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

Creative Microwave Technology

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

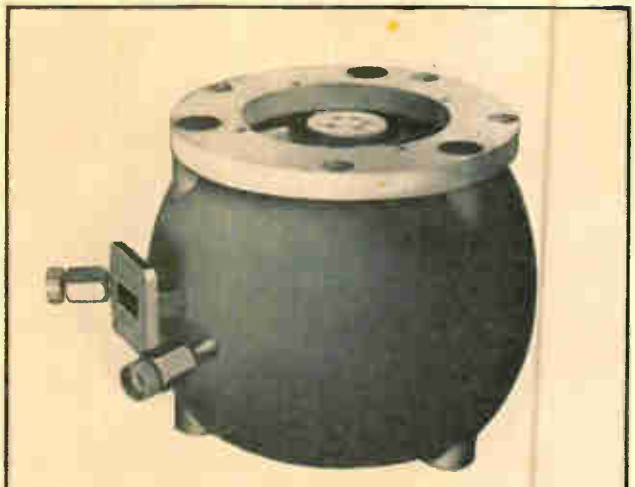
RAYTHEON "M"-TYPE BACKWARD WAVE OSCILLATORS

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.

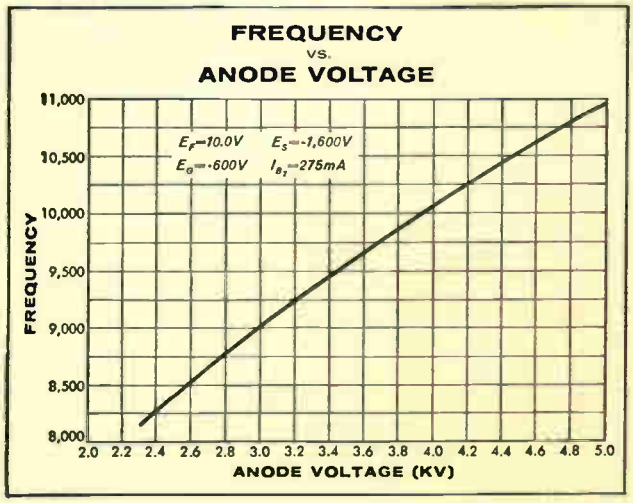
The QK-634A has a nominal power output of 200 to 250 watts and is electronically tunable over its entire frequency range. Precise determination of the radiated spectrum is accomplished by adjusting the voltage applied to either the anode or the sole. Amplitude modulation is also accomplished electronically.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

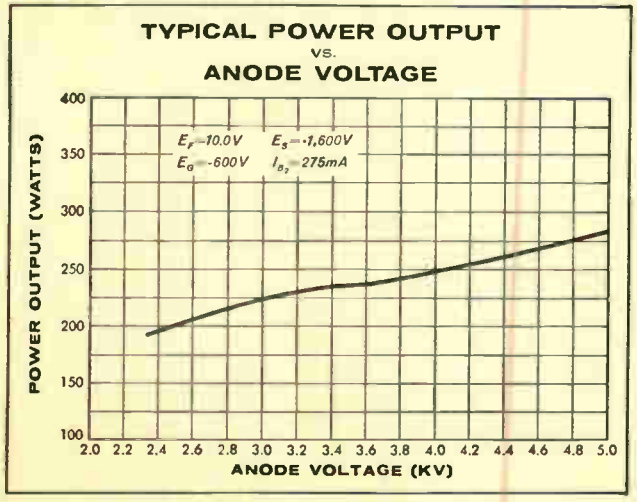


QK-634A Backward Wave Oscillator

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.

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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

Computer Installation Speeds Saturn Project 28

Will Space Equipment Sales Reach $6 Billion in 1975? 32

Services Adopt Interference Standard. What it covers 37

Nuclear Society Ponders Controls. Report on Chicago meeting 38

Truth in Advertising 116

Crosstalk 4
Comment 6
Electronics Newsletter 11
Washington Outlook 14
Financial Roundup 19
25 Most Active Stocks 19
Market Research 22
Current Figures 22
Meetings Ahead 40

ENGINEERING

Study of exploding wires may lead to their use in space vehicle propulsion systems. See p 43 COVER

Instrumentation for Exploding Wire Research. Kerr cell camera has 5-nanosecond exposure time By N. Chase, N. Hankin and F. Webb 43

Photoelectric Control Using Cold Cathode Amplifiers. Designs for different applications are presented By P. Berweger 46

Solid-State Modulator Feeds Subminiature Transponder. Range accuracy remains within 6 millimicroseconds By L. Diven 48

Semiannual Index 75

Using Off-Balance Bridges for Measurement and Control. Basic design equations for capacitance bridges By G. Revesz 52

Transistorized Data Amplifier Has High Gain Stability. Uses operating point feedback By F. Offner 55

