mil wire requires a current density rise greater than 10^{16} amp/sec/cm^2.

Use of exploding wire phenomena in optical radar is another potential application. It now appears that brightness temperatures above the range of 50,000 C are readily obtainable. This would provide a light source far brighter than a carbon arc, and is competitive with or better than high pressure gas discharges or air spark gaps.

Exploding wires may also provide an answer to the problem of obtaining hypervelocities on a laboratory scale for high-speed impact

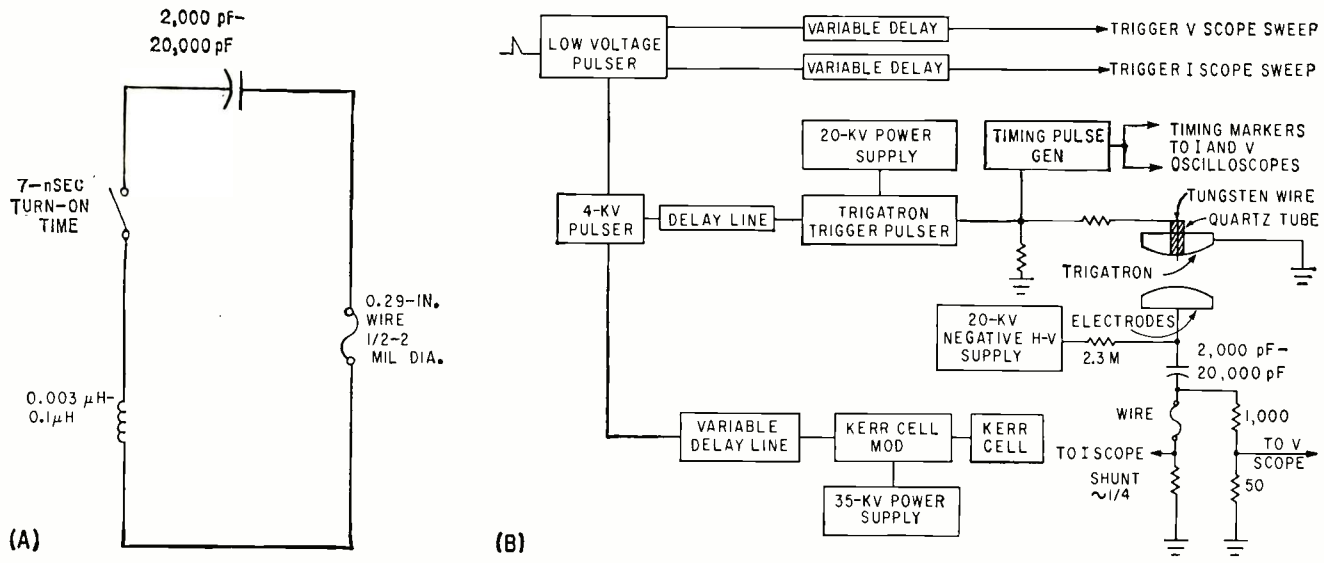


FIG. 1—Basic exploding wire circuit (A) uses switch with 7-nanosecond turn-on time; experimental test circuit (B) includes two traveling-wave oscilloscopes and Kerr cell camera. (See the front cover)

studies. Dense vapor or plasma produced by exploded wires possess impact characteristics similar to solid materials and could be accelerated to 20 to 30 km/sec.

A wire is suddenly exploded electrically by discharging a stored energy source such as a capacitor into it. The entire phenomenon is usually complete in much less than a microsecond.

For a single exploding wire, the voltage across the wire and the current flowing through it are simultaneously recorded as functions of time on two traveling-wave oscilloscopes. Single-frame photographs of the exploding wire in known time synchronism are also obtained by actuating a Kerr cell shutter.

The timing and energy input are highly reproducible, so that a timed series of single-frame photographs of separate wires can be put together to make a movie of the explosion. The products from the exploding wire are typically luminous, and it is possible to follow the expansion rate and other visible characteristics of the exploding wire.

The basic exploding wire circuit is shown in Fig. 1A and an experimental setup in Fig. 1B. The setup employs two traveling-wave oscilloscopes (with frequency response to 2,000 Mc), a Kerr cell camera with a 5-nanosecond exposure time, a time marker pulse generator, wire exploding circuit with voltage and current sensors, and auxiliary apparatus.

Sequence of operation is as follows. A triggering pulse activates a low-voltage pulser whose output pulse is split, with part simultaneously triggering the oscilloscopes after the appropriate time delays, and also activating a high-voltage pulser. The high-voltage pulser in turn activates the wire exploding circuit and the Kerr cell modulator after appropriate time delays. A pulse, taken from the wire exploding circuit with appropriate attenuation is applied to the vertical deflection of the I (current) and V (voltage) scopes, serves as a timing marker, allowing a time correlation to be made between the current and voltage measurements. Pulses from the current and voltage sensors are recorded on the I and V scopes respectively.

The Kerr cell modulator charges a delay line to 35 Kv which is actuated and discharged into the KSC-50 Kerr cell shutter at the appropriate time during the wire explosion. The voltage pulse to the Kerr cell is sensed with a resistive voltage divider placed between ground and the input to the Kerr cell then attenuated and applied to the scope. This provides the exact timing of the Kerr cell wire picture with respect to the voltage and current measurements. After the wire explosion, in another sweep, a 100-Mc sine wave is placed on the oscilloscopes for a time base.

The wire exploding circuit consists of a capacitor, switch, wire holder and wire, and current and voltage sensors. These components are housed almost completely coaxially and have a low inductance. The capacitor itself has a low inductance.

The switch is a triggerable air spark gap (or trigatron); it is operated by placing a negative high voltage across two electrodes, whose surfaces have a 3-inch radius of curvature, and then suddenly applying a high-voltage positive pulse to a tungsten wire placed in the center of the grounded conductor and insulated from it by a quartz tube. The high-voltage pulse causes a breakdown to occur between the tungsten wire and the ground electrode, which then causes a discharge between the ground and high voltage electrodes. The rise time of this switch is typically 7×10^{-9} second. The potential difference between the ground and high voltage electrode is originally placed at approximately 95 percent of that required to break down the air gap. The adjustment of the spacing between these two electrodes is critical.

A resistive, high-voltage, high-frequency current shunt is shown in Fig. 2. It is composed of 40, 10-ohm, ½-watt carbon resistors mounted circumferentially between two copper plates yielding a shunt resistance of ¼ ohm. The lower end of the wire holder is mounted into the top plate of the current shunt. The lower plate of the current shunt is circuit ground. The ground return conductor is placed coaxially around and very close to the shunt resistors, permitting large conductor diameters and very small shunt

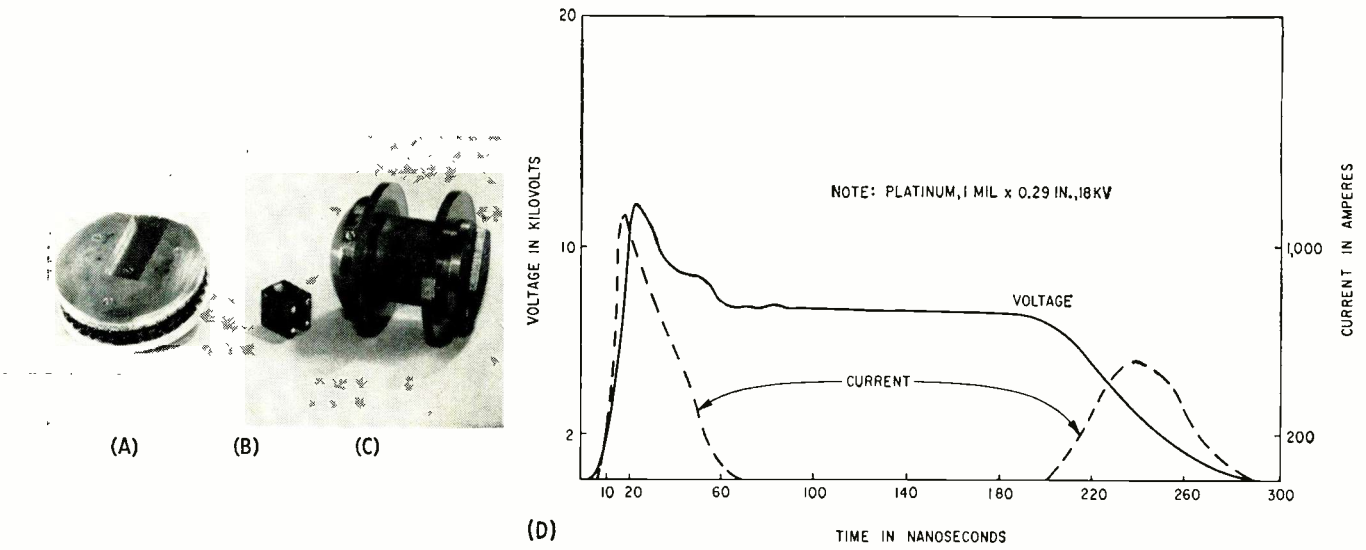


FIG. 2—Trigatron shunt (less coaxial return conductor) is shown in (A), trigatron wire holders in (B); trigatron energy storage unit (C). Current and voltage for an exploded platinum wire are indicated in (D)

inductance. The frequency response of this shunt is probably close to 1,000 Mc.

Certain basic requirements can be established for the circuit components of exploding wire apparatus for use in the submicrosecond range. First, the capacitor should be able to store many times the energy required to vaporize the wire, and have a low inductance.

Second, to dump the energy rapidly into the wire requires circuit inductances of a small fraction of a microhenry. Third, the switch must be capable of closing in a small fraction of the circuit period. A switching time of a few nanoseconds is desirable. Also, the sensing instrumentation must not unduly influence the phenomena being observed.

Typical values of the circuit parameters employed in our work are: capacity of approximately 2,000 to 20,000 pf, circuit inductances of about 0.03 to 0.1 μh, charging voltages from 10 to 20 Kv, $\frac{1}{2}$- to 2-mil wire approximately $\frac{1}{4}$ inch long, and triggerable switches with rise times of approximately 7×10^{-9} second.

The technique of measuring voltages across the wire of the order of 20 Kv with rise times of the order of several nanoseconds has been developed to the point where these measurements are accurate to about 5 percent. A similar statement applies to the measurement of current through the wire. The currents have an order of magnitude of 10,000 amperes, and a rise time of several nanoseconds. This technique has permitted determining wire energy input and resistance as functions of time.

The wire current is determined by measuring the voltage across the known shunt resistance. The voltage across the shunt is sensed on the shunt axis, attenuated and displayed on the I scope. The voltage across both the wire and shunt is sensed on the V scope and the shunt component subtracted. Because both current and voltage are measured and it is necessary to maintain an appropriate ground, the voltage must be measured in this way.

The voltage sensor is a resistive divider placed across the wire and shunt. The divider consists of ten 100-ohm, 2-watt resistors connected in series, terminated at the divider by a 50-ohm resistor in parallel with a 50-ohm terminated cable going to the V scope. The divider ratio is then 40:1. The frequency response of the divider is better than 500 Mc. Additional attenuation is used and the signal is then displayed on the V scope.

When wires are exploded in this experimental setup, they heat rapidly and vaporize with explosive force. Current begins to flow with the initial switching of the voltage across the wire, but is gradually halted by the increasing wire resistance. Initially the voltage drop across the wires is predominantly inductive, but with the increasing resistance it soon becomes predominantly resistive.

Usually not all of the charge initially on the capacitor has left it by the time vaporization occurs, so that a high voltage (many Kv) remains across the gap. The initial conduction phase is followed by a period of low current conduction which is called current dwell. Current dwell is followed by a phase of resurgence of current flow called post-dwell conduction which presumably occurs when the pressure of the metallic vapor is reduced to a sufficiently low level to permit an arc-type discharge to restrike across the gap. If all the charge is removed from the capacitor in the initial conduction stage, however, no post-dwell conduction phase occurs. The current and voltage as functions of time for an exploded platinum wire are shown in Fig. 2D.

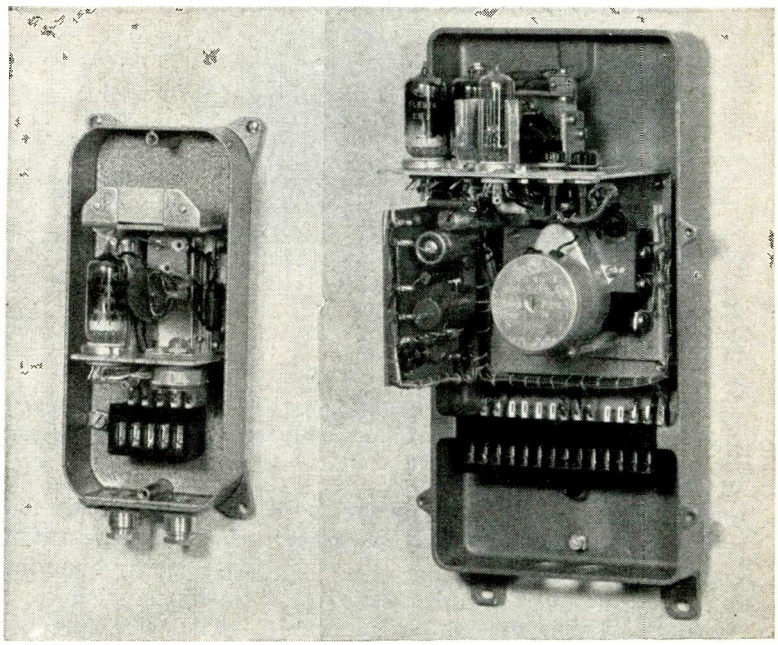
High energy densities can be placed in the wire during the initial conduction period. A typical value of the energy density obtained in an aluminum wire 1 mil in diameter and 0.29 inch long at 18.3 Kv is 11 electron volts per atom (corresponding to an energy input of about 400 millijoules.) These energy densities result in such characteristic exploding wire phenomena as emission of intense light, generation of strong shock waves and magnetic fields, high current densities (typically 4×10^8 amp/cm^2), pressures, temperatures and plasma density regions.

This work is supported by contract with U. S. Army Ordnance Corps, Picatinny Arsenal.

Photoelectric Control

Merits of photoconductive cells and photoemissive vacuum tubes are discussed and contrasted. Two control circuits use both types of light sensing elements

By P. BERGWEGER,
Elesta AG, Bad Ragaz, Switzerland



Smaller control box on left uses photoconductive cell and is operated from an a-c supply. Precision control on right uses photoemissive vacuum tube and requires d-c supply

NUMEROUS circuits and designs of automatic light controls have been published whose usefulness is essentially a question of reliability; that is, they must all have long and trouble free operating life, they must be insensitive towards voltage surges, and, to carry out the function for which they were designed, the controls must offer high stability even under adverse operating conditions.

The crucial elements of such controls are of course the light sensitive element and the associated amplifier. Two basic circuits satisfying the above requirements will be described and some applications discussed. One of the circuits employs a high-vacuum photocell and d-c cold-cathode-tube amplifier to provide a high degree of accuracy and stability, whereas the second combination uses a photoconductive cell and a-c cold-cathode-tube amplifier where switching requirements are less stringent.

Experience shows that the best light sensitive elements are vacuum phototubes and some photoconductive cells. Vacuum phototubes offer a very high degree of stability and long life expectancy, provided they are operated at sufficiently low currents. Cadmium sulfide and cadmium selenide photoconductive cells on the other hand belong to the most sensitive group of photo elements. Typically, the sensitivity of these cells is about 1 million times greater than that of photoemissive tubes.

Several years of experience with large numbers of photoconductive cells have shown that the hermetically sealed types can be used for a large number of lighting control applications, even though they do not quite reach the stability levels of high vacuum cells. Furthermore, the high sensitivity of these photoconductive cells enables them to actuate relays directly, whereas the vacuum phototubes must always be followed by an amplifier before they can operate a relay. However, when photocells are used to operate a relay directly —without an amplifier—they must be protected against overheating.

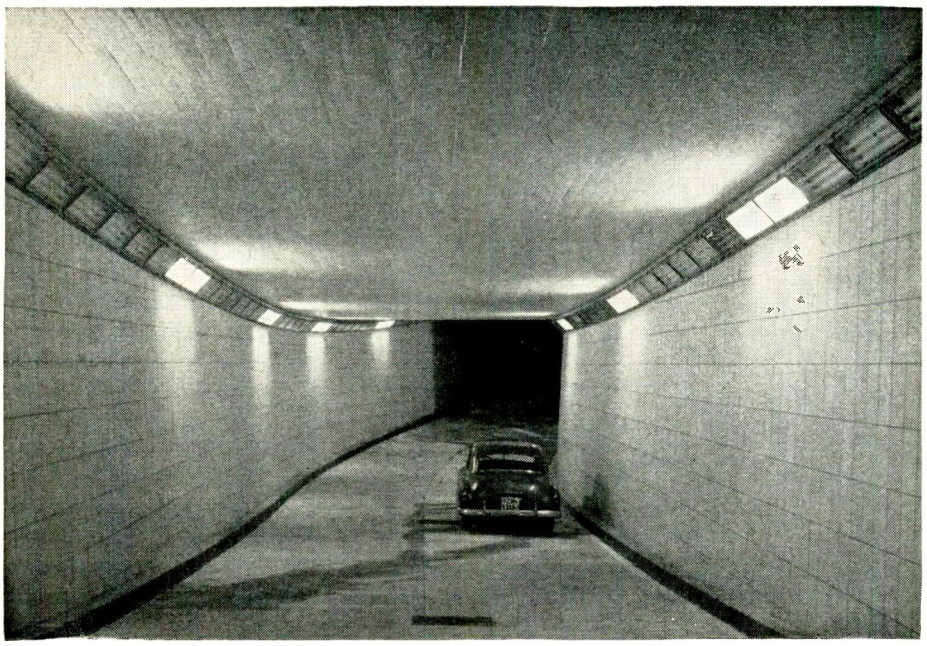
Photoelectric light controls often have to sense the difference between night and day; moreover, they must operate at a given level of dust and switch off again when daylight is partially restored. Since this ambient level of illumination changes very slowly, such controls incorporate a special delay circuit which prevents triggering by fluctuations in ambient illumination, as might be caused by automobile headlights or lightning, for example. With this added complication, it is easier to use a miniature photoconductive cell that operates a delay relay through an amplifier stage.

Cold Cathode Tubes with pure metal cathodes offer a number of exclusive features for illumination control applications.

Such tubes are on-off devices with normally three main electrodes but no heater. Absence of heater eliminates stand-by power and warm-up difficulties and so removes a source of potential trouble. The anode cathode gap can be triggered by extremely low starter-electrode currents, which may, with capacity control, be as low as 10^{-6} amp for a-c tubes and 10^{-9} amp for d-c operated tubes.

The anode current is normally about 15 to 30 ma, thus being high enough to control robust industrial relays. The extremely low starter current with d-c operation permits use of much higher load resistors in connection with photocells than

Using Cold Cathode Amplifiers



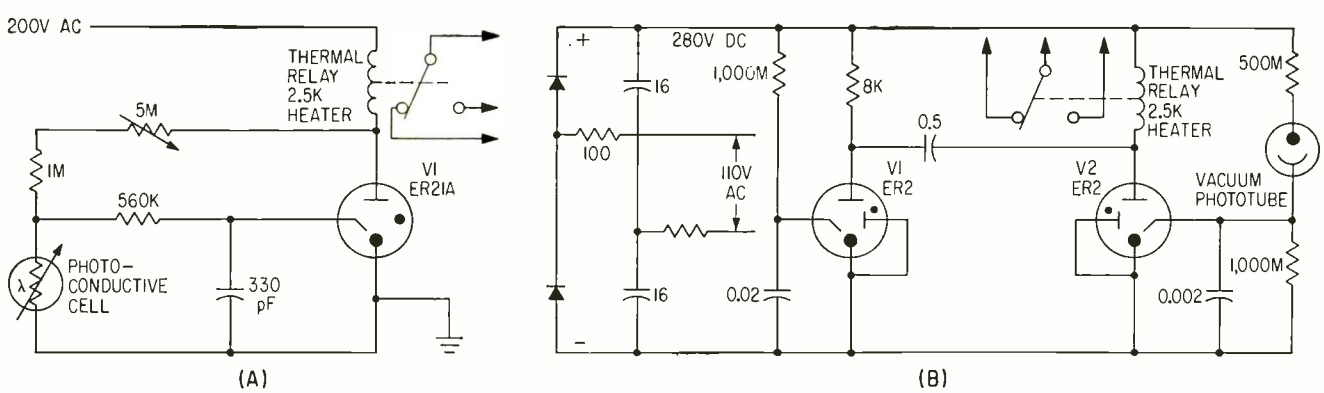
Automatic light control continuously adjusts tunnel illumination so that it equals the ambient light outside, thereby preventing automobile drivers from being temporarily blinded

in any vacuum tube or transistor amplifier. Further advantages are an extremely long service life (exceeding 50,000 hours in a control application having a 50 percent duty cycle) with a high constancy of electrical characteristics, and insensitivity towards temperatures up to 80 degrees C.

Figure (A) shows the circuit of a simple automatic light control with photoconductive cell and cold cathode tube for a-c operation. The voltage at the starter electrode of cold cathode tube V_1 is determined by the voltage dividing resistors in series with the photoconductive cell. At dusk the cell resistance increases till the starter breakdown voltage is reached, thereby switching the tube on. In the tube's anode circuit is a temperature compensated thermal relay consisting of a bimetal operated micro switch, which prevents the control from reacting to short fluctuations of the ambient illumination. The cold cathode tube, operating on a-c, is triggered by the starter electrode during each positive half cycle, until at dawn, the illumination increases and reduces the output of the photoconductive cell below the triggering level of the cold cathode tube.

As mentioned before, d-c cold cathode tubes give an extremely high d-c amplification. Vacuum phototubes may typically be operated at emission currents of 10^{-7} amp, giving them a practically unlimited and stable service life.

With d-c operation, a conducting cold cathode tube can only be switched off by interrupting or lowering its anode voltage, therefore for on-off devices, two tubes are often used in multivibrator circuits. Figure (B) shows such an arrangement for an automatic light control. With the blue-sensitive phototube not sufficiently illuminated, a stable condition exists with V_1 conducting. The thermal relay is not heated, the lights being switched on by its normally closed contacts. Increased illumination raises the voltage at the starter grid of V_2 and the multivibrator becomes astable or free running. The mark-space periods of the cold cathode multivibrator are chosen in such a way that V_2 is on most of the time, being switched off only for very short intervals. The thermal relay gets heated sufficiently to switch off the lights, and serves the dual purpose of bridging the off periods of the multivibrator and preventing the control from reacting to short fluctuations of the ambient light. High switching accuracy without voltage stabilization is possible because the phototube is a saturating element.



Simpler of the two control schemes uses photoconductive cell to sense light changes (A); photoemissive vacuum tube provides greater precision in light sensing, and is followed by a multivibrator-type d-c amplifier (B)

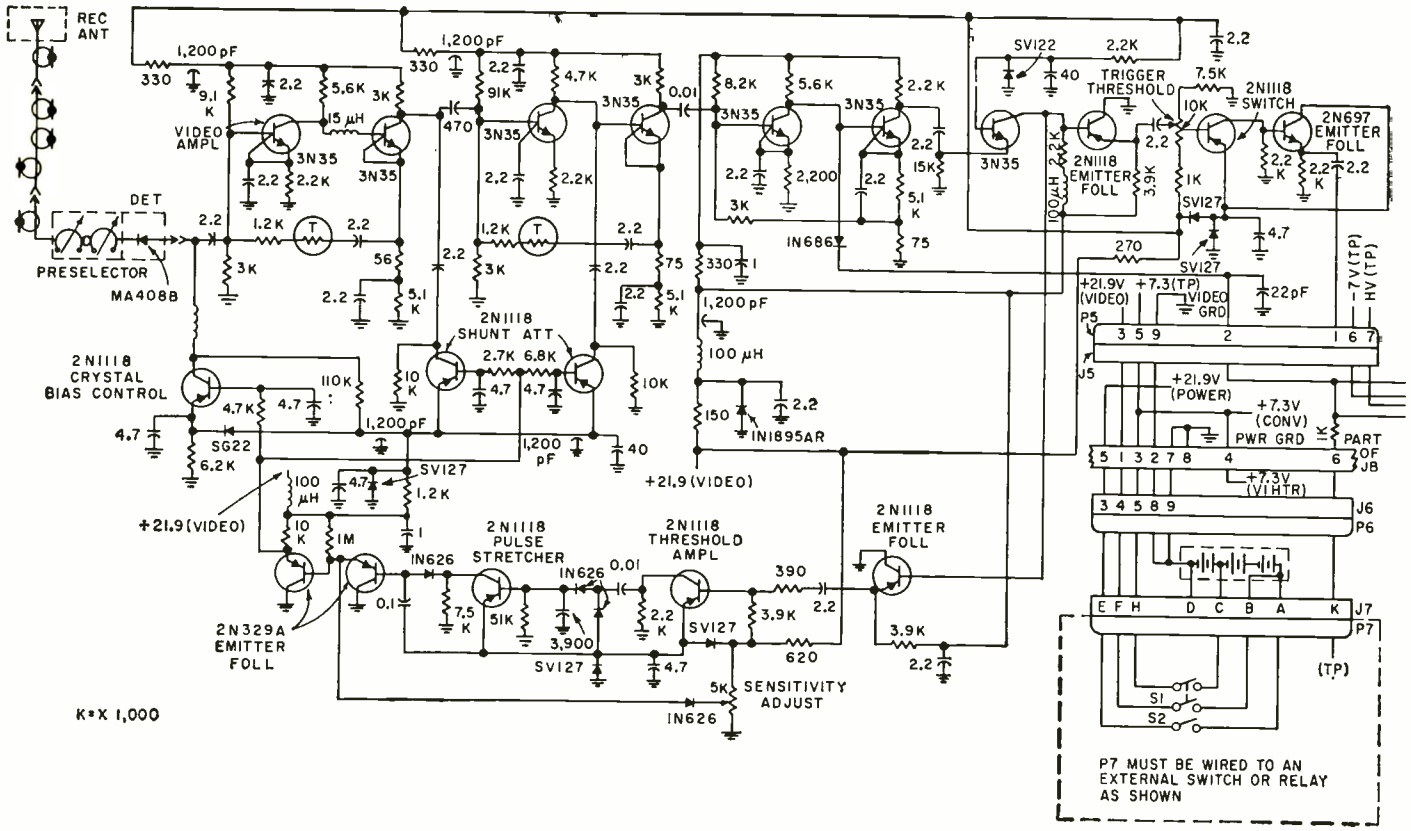


FIG. 1—Complete schematic of the subminiature transponder. Unusual features are the semiconductor modulator and

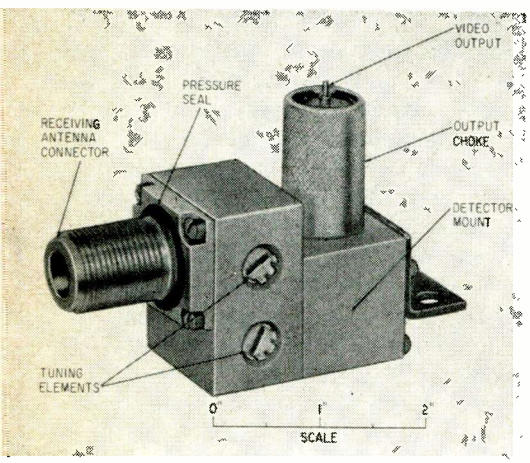


FIG. 2—Preselector and detector mount are an integral unit

Solid-State Modulator

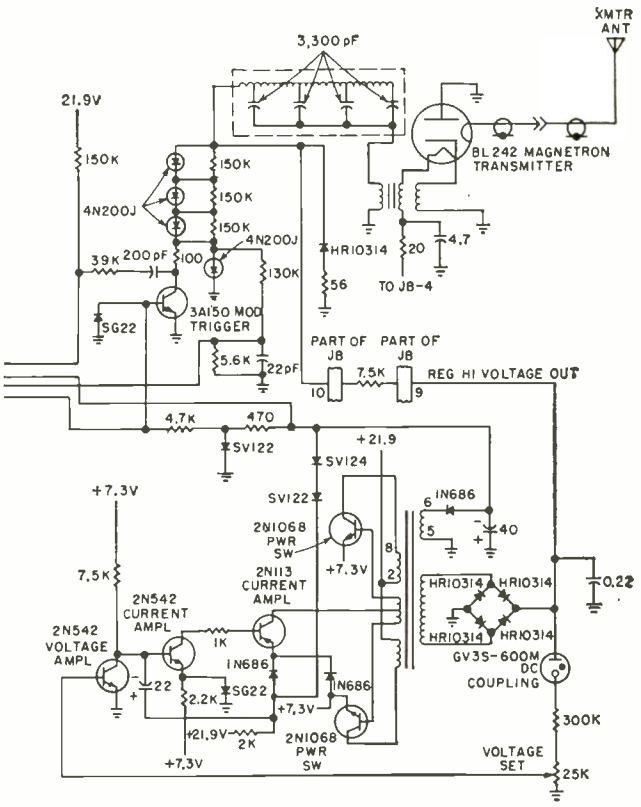
Transponder features a semiconductor modulator whose fast switching time results in an r-f output pulse with extremely fast rise and fall times. Delay stability provides a range accuracy of one yard over a wide range of interrogation signal levels

By LISCUM DIVEN,
Section Head, Transponder Section, Motorola Inc., Scottsdale, Arizona

FOR MISSILE TEST firings, one or two radar transponders may be used for tracking. Such range instrumentation, however, does not usually form part of the electronics system of the tactical missile. For this reason, the transponder should be completely self-contained, including primary power supply; furthermore, as with all missile-borne electronic equipment, it should be small and light. Temperature rise in the transponder is a significant factor and must be guarded against; accordingly, power dissipation within its envelope must be reduced as much as possible.

Significant contributions towards the fulfillment of such requirements have come from the development of semiconductor devices, and transistorized video and i-f circuits are becoming commonplace. Until recently, however, the modulator switch required to deliver high peak power to the r-f transmitter has been a stumbling block. Conventionally, either thyratrons or hard tubes have been used, requiring considerable space, plus power for the tube heater. With transistorized circuits, this power may well be a substantial portion of that required for the entire transponder. Thus, there has been a standing requirement for a suitable semiconductor modulator.

Such a modulator has been developed as part of an extremely small, lightweight airborne transponder to be used with the AN/FPS-16 C-Band radar in tracking various short-range missiles and drones. Range tracking error of the transponder had to be kept to one or two yards at the maximum range of 200 miles.



agc in transistorized crystal video receiver

Typical production transponder undergoes final test in laboratory

Feeds Subminiature Transponder

The resultant transponder, bearing the military nomenclature AN/DPN-63, has a sensitivity of —45 dbm and is tunable over a frequency range of 5,400-5,900 megacycles. It is a crystal video type, compact but designed for easy maintenance. Weight without batteries is about 4 pounds; with self-contained batteries, 5 pounds 3 ounces. The transponder will operate for one hour or more from these batteries. The transponder itself is pressure sealed for operation up to 100,000 feet, and meets other missile environmental requirements of temperature, vibration, shock and humidity. Power consumption is 7 to 15 watts, depending on the interrogation rate.

Volume of the AN/DPN-63 alone is 75 cubic inches and with batteries is about 100 cubic inches. The magnetron transmitter is rated at 400 watts peak power and is the only tube in the transponder. Silicon semiconductors are used exclusively. Figure 1 shows the complete schematic of the transponder.

A feature of this transponder is its high delay stability. For an input signal range of 0 to —40 dbm, the change in delay of transponder reply is no greater than ±6 millimicroseconds. An automatic gain control circuit for the transistor video amplifier was developed so that the rise time of the received pulse would not cause delay change, which would be the case without such provisions. For signal inputs of 0 to —45 dbm, the automatic gain control circuit provides a constant amplitude pulse to the modulator with unchanging rise time. Automatic gain control is applied to two stages, and also to the crystal detector.

The antenna feeds a double-tuned preselector cavity and crystal detector. Video amplifier bandwidth has been made 10 Mc to preserve rise times, thus reducing delay variations. The output amplifier feeds both the agc circuitry and an avalanche triode which serves as a modulator trigger. The semiconductor modulator switch drives a Bomac BL-242 magnetron transmitter. High voltage for the modulator is derived from a d-c to d-c converter. Power for the transponder comes from a battery pack of 15 silver-zinc cells.

The preselector prevents crystal burnout by the beacon transmitted pulse and prevents triggering by radars operating at frequencies other than the frequency to which the beacon receiver is tuned.

The preselector and video detector, shown in Fig. 2, are assembled as an integral unit. The preselector is a two-cavity quarter-wave coaxial resonator operating in the fundamental TEM mode.

The two cavities are machined in a brass block with a coupling aperture milled between them. Energy is coupled in and out by loops that are effectively extensions of the input and output coaxial connectors. The input antenna connector is type N pressurized and makes an O-ring pressure seal with the wall of the beacon body. Tuning elements are slotted for screwdriver adjustment and are accessible externally from the beacon. The tuning elements are made of

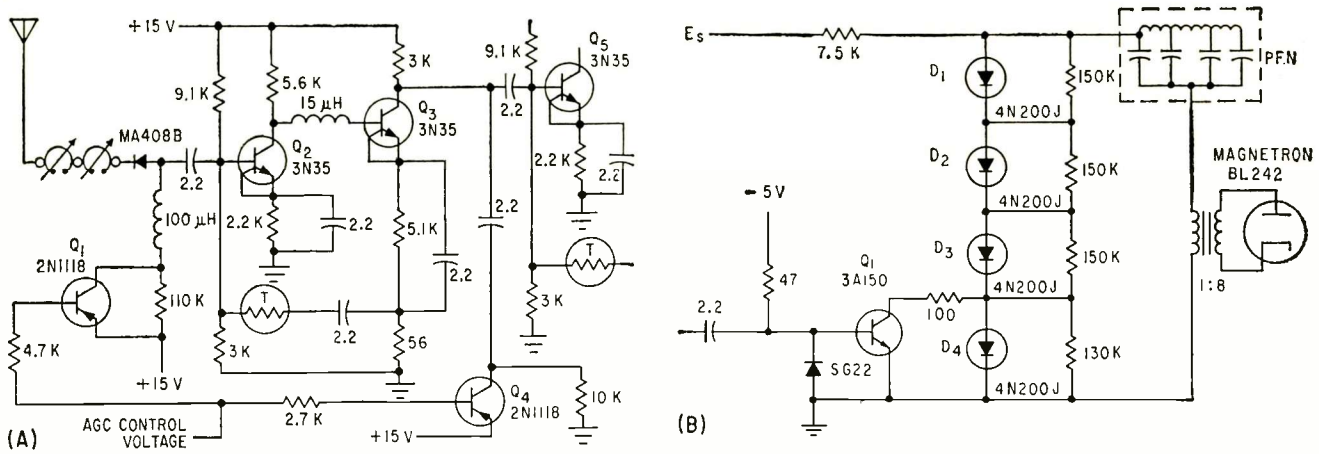


FIG. 3—Enlarged views of typical video and age stages (A), and modulator (B) whose switching action is similar to that of a hydrogen thyratron, but which requires no heater power or warm-up

invar and provide a good frequency stability with temperature.

The video detector crystal requires a nominal bias current of 65 μa. This bias current optimizes sensitivity, lowers both the video and r-f impedance of the crystal, and produces more stable operation with temperature variations. The d-c return for this bias is provided through the output coupling loop of the preselector.

The video amplifier, consisting of 10 transistor stages, provides 98 db of voltage gain. The output pulse has a rise time better than 0.1 μsec. The amplifier operates with essentially constant gain over an ambient temperature range from −55C to +85C.

The first six stages consist of three direct coupled pairs. A typical pair is shown in Fig. 3A. It uses 3N35 tetrode transistors. Direct-current pairs are used to reduce the number of components required, provide bias stability, and minimize overshoot.

High-value emitter resistors set the base operating point and provide d-c stabilization against changes in gain with temperature and source voltage variations. Bandwidth is improved by a 15 μh series peaking coil.

The series feedback path includes a thermistor with a negative temperature coefficient that provides more feedback with increasing temperature to compensate for changes in transistor characteristics with temperature. The lower limit of the video amplifier pass band is set by value of the coupling capacitor in the first pair. This cut-off frequency is kept high to improve s/n ratio, since the main source of transistor noise is inversely proportional to frequency.

Zener diodes, used for voltage stabilization throughout the amplifier, have been chosen such that changes in voltage reference with temperature compensate for the negative temperature coefficients of the base emitter diodes of associated transistors.

The video amplifier output stage is a 2N1118 transistor operated as a saturating switch that drives the modulator trigger stage through an emitter follower.

A blanking pulse, derived from the modulator, disables the receiver during transmission to prevent the transmitter from affecting the age voltage or retriggering the beacon.

Delay stability with change in input r-f signal is accomplished by an age loop applied to the video amplifier.

A signal from the video amplifier output is stretched, rectified and applied as a d-c control current to shunt attenuators across the first two video stages and the detector crystal as well. Attenuator transistor Q_4 (Fig. 3A) forms a portion of a voltage divider network which shunts larger amounts of video signal to ground through the 2.2 μf capacitor with increased age voltage. The d-c operating point of the video pair is not affected, thus ensuring stability of gain and bandwidth with age action.

Increased signal level will also tend to turn transistor Q_4 on, shunting the resistor across it and increasing crystal bias current.

By increasing current from the nominal 65 μa to 4 ma, over 45 db of video attenuation may be obtained. Use of this technique avoids overload and delay change at high signal levels.

Figure 3B shows a schematic of the modulator. It resembles the conventional line-type pulser, with a pulse-forming network (PFN) and a 1:8 pulse transformer driving the magnetron. However, the hydrogen thyratron has been replaced with a semiconductor switch consisting of four Shockley 4N200J four-layer diodes in series, triggered by a type 3A150 avalanche triode connected in parallel with the bottom diode.

The switching action is similar to that of a hydrogen thyratron, but with the advantage that no heater power and warmup is required, dynamic impedance is lower, and recovery time is shorter than with the more conventional thyratron circuit.

The avalanche triode (Q_1) will not conduct unless the voltage across it exceeds 150 volts, or unless the base is triggered with a positive going pulse. For a 10-ampere pulse the four diodes in series have a total voltage drop of 25 volts, that is, a dynamic resistance of 2.5 ohms for the entire switch.

Each of the four diodes has a voltage breakdown rating of approximately 200 volts for a total hold-off condition of 800 volts, well above the 635-volt potential on the PFN. Thus, an external trigger is

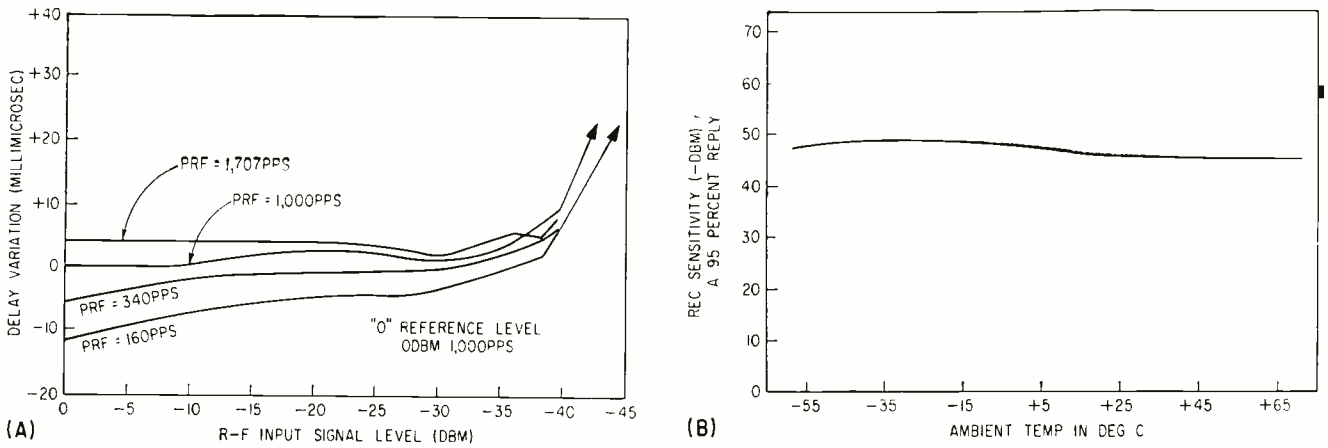


FIG. 4—Delay stability as a function of r-f input signal level for various interrogation rates (A); and receiver sensitivity as a function of temperature (B)

necessary to break these units down to their conducting state. When a video pulse triggers Q_1, it breaks down and brings the bottom of D_4 to ground potential. The 635 volts of the PFN is then applied across the top three series diodes, D_1, D_2, and D_3. This step voltage change is enough to cause avalanche breakdown of these three diodes and as the entire voltage tries to appear across the bottom diode, D_4, it also breaks down. The whole action takes place in less than 0.1 microsecond. Output pulse rise time is deliberately lengthened by the characteristics of the PFN to 0.2 μsec, the minimum permissible for proper firing of the magnetron. Both the modulator switch and the pulse transformer are capable of faster rise times.

Leakage current of the four-layer diode is a function of temperature; as temperature increases, leakage through the four units in series also increases. To stabilize the modulator switch a bleeder network of four resistors shunts the four diodes. The bleeder network conducts currents in the order of 5 to 10 times greater than the leakage currents of the diodes at any temperature. Thus, the voltage across each diode is determined by the bleeder instead of the diode characteristics. Resistance charging of the pulse forming network is used. This consumes more power than inductance charging but is inherently more suitable for minimizing delay variation. With resistance charging, the voltage across the pulse-forming network charges to the same value, independent of leakage currents and pulse repetition frequency (PRF), whereas with inductance charging this voltage is a function of PRF, and leakage. Different potentials on the switch diode at the time of trigger results in delay variations since the avalanche breakdown will commence on different portions of the leading edge of the trigger pulse. Thus, resistance charging is considered superior.

The magnetron and d-c to d-c converter are conventional. A feedback type voltage regulator holds the +635 volts to within ±1 percent from no load to full load and over a temperature range from −55C to +85C.

Figure 4A shows stability of transponder delay as a function of r-f input signal level for various interrogation rates. It will be noted that, for PRF's betweeen 340 and 1,707 pps, for signal levels from zero down to about −38 dbm, delay remains well within ±6 millimicroseconds, a range accuracy of about 1 yard.

Results of temperature compensation are shown in Fig. 4B where receiver sensitivity is plotted against temperature. From −46 dbm at 25C, sensitivity drops only 1 db at the high temperature extreme. A 2 db increase is noted at −25C, dropping slightly to −47.5 dbm at −55C.

The silver-zinc alkaline battery provides almost 90 percent additional capacity over that required for normal operation. Cells can be charged and discharged for at least 10 cycles and can be stored in either charged or discharged condition for about 3 months.

Sensitivity of the receiver remains essentially constant as a function of time, changing from −47 dbm to −46.5 dbm in 67 minutes, dropping to −46 dbm at 74 minutes, at which point battery voltage has begun to fall off. Complete discharge is considered to be at 80 minutes, where the voltage at the tap supplying the magnetron filament has fallen from 7.4 to 5.8.

In the completely assembled transponder, the magnetron is provided with a flange, making possible a pressurized mounting scheme that permits tuning from the outside. Preselector tuning and sensitivity adjustments are also accessible.

Removal of the cover exposes the video amplifier and agc circuitry, which are mounted on an easily removable plug-in tray. The open tray can be seen in the test setup photo. Located below the video tray are the magnetron, modulation transformer, preselector and detector mount, and a compartment which houses the modulator and d-c to d-c converter. This is accessible by removal of a metal plate. The modulator and power supply circuit boards are mounted in a silicone rubber potting compound that can be removed.

The battery case, which is not pressurized, may be easily detached from the transponder. Battery power may be applied to the beacon externally through the external power plug.

Using Off-Balance Bridges for

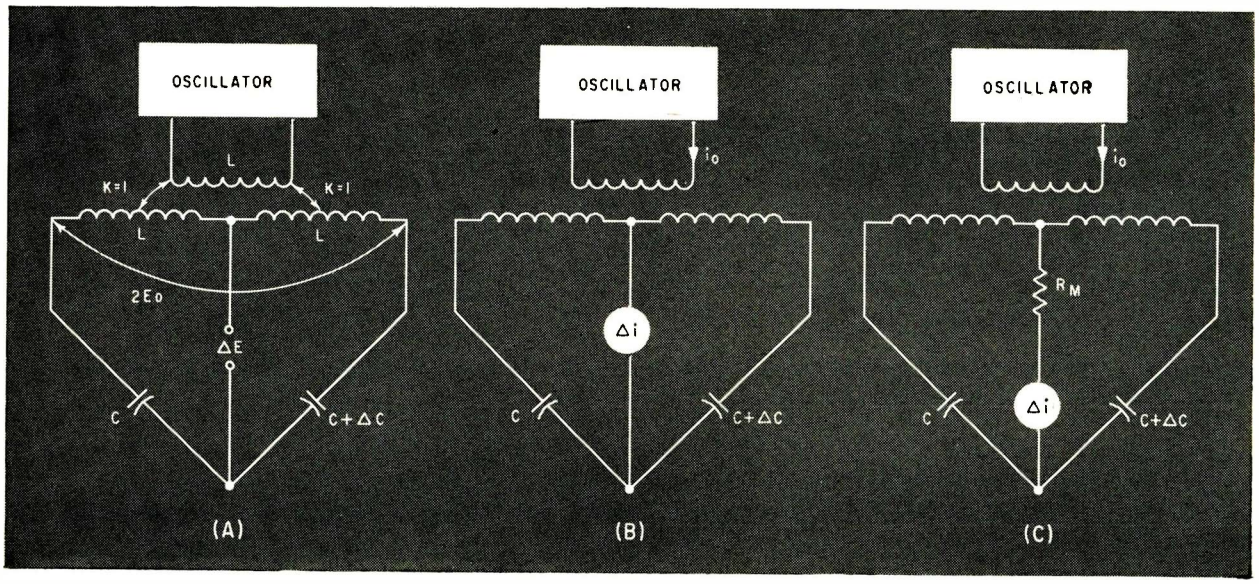


FIG. 1—Basic bridge circuit diagrams for open circuit (A), short circuit (B) and intermediate (C) cases are basis of circuit analysis. Equations for each case are derived in text

Analysis of off-balance capacitance bridges provides basic design equations. Example shows design of bridge that measures capacitances ranging from 10 to 100 picofarads

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BALANCED BRIDGES have been widely used for measurements and their behavior extensively analyzed in the past but analysis of off-balance bridges has been almost neglected.

To help fill this gap, the analysis of such networks will be made here. Although the technique used in this analysis can be extended to cover a wide range of off-balance bridges, the method has been applied in detail only to a narrower class, a capacitance measuring bridge.

It will be shown that off-balance bridges are basically nonlinear; that is, the output current is a nonlinear function of the input variable change. However, this nonlinearity can be kept small (1-2 per cent of full scale reading). Noting this fact and taking into account the ruggedness and sensitivity of the design, it is seen that the approach results in a satisfactory instrument.

The bridge analysis is based on the diagrams shown in Fig. 1. Certain assumptions have been made which will simplify the calculations while still allowing certain important conclusions to be drawn. Assumptions under which the following theory will be developed are that all inductances are identical and that they are all high compared to the capacitive impedances involved and that there is unity coupling between all of them.

Under these assumptions it can be shown that unbalancing the bridge by increasing one of the capacitances by the amount ΔC, a voltage will appear across the open terminals, as shown in Fig. 1A. This voltage will have the following form

$$\Delta E = E_o \Delta C/(2C + \Delta C) \quad (1$$

Similarly, by short circuiting these open terminals (Fig. 1B) the current in this short circuit will be of the form

$$\Delta i = i_o \Delta C/(2C + \Delta C) \quad (2)$$

These two cases represent the two extreme conditions under which the bridge is likely to operate: with no load impedance or with infinite load impedance. In form Eq. 1 and 2 are identical. In fact, they can be expressed in the general form

$$\Delta E/E_o = \Delta i/i_o = \Delta C/(2C + \Delta C) \quad (3)$$

The graphic representation of these two curves is given in Fig. 2A. This shows that the circuit is an inherently nonlinear device; that is, the output voltage or current from the bridge will not be a linear function of unbalance ΔC. Then since the two extreme cases are nonlinear in the same way, the intermediate case with a finite meter impedance will have the same type of nonlinearity.

Steps can be taken to correct this nonlinearity, but only to a certain extent. Given an accuracy requirement for the measurements, allowance has to be made for a nonlinearity within that accuracy.

The generalized case for the circuit is where a current-indicating device that has a finite impedance is connected across the output ter-

minals of the bridge. Assume the ohmic resistance of the bridge circuit is included in this impedance and denote this total resistance as R_M. The circuit for this condition is shown in Fig. 1C. Deriving the expression for the current measured in this current-indicating device as a function of an unbalance ΔC gives

$$\Delta i = i_o \frac{\Delta C}{C} \frac{1}{2+\Delta C/C+4R_M j\omega C(1+\Delta C/C)} \quad (4)$$

This expression reduces to the short circuit current expression, Eq. 2, by equating R_M with zero. Figure 2B compares the shape of this curve to that for the open circuit or short circuit case. For the loaded case the maximum current is reduced.

An improvement in linearity can be achieved by assuming that R_M includes a variable inductance L_P. This inductance (a peaking coil) can be used to improve linearity. Assume L_P is adjusted to resonate with the total capacitance of the circuit at the value $\Delta C = 0$. This occurs when

$$\omega L_P = 2/\omega C \quad (5)$$

Substituting this value into Eq. 4, the current equation is obtained

$$\Delta i = i_o \frac{\Delta C}{C} \frac{1}{-\Delta C/C+4R_M j\omega C(1+\Delta C/C)} \quad (6)$$

Similar reasoning applies when inductance is adjusted to resonate with the total capacitance of the circuit at the full scale value of ΔC. This occurs at the peaking coil value

$$\omega L_P = (1/\omega C)\frac{2C+\Delta C_{max}}{C+\Delta C_{max}} \quad (7)$$

for which value the output current is

$$\Delta i = i_o \frac{\Delta C}{C} \frac{1}{1-\dfrac{1+\Delta C/C}{1+\Delta C_{max}/C}+4R_M j\omega C(1+\Delta C/C)} \quad (8)$$

Summing up the preceding considerations, these three cases have been analyzed:

(a) the output containing no peaking coil, (b) peaking coil resonated by balance point (ΔC = zero) and (c) peaking coil resonated at full scale value ($\Delta C = \Delta C_{max}$). The output current will be different for these three cases. The results have been summed up in Fig. 3 and the table.