Survey of Thermistor Characteristics. Handy guide. By J. Van Dover and N. F. Bechtold 58

DEPARTMENTS

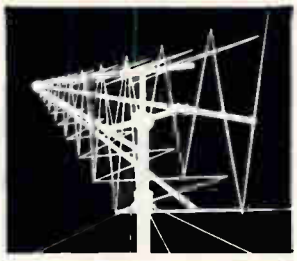
Research and Development. Control Is Key to Timer Accuracy 62

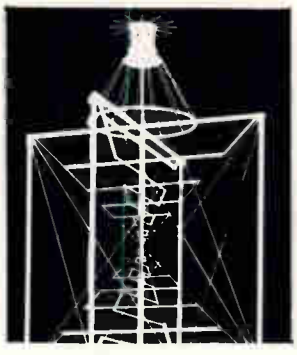
Components and Materials. Thin Film Extends Mesa Performance 66

Production Techniques. Closing Space Spreads Bonding Resin 70

New On the Market 102
Literature of the Week 109
People and Plants 110
Index to Advertisers 115

BROAD-BAND LOG-PERIODIC ANTENNAS FROM GRANGER ASSOCIATES





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

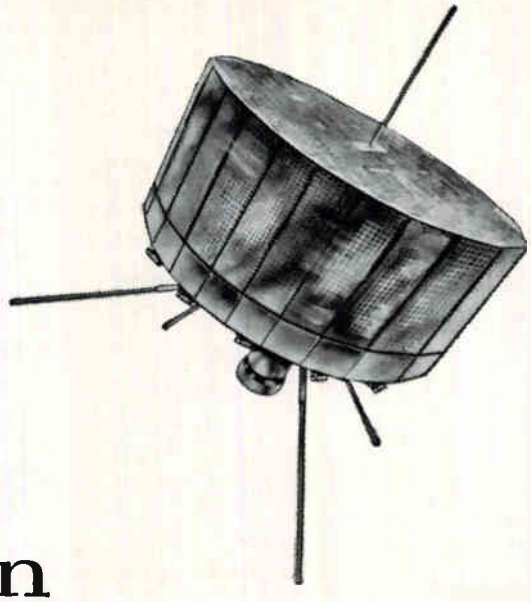
	Model 720 (uni-directional)	Model 721 (omni-azimuthal)
Frequency range	50 to 1000 megacycles	
Polarization	Linear, remotely selected vert. or horiz.	
Pattern Beamwidth		
Horizontal Polarization	Azimuth 60 deg. Elevation 60 deg.	Azimuth 360 deg. Elevation 55 deg.
Vertical Polarization	Azimuth 60 deg. 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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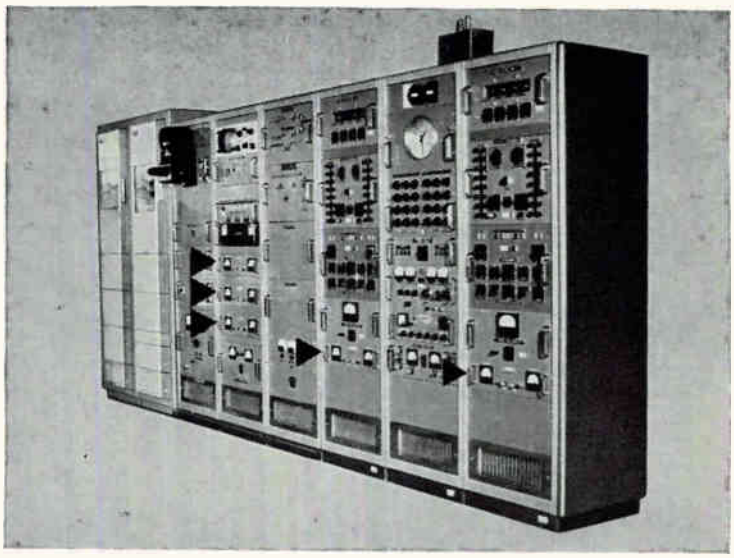

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CROSSTALK

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.

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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. . .