From Fig. 3 it can be seen that Δi starts out with small $\Delta C/C$ values as a linear function; with large ΔC values the current tends to become a constant value and both the slope of the linear part and the final constant value will be different for the three cases.

Comparing it to the unpeaked case, the case where the inductance is tuned at balance has a steeper slope with small ΔC values, but the final value of the current tends to the same value as in the unpeaked case. Thus while the sensitivity for small ΔC values is higher, the nonlinearity is worse.

Again, compared with the unpeaked values, when the resonant coil is tuned to maximum ΔC, the slope of the current increase is larger than that of the unpeaked value but the final current value is higher than either of the preceding two cases.

Thus the circuit where the inductance is tuned to be resonant at full-scale value will show a higher sensitivity than the unpeaked case and a better linearity than the circuit peaked at balance.

Therefore, if the requirements are for a high sensitivity with relatively small ΔC_{max} values, the circuit should be tuned to resonate at

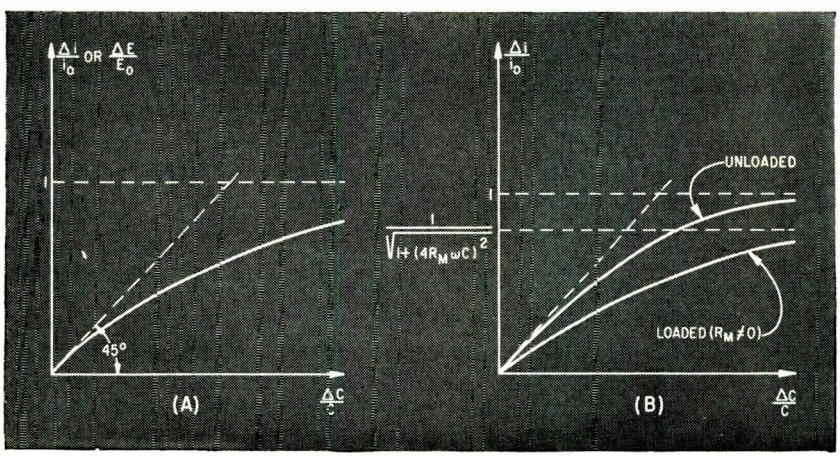

FIG. 2—Curve for no-load and infinite load is shown in (A). Comparison in (B) shows loading effect resulting from meter impedance

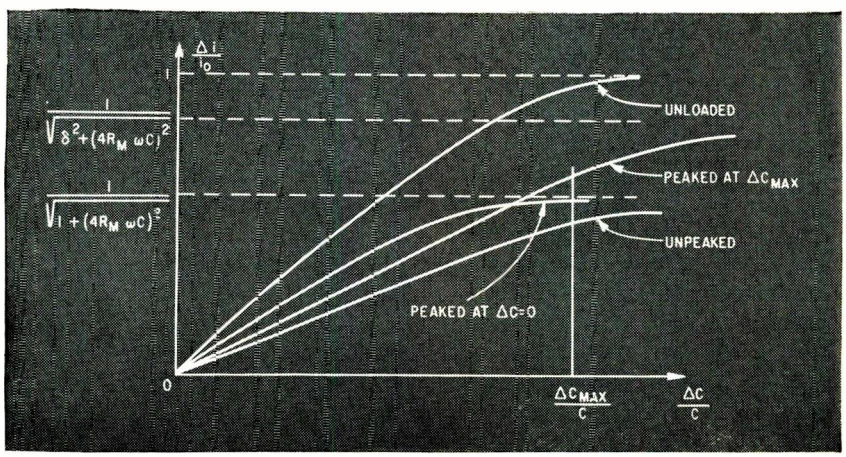

FIG. 3—Effects of loading and peaking on sensitivity and linearity limit design freedom

IMPORTANT PARAMETERS

Case	Slope at small $\frac{\Delta C}{C}$	Limit for $\frac{\Delta C}{C} \to \infty$	Remarks
Unloaded $[R_M = 0]$	Tan 45° $= \frac{1}{2}$	1	——
Unpeaked $[L_p = 0]$	$\frac{1}{\sqrt{2^2 + (4R_M\omega C)^2}}$	$\frac{1}{\sqrt{1 + (4R_M\omega C)^2}}$	— —
Peaked at $\Delta C = 0$	$\frac{1}{4R_M\omega C}$	$\frac{1}{\sqrt{1 + (4R_M\omega C)^2}}$	$\gamma = \frac{\Delta C_{max}/C}{1 + \Delta C_{max}/C} < 1$
Peaked at ΔC_{max}	$\frac{1}{\sqrt{\gamma^2 + (4R_M\omega C)^2}}$	$\frac{1}{\sqrt{\delta^2 + (4R_M\omega C)^2}}$	$\lvert\delta\rvert = \frac{1}{1 + \Delta C_{max}/C} < 1$

balance while, if linearity considerations are of primary importance, the circuit has to be tuned at its full-scale value ΔC_{max}.

From the preceding analysis of the bridge circuit, the following conclusions can be made and applied to the practical problem of setting up the system:

(1) The current output is always a nonlinear function of the capacitance change and, for each measurement, the nonlinearity permissible has to be determined. It is, however, possible to achieve a linearity within a specified accuracy figure, using certain precautions.

(2) For a given ΔC for full-scale reading, the linearity can be improved by increasing the terminal capacitance C of the network. This means that a fixed capacitor may have to be added across the terminals of the bridge, this fixed capacitance C being a function of ΔC_{max} and the required linearity.

(3) The effect of this padding capacitance is, first, to improve linearity, and second, to reduce the sensitivity of the bridge. In the expressions of the current Δi (Eq. 4, 6 and 8), there is the expression $4R_M j\omega C$ where C is the padding capacitance. Since this expression occurs in the denominator, an increase in C will result in a decrease in Δi, or a decrease in sensitivity.

(4) Such a decrease in sensitivity can be counter-balanced by reducing R_M. This is done by using a series rheostat in the meter circuit and varying its value, depending upon the full-scale reading required.

(5) If the terminal, or padding, capacitance required is so high as to prevent full-scale reading obtained even with minimum value of R_M, the frequency can be lowered. An increase in capacitance C can be counter-balanced by a reduced frequency ω.

(6) By using a peaking coil, both linearity and sensitivity can be improved in the following way:

Assume that the circuit is to be tuned at full scale reading ΔC_{max}. Let this condition be physically realized so that the indicator shows full-scale reading. Now, by use of the peaking coil, this reading is increased and this increase counterbalanced by an increase of R_M (by increasing the resistance of the rheostat). By manipulation of the peaking coil and the sensitvity rheostat, a condition can be achieved where the system indicates full scale at a particular position of the peaking coil and less than full scale on either side of this position. This means that the circuit is now tuned to full scale. In this condition linearity will be optimum and sensitivity unchanged from the unpeaked condition.

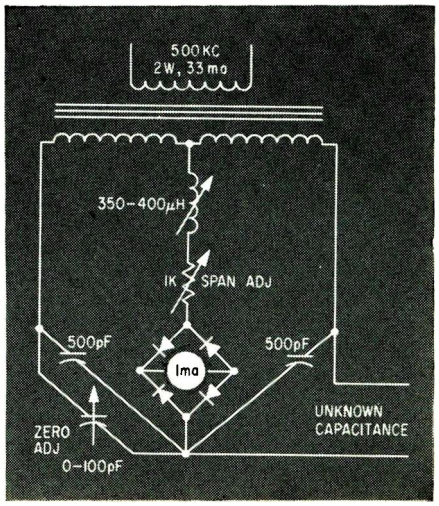

FIG. 4—Resistance of meter in practical circuit shown is 100 ohms

To illustrate the method outlined assume the following specifications: Design a bridge capable of giving full-scale indication on a 1-ma meter for capacitance values between 10 and 100 pf. The meter resistance is 100 ohms and the oscillator frequency is 500 Kc.

Using Eq. 8 full-scale current is $\Delta i_{max} = i_o\, m/[(1 + m)\ (4R_M\omega C)]$ where $m = \Delta C_{max}/C$. According to the specifications:

ΔC_{max} = 10 to 100 pf R_M = 100 ohms and $\omega = 3.14 \times 10^6$ sec^{-1}.

Choose C = 500 pf (fixed padding capacitors), then for the smallest span $m = 10/500 = 0.02$, $\Delta i_{max} = 0.03\ i_o$ and the oscillator current for Δi_{max} = 1 ma is i_o = 33 ma. This measurement has a maximum nonlinearity at the 50-percent reading of about 1 percent.

For the widest span (ΔC_{max} = 100 pf), with Δi_{max}, i_o and C unchanged, R_M has to be increased to about 1,000 ohms by a rheostat.

The necessary peaking coil in series with the meter is $\omega L = (2C + \Delta C_{max})/\omega C\ (C + \Delta C_{max})$ thus, L = 350 to 400 μH (variable).

The oscillator power requirement is about 2 watts. The circuit is shown in Fig. 4.

Capacitance bridges are valuable tools since a wide range of physical variables (such as level, composition or thickness) can be readily converted into changes of capacitance by electrodes.

While balanced bridges need manual setting or expensive electromechanical rebalancing methods, off-balance bridges can be used as a simple, inexpensive indicating or controlling means.

Transistorized Data Amplifier Has High Gain-Stability

Circuit refinements and careful design give a data amplifier high gain-stability and linearity and low output impedance

By FRANKLIN OFFNER, President, Offner Electronics Inc., Schiller Park, Ill.

HIGH ACCURACY d-c amplifiers are inherently more difficult to design and build than a-c amplifiers. As a result, a-c signals are used in measurement applications wherever possible, even sometimes at the sacrifice of a fundamentally simpler and more accurate system.

The primary difficulty in a d-c amplifier is drift, or random change in no-signal output. With conventional amplification techniques, drift can only with difficulty be kept as low as a few millivolts equivalent input, which may be a thousand times too large for low voltage signal devices such as thermocouples. Of the methods to reduce or nullify drift, chopping is successful and widely used. Chopper amplifiers may be designed to have no appreciable change in output with constant input signal, so that drift effects are reduced to a negligible value.

If a chopper amplifier is to be used only as a null device, design problems are minimal. Such amplifiers have long been used with self-balancing potentiometers, for example. If, however, an output strictly proportional to the amplifier input signal is desired, new problems are introduced, their magnitude depending upon the precision of amplification required.

Both experimental and theoretical investigation of the conventional chopper amplifier indicate fundamental limits to its accuracy, beyond which it is impractical to go. These limitations result in part from the basic nature of such amplifiers, and in part from the natural imperfections of any chopper switch. The first limitation, that of the basic design of the amplifier, shows up in transient errors, evident in response to a step input.

The problem resulting from the chopper itself results primarily from the impossibility of holding chopper dwell times and phase relationships precisely constant. These fluctuations have two effects on the amplifier performance: they change the overall amplification; they introduce ripple at chopper frequency in the amplifier output. While fluctuations in a chopper can be kept to one or two percent, this performance is inadequate if an amplification constancy of a few hundredths of one percent is desired. Furthermore, if there is appreciable ripple at chopper frequency in the output, the ripple must be filtered out; the filter increases the response time of the amplifier. This may not be permissible where rapid response is essential, as in applications where a number of data points are scanned by a single amplifier.

With the chopper output circuit of Fig. 1A, which will be explained in more detail, and with vacuum tubes as amplifying elements, data amplifiers with gain and linearity constant to 0.01 percent over the ambient temperature range from

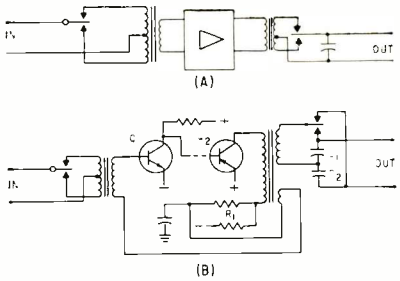

FIG. 1—Conventional chopper amplifier of (A) works well in null type servo but for precise and constant gain, the circuit of (B) is superior

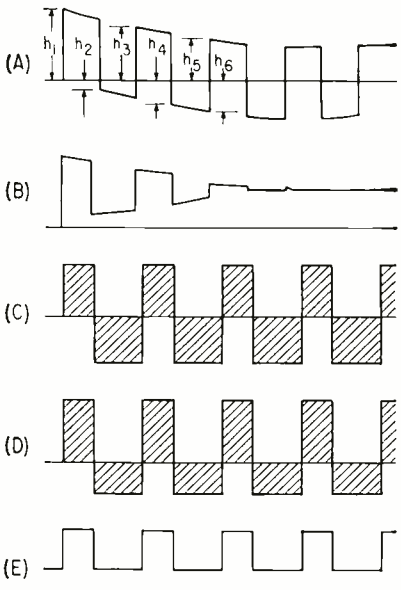

FIG. 2—Transient response of conventional chopper amplifier to a step input (A) is shown in output (B), and the effects of unequal dwell time in (C), (D) and (E)

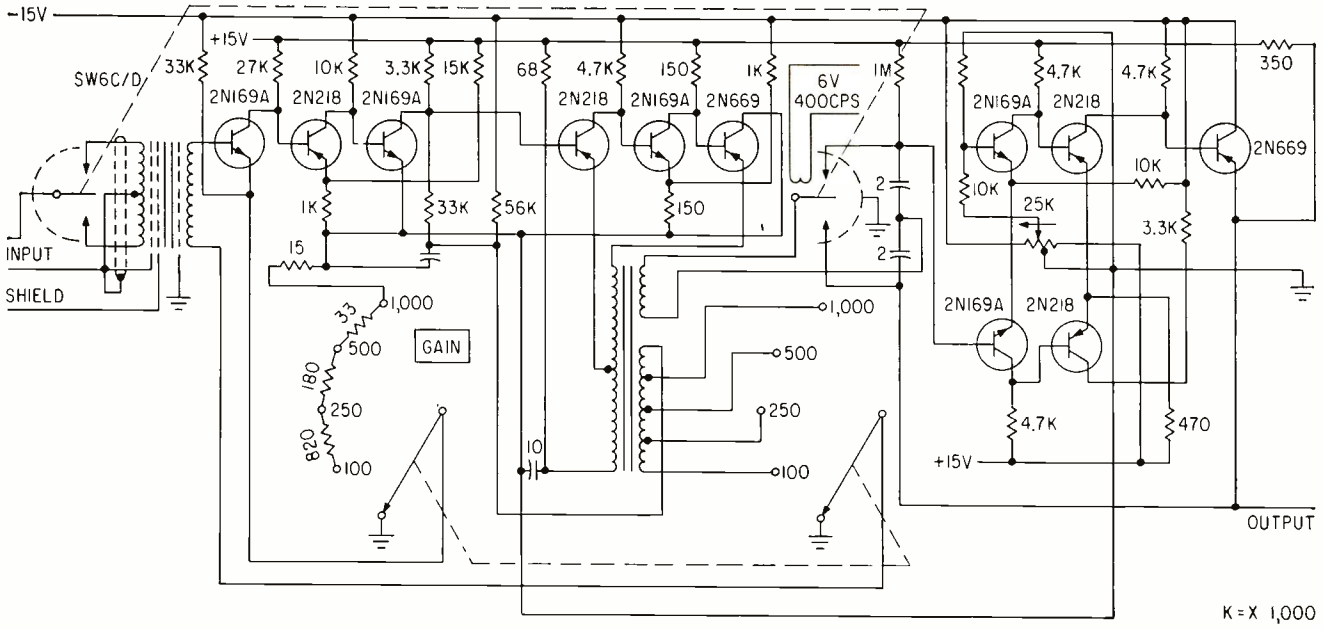

FIG. 3—Transistorized data amplifier has gain stability and linearity of 0.01 percent from 15 to 55 C. Gain is adjusted by changing the amount of feedback

−55 to 85 F have been built. Chopper characteristics can change several percent with practically no change in output.

Where extreme gain constancy is desired, transistors present problems not found in vacuum tubes. These are due primarily to the effects of temperature changes on transistor characteristics. For any type of general use, a data amplifier should operate within its specified accuracy over an ambient range of at least 0 to 40 C. This would permit operation in a non-air-conditioned atmosphere and only require such heating as would be necessary to prevent freeze-up of other equipment. Operation over a wider ambient range might have further advantages in some limited applications, but accuracy should not be compromised over the range stated.

There are three major effects on transistor characteristics from ambient temperature changes.

First, leakage current approximately doubles for each ten degrees C rise. Second, the current amplification factor increases with temperature, an effect troublesome at low temperatures, where current-gain reduction may be serious. Finally base-to-emitter contact potential changes about 2.5 mv per degree C. For a fixed base voltage, this results in a rapid change in collector current with temperature.

All three effects are greatly diminished with chopper amplifiers, since the shift in amplifier operating point will not result in any change in the zero-signal output of the amplifier. But temperature change will still cause a change in amplifier gain, and may also cause distortion and limited output if the amplifier operating point shifts too far from its design point.

Techniques to overcome these three parameter variations are illustrated in the simplified block diagram of Fig. 1B. Basically, the circuit is a direct-coupled transistor amplifier with transformer-coupled chopper input and output circuits. The amplifier stability is maintained by two feedback circuits. Operating point feedback (patents granted and pending) is obtained from the voltage drop across R_1. The d-c voltage across R_1 is fed to the base of Q_1, holding the voltage across the resistor, and thus the current through the output stage Q_2, substantially constant. This substantially eliminates the effect of all three parameter changes on amplifier operating point.

The remaining effect of importance is the change in current gain that affects net amplification. This is minimized by using a large amount of inverse feedback, taken from the tertiary winding of the output transformer. Sufficient feedback is employed to hold the gain within the desired accuracy limits.

These techniques of amplifier stabilization have been found superior to the use of compensation circuits, in which, for example, thermistors are used to cancel the change of transistor parameters. The latter requires that the compensation circuits be matched to the individual transistors; thus production matching, as well as field replacement, become major problems.

Of particular interest is the output chopper circuit (Fig. 1B) which overcomes the deficiencies of the conventional circuit of Fig. 1A. This circuit uses a single secondary winding and center-tapped capacitors. The conventional chopper output circuit, in contrast, uses a single capacitor and a center-tapped transformer. The new circuit eliminates initial switching transients, greatly reduces ripple and gives extremely constant gain. The reasons for this improvement will be made clear by Fig. 2. Figure 2A shows the waveform at the secondary of the output transformer following the application of a sustained d-c to the input of the amplifier. There is an initial transient term that dies out exponentially, leaving a square wave varying symmetrically about the zero line (assuming a balanced input chopper). The output chopper circuit of Fig. 1A flips the bottom halves of the waves up, producing the wave-form shown in Fig. 2B.

The oscillatory form of the initial transient is apparent.

Now consider the action of the circuit in Fig. 1B. On the first half of the cycle, capacitor C_1 is charged to the voltage of the first half of the first wave, h_1. On the second half of the cycle C_2 is charged to the voltage h_2, the amplitude of the lower half of the first wave. Thus after one complete cycle the output is the total top-to-bottom distance (voltage) of the square wave. But this distance, $h_1 + h_2$, is practically the same as $h_3 + h_4$, or $h_5 + h_6$, etc. Thus the output rises after a single chopper cycle to its full value and remains there unchanged, with no oscillation or overshoot.

The above discussion assumed that a symmetrical square wave existed after the initial transient. Now assume that the input chopper has unequal dwell times on the two sides. Figure 2C shows the waveform at the primary of the input transformer for a chopper with only half the dwell time on one side as on the other; the upper wave has only half the width of the lower. After passing through the input transformer the d-c component of this wave is eliminated, as the transformer cannot transmit d-c. Therefore, the waveform at the secondary of the output transformer must have equal areas up and down; since the duration of the up-wave is one-half the down, its amplitude must be double, as shown in Fig. 2D. For the conventional chopper output circuit of Fig. 1A, the output will have 50 percent ripple as shown in Fig. 2E. But the circuit of Fig. 1B again gives an output equal to the total height, $h_1 + h_2$, $h_3 + h_4$, etc. independently of swell time. Again, this height is constant and, ideally at least, there will be no ripple.

It will similarly be seen that while the individual height of the up-and-down-waves depends critically on chopper adjustment, the total top-to-bottom height does not, and therefore amplifier gain with the modified circuit is fundamentally independent of chopper adjustment, and no output filtering is required to obtain low output ripple and critically damped response.

For a given accuracy of amplification, the improved circuit provides much more rapid response. Typically, a conventional 400-cps chopper amplifier would require about one-twentieth of a second to come to 99.7 percent of full step-function response (based on 0.1 percent ripple). The improved circuit responds in one chopper cycle —1/400 second.

The complete circuit of the transistorized data amplifier is shown in Fig. 3. The basic amplifier has five direct coupled stages, employing alternate *pnp* and *npn* transistors; d-c feedback is used for operating-point stabilization. Gain is controlled by switching the number of turns used in the tertiary feedback winding. At the same time, an emitter resistor is varied in one stage to hold the loop gain approximately constant, to preserve stability.

If appreciable load is drawn from the output capacitors, ripple will

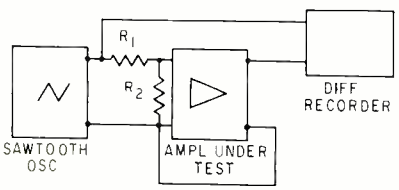

FIG. 4—In test circuit, amplifier makes up gain loss of input network to give straight line output

be introduced into the output. To permit a low impedance load to be used, an output buffer amplifier of unity gain is employed. The amplifier has an extremely constant gain and does not measurably affect the over-all gain stability. It does, however, provide the possibility of some zero-point shift with ambient temperature. This is minimized by the balanced design. The output voltage for zero input will under most conditions not vary more than a fraction of a millivolt, equivalent to a fraction of a microvolt input error at a gain of 1,000. Output impedance is less than 1/100 ohm.

These amplifiers are designed primarily for fixed installations where space is not at a premium. Primary consideration is accessibility. Two channels are mounted on each plug-in chassis; 16 channels can be mounted in 8¾ in. of 19-in. rack space.

With the input of the amplifier transformer coupled, it has fundamentally zero response to common-mode (in-phase) signals. This complete rejection of common-mode signals is easily realized at d-c. Maintenance of high rejection of common-mode a-c signals requires careful attention to shielding. The input transformer, for example, requires three shields between primary and secondary, the intermediate shield being connected when required in the now-familiar guard ring manner. Rejection at 60 cps is readily kept better than a million to one, or 120 db.

Gain stability of the amplifier for long-term operation (1,000 hours) is within 0.01 percent from 15 to 35 C; linearity is equally precise for the normal output range of ±10 volts. Measurement of amplifier performance to such precision requires care. It may be performed in a bridge circuit, in which the difference between the amplifier output and input is recorded, as illustrated in Fig. 4. The low frequency saw-tooth oscillator is set to give an output voltage equal to the maximum desired from the amplifier.

The direct-writing oscillograph with true differential input records the difference between the oscillator and amplifier outputs. The ratio $(R_1 + R_2)/R_2$ is varied to give as flat a trace as possible. Then the above ratio is the amplifier gain. The departure of the trace from a straight line measures the nonlinearity; its change with time gives the amplifier gain stability.

For the range from 0 to 55 C, the gain of the transistorized data amplifier remains within 0.02 percent. Low temperatures tend to have a greater effect on the standard model amplifier, particularly because of the aluminum electrolytics; performance can be improved by substituting tantalum capacitors. However, it does not appear practical to achieve the same independence of amplifier gain from ambient temperature with transistors as with vacuum tubes.

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TABLE I — NEGATIVE-TEMPERATURE-COEFFICIENT THERMISTORS

Type	Resistance Range at 25 deg C	Max. Rating	Dissipat'n Constant at 25 deg C	Max. Operat. Temp.	Temp. Coef.	Time Constant	Dimensions	Primary Applications
	ohms	watts	mw/deg C	deg C	%/deg C	sec	in.	
Glass-coated Bead	100–12 M[a]	0.2	0.09–0.8	500[c]	−3.1 to −5.2	0.5–3	0.006–0.110 diam	wind velocity, temp., gas analysis liquid level, power control
Bead in container[b]	100–5.3 M[a]	0.2	1	500	−3.1 to −5.1	1–25	0.1 diam, ½–3 long	time delay, medical probe, voltage control, very low temp.
Disc	1 to 10 K[d]	4	3–800	150[e]	−3.8 to −1.4	2–200	0.1–1.1 diam	temp. comp., fire alarms, osc. ampl. stab'zn., temp. control
Rod	2 K–100 K[d]	2	2.5–6	150[e]	−3.8 to −1.4	20–95	¼–2 long	filament protection, volt. control and reg., meteorological temp. meas.
Washer	10–1,100	10	100–850	150	−3.8 to −1.1	4–21	½–1 diam	higher-power temp. comp., surge suppression
Wafer	10–1 M[a]	0.5	2.5–7.8	150	−3.9 to −6.8	7–35	1/16–1/2 sq	temp. meas. & control, high-temp. alarm

(*a*) M equals 10^6; (*b*) Container is glass probe or bulb; (*c*) Special units go to 1,200 C; (*d*) K equals 10^3; (*e*) 125 C with soldered leads

TABLE II — POSITIVE-TEMPERATURE-COEFFICIENT THERMISTORS

Type	Resistance Range at 25 deg C	Max. Rating	Max. Operat. Temp.	Temp. Coef.	Time Constant	Dimensions	Primary Applications
	ohms	watts	deg C	%/deg C	sec	in.	
Rod	100–1,000	¼	100	+0.7	35–54	0.4–0.6 long	Transistor temp. comp., temp. meas.
Sealed[a] Metal Case	100–1,000	⅛	125	+0.7	54	0.350 diam, 0.215 long	Transistor temp. comp. in high-humidity ambients
Glass Probe	100–1,000		200	+0.7	9	0.078 diam, 0.5 long	Temp. meas. and control

(a) Hermetically sealed

Survey of Thermistor Characteristics

Breakdown of thermistors into two basic types and several categories under each type. A convenient way to look up thermistor characteristics and applications

By JAMES VAN DOVER
NORMAN F. BECHTOLD

U. S. Army Signal Research and Development Laboratory, Fort Monmouth, N. J.

INDUSTRY is finding more and more uses for thermistors. Increased demands of reliability, extreme environments and a high degree of measurement accuracy have accelerated techniques for their use and stimulated their production. To make electronic circuits reliable, thermistors compensate for temperature changes, regulate current or voltage and control remote circuits. In the medical, meteorological and mechanical fields, thermistors are used for accurate measurement of temperature, pressure and liquid levels. With increased production capabilities, quality and cost have become more favorable to the potential user.