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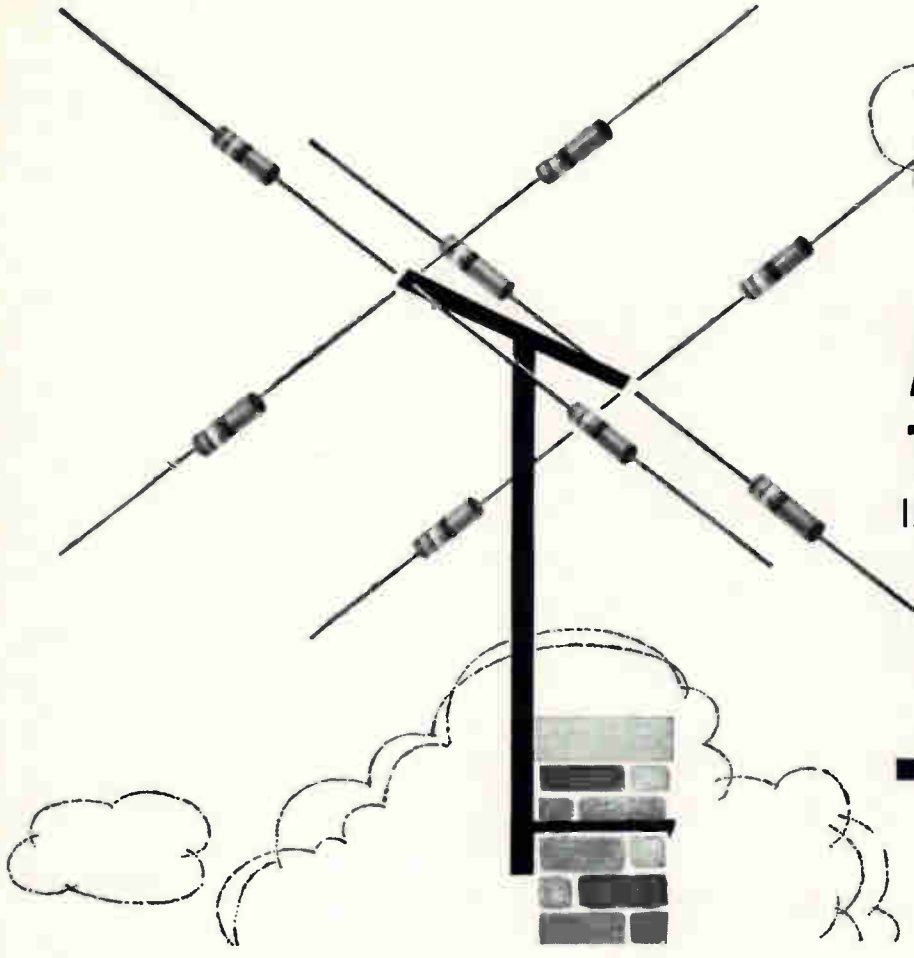

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Miniaturization PLUS Stability

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.

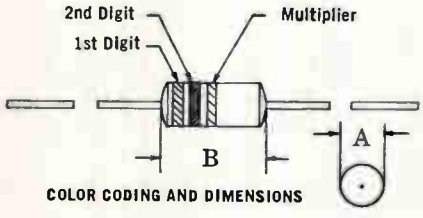
TYPICAL CHARACTERISTICS OF INDUCTOR DESIGNS BASED ON 1000 UH VALUE

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
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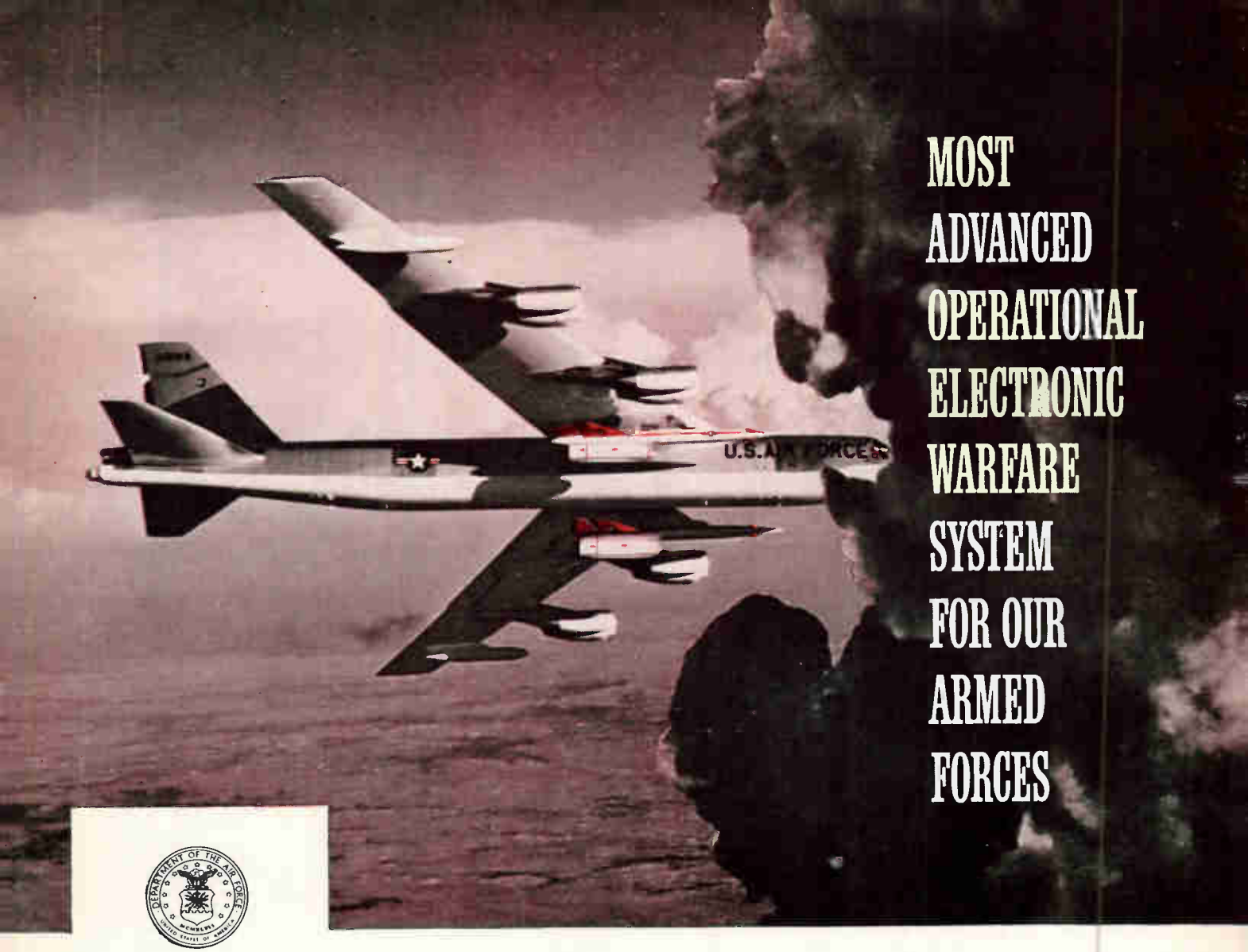
Onondaga Electronics, Syracuse, N.Y. · Speer Resistor, Bradford, Pa.



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 2¾ 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.

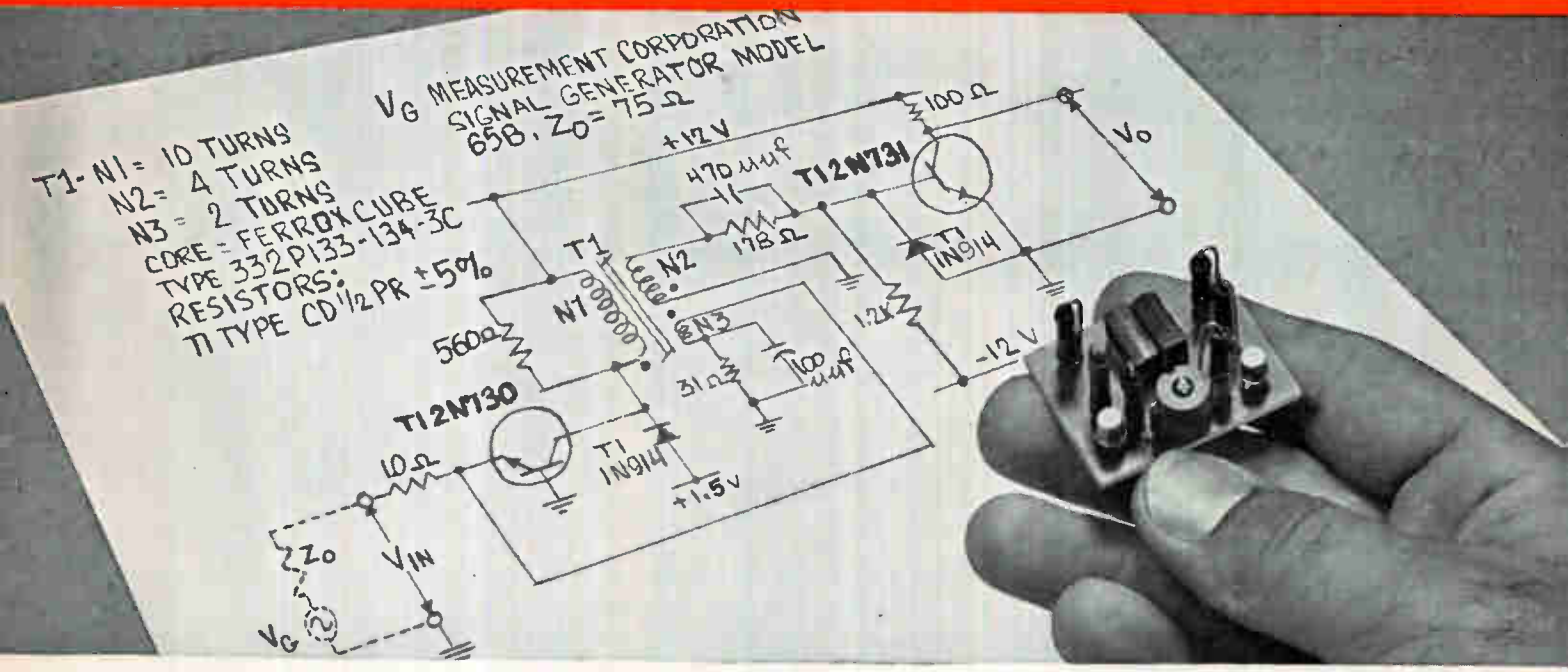
What about temperature stability? Our linear cores are used with polystyrene capacitors, cutting costs in half compared to temperature stabilized moly-permalloy cores with silvered mica capacitors. Yet frequency stability over a wide swing in ambient temperatures is increased!