These thermally-sensitive resistance elements are of two basic types, having negative- and positive-temperature-coefficients (NTC and PTC). The NTC thermistors (Table I) are more varied and have seen considerable service in the applications listed; these thermistors are made primarily from a composition of oxides of nickel, manganese and cobalt. PTC types (Table II), whose production was stimulated by the need for temperature compensation of semiconductor circuitry, are more limited in number and scope. Present commercial PTC thermistors are made from single-crystal silicon. Performance ranges shown in the tables are representative of readily available off-the-shelf thermistors.

Although semiconductor temperature compensation with both NTC and PTC thermistors is a potential area for wide use, especially in military applications, matching of the thermistor resistance/temperature characteristics with the particular semiconductor involved has

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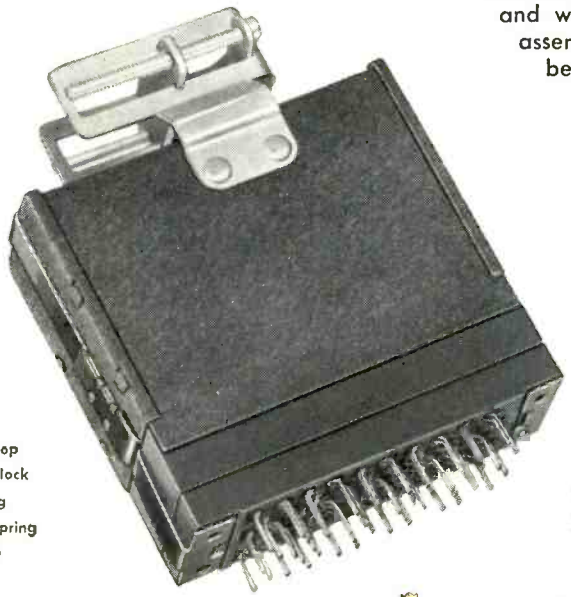

(Left) Lifting up top section releases lock prior to unlocking Pulling out on spring unlocks assembly

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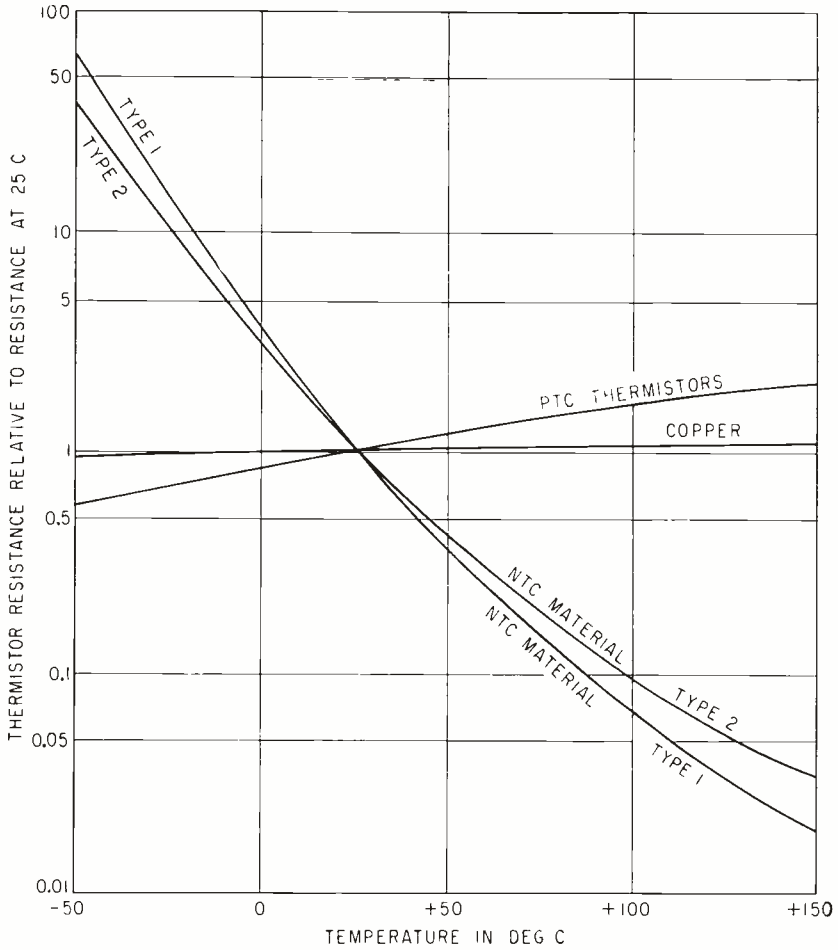

FIG. 1—Variation of thermistor resistance with temperature

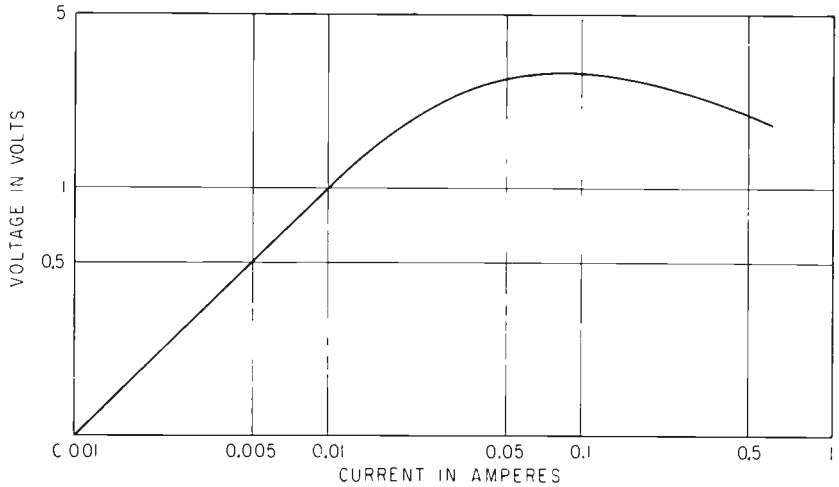

FIG. 2—Static V/I characteristic for typical NTC disk thermistor

become a problem of considerable concern. To eliminate deterioration of amplifier gain with increasing temperature, the PTC types can be connected in series with the base or collector of a transistor and the NTC types connected in shunt. In both cases, the thermistor is often used as part of a network with conventional linear resistors, the specific design depending upon total allowable resistance, operating temperature range, and degree of compensation required. An effort is currently underway within the USASRDL to develop a family of preferred compensating devices to include these variables. The non-uniformity of transistor characteristics within the same batch is the problem of most concern.

The curves of Fig. 1 demonstrate typical resistance properties of the various thermistor types. Curves may be matched or fitted to specification, but any radical departures from those shown require special design considerations. Higher values of resistance ratio are available in the NTC than in the PTC types. Increased resistance-change rates promised by new materials and techniques will produce greater temperature sensitivity and faster response times; it is even possible that an effective solid-state thermal switch might be developed.

Figure 2 shows a typical voltage-current characteristic of a disk-type NTC thermistor. Ohmic properties are maintained at low currents where negligible heat is generated within the element. As self-heating begins, a critical operating point is reached beyond which the characteristic goes into the negative-resistance range. This knee is more pronounced in the characteristics of smaller units because of faster thermal-dissipation properties; see the *Dissipation Constant* column in Table I.

In addition to the types noted in the tables, special mounting assemblies may be obtained for higher wattage dissipation, uhf power measurement and liquid-level detectors. Built-in filaments are available for indirect-heating applications and matched pairs are sold for accurate measurement in bridge circuits.

Figure 3 shows a simple application.

Although no coordinated standards are presently available, industry and the armed services are devoting effort toward agreement on preferred types.

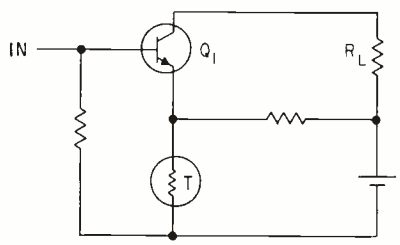

FIG. 3—Temperature compensation with a PTC thermistor

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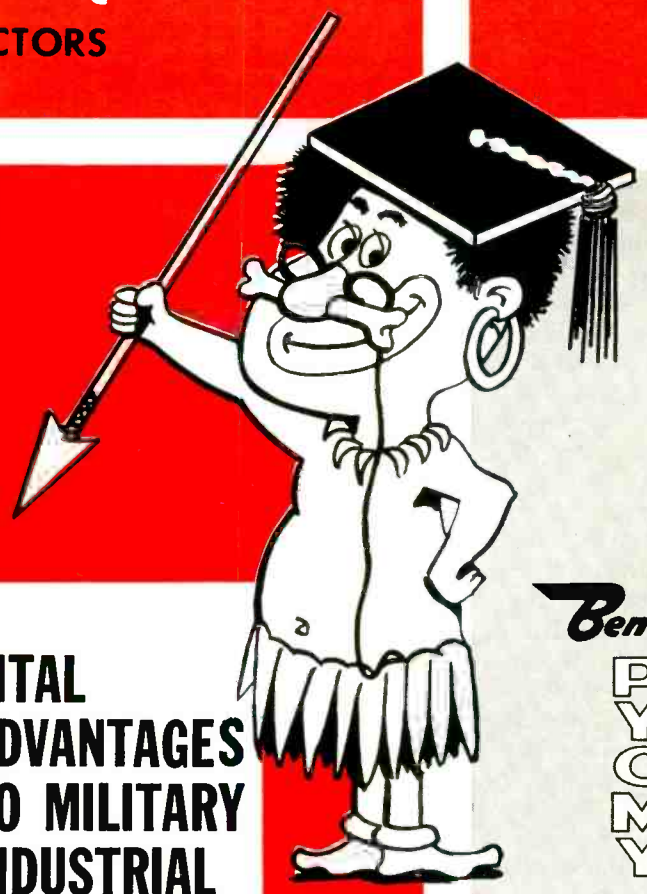

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Tests Show Control Is Key to Timer Accuracy

BY FRED W. KEAR, Lytle Corp., Albuquerque, N. M.

COMPARATIVE tests were made of crystal-controlled oscillator timers and precision electrical timers for measurements within the resolving capabilities of the timers. No appreciable differences resulted in those time runs requiring no greater accuracy than 0.01 percent. The key to obtaining this accuracy from electrical timers lies in the method of controlling the on and off signals to the timers.

Start-stop control of most timers is accomplished by magnetic clutches, which may be operated with either a-c or d-c power. Timers using d-c clutches that can be readily controlled by transistors are more advantageous for accurate timing circuits. Reset and timing motors are normally operated from 117 v a-c because of the amount of current needed and the liberal timing requirements.

The circuit in Fig. 1 was designed to control four precision timers in a test setup for accurate simultaneous measurement of the time interval of four integrating circuits. Functions of the circuits to be tested were integrating digital information, converting it to analog form and providing a single positive output pulse. Time between the first digital output pulse and firing of the circuit had to be determined within about 0.01 percent. The same start pulse was used for all four circuits but stop pulses varied over a wide range.

The positive output pulse of the circuit under test was used to saturate an *npn* transistor capable of handling heavy currents. Saturation of the transistor grounds the external start input of Fig. 1. By grounding this point, power is supplied through Q_5 to all control transistors and to the start clutches of the timers. The accumulated delays in the transistors and clutches constitute total error of the circuit. Stop signals ground points 1 through 4 in Fig. 1, energizing control relays K_1 through K_4. When a control relay is energized, it cuts off the associated transistor.

Comparative readouts from digital display equipment and from the precision timers revealed that very little error was induced into data derived from the precision timers because of the type of readout. The timers used with this circuit operated at one revolution per second, and times could be read with little difficulty to the nearest millisecond. A second hand allowed timing runs

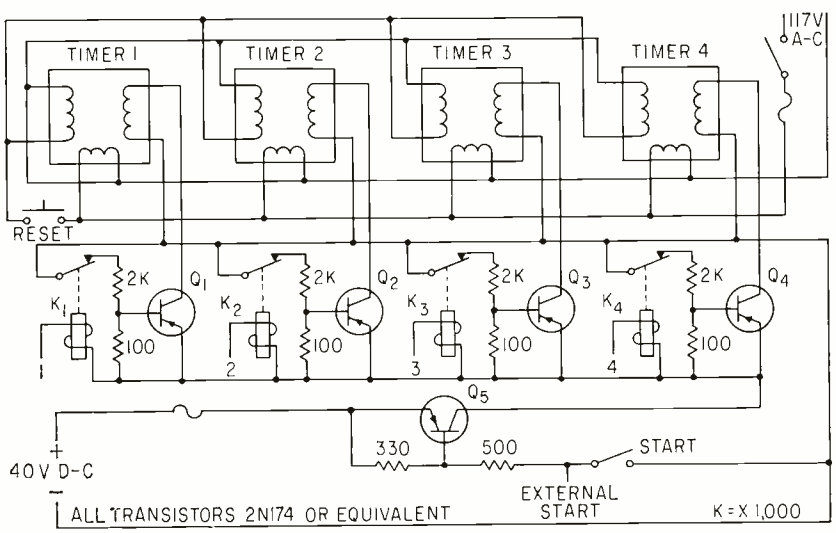


FIG 1—Four simultaneous measurements are provided by transistor control of precision electrical timers

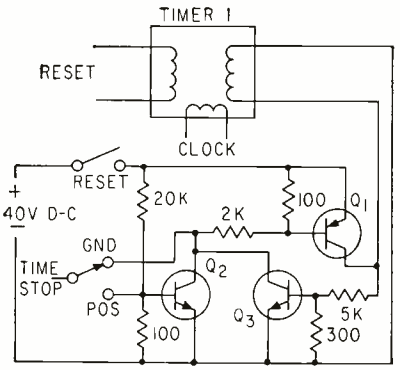


FIG. 2—Transistor switching replaces relays and either polarity start or stop pulses can be used

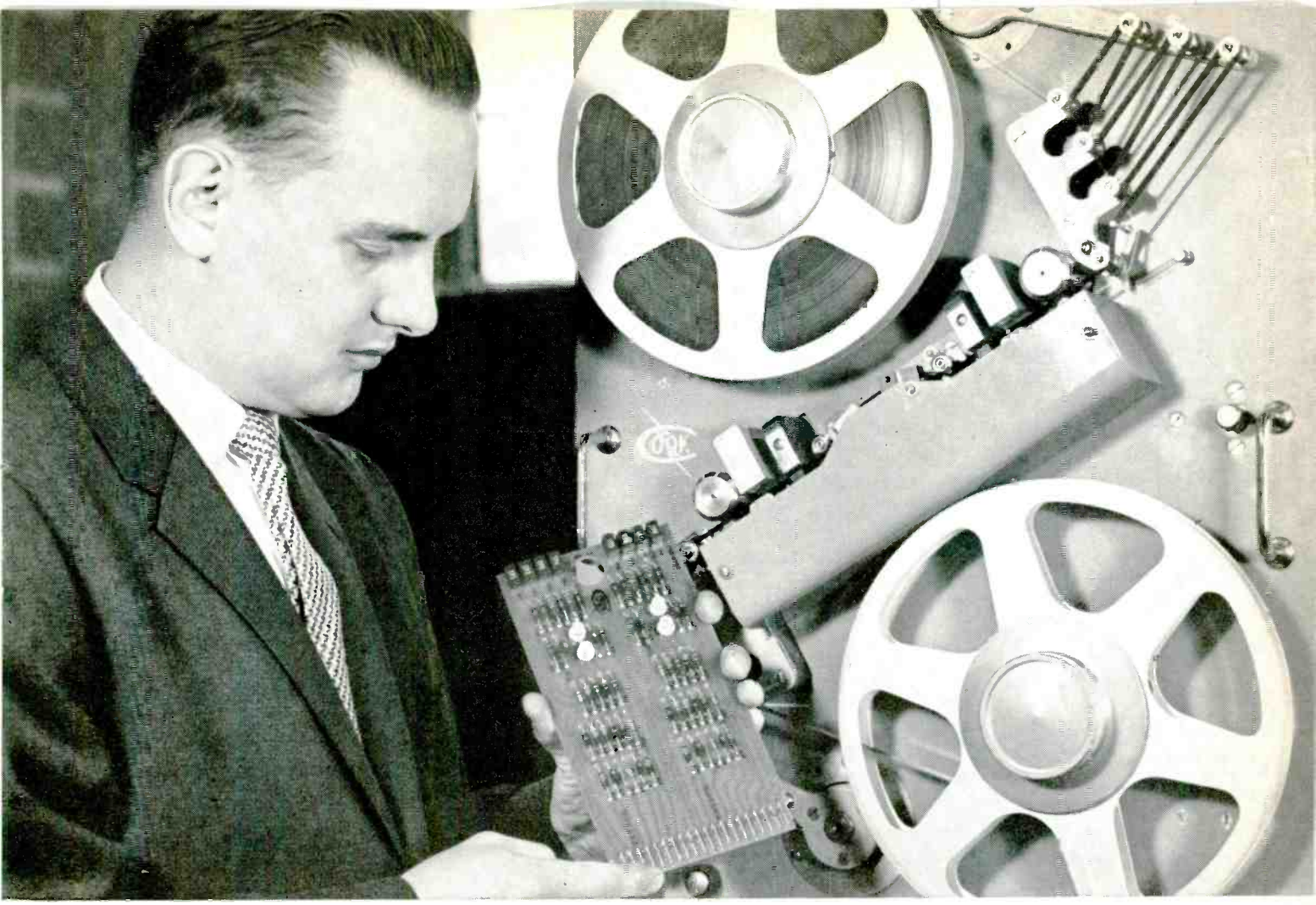
up to several minutes without circuit changes.

Cost considerations for multiple or simultaneous timing of the nature described would in most cases prohibit use of conventional timers with crystal-controlled time bases and digital displays. The cost of the circuit in Fig. 1 is modest considering the results obtained. Simplicity contributes advantages of low maintenance costs and savings in rack space.

It is desirable to provide these timers with polarity switching on both start and stop timer circuits. The switches would connect the relay coils to either the positive or the ground bus so that either positive or negative pulses could be used to control the timer. Such a switching arrangement is illustrated in Fig. 2, which also shows the use of transistor stop switching instead of the relays used in Fig. 1. Transistor Q_3 forms a clamping circuit for use where the stop pulse is of short duration making readout difficult. The circuit is useful for many applications where repetitive testing is not required.

Time Delay for Nuclear Reactor Simulation

MAJOR problem in designing and operating nuclear reactors is to determine how the coolant circuits



Tung-Sol transistors handle critical switching in COOK ELECTRIC high speed tape transport

Cook Electric's Model 59 Digital Tape Transport embodies the design know-how gathered by Cook during its 12 years of active participation in missile programs which include the Atlas, Polaris and Titan missiles. It was built to fulfill the demands of modern industry for reliable, high-speed data processing and storage equipment. This tape transport is a direct adaptation of the equipment originally developed to provide unattended, 45-day documentation of the Polaris Missile system.

Gratified with the superior performance demonstrated by Tung-Sol switching transistors in the Polaris version, Cook assigned Tung-Sol units to these critical tasks in the industrial model. Tung-Sol's 2N414 germanium high-speed switching transistors serve in the flip-flop and logic circuits. Here's how Cook engineers evaluated the Tung-Sol semiconductors: "Tung-Sol transistors meet our exacting demands for performance and reliability"

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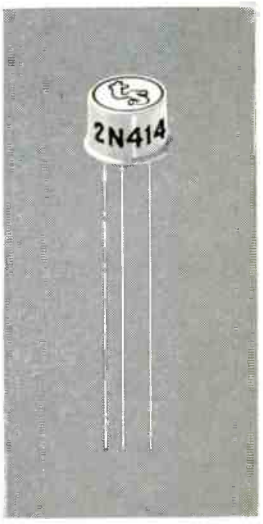

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would behave under unusual conditions like sudden failure of the circulating pumps. Pump failure could seriously damage the reactor if control arrangements were not adequate.

These potentially dangerous conditions can not be studied on the reactor, but design information can be obtained from an analog computer used as a simulator. The most difficult problem is electronic simulation of variable transport lags. E. M. I. Electronics, Ltd., supplied to the Centro di Studi Nucleari di Ispra Milan a variable time delay unit that is said to solve the problem more accurately than previously possible.

Data can be delayed a continuously variable amount determined by voltage applied to a delay control input. This unit controls speed of a loop of magnetic tape that passes prepositioned record and playback heads. Total delay range is 0.1 to 10 seconds in three preselected ranges. Two separate information channels are provided.

Using a recording system with precision pulse-width modulation based on other analog computers of the company, delay is made variable with tape speed. Amplitude distortion that could arise with other recording methods is eliminated. Full use is made of the information capacity of magnetic tape with high accuracy and useful bandwidth provided.

The new unit is suitable for study of nuclear reactor control problems involving variable time lags. The choice of input and output levels make the time delay compatible with standard analog computers.

The 100-inch loop of 1-in. wide tape is driven by a servo amplifier and a-c capstan drive motor. Accurate control of tape speed is obtained with d-c tachometer feedback, which also provides precision clipping in the data playback channels. Two separate tracks are recorded and delayed outputs taken from a dual-track playback head selected for one of the three available ranges.

About 80 inches of the magnetic tape loop are active in the unit. Tape speeds range from about 8 to 40 inches per second.

High-Fidelity High-Power Audio for Medical Study

HIGH-INTENSITY acoustical system has been developed that provides high-fidelity output. It generates undistorted sound throughout the 11-octave range of normal audibility from the threshold of hearing to a maximum volume that would damage the human ear at close range.

The system was developed by Stromberg-Carlson division of General Dynamics for the Aerospace Medical Division of the Wright Air Development Center. It will be used in studies of physiological effects of high-intensity sound.

The system includes an assembly of 480 loudspeakers mounted in 32 separate baffles for maximum flexibility in arrangement and control. Each baffle has three low-frequency and 12 high-frequency speakers. All transducers are specially designed to deliver high-fidelity sound at high acoustical power for sustained operating periods.

The system console provides four possible inputs—sine wave, white noise, tape recordings of jet engine, missile or other noise, or an external source. Preamplifiers can be adjusted to establish a specified line level, which is indicated by a meter. The fixed line level is then fed into a mixer that accepts any or all four inputs, which can be mixed in any desired proportion. Mixer output goes to a line amplifier that is also adjustable to provide a specified output level.

After passing through a master attenuator, the signal goes into the main audio power equipment, which consists of two pairs of audio amplifiers. One pair is for low-power use only, with each amplifier providing an output of 200 watts. Each of the pair of high-power amplifiers delivers an output of 7,000 watts. The system frequency response is flat from 20 to 20,000 cps.

To avoid unintentional exposure of subjects to high-intensity sound, the operator at the control console must first set the controls at the low-power position. Only after this operation can energy be supplied to the high-power amplifiers.

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MAXIMUM RATINGS (25° C)—(Note 1)

WIV	Working Inverse Voltage	150 V
I_O	Average Rectified Current	100 mA
I_F	Forward Current Steady State D.C.	150 mA
i_f	Recurrent Peak Forward Current	300 mA
i_f (surge)	Peak Forward Surge Current Pulse Width of 1 sec.	500 mA
i_f (surge)	Peak Forward Surge Current Pulse Width of 1 μsec.	2000 mA
P	Power Dissipation	250 mW
P	Power Dissipation	100 mW @ 125° C
T_A	Operating Temperature	−65 to +175° C
T_{stg}	Storage Temperature, ambient	−65 to +200° C

ELECTRICAL SPECIFICATIONS (25°C unless noted)

SYMBOL	CHARACTERISTICS	MIN.	TYPICAL	MAX.	TEST CONDITIONS
V_F	Forward Voltage			1.0 V	I_F = 100 mA
I_R	Reverse Current			0.1 μA	V_R = 150 V
I_R	Reverse Current (150°C)			100 μA	V_R = −150 V
BV	Breakdown Voltage	200 V			I_R = 100 μA
t_{rr} (Note 2)	Reverse Recovery Time			50 mμsec	I_f = 30 mA I_r = 30 mA R_L = 150 Ohms
C_O (Note 3)	Capacitance			5.0 $\mu\mu$f	V_R = 0 V f = 1 mc
RE (Note 4)	Rectification Efficiency	35%			f = 100 mc
	Forward Voltage Temperature Coefficient		−1.8 mV °C		

NOTES:

(1) Maximum ratings are limiting values above which life or satisfactory performance may be impaired.
(2) Recovery to 1.0 mA.
(3) Capacitance as measured on Boonton Electronic Corporation Model No. 75A-S8 Capacitance Bridge or equivalent
(4) Rectification Efficiency is defined as the ratio of D.C. load voltage to peak rf input voltage to the detector circuit, measured with 2.0 V r.m.s. input to the circuit. Load resistance 5 K ohms, load capacitance 20 $\mu\mu$f.