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.

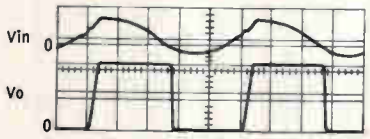
Why not write for complete information? Like all of our components, molybdenum permalloy powder cores are *performance-guaranteed* to standards unsurpassed in the industry. *Magnetics Inc., Dept. E-82, Butler, Pa.*

MAGNETICS inc. ®

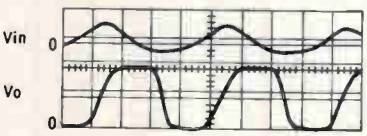
HOW TO GENERATE 100-ma PULSES AT 10 mc



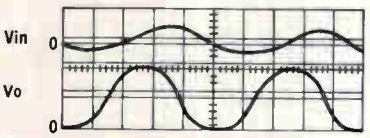
. . . WITH TI 2N730 and 2N731 SILICON MESA TRANSISTORS



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

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CIRCLE 13 ON READER SERVICE CARD

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.

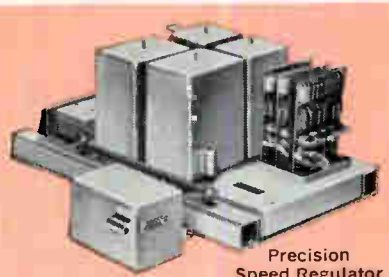
Below are typical TAPCO components now available for integration into systems for such applications. Other available TAPCO electrical power components include tachometer generators, speed sensors, high temperature electromagnets and solenoids, nuclear reactor rod drive controls, static inverters, voltage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



Precision
Speed Regulator

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".

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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TRW

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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!

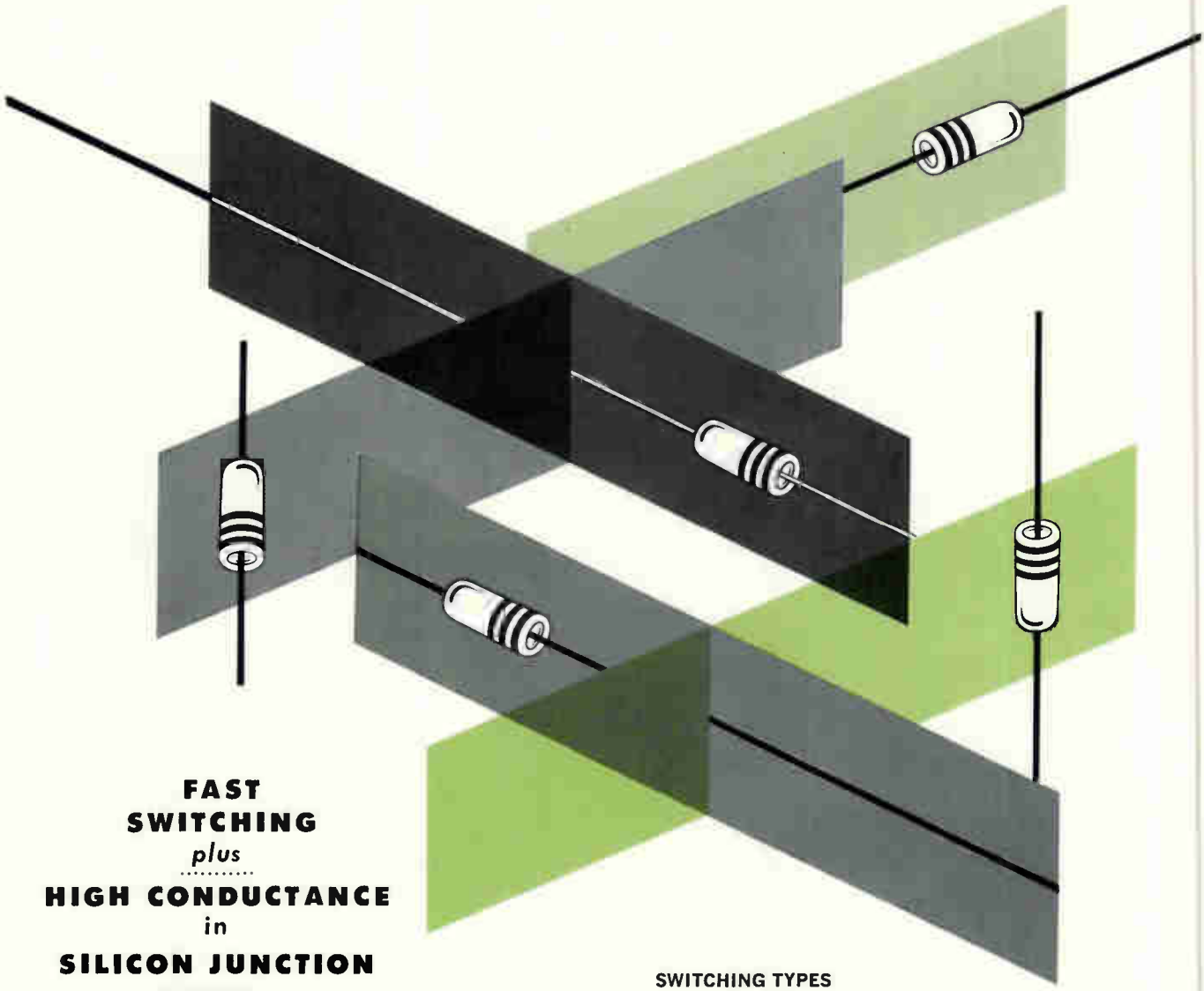
Another benefit is the clean, readable copies you can now produce from soiled, yellowed documents and low-translucency materials much faster than ever before.

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 multi-purpose 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.

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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

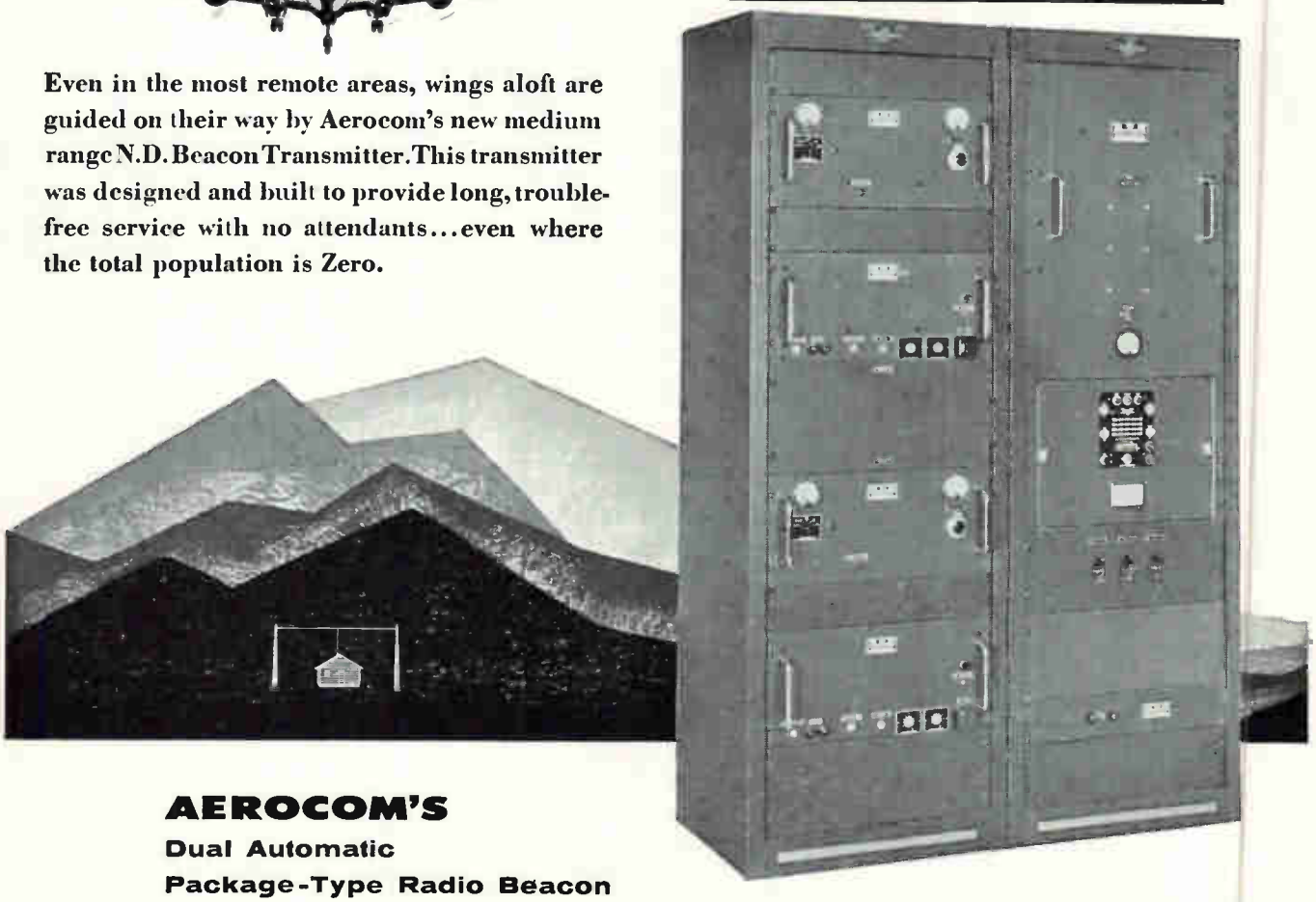
	SHARES (IN 100's)	HIGH	LOW	CLOSE
Standard Kollsman	5,988	27½	19	27⅛
Univ Controls	2,788	19¼	15¼	17¼
Sterling Precis	1,837	3⅝	2¾	3⅜
Lear Inc	1,810	22⅞	18⅛	22⅝
Ampex	1,803	39¾	36	36¾
Gen Tel & Elec	1,635	31⅞	30¾	31⅛
Du Mont Labs	1,506	11¾	9⅞	11
Collins Radio	1,503	73⅜	63⅜	72⅞
Transitron	1,335	60	51⅛	58⅜
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.