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Thin Film Extends Mesa Performance

REDUCES SWITCHING TIME AND COLLECTOR RESISTANCE

A CONVENTIONAL MESA transistor has a collector region that is required to attain low capacitance and high voltage breakdown. But this region is much thicker than it need be electrically. And this very thickness is what puts a limit on the switching time and collector resistance of the device.

For faster switching, it would be highly desirable to construct a thin film collector of lightly doped, highly resistive material. Ideally this region should be about 0.1 mil thick, which is a factor of about 30 thinner than normally used.

But up to now no one has shown us how to form a very thin film collector on a low resistive single crystal substrate.

On June 13, at a joint IRE AIEE Solid State Device Research Conference held in Pittsburgh, H. H. Loar of Bell Laboratories presented a solution to this problem to top research men in the semiconductor field. And the Bell answer was received by experts as a major development that is expected to have far reaching implications in both the fabrication and application of semiconductor devices.

For example, in two similar silicon transistor structures, one conventional and the other using the Bell fabrication process, switching time in a typical circuit has been reduced from 200 to 20 nano seconds. Further, collector series resistance of the new transistors was reduced by a factor of more than ten and was comparable to that of conventional devices 15 times larger.

Bell calls these new devices epitaxial diffused transistors. And the diagram shows the new structure (B) compared to the conventional mesa (A).

The key to the new structure is the lightly doped epitaxial film grown on and supported by a low resistivity substrate that gives the desired combination of electrical properties and mechanical strength.

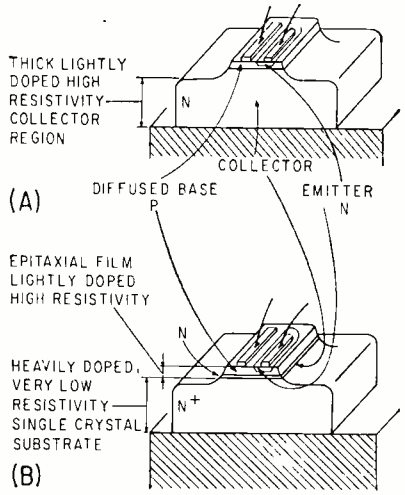
The word epitaxy is defined as an oriented *intergrowth* between two solid phases. The surface of one crystal provides, through its lattice structure, preferred positions for the deposition of the second crystal. And the epitaxial film is a direct extension of the single crystal structure of the substrate wafer.

Experiments with germanium indicate that use of epitaxial layers will extend the frequency response of germanium transistors well beyond that of the 2Gc device recently described by Bell.

Although exact techniques for fabrication are not revealed due to proprietary rights, fabrication is something like this: Single crystal wafers of heavily doped material are first cut and polished. These wafers are introduced into a hot environment. Into this furnace is also introduced a silicon compound. By gaseous deposition, a layer of the correct resistivity is deposited on the base wafer as a thin film, 0.1 mil thick. The lightly doped silicon grows onto it in homogeneous crystalline arrangement. This film provides the desired thin, lightly doped collector region. From this point on, standard techniques to fabricate mesas are used. Only the epitaxial stage is new. But this is what really makes the difference in mesa performance.

Silicon epitaxials are posited as high-frequency switches. The germanium models are usable at frequencies higher than 2,000 Mc as amplifiers.

The use of this new technique not only results in major improvements in switching time and collector resistance, but in addition simplifies the design and understanding of transistor devices and brings them closer to ideal forms, such as *npin* structures. Further, the addition of the epitaxial film technique to the well established diffusion technology provides the design engineer with an extra degree of design freedom which should result in new devices difficult or impossible to achieve by older techniques.



The usual mesa transistor construction (A) is compared to the epitaxial diffused transistor construction (B). In the latter, the lightly doped collector region has been minimized by using an epitaxial film grown on and supported by a heavily doped, low resistivity substrate

High-Melting Powders

METHODS of producing ultra-fine metal powders of such high melting point metals as tantalum, molybdenum and niobium are now under investigation by scientists at National Research Corporation. The study on these refractory metals is being conducted for the Bureau of Naval Weapons.

More than a year ago the company announced discovery of a process for making metal powders with particles only one-millionth of an inch in diameter—a thousand times smaller than any previously obtainable. Lower melting metals which lend themselves to NRC techniques include aluminum, iron, nickel, copper, silver, cobalt, manganese, lead, gold, zinc and the alkaline earths. Under the new

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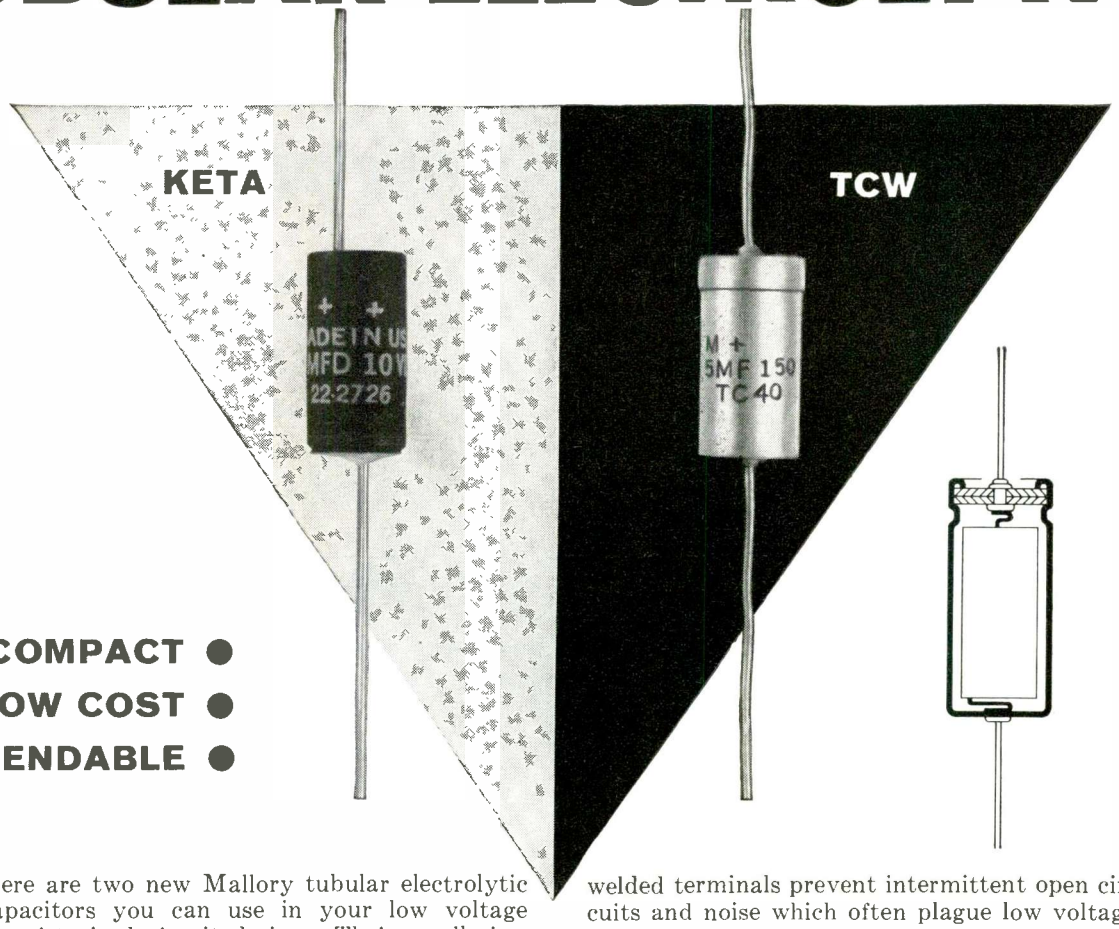

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Here are two new Mallory tubular electrolytic capacitors you can use in your low voltage transistorized circuit designs. Their small size, high capacity per unit size, excellent performance characteristics and long life fit the exacting demands of these space-squeezed applications.

Both the Mallory Type TCW aluminum tubular and the Type KETA plastic case tubular feature rugged, leak-proof construction. All-welded terminals prevent intermittent open circuits and noise which often plague low voltage circuits when capacitor connections are crimped or riveted.

Both the TCW and the KETA exhibit exceptionally low leakage current characteristics—an indication of their reliability, long life and high temperature capability.

Type	Capacity Range	WVDC	Temperature Range	Case Diameter Range	Case Length Range
TCW	2-750 mfd.	150-3v.	−40 to +85°C	⅜"-⅝"	⅝"-1 13/16"
KETA	1-1400 mfd.	50-3v.	−30 to +65°C	3/16"-⅝"	⅝"-2"

Type KETA available in dual ratings, in ½" and ⅝" diameter cases; and in non-polarized ratings of approximately one-half the above capacitance values.

Write today for complete data on the Types TCW and KETA . . . and for a consultation with a Mallory capacitor specialist on your specific circuit requirements.

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Navy contract, the process is now being directed toward the high temperature metals.

For powder metallurgy development, the ultra-fine powders may offer new, exact composition alloys with superior physical properties, company metallurgists indicate. Possible electronic applications include additives for plastics to alter dielectric properties, magnetic circuitry and suspensions in liquids to produce non-ionic-conducting liquids. Other potential applications appear in the catalytic chemical process field.

Watertight Servos

PROVIDING servo response up to 15 cps, moving freely inside the housing, and impervious to sea water was a packaging problem solved by Lear, Inc., Santa Monica, California. The problem was presented by elevator and aileron servo actuators, a portion of the radio-controlled Q2C jet target drone automatic flight control system. A magnetic powder clutch provides control surface torque proportioned to command and stabilization signal.

Requirements called for the servos to withstand a pressure build-up during a 3,000 ft-per-minute drop from 60,000 ft to sea level, violent shock on impact with water, total submersion in water and a rapid temperature change on immersion, with attendant contraction of the metal.

The servos withstand one atmosphere pressure differential (approx. 14 psi), vibrations of 10 G's, shocks measuring 25 G's, and absolute impregnability during submersion for 1½ hours.

Spaceship Control

A RELATIVELY simple gyroscope system, developed by Chance Vought, will control the attitude of space vehicles. The twin-gyroscope controller consists of two identical gyroscopes mounted in tiltable rings inside a common frame. Three such controllers would be installed in each space vehicle to keep it from rolling, pitching or yawing.

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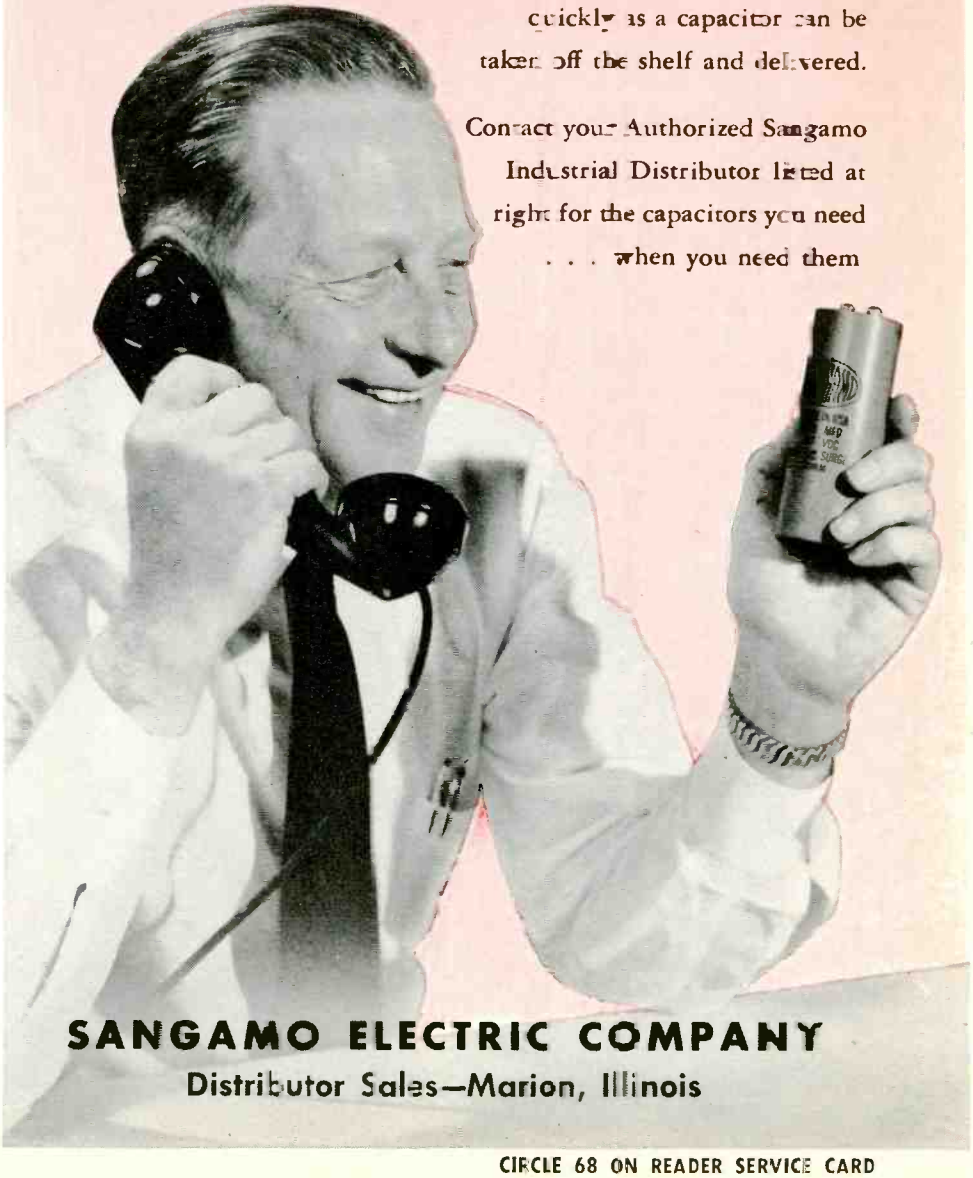

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gyroscopes require little power. They could be driven by energy from the sun.

The Vought gyroscope system serves as the control units and actually carry out the attitude corrections in response to the reference system.

Current systems for controlling the attitude of space vehicles consist of reaction jets or of motor-driven inertia wheels which create corrective torque and spin when an attitude adjustment is indicated.

Vought's controller was conceived by Donald R. Sellers, supervisor of the Electronics Division's Space-Vehicle Control Group.

Wire for 1,000 F

A FLEXIBLE ceramic insulated wire, claimed to be suitable for operating continuously at 1,000 F and to withstand 1,700 F for short periods, has been introduced under the name CERAMICITE by Wandleside Cable Works, Garrett Lane, London SW 18.

This ceramic insulated wire has space factor comparable with enamel wire and can be used for winding magnet coils since it has a high degree of flexibility. Insulation strength is nearly 600 volt/mil at room temperature and insulation resistance at 1,000 F of 2 megohm 100 ft for a wall thickness of 0.35 mils.

Although insulation resistance falls if exposed to a humid temperature, and it is not recommended for such conditions, the company is working on a waterproof coating. The CERAMICITE coating is formed on a nickel-clad copper conductor and gives a coating claimed to have excellent abrasion-resistant properties.

Wandleside Cable Works also manufactures TEFBOND, a bondable cable.

Two-Gap Klystrons

INCREASED bandwidth for equivalent output is attained by two-gap, double tuned cavities which have been built by Litton Industries, San Carlos, Calif., and Eitel-McCullough, San Bruno, Calif.

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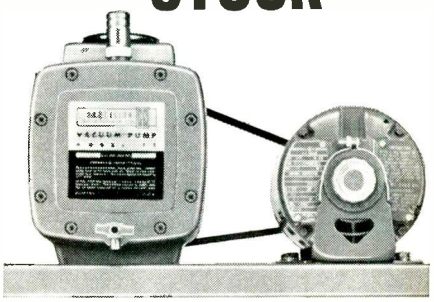

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View of line from unloading station. Long length of conveyor permits heated epoxy to set before the tube and shield assembly is transferred

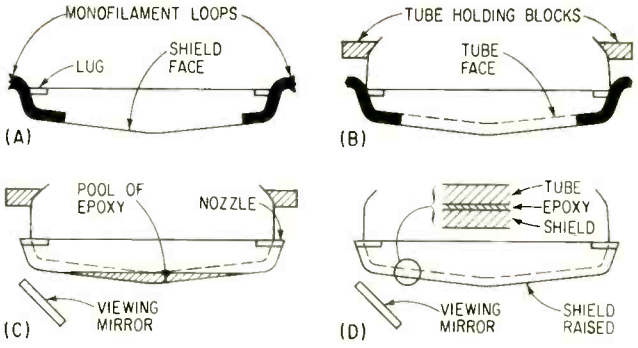


FIG. 1—Fixture provides space between tube and shield. After bonding resin is inserted, shield is raised to complete lamination

Closing Space Spreads Bonding Resin

PRESSED GLASS, wrap-around implosion shields are laminated with epoxy resin to some types of tv picture tubes. A major production problem is placing an adequate, uniform amount of liquid resin between the glass parts at a speed consistent with volume production.

To mechanize its production of this type (Bonded Shield) of tube, Sylvania Electric Products, Inc., devised methods which differ considerably from experimental methods previously reported (ELECTRONICS, p. 128, Oct. 10, 1958). Mechanized lines are in operation at Seneca Falls, N. Y., for 19-inch and 23-inch tubes, and at Ottowa, Ohio, for 23-inch tubes.

Similar techniques can also be applied to industrial and military cathode ray tubes. Laminated shields, according to the firm, are practical when reticles must be used for marking and improve safety, visibility and dirt protection.

Each production line has a loading station, preheat oven, resin filling and spreading stations, curing section and unloading station. The conveyors are of the indexing, endless chain type with fixtures returned under the conveyor frame. Cleaned and pretested picture tubes are delivered to the lines on overhead conveyors. They differ from conventional tubes only in the envelope, which is designed for the shield. Shields are cleaned and inspected, then placed on a moving

Shields are inspected and cleaned on light tables

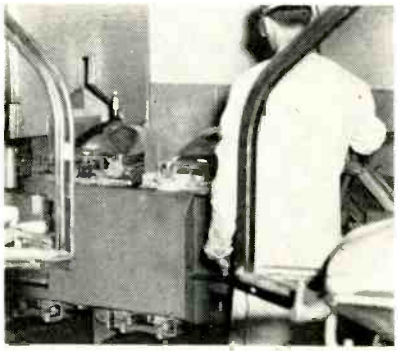
belt conveyor. At Seneca Falls, both conveyors supply 2 bonding lines, so tube and shield sizes alternate on each supply conveyor.

Fixtures are designed to hold a shield and tube in alignment and at the correct separation for insertion of the epoxy. The shield, placed in the fixture with its cavity up, rests on 4 lugs or mounting ears at each corner of the shield. Small blocks swing over the lugs to lock the shield in position.

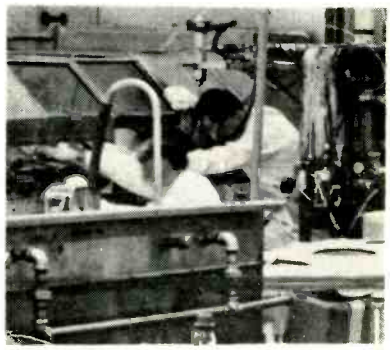
After the shield is positioned, the operator places a frame on the fixture and loads the tube. The frame is equipped with spacers to provide the necessary lateral spacing of the parts and the space between the tube face and shield. A slippery monofilament (Fig. 1A) pulls out, leaving a free air space between shield and tube (Fig. 1B). The space is slightly larger than the space between tube and shield in the finished assembly.

The conveyor then passes through the preheat oven. The assembly is heated to 200-250 F and resin temperature is 200 F, to facilitate curing. Resin is DER 741-A and hardener is DEH 61 (Dow Chemical Co.), at present.

Resin and hardener are piped from supply tanks in an adjoining room and mixed by an automatic dispenser at the filling station. The compound is delivered to a nozzle which fits between the tube and the



Fixture loading. Assemblies are seen entering preheat oven through the port at left



Resin dispensing and spreading stations. Operators are looking down into mirrors

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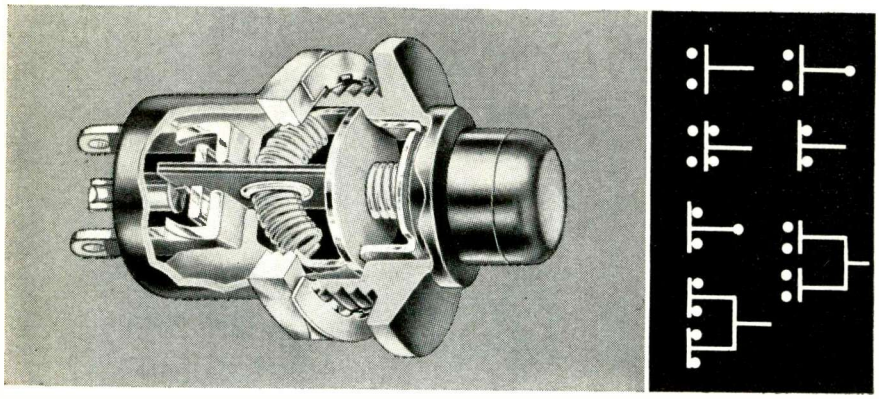

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lip of the shield (Fig. 1C). A hand control at the nozzle permits the operator to control flow of compound and also to clear the nozzle of partially cured resin should there be a delay in its use. The charge of resin fills about half the space. The operator watches the filling action through a mirror under the conveyor. Resin should appear as a clear, circular pool.

At the next station, the shield is raised slightly toward the tube by means of a handwheel, screw and cams in the fixture. As the operator watches in another mirror, the resin pool spreads until it completely fills the space (Fig. 1D). The layer must have a uniform, minimum thickness of 0.060 inch.

Both filling and spreading operations are critical. If either operator notices any gas bubbles or imperfections in the resin, the tube and shield are immediately removed from the fixture. The parts are cleaned with solvent and returned to stock.

The epoxy cures as it travels the remainder of the conveyor. The tubes are reloaded onto the overhead conveyor for subsequent finishing, inspecting, labeling and packaging. Among the finishing steps is a spray coat of lacquer which protects the joint between shield and tube.

Grinder Bonds Solder To Difficult Materials

DIFFICULT-TO-SOLDER materials can readily be prepared for soldering by coating the surface of the material with a solder-loaded abrasive wheel. Strong coatings are obtained on metals which quickly oxidize, ceramics, carbides, glass, thermosetting plastics and wood. Connections made to ceramic, for example, by soldering wire to the coating were found to be stronger than the wire. Flux is not used.

The wheel is prepared by rubbing it with a bar of coating metal while the wheel is rotating. The loaded wheel is then rubbed against the surface to be coated, while the wheel is rotating at high speed. If the base material is a metal such as aluminum, the abrasive burnishes the surface while applying the

metal. Lower speeds (about 250 rpm) are used for nonmetals and care must be taken not to char wood or plastics.

A recommended production method is to place the wheel in a drill press and press it down on the surface to be coated. A spot the diameter of the wheel is covered. Hand grinders, hand drills, emery paper or sandpaper can also be used.

An alternate method is to lay a thin sheet of the coating material over the surface to be covered and bear down on it with an unloaded wheel. If high-temperature solder is to be used, the wheel or the base material should be heated to the melting point of the solder or slightly higher.

Wheels with 100 grit abrasive are satisfactory for most materials. A coarser, 75 grit wheel is best for aluminum. A variety of fusible alloys can be used, including lead-tin solders, bismuth-lead-tin-cadmium-indium solders, tin-indium, tin-cadmium and indium. Gold and silver will coat if the temperature is raised. Wood's metal is best for aluminum. Once the initial coating is applied, additional coatings and solder can be applied by conventional methods.

Details of the technique are described in a patent (2,914,425) assigned to the U. S. Atomic Energy Commission by J. C. Maguire. The patent was recently made available to industry by the AEC.