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 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

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.

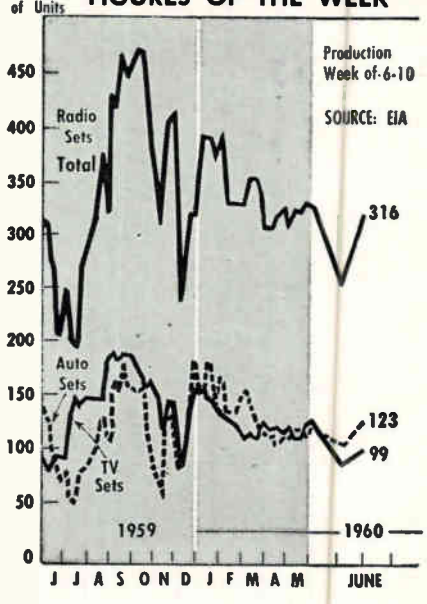
Shipments in 1959 of radios and radio-phono combinations, excluding auto radios, totaled 10.3 million sets worth $289 million, as against 8.8 million sets worth $242 million in 1958.

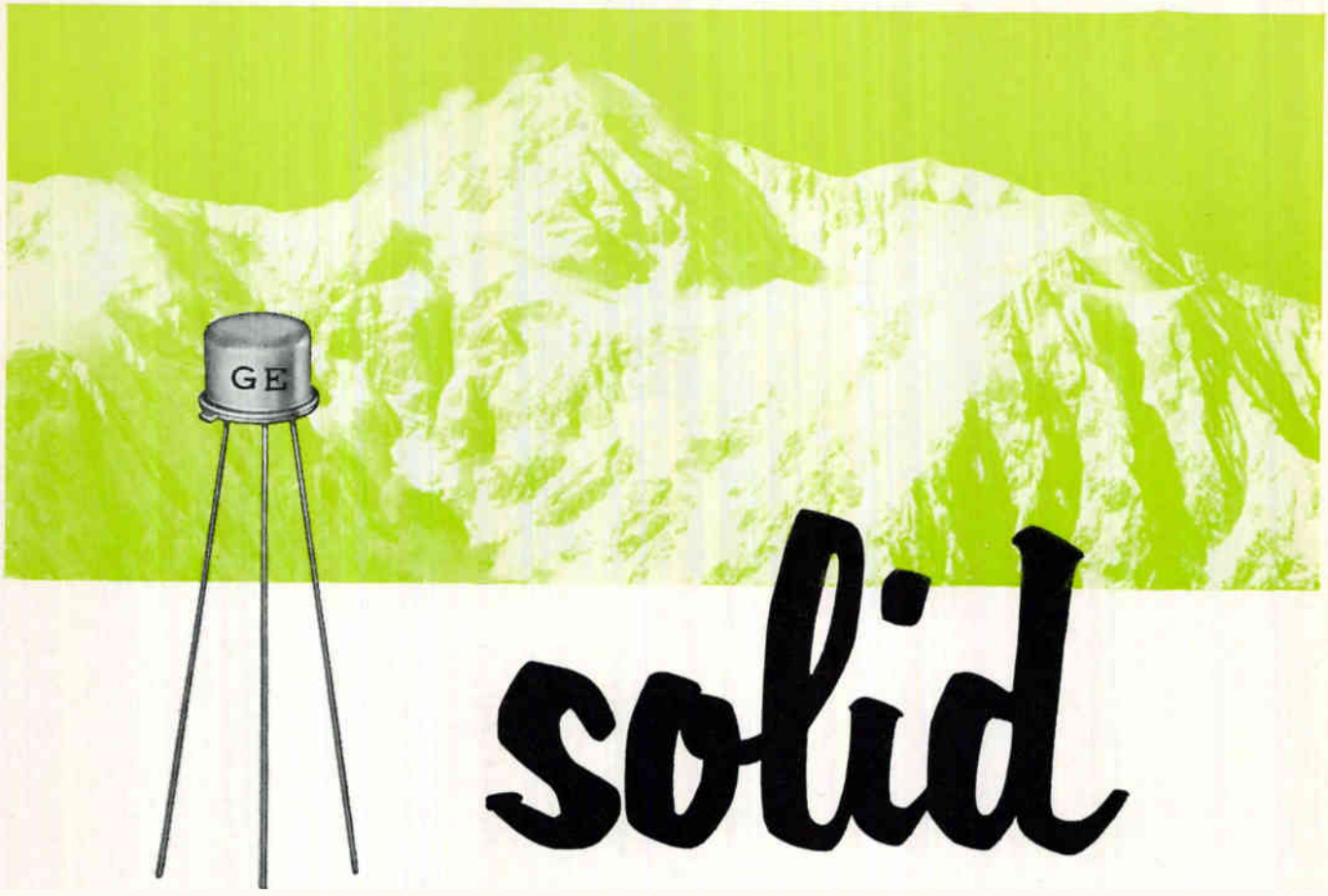
Auto radio shipments rose from 3.9 million units ($102 million) in 1958 to 5.7 million units ($133 million) in 1959.