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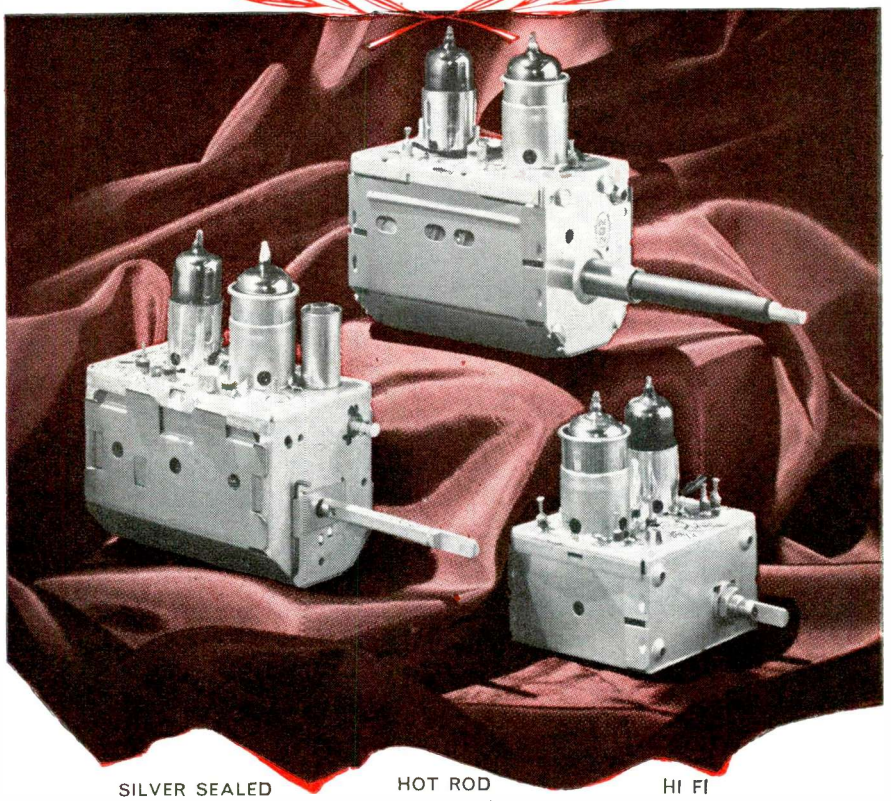

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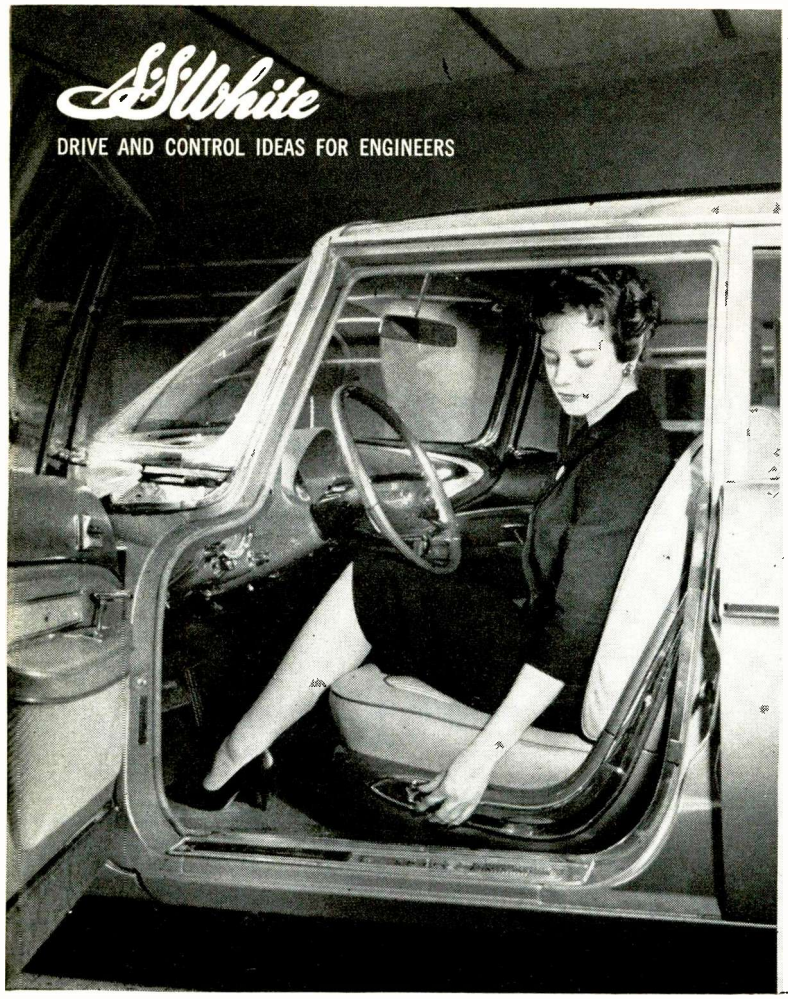

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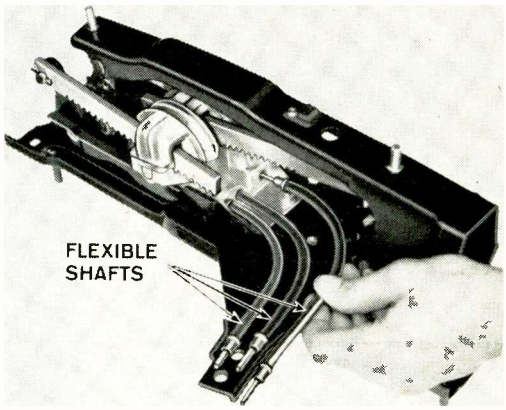

Flexible Shafts Solve Space Problems in Chrysler Power-Seat

Chrysler Corporation faced a design challenge in its power-operated seat adjuster. Six-way motion was called for: fore and aft, up and down, and tilt. Yet there was limited space under the seat for the mechanism. After much Chrysler testing and development, a design submitted by subcontractor Ferro Stamping Company was approved, utilizing flexible shafts.

According to Chrysler, the decision to go to flexible shafts was based on the following advantages:

1. SPACE ECONOMY..."flexible shafts provided means to transmit power from a single electric motor, without compromising seat design."

2. REDUCED STRESSES..."flexible shafts act as torsion bars to reduce motor armature stresses induced when the mechanism was stopped or stalled suddenly."

3. RELIABILITY..."not a single shaft fatigue failure reported from the field to date."

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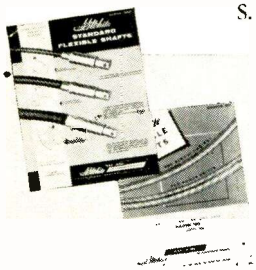

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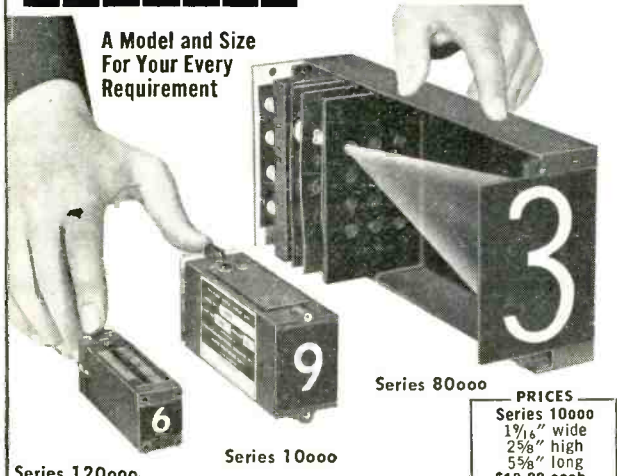

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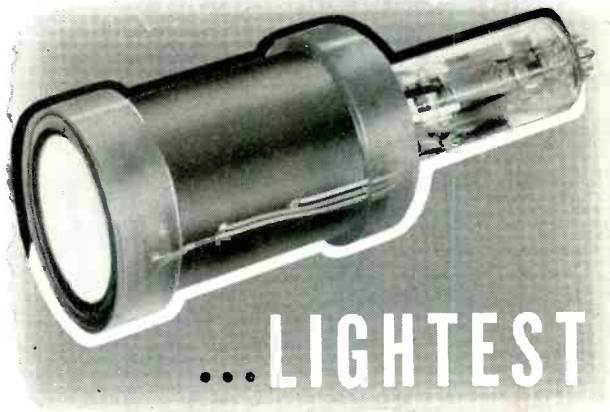

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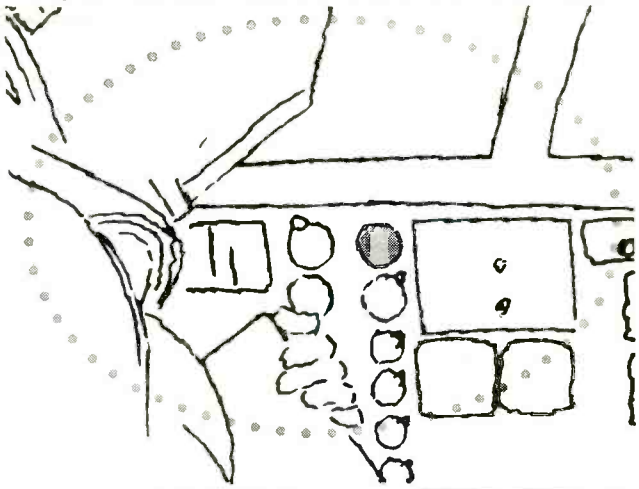

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BRIGHTNESS: 1500 Foot lamberts.
PERSISTENCE: Operator controllable up to 30 sec.
FOCUS and DEFLECTION: Electrostatic.

The new ITT FW-211 IATRON is a major advance in weight and size reduction for direct view storage tubes.

This new tube is small enough and light enough to be installed in the crowded panels of even the most sophisticated aircraft or research vehicles for radar or infrared data presentation.

The FW-211 offers the additional advantages of low power requirements and high brilliance for good visibility even in direct sunlight. It also features ITT's exclusive coaxial gun design which eliminates all possibility of trapezoidal distortion.

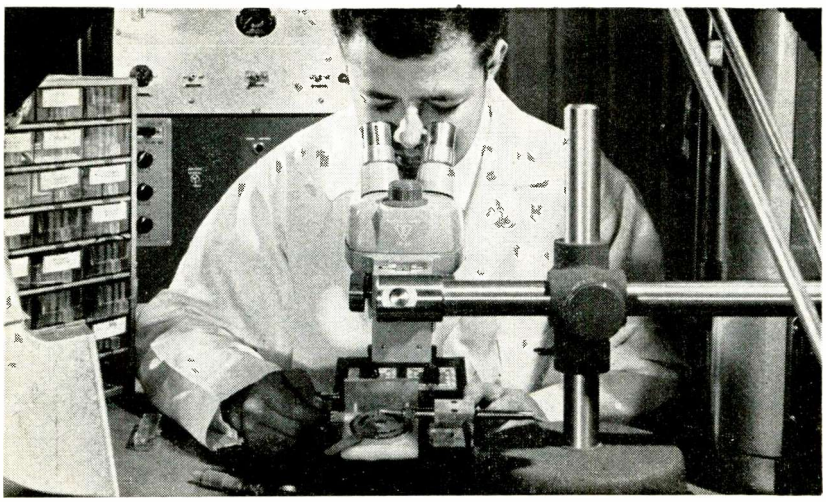
Other IATRON types and sizes are also available.

ITT Laboratories
INTERNATIONAL TELEPHONE AND TELEGRAPH CORPORATION
3701 E. Pontiac Street • Fort Wayne, Indiana

SEND FOR COMPLETE FW-211 IATRON DATA

CIRCLE 101 ON READER SERVICE CARD

New On The Market



Micromodule Kit

CUTS DESIGN TIME

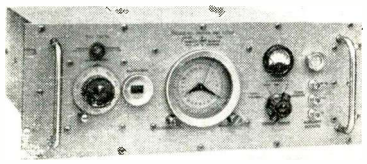
SELF-CONTAINED micromodule laboratory kit is available for less than $8,000 from RCA Semiconductor and Materials Div., Somerville, N. J.

Engineers can design and fabricate micromodules and electronic circuits with packing densities of several hundred thousand parts per cubic foot. The kit enables manufacturers and engineers to experiment with micromodules in their own laboratories with a speed that is not now possible because of demand on RCA facilities. Design time may be reduced from weeks to days.

With exact tolerances and specifications already built into the experimental circuit RCA facilities can be used for mass production. Ten feet of work bench and a tank of nitrogen are the only additional equipment needed.

Micromodule laboratory kits start with the completed wafers and include all equipment necessary to build and test up to ten modules with the exact values, configurations and densities desired. Included are an air-abrader, an automatic control device to shut off the air-abrader, curing oven, vacuum dust collector, 10 to 20 power stereo-zoom lens microscope, parts cabinet, heat sink, encapsulation mold, other support elements and design handbook.

CIRCLE 301 ON READER SERVICE CARD



Frequency Divider

AND CLOCK

A FREQUENCY DIVIDER and clock, for precise time comparisons between stable oscillators and standard WWV or other transmitted time signals, is available from Hewlett-Packard Company, 1501 Page Mill Road, Palo Alto, Calif.

The instrument, model 113AR, permits adjustment of frequency or time standards and simplifies data gatering of drift rates, or time or frequency differences between oscillators in widely separated systems. Propagation path errors can be averaged out and doppler errors are virtually eliminated.

The clock has a 10 microsecond time comparison capability, resulting primarily from a directly calibrated, precision phase shifter and a jitter-free optical gating system. Regenerative dividers, a phase-stable motor and precision gear train provide fail-safe pulse counting operation.

Only 7 inches high, the unit is conservatively designed with premium components. It is fully transistorized and meets all performance requirements of MIL-E-16400. Price is $2,500; delivery is 6 weeks.

CIRCLE 302 ON READER SERVICE CARD

Nuvistor Oscillator Kits

THREE BLOCKING OSCILLATORS

TEST KITS of 6 standard nuvistorized blocking oscillator units are available for research, breadboarding and experimental laboratory applications. Manufacturer is Mini-Rad, Inc., 7416-E Varna Ave., North Hollywood, California.

Units in the MBO (monostable blocking oscillator) kit provide a complete range of output pulse widths from 0.05 to 25 μsec.; the ABO (astable blocking oscillator) kit contains 6 units which provide

output pulse (free running) repetition rates from 1 to 1,000,000 pps; the six units of the CBO (counting blocking oscillator) kit provide a d-c control pulse repetition rate countdown from 1 to 1 to 10 to 1 over an input pulse repetition range of 100 to 1,000,000 pps.

Units are furnished either nuvistorized or transistorized, in kits containing all of one type, or mixed at prices from $125 to $475 for a kit of six units.

CIRCLE 303 ON READER SERVICE CARD

Absorber Ceramics

FOR MICROWAVE APPLICATIONS

A NEW microwave absorber ceramic, CFI Body Series 1000, is now available in commercial quantities. The high-power ceramics are well suited for microwave use over a broad frequency range for high and low-power applications. They are available from Ceramics for Industry, Cottage Place, Mineola, N. Y.

A typical high-power absorber ceramic, CFI-1003, exhibits excep-

NOW! 2 GREAT NEW AMPLIFIERS

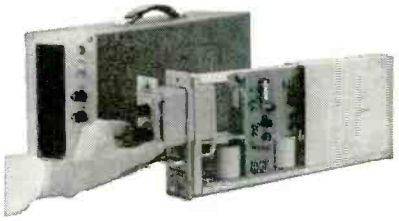
Model A14—High input source impedance for operational applications.

Model A15—Noise level less than 1 microvolt!

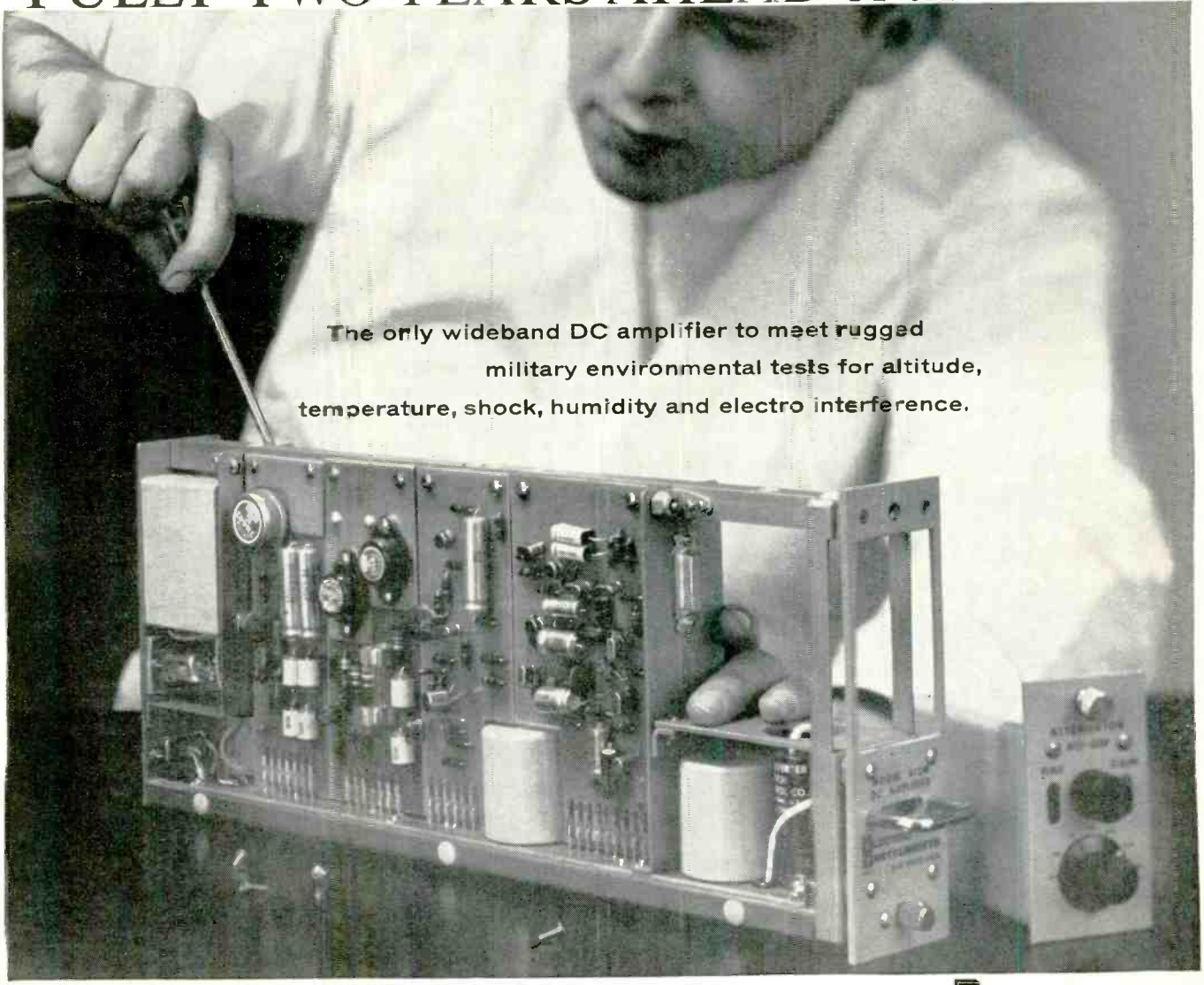
Electro Instruments Model A12 D.C. Amplifier

Totally transistorized—dissipates only 7 watts.
Long term drift less than 2 microvolts.
.01% linearity and stability.
100 megohms input impedance—40 milliohms output impedance.
1 db DC to 10 KC.
Noise less than 10 microvolts wideband.
Single ended or differential input.
Operates to specifications from 0° to 50° C.
Self-contained power supply—operates on any line frequency from 50-400 cps.
Mil-type chopper gives unmatched reliability for the life of the instrument.
7" x 19" panel accommodates 8 instruments.

Plug-in attenuators of the A12 provide convenience, flexibility and economy. Special variations, gain settings, etc., can be tailored to your system at no extra cost.



FULLY TWO YEARS AHEAD of the FIELD!



Electro Instruments, Inc.

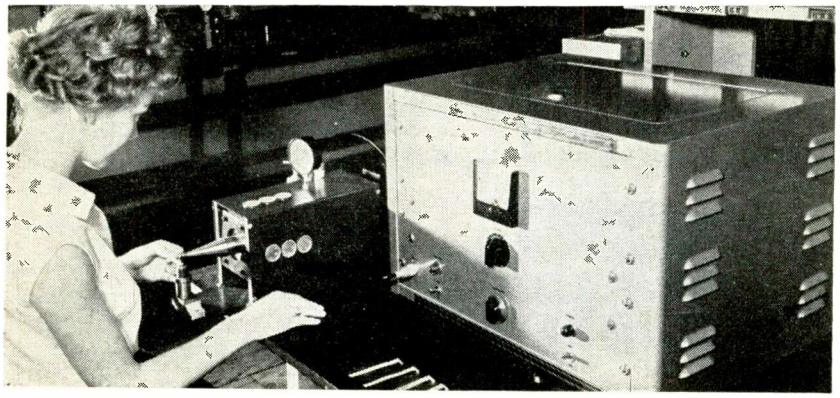
3540 AERO COURT
SAN DIEGO 11, CALIF.

CIRCLE 103 ON READER SERVICE CARD 103

tionally high losses of 9.05 db per cm at 25 C and minimum attenuation over an extremely wide range of frequencies. In addition, CFI-1003 is stable at temperatures in excess of 1,000 C in both low and high power systems.

These microwave absorber ceramics are being used in mode suppressor, level-set and variable attenuators and termination applications.

CIRCLE 304 ON READER SERVICE CARD



Ultrasonic Spot Welder

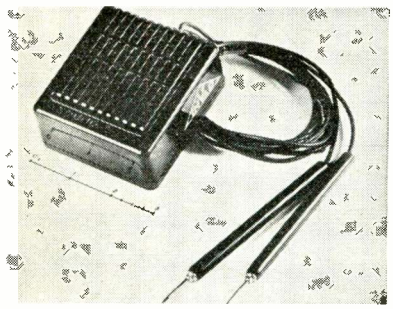
SELF-TUNING CIRCUIT

AN ULTRASONIC spot welder with a high temperature high efficiency transducer construction and a self-tuning circuit is announced by International Ultrasonics, Inc., Rahway, N. J. an affiliate of Aero Supply Mfg. Co., Inc. Self-tuning assures weld uniformity and minimizes need for operator skill.

The spot welder is used for joining similar or dis-similar metals, of equal or different thickness. The top piece may be up to 0.006 in. in thickness with no limit on thickness of the bottom piece; materials as thin as 0.00025 in. have been joined. Typical applications include joining leads to capacitor foil, joining foil tape for foil-wound transformers, attaching leads to transformer tape, making lead connections to transistors and diodes and making attachments to copper and aluminum printed circuit boards.

The 100-watt generator operates on 50-60 cps, 115 volt a-c; nominal frequency is 40 Kc; automatic timer is variable between 0.1 and 5 seconds. The welding head is supplied for bench mounting but can be built into handling or assembly machinery. Clamping is by air cylinder; interchangeable tips are provided for fine, medium and heavy welding.

CIRCLE 305 ON READER SERVICE CARD



Continuity Tester

HAS VARIABLE TONE

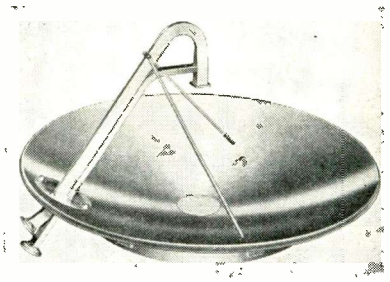
AN INEXPENSIVE continuity tester, the CIRCUITESTER for production line or lab wiring continuity checks is announced by Invar Electronics Corp., 323 W. Washington Blvd., Pasadena, California. The tester is a transistorized buzzer which gives an audible tone when path resistance is less than 0.5 ohm. Path resistance changes between 0.5 ohm and 15 ohms change the pitch of the buzzer substantially, and above 15 ohms path resistance there is no tone. The device tests for direct wire paths and is not sensitive to paths through inductances or capacitors. Low operating current prevents damage to sensitive components such as transistors and diodes and extend the tester battery life.

CIRCLE 306 ON READER SERVICE CARD

Polarized Antennas

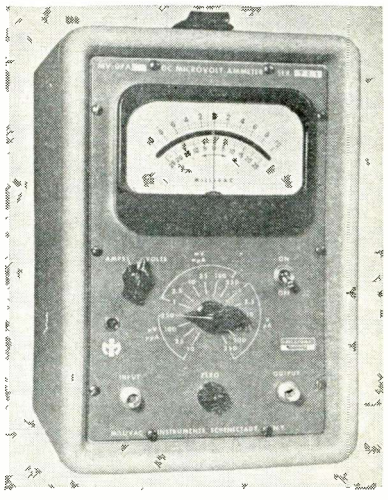
ELIMINATE CIRCULATORS

A SERIES of dual polarized 6 Gc antennas is offered by Andrew Corporation, P. O. Box 807, Chicago 42, Illinois. The antennas combine two microwave signals in a single antenna, with the two signals fed to the antenna by independent waveguides. This design eliminates the need for circulators and reduces tower windloading, installation and maintenance cost.



Mechanical specifications of these antennas are similar to those for comparable sizes of the Andrew plane-polarized 6 Gc antennas; units are offered in 4, 6, 8 and 10 foot sizes.

CIRCLE 307 ON READER SERVICE CARD



Micromicro Ammeter

ALSO MEASURES MICROVOLTS

MILLIVAC INSTRUMENTS, Division of Cohu Electronics, Inc., Box 997, Schenectady, New York, announces the new MV-07A d-c microvolt and

A slight electrical potential exists between all objects.

It can raise the dickens inside a hi-fi tube!

To live with it in your amplifier you must either–

lose gain, accept distortion, or use tubes that have

Controlled Contact Potential.

DOESN'T SOMEBODY CONTROL CONTACT POTENTIAL IN HI-FI TUBES?

YES...GENERAL ELECTRIC!

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All General Electric hi-fi amplifier tubes are controlled for low Contact Potential. Use them. They're the BEST.

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Leadership in audio

GENERAL ELECTRIC

411-201

CIRCLE 105 ON READER SERVICE CARD 105

new GEN-PRO®

TAPER PIN TERMINAL BOARDS

New single row Taper Pin Terminal Board available in 10 or 20 feed-thru type taper receptacles, single and double feed-thru connections. Ideal for computer and data processing programming, multi-channel communications systems, etc.

EASY TO MOUNT AND STACK

TPB-20-S

Barriers across both faces increase creepage path; elongated holes facilitate mounting; nesting projection and recess aid stacking. Brass receptacles provide low contact resistance. 14 lbs. min. pull out with standard solderless taper pins. Molding compound is MAI-60 (Glass Alkyd) of MIL-M-14E.

Gen-Pro boards have passed Navy 2,000 ft. lb. high shock requirements as specified by MIL-S-901B.

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CIRCLE 206 ON READER SERVICE CARD

ELECTROMECHANICAL SWITCHES FOR TELEMETERING SYSTEMS!

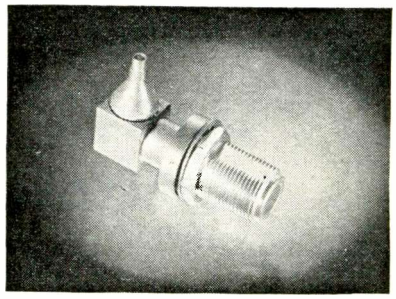
Specifications, performances, applications for typical electromechanical commutators for long-range sampling, programming. Quick comparisons let you know what's going on . . . see October 2nd, 1959 issue (did you miss it?). Another reason to subscribe to electronics (or renew your subscription). Fill in Reader Service Card box. Easy to use. Postage free.

FIND WHAT YOU NEED IN...

electronics

micromicro ammeter. The instrument has full-scale ranges from 10 μv to 250 v and 10 $\mu\mu$a to 250 μa. Voltage as low as 1 μv d-c and current to 1 $\mu\mu$a are measured with long term drifts of 2 μv and 2 $\mu\mu$a. Individual range calibration controls provide 2 percent full-scale accuracy for all voltage ranges except the lowest, 0-10 μv (3 percent); 3 percent accuracy for all current ranges. Cascode input stage provides an excellent signal-to-noise ratio while a twin T-filter cuts down the bandpass for further noise reduction.

CIRCLE 308 ON READER SERVICE CARD

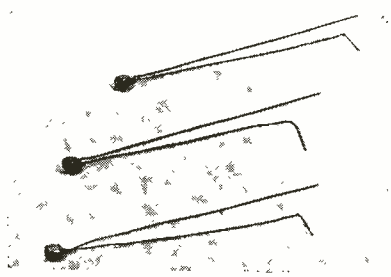


Bulkhead Adapter

FOR COAXIAL CABLE

SEALECTRO CORP., 139 Hoyt St., Mamaroneck, N. Y., announces a new right-angle bulkhead coaxial cable adapter. The new ConheX product permits bulkhead connections between large-size coaxial transmission lines to miniaturized coaxial cable, through a regular Conhex cable connector. Impedance of the unit is 50 ohms, and it is designed for minimum power losses.

CIRCLE 309 ON READER SERVICE CARD

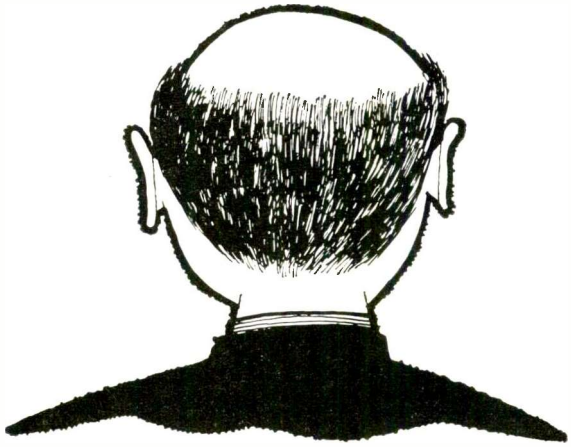


Selenium Diodes

SUBMINIATURE

RADIO RECEPTOR CO., 240 Wythe Ave., Brooklyn, N. Y., has announced new and smaller plastic encapsulated selenium diodes. Priced at only 13 to 30 cents, they come

IT'S WHAT'S IN HERE THAT COUNTS



Do you know, for instance... which electronic stocks are hottest? Who's in the news and why? About "Three Approaches to Microminiaturization"? About the newest product ideas hitting the market? What's up in production? Opportunities overseas? What's going on in Washington?

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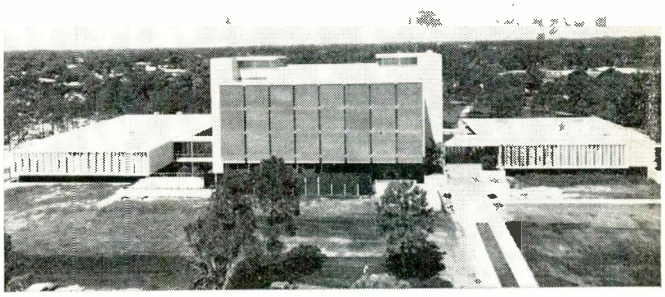

The University of Miami's School of Engineering offers the latest in research and advanced educational facilities in the engineering fields of: architectural, civil, electrical, mechanical and engineering science.

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CIRCLE 207 ON READER SERVICE CARD

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ELECTRONIC TUBE GENERATORS:
1 kw; 2½ kw; 5 kw; 10 kw;
20 kw; 30 kw; 50 kw;
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2 kw; 4 kw; 7½ kw;
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WRITE FOR THE NEW LEPEL CATALOG 36 illustrated pages of valuable information.

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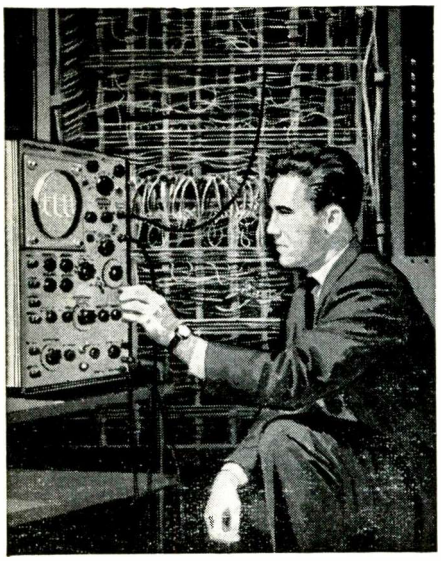

digital computer designers

The Crosley Division of Avco Corporation has openings for electronic engineers with from two to ten years' experience for unusually responsible positions involving digital computer and data processing equipment design.

At Crosley, all projects offer engineers of talent and capability unlimited challenge and definite authority. An alert, aggressive management team provides maximum support and backing to each of the outstanding professional teams working on the frontiers of data processing for industrial systems.

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- digital systems design
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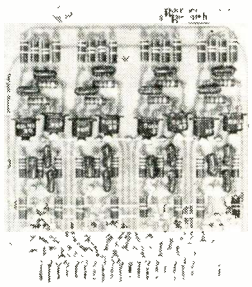
Manager of Scientific and Administrative Personnel
Department E-710
Crosley Division
Avco Corporation
1329 Arlington Street
Cincinnati 25, Ohio
Phone: KIrby 1-6600.

Avco/Crosley

in eight types, with peak voltage ranges up to 400 v at 3.75 ma. Maximum case length is 0.188 in. for all types, with widths ranging from 0.188 in. for the 50 and 100 piv units to 0.350 in. for the 350 and 400 piv units. They are capable of operating in ambient temperatures from — 50 C to + 100 C without derating. Diodes are color coded for identification of type and indication of polarity.

CIRCLE 310 ON READER SERVICE CARD

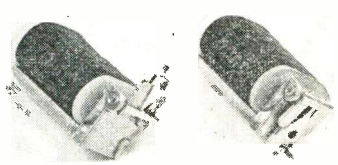


Converter

ANALOG-TO-DIGITAL

RANSOM RESEARCH, 323 W. Seventh St., San Pedro, Calif. Model 301 analog to digital converter is intended for use as the heart of an analog to digital system. It will convert any input voltage of — 0.999 v full scale to three decimal digits with an overall accuracy of ± 1 digit, or an equivalent of ± 1 mv. Conversion time is 1 millisec for any input. The instrument consists of a rack mounting card file which contains plug-in printed circuit computer elements which include the power supply and reference voltages. This modular construction permits the addition of many optional features and easy maintenance.

CIRCLE 311 ON READER SERVICE CARD

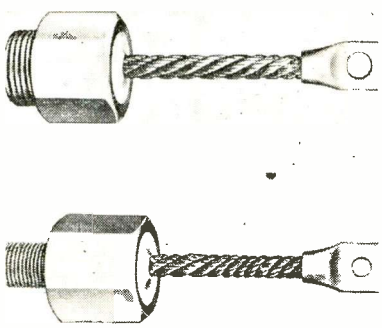


Solenoid Actuator

COMPACT AND LIGHT

JAMES CUNNINGHAM SON & CO., INC., 103 Litchfield St., Rochester 8, N. Y., announces the type L13 electromagnetic d-c actuator designed for optimum power output. It is available with both push and pull linkages and has application in reciprocating motion, vibration generators, rotary step motion, model actuators, remote switches, valve actuators, computers and automated equipment. The actuator utilizes a patented linkage system which magnifies the original air-gap movement in a 8 to 1 ratio, thereby delivering maximum pull and stroke from small input. Unit has a life of 100 million operations and is capable of 7 millisec operating time at normal voltages. The actuator may be set for either push or pull by simply reversing the position of the arm. It has a maximum stroke of 0.125 in., exerting a pull of 100 to 550 grams. Type L13 features a nylon coil bobbin, fungus resistant components, light weight construction (50 grams) and a low input of 1.5 w.

CIRCLE 312 ON READER SERVICE CARD



Silicon Rectifiers

TWO NEW STYLES

SYNTRON CO., 241 Lexington Ave., Homer City, Pa. Styles ES-51 and ET-51 silicon power rectifiers have peak forward voltages of 1.25 v maximum at 200 amperes. The peak inverse current is 50 ma at 100 C case temperature. The thermal drop is 0.50 C/w maximum from junction to case. Temperature range is — 35 C to + 120 C (case) and — 35 C to + 150 C (junction). Mounting torque for style ES-51 is 800 in.-lb maximum and for ET-51 it is 1,000 in.-lb maximum. Overall length for ES-51 is 5½ in. maximum and ET-51 is 5 in. maximum. Piv ranges from 100 to 400 v in 100 v steps.

CIRCLE 313 ON READER SERVICE CARD

Literature of the Week

MULTIPLEXER Radiation Inc., Melbourne, Fla. A four-page brochure describes "Radiplex 89," a low-level switching multiplexer which features flexibility, compactness and economy.

CIRCLE 325 ON READER SERVICE CARD

THERMOSET MATERIALS Fiberite Corp., Winona, Minn. A new comparative chart for compression molders and for transfer molders shows the mechanical, electrical and thermal properties of all general purpose thermoset materials comparatively.

CIRCLE 326 ON READER SERVICE CARD

SURGE TEST ADAPTER Wallson Associates, Inc., 912 Westfield Ave., Elizabeth, N. J. Technical data sheet 107 contains a detailed description of the model 142A completely self-contained 75 ampere surge test adapter.

CIRCLE 327 ON READER SERVICE CARD

SEALED LIMIT SWITCHES Micro Switch, Freeport, Ill. Data sheet No. 171 presents two pages of information on the new 400 EN series sub-subminiature sealed limit switches.

CIRCLE 328 ON READER SERVICE CARD

TRANSISTORIZED POWER SUPPLIES Electrodynamic Instrument Corp., 1841 Old Spanish Trail, Houston 25, Texas, has published a brochure on a line of transistorized power supplies. It contains information and specifications on d-c/d-c converters, d-c/a-c inverters, and a-c/d-c power supplies for laboratory, airborne, mobile, communications and automation applications.

CIRCLE 329 ON READER SERVICE CARD

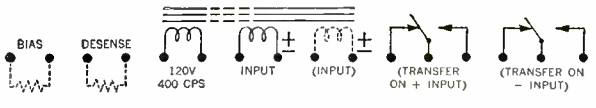
DIGITAL TRANSDUCERS Datex Corp., 1307 S. Myrtle Ave., Monrovia, Calif. Bulletin No. 150 illustrates and describes the DX-100 series digital transducer which receives pressure, flow or temperature variables and provides a digital output in the form of contact closures for data recording or transmission.

CIRCLE 330 ON READER SERVICE CARD

unusual potting, push-pull design increase stability of new 400-cycle magnetic amplifier relay

If you pried the base off the can of this new magnetic amplifier relay (which you probably wouldn't after paying good money for a hermetically sealed device) you might be surprised. Sitting there in quiet intimacy would be an isolation transformer, reactor, one or two relays and sundry other items — all immersed in a transparent, slightly wiggly material, just like grapes in a gelatin salad. The compound is selected for its ability to soak up shock, vibration and thermal expansion. In that order, the specs for this device are 100 g's, 10 g to 55 cps, −55° to +100°C.

What you can do with the Series 8300 is the same thing you can almost do with any good transistor- or meter-relay — except this one will work on DC inputs as low as 0.2 μw. and remain stable (circuit is push-pull) under ±10% variations in line voltage, frequency, and the 155° spread mentioned earlier. Standard models also have single or dual coils, a contact rating of 1 amp. at 28 VDC/120 VAC, resistive, for at least 100,000 operations, and terminals for connecting bias and desensing resistors. The connection schematic looks like this, but has the circular floral arrangement as pictured:



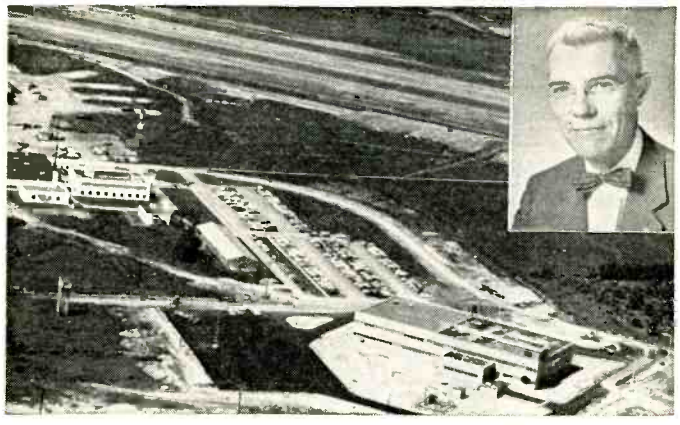
If you have an application that demands an even fancier version with such features as DPDT output contacts, higher vibration and load ratings (and less sensitivity), built-in DC power supplies, reference sources, etc., we may be able to do something for you on a special order basis. First, however, it would probably be a good idea to see our 5 ±20%-page Series 8300 Preliminary Bulletin — collated, stapled, 3-hole punched and unpotted.

= μH

SIGMA

SIGMA INSTRUMENTS, INC.
62 Pearl St., So. Braintree 85, Mass.

AN AFFILIATE OF THE FISHER-PIERCE CO. (since 1939)



GE's Advanced Electronics Center

GENERAL ELECTRIC'S Light Military Electronic Department has just added a new million-dollar research and development building (lower right in photo above) to its Advanced Electronics Center on the edge of the Tompkins County airport near Ithaca, N. Y.

Managed by Harry Mayer (inset), the Center constitutes the first occupant of Cornell University's Industry Research Park. Employing 376 scientific, technical and administrative people on its permanent staff and many specialized consultants, the Center is actively investigating anti-jamming frequency-diversity radar, contact analog displays with which it is hoped the flying of complex airplanes can be simplified and the so-called "Roberts Rumble" effect having to do with the reception of signals well in the aftermath of passing satellites.

Other current in-house programs include automatic message authentication, study of the ionosphere from above, the possibility of applying a photo input of high resolution to thermoplastic tape, natural noise at high altitudes and in space, tracking ground-launched missiles from satellites, development of infrared equipment to sense colors and thermocouple energy converters.

The Center works primarily on contracts received direct or through its parent department from government agencies but also cooperates with other GE divisions, and occasionally with other firms, on projects of an advanced nature.

Jordan Electronics Hires Beltz

ROBERT BELTZ has joined the Jordan Electronics Division of The Victoreen Instrument Co., as senior engineer.

Jordan Electronics, Alhambra, Calif., is developer and manufacturer of electronic devices for missiles and aircraft including a programmer which schedules all events of missile flights.

Beltz came to Jordan from Hughes Aircraft Co. where he was a staff engineer. He previously was an engineer with Western Design and Mfg. Co.; Vard, Inc.; and Electrofilm Corp.

Amperex Promotes Two Key Men

EDWARD FEINBERG has been promoted to the position of product manager, industrial and government semiconductors and special purpose tubes, at Amperex Electronic Corp., Hicksville, L. I., N. Y. He previously was assistant product manager of the same department.

Promotion of Edward Meagher to the position of product manager, entertainment tubes and semiconductors, is also announced. He was previously sales engineer in Amperex's Chicago office.

Amperex Electronic Corp. is engaged in the research and development, manufacture and sale of electron tubes and semiconductors for communications, defense and industry.

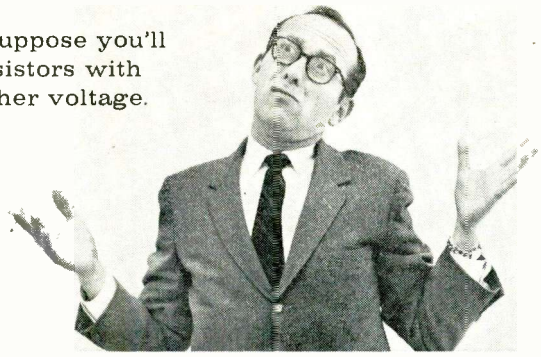
Both promotions are part of Amperex's current expansion program, which also includes the acquisition of a new plant in Slatersville, R. I., for the manufacture of transistors and diodes.

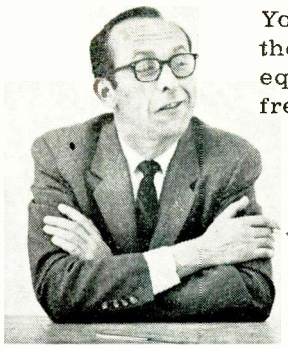
Petruschke Joins Assembly Products

APPOINTMENT of Reinhold Petruschke to the newly-created position of chief industrial engineer at Assembly Products, Inc., Chesterland, O., has been announced. He will be in charge of production of all parts and sub-assemblies for the company's meter-relays, panel meters and complete controls. He will also be responsible for plant maintentance, job evaluation, new employee testing, and administration of the bonus plans.

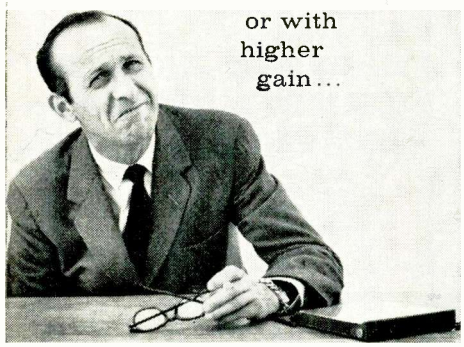
Before joining Assembly Products, Petruschke was production manager of the phonograph plant at the V-M Corp., Benton Harbor, Mich.

Yes, I suppose you'll find transistors with higher voltage.

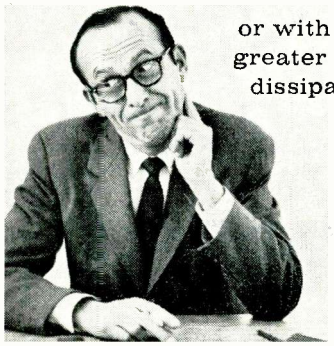




You'll find them with equal or higher frequency...



or with higher gain...

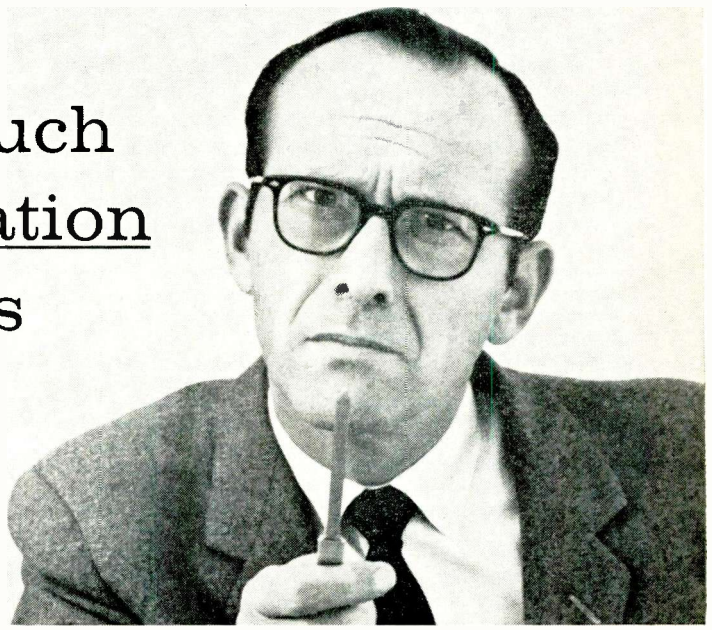


or with greater power dissipation

One or two others even approach the temperature range. BUT..

no other transistor has such an ideal combination of parameters

as the Hughes 2N1196 or 2N1197 transistor amplifier



No other transistor gives you such ideal parameters, no other gives you such reliability. These Hughes high-frequency devices meet or exceed every possible amplifying requirement of a PNP silicon transistor. They have high operating voltage, high temperature rating, high alpha cutoff frequency, high gain at high frequencies, low collector shunt capacitance, good power dissipation, and low signal distortion. In a 5000-hour storage-life test at 200°C, the units re-proved their ruggedness and reliability by showing no significant changes in the beta or leakage current.

The Hughes 2N1196 & 2N1197 transistors were originally developed in conjunction with the U.S. Army Signal Corps on an IPS contract for military devices, and meet the exacting requirements of MIL-T-19500A.

Now they're available for you. If you need high-frequency, double-diffused, mesa transistors for i.f. amplifiers, h.f. amplifiers, oscillators, for communication telemetering, or similar electronic equipment, order from Hughes today. Just call or write your nearest Hughes Semiconductor sales office or authorized distributor—or write Hughes Semiconductor Division, Marketing Department, 500 Superior Avenue, Newport Beach, California.

SPECIFICATIONS @ 25°C			
ABSOLUTE MAXIMUM RATING	2N1196	2N1197	Units
V_{CEO} @ I_{CEO} = −100 μA	−70	−70	volts max
V_{CBO} @ I_{CBO} = −100 μA	−70	−70	volts max
V_{EBO} @ I_{EBO} = −100 μA	− 4	− 4	volts max
ELECTRICAL CHARACTERISTICS			
P.G. @ V_{CE} −10v, I_E = 2mA	28 @ 4.3MC	22 @ 12.5MC	db typ
F_{ab} @ V_{cb} = −10v, I_E = 2mA	45	55	MC typ
C_{ob} @ V_{cb} = −10v, I_e = 0, f = 140KC	3	3	μμ fd typ
h_{fb} @ V_{cb} = −10v, I_E = 2mA, f = 1KC	.9	.94	typ

350 mW dissipation in Free Air
Operating temperature range −65°C to +200°C

Creating a new world with ELECTRONICS

HUGHES

SEMICONDUCTOR DIVISION
HUGHES AIRCRAFT COMPANY

CIRCLE 111 ON READER SERVICE CARD

STIMULATING!

Motorola engineers are the most stimulated and enthusiastic individuals you'll find anywhere. And, for sound reasons.

First, the work. Electronics—challenging fields that plead for vision, creativeness and imagination.

Secondly, the company, An "engineers' company"—developed by technical minds dedicated to engineering excellence. A rewarding company—quick to recognize and advance skill. A secure, diversified company—not wholly dependent on one single market.

Thirdly, the place, Chicago—exciting and quiet. Cosmopolitan and suburban. Mid-America's nucleus of culture, education and entertainment—where everyone can find the perfect environment.

- Radar transmitters and receivers
- Radar circuit design
- Electronic countermeasure systems
- Military communications equipment design
- Pulse circuit design
- IF strip design
- Device using kylstrom, traveling wave tube and backward wave oscillator
- Display and storage devices

2-WAY RADIO COMMUNICATIONS

- VHF & UHF receiver
- Transmitter design and development
- Power supply
- Systems engineering
- Antenna design
- Selective signaling
- Transistor applications
- Crystal engineering
- Sales engineering
- Design of VHF & UHF FM communications in portable or subminiature development
- Microwave field engineers
- Transistor switching circuit design
- Logic circuit design
- T.V. circuit design engineering
- Home radio design
- New product design
- Auto radio design
- Mechanical engineering
- Semi-conductor device development
- Semi-conductor application work

Also Splendid Opportunities in:

Phoenix, Arizona and Riverside, California

Send Complete Resumé to:

MR. L. B. WRENN
Engineering Personnel Mgr.
Dept. D
4501 Augusta Blvd.
Chicago 51, Illinois

EQUAL JOB OPPORTUNITY For All Qualified Applicants

MOTOROLA Inc.

SINGER

More than a Century of Engineering Tradition

The connecting factor between bobbins and broadband preamplifiers is the engineering tradition that brought them to fruition. Since 1850, the Singer Manufacturing Company has evolved a habit of alert engineering skill and steady business growth. These inherent factors for your professional success are now a part of the new Military Product Division at Singer-Bridgeport.

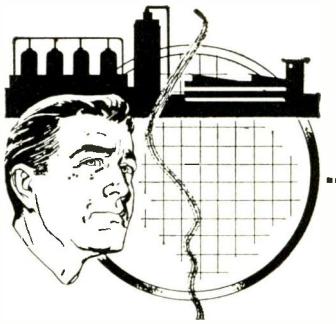
Openings exist for:

- **ELECTRONIC ENGINEERS**
- **ELECTRICAL ENGINEERS**
- **MECHANICAL ENGINEERS**

Singer-Bridgeport assures you the rare combination of security and genuine ground-floor opportunity that is vital to your professional growth. Your projects receive strong support from Singer-Bridgeport's integrated organization which has the advantages of development, production, assembly and environmental test facilities.

Send your resume in strict confidence to Mr. Fred Corbett, Supervisor of Employment

SINGER-BRIDGEPORT
A DIVISION OF THE SINGER MANUFACTURING COMPANY
915 Pembroke Street Bridgeport 8, Conn



Creative Opening for an

Electronics Engineer

in Controls Development

This career opportunity requires experience in electronic circuit design and a familiarity with vacuum tube and solid state components. Join a newly formed select group where individual initiative and achievement are quickly recognized.

At RIG you will find the rare combination of career advancement plus interesting assignments to match your training.

Send resume to:
Director of Engineering

SCHLUMBERGER
RIDGEFIELD INSTRUMENT GROUP
RIDGEFIELD CONNECTICUT

active programs in 19 critical electronic areas

Offer You Opportunities To Participate In Significant Advances at STROMBERG-CARLSON Division of General Dynamics

Top-calibre research and development teams at Stromberg-Carlson are tackling the prime problem areas in electronics affecting commercial communities and national defense. Programs and R & D staffs are expanding, backed by the vast resources of General Dynamics and the Stromberg-Carlson engineer-oriented management.

Every senior engineer and scientist who feels he can contribute to the expansion of man's capabilities in any of the following areas is invited to contact us.

We are particularly interested in people with advanced degrees in Physics, Electrical Engineering or Mathematics and experience in one or more of the areas listed. Please send resume in confidence to Technical Personnel Department.

ENGINEERING AND ADVANCED DEVELOPMENT

Advanced ICBM Communications
Electronic Switching
Nuclear Instrumentation
High-Speed Digital Data Communications
Electronic Reconnaissance Systems
Single Sideband Communications
Synchronous Data Transmission
Advanced ASW Techniques
Machine Tool Automation
Radio Data Links • Tacan Equipment
High Intensity Sound Generators
Advanced Air Acoustics
Shaped Beam Display Systems
High-Speed Automatic Missile Check-Out Equipment
Super-Speed Read-Out and Printing Equipment

RESEARCH

Paramagnetic Resonance • Ferroelectricity
Thin Photoconductor Films
Propagation and Coding • Speech Analysis
Bandwidth Compression • Hydro-Acoustic Transducers
Defect Solid State Physics
Parametric Devices • Molecular Electronics
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STROMBERG-CARLSON
A DIVISION OF **GENERAL DYNAMICS**

1422 N. Goodman St., Rochester 3, New York

AERONUTRONIC a Division of Ford Motor Company has immediate openings in

ELECTRONICS ACTIVITY OF TACTICAL WEAPON SYSTEMS OPERATIONS

for ELECTRONICS ENGINEERS

TO WORK IN

- IR Development
- Instrumentation Development
- Transistor Circuit Development
- Electronic Systems

Immediate expansion of new and existing programs is creating outstanding opportunities in R&D and PRODUCTION on advanced programs such as :

- Shillelagh, surface-to-surface tactical missile
- Air Cushion Vehicles
- Anti-submarine Warfare
- Air-to-surface tactical weapons

Positions are at interim facilities in Santa Ana near Aeronutronic's new $22 million Engineering and Research Center now being completed at Newport Beach, Southern California – the West's most ideal location for living, working and year 'round recreation.

Experienced engineers with demonstrated ability are invited to share in research and development work – work that is challenging and stimulating as well as exceptionally rewarding.

Send inquiries and resumes to Mr. John Starbuck, Dept. 5

TACTICAL WEAPON SYSTEMS OPERATIONS

AERONUTRONIC
a Division of FORD MOTOR COMPANY
FORD ROAD, NEWPORT BEACH, CALIFORNIA

3M COMPANY

MARKET RESEARCH ENGINEER

Continued growth of the 3M Company has created an opportunity in the Electrical Products Division. Electrical engineering or physics degree preferred. Three to five years experience with a manufacturing company in sales, market research, or product development very helpful. You will be responsible for search and evaluation of markets for new products. You will be expected to keep abreast of design trends in electrical equipment and electronic apparatus through attendance at professional society meetings and calls on research directors and advance planning engineers of customers. You must be capable of conducting market research studies for new and improved products with particular emphasis on size, geographical distribution, and growth potential. Ability to evaluate competitive product developments.

Location in St. Paul, Minnesota, provides easy access to nation's outstanding hunting and fishing areas. Salary commensurate with training and experience. Advancement based on individual merit.

Write or send resume to:

Technical Employment Manager
MINNESOTA MINING & MFG. CO.
900 Bush Ave., St. Paul 6, Minnesota

DISENCHANTED ENGINEERS

If your present employer has failed to utilize your full potential, why not permit us to explore the parameters for your personal qualifications with the many dynamic young companies in aviation, electronics, missiles and rockets. We now have in excess of 4,000 openings in the $8,000 to $40,000 bracket, all of which are fee paid. Why wait? Send resume in duplicate at once indicating geographical preferences and salary requirements.

FIDELITY PERSONNEL
1530 Chestnut Street, Philadelphia 2, Pa.
Established 1943

MANUFACTURERS' REPRESENTATIVES

IN THE ELECTRONIC INDUSTRY

SAMUEL K. MACDONALD, INC.
manufacturers representatives over 25 years
1531 SPRUCE STREET, PHILA. 2, PA.

Territory:
Pennsylvania • New Jersey
Delaware • Maryland
Virginia • West Virginia
District of Columbia

Other Offices:
Pittsburgh
Baltimore
Washington, D.C.

An employment advertisement in this EMPLOYMENT OPPORTUNITIES section will help you find the engineers you need. It's an inexpensive, time-saving method of selecting competent personnel for every engineering job.

SEARCHLIGHT SECTION

(Classified Advertising)

BUSINESS OPPORTUNITIES

EQUIPMENT - USED or RESALE

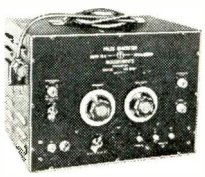
DISPLAYED RATE

The advertising rate is $24-75 per inch for all advertising appearing on other than a contract basis. Contract rates quoted on request. An ADVERTISING INCH is measured ⅞ inch vertically on one column, 3 columns—30 inches—to a page. EQUIPMENT WANTED or FOR SALE ADVERTISEMENTS acceptable only in Displayed Style.

UNDISPLAYED RATE

$2.40 a line, minimum 3 lines. To figure advance payment count 5 average words as a line. BOX NUMBERS count as one line additional in undisplayed ads.

MEASUREMENTS CORP. Pulse Generator



MEAS. CORP. MOD. 79-B Pulse Generator, 60-100,000 cy + pulses ½-40 usecs wd, and + sync pulses delayed ½ period. Can pulse modulate an external RF source and can be synched by an external sine source. This is the model preceding the current catalog model which sells for $495.00. Brand new in original packing, with instruction book, 40 lbs fob Harrisburg, Pa. **$97.50**

0.1% SORENSEN Line Voltage Regulator

±5000S brand new at a low surplus price! Output is adjustable 110-120 volts and holds the pre-set voltage to ±0.1% at line frequency, or to ± 0.25% if the line frequency drifts 5%. Taps for 50 or 60 cy., 1 phase. Regulates against line changes of 95-130 V, and against load changes from 0 to 5000 VA. Because of the low price, it is very smart planning to use it for lower-power applications which may later be expanded to 5 KVA. Max. harmonics less than 3%. Recovery time 0.15 seconds. In rack cabinet 28" h, 22" wd, 15" dp. Net wt 190 lbs. Note that input to control circuit can be moved to actual point of use of power, to compensate for line drop. Shpg wt 285 lbs FOB Utica, N. Y. warehouse. Packed for export. (13 cu ft.) Catalog net price is $695.00. less spares. Our price, new, in original packing, WITH SPARES, is only..... **$349.50**

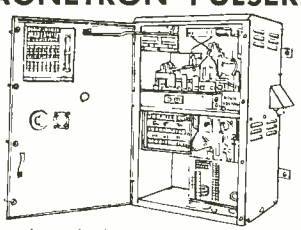
FOR OPERATION ON 230 OR 460 VOLTS: Max. input at nominal 115 volts when 5 KVA is used, is 71 amps (8165 VA). For use on 460/230 V lines, an 8½ KVA isolating step-down transformer is required. We can get it wound to order in Los Angeles, 1 ph., fully cased, boxed for shipment: 60 cy, $155.00, shpg wt 160 lbs. 50/60 cy: $170.00, shpg wt 175 lbs. Check your local winders; you may do as well or better. If not, order from us FOB Los Ang.

Circle Readers Service Card for our new listing of budget stretchers selected for you from surplus.

R. E. GOODHEART CO.
P. O. Box 1220-E Beverly Hills, Calif.

CIRCLE 460 ON READER SERVICE CARD

HARD and SOFT MAGNETRON PULSERS...



. . . *at bargain basement prices!* Will drive dozens of types of Magnetrons up to 250 kw. **from $675.00**

Phone: WAlker 5-6000

LIBERTY ELECTRONICS, INC.
582 BROADWAY
NEW YORK 12, N. Y.
Cables: TELSERSUP

CIRCLE 461 ON READER SERVICE CARD

LOOKING FOR

USED/SURPLUS ELECTRONIC EQUIPMENT/COMPONENTS?

For an up-to-date listing of such equipment see Searchlight Section of June 10th.

INDEX TO ADVERTISERS

Audited Paid Circulation

CLASSIFIED ADVERTISING

F. J. Eberle, Business Mgr.

ADVERTISERS INDEX

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Give your Products
MORE RELIABILITY and BETTER PERFORMANCE with
FREED QUALITY

HERMETICALLY SEALED
MIL-T-27A
PULSE TRANSFORMERS

- Maximum power efficiency and optimum pulse performance.
- For use in blocking oscillator, interstage coupling and low level output circuits.
- Ruggedized construction — Grade 4.
- Series or parallel connection of windings for optimum turns ratio.


DM-01

DM- 8

DM-20

DM-18

Cat. No.	MIL Type	Pulse Voltage Kilovolts	Char. Imp. Ohms
MPT- 1	TF4RX35YY	0.25/0.25/0.25	250
MPT- 2	TF4RX35YY	0.25/0.25	250
MPT- 3	TF4RX35YY	0.5/0.5/0.5	250
MPT- 4	TF4RX35YY	0.5/0.5	250
MPT- 5	TF4RX35YY	0.5/0.5/0.5	500
MPT- 6	TF4RX35YY	0.5/0.5	500
MPT- 7	TF4RX35YY	0.7/0.7/0.7	200
MPT- 8	TF4RX35YY	0.7/0.7	200
MPT- 9	TF4RX35YY	1.0/1.0/1.0	200
MPT-10	TF4RX35YY	1.0/1.0	200
MPT-11	TF4RX35YY	1.0/1.0/1.0	500
MPT-12	TF4RX35YY	0.15/0.15/0.3/0.3	700


Ruggedized,
MIL STANDARD
POWER & FILAMENT TRANSFORMERS
Primary 105/115/125 V 50-60~

Cat. No.	Appl.	MIL Std.	MIL Type
MGP 1	Plate & Fil.	90026	TF4RX03HA001
MGP 2	Plate & Fil.	90027	TF4RX03JB002
MGP 3	Plate & Fil.	90028	TF4RX03KB006
MGP 4	Plate & Fil.	90029	TF4RX03LB003
MGP 5	Plate & Fil.	90030	TF4RX03MB004
MGP 6	Plate	90031	TF4RX02KB001
MGP 7	Plate	90032	TF4RX02LB002
MGP 8	Plate	90036	TF4RX02NB003
MGF 1	Filament	90016	TF4RX01EB002
MGF 2	Filament	90017	TF4RX01GB003
MGF 3	Filament	90018	TF4RX01FB004
MGF 4	Filament	90019	TF4RX01HB005
MGF 5	Filament	90020	TF4RX01FB006
MGF 6	Filament	90021	TF4RX01GB007
MGF 7	Filament	90022	TF4RX01JB008
MGF 8	Filament	90023	TF4RX01KB009
MGF 9	Filament	90024	TF4RX01JB012
MGF 10	Filament	90025	TF4RX01KB013


Ruggedized,
MIL STANDARD
AUDIO TRANSFORMERS

Cat. No.	Imped. level—ohms	Appl.	MIL Std.	MIL Type
MGA 1	Pri. 10,000 C.T. Sec. 90,000 Split & C.T.	Interstage	90000	TF4RX15AJ001
MGA 2	Pri. 600 Split Sec. 4, 8, 16	Matching	90001	TF4RX16AJ002
MGA 3	Pri. 600 Split Sec. 135,000 C.T.	Input	90002	TF4RX10AJ001
MGA 4	Pri. 600 Split Sec. 600 Split	Matching	90003	TF4RX16AJ001
MGA 5	Pri. 7,600 Tap @ 4,800 Sec. 600 Split	Output	90004	TF4RX13AJ001
MGA 6	Pri. 7,600 Tap @ 4,800 Sec. 4, 8, 16	Output	90005	TF4RX13AJ002
MGA 7	Pri. 15,000 C.T. Sec. 600 Split	Output	90006	TF4RX13AJ003
MGA 8	Pri. 24,000 C.T. Sec. 600 Split	Output	90007	TF4RX13AJ004
MGA 9	Pri. 60,000 C.T. Sec. 600 Split	Output	90008	TF4RX13AJ005

FREED TRANSFORMER CO., INC.
1760 Weirfield St., Brooklyn (Ridgewood) 27, N. Y.
CIRCLE 115 ON READER SERVICE CARD

Truth in Advertising

ON FEBRUARY 17th, 1927, three years before this magazine was founded, James H. McGraw, founder of the McGraw-Hill Publishing Company, received the Harvard Advertising Awards Gold Medal for services to advertising. In his acceptance address Mr. McGraw said:

> *"Primarily the function of advertising as a business force is to interpret or expand a personality, whether of a product or of a service or of an industry."*

He also said,

> *"It is evident, therefore, that the industrial division of the business press has an important beneficial effect on the profit margin. Its reading pages are a textbook of economy in manufacture; its advertising pages a textbook of equipment for doing jobs at lower cost."*

Last year 1,169 advertisers placed 5,096 advertisements between the covers of ELECTRONICS. Between those same covers were 3,029 pages of editorial material. The editorial staff monitored the truthfulness of the editorial pages. The truth in advertising was largely in the hands of the advertisers. Our business department exercised all possible vigilance, but to monitor each specification, each parameter of each product, would obviously be impossible in this multiple product field.

Each advertisement is accepted for publication in ELECTRONICS subject to the following:

> *Advertisers and advertising agencies assume liability for all content (including text, representations, illustrations, or of any sketch, map, labels, trademark or other copyrighted matter) of advertisements printed, and also assume responsibility for any claims arising therefrom made against the publisher. The publisher reserves the right to reject any advertising that does not conform to publication standards.*

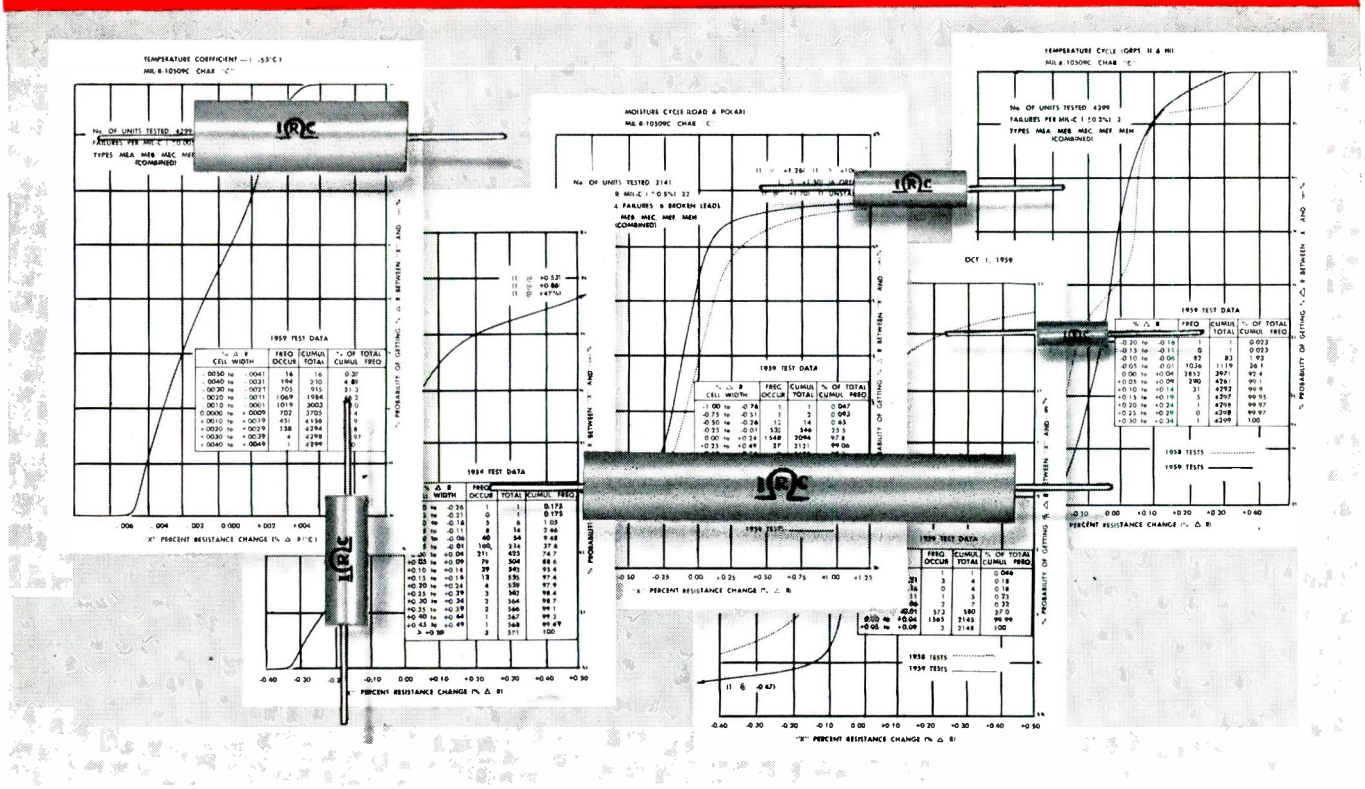
For the most part, manufacturers in the electronics industry have cooperated, with a remarkable degree of self-censorship, to preserve truth in their advertising pages. There have been astonishingly few exceptions through the years. For this we thank them. And we charge them at the same time with the continuation of this discipline. If relaxed, it would introduce nonbelievability and create the kind of a personality which could be damaging to their industry, and their profit position.

Should you, by the way, wish a copy of James H. McGraw's speech "The Function of Business Paper Advertising" circle number 250 on the Reader Service card. We'll be happy to mail it. No charge, of course.

James Gilwood

PUBLISHER

In PRECISION FILM RESISTORS : **if it's news, expect it first from IRC**



New tests confirm high reliability and stability of IRC Molded Metal Film Resistors

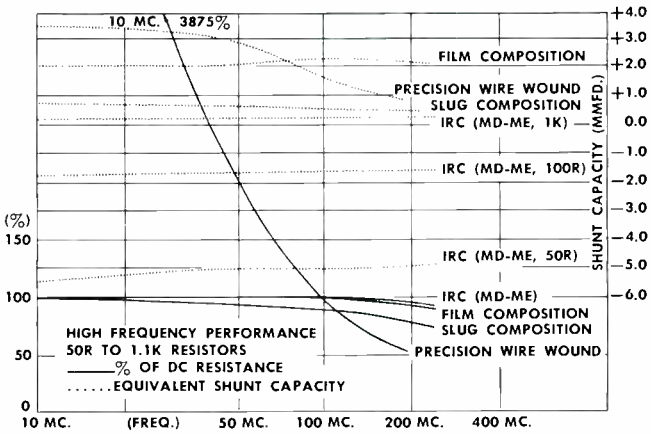
IRC has completed a new series of tests upon 7500 molded metal film resistors. The charted results are presented in a booklet just released: "Performance and Reliability of IRC Molded Metal Film Resistors."

This booklet is a sequel to IRC's report on a similar series of tests conducted in 1958. Where data are comparable, the earlier results are plotted against the new findings.

Tests are based upon MIL-R-10509C specifications, and are presented through the use of the probability technique. They include Temperature Cycle, Low Temperature Operation, Short Time Overload, Terminal Strength, Dielectric Strength, Effect of Soldering, Moisture Resistance, Temperature Coefficient and Load Life. Noise characteristics, shelf and operational stability, and high frequency characteristics are also reported and graphed.

The tests encompass IRC's full line of Molded Metal Film Resistors—5 types: ⅛, ¼, ½, 1 and 2 watts. The overall superiority of these advanced precision film resistors is shown conclusively. Their capability to provide high reliability over extended periods is confirmed again by this rigorous series of tests.

TYPICAL HIGH FREQUENCY PERFORMANCE OF IRC MOLDED METAL FILM RESISTORS



A booklet is reserved for your company and available by request on your company letterhead or through your local IRC representative. For product data, write for Bulletin B-3. International Resistance Co., Dept. 376. 401 N. Broad St., Philadelphia 8, Pa.

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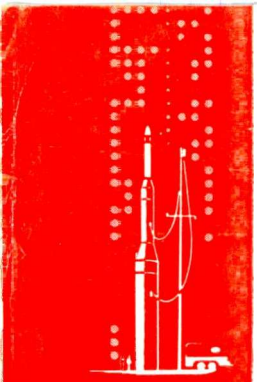

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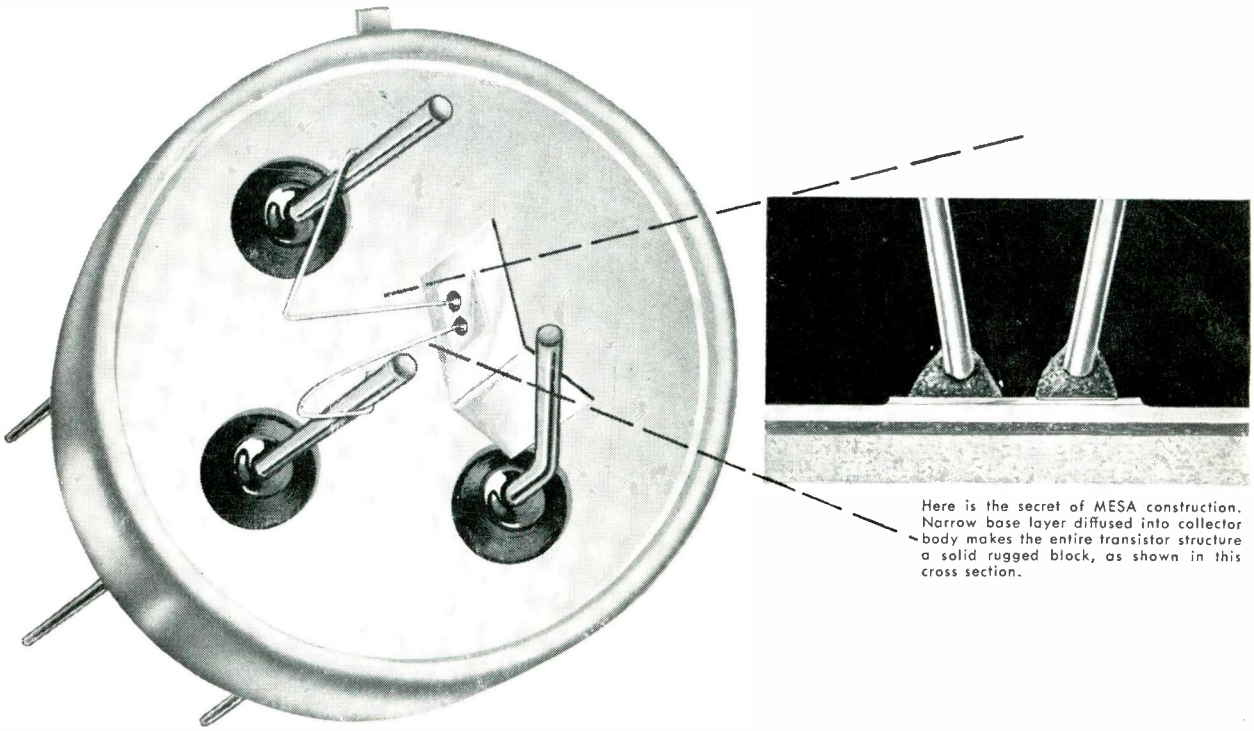

Here is the secret of MESA construction. Narrow base layer diffused into collector body makes the entire transistor structure a solid rugged block, as shown in this cross section.

RCA-2N1300 and 2N1301 MESA COMPUTER TRANSISTORS

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