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 (Ic)	25 ma	20 ma	25 ma
Collector dissipation @ 25°C (Pc)	150 mw	125 mw	500 mw
Operating temperature (TJ)	—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

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

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

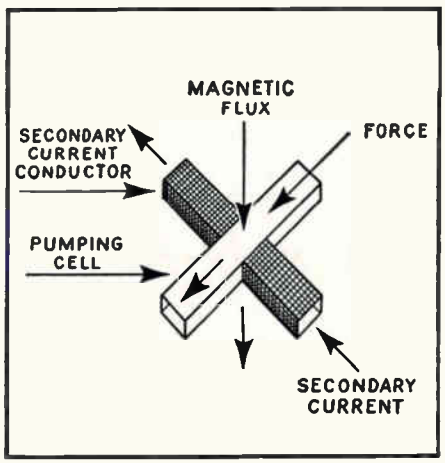
Vol. 2, No. 2

Nickelonic News

DEVELOPMENTS IN NICKEL AND NICKEL ALLOYS AND THEIR APPLICATIONS

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

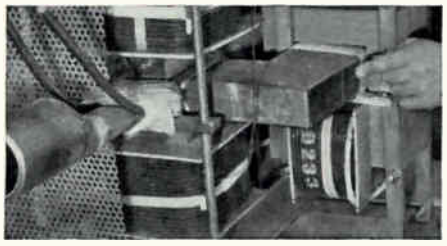
CALLERY, PA.—In nuclear reactor systems, molten metal coolants must be pumped safely and effectively. To do this, the MSA Research Corporation has developed an interesting ac conduction-type electromagnetic pump. It has no moving parts, packing glands, or throttling valves. This pump can handle molten 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.

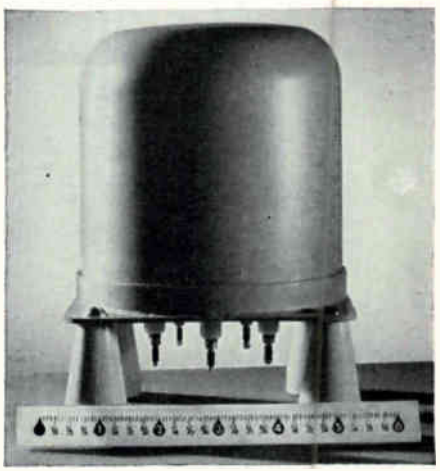
Raytheon Company has designed and tested transformers of four basic types – plate, radar pulse, audio and high-voltage plate and filament – for operation at temperatures in the vicinity of 600°C for 1000 hours.

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

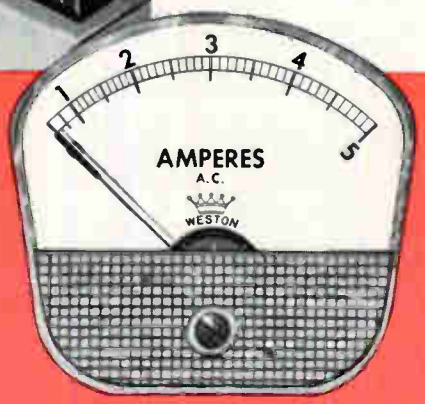
A newly-designed AC moving iron instrument with improved ballistic characteristics joins the Weston line of "Crown" meters. Instruments in this matched group combine economy with dependable accuracy, and incorporate many time-proven Weston features.

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."

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.**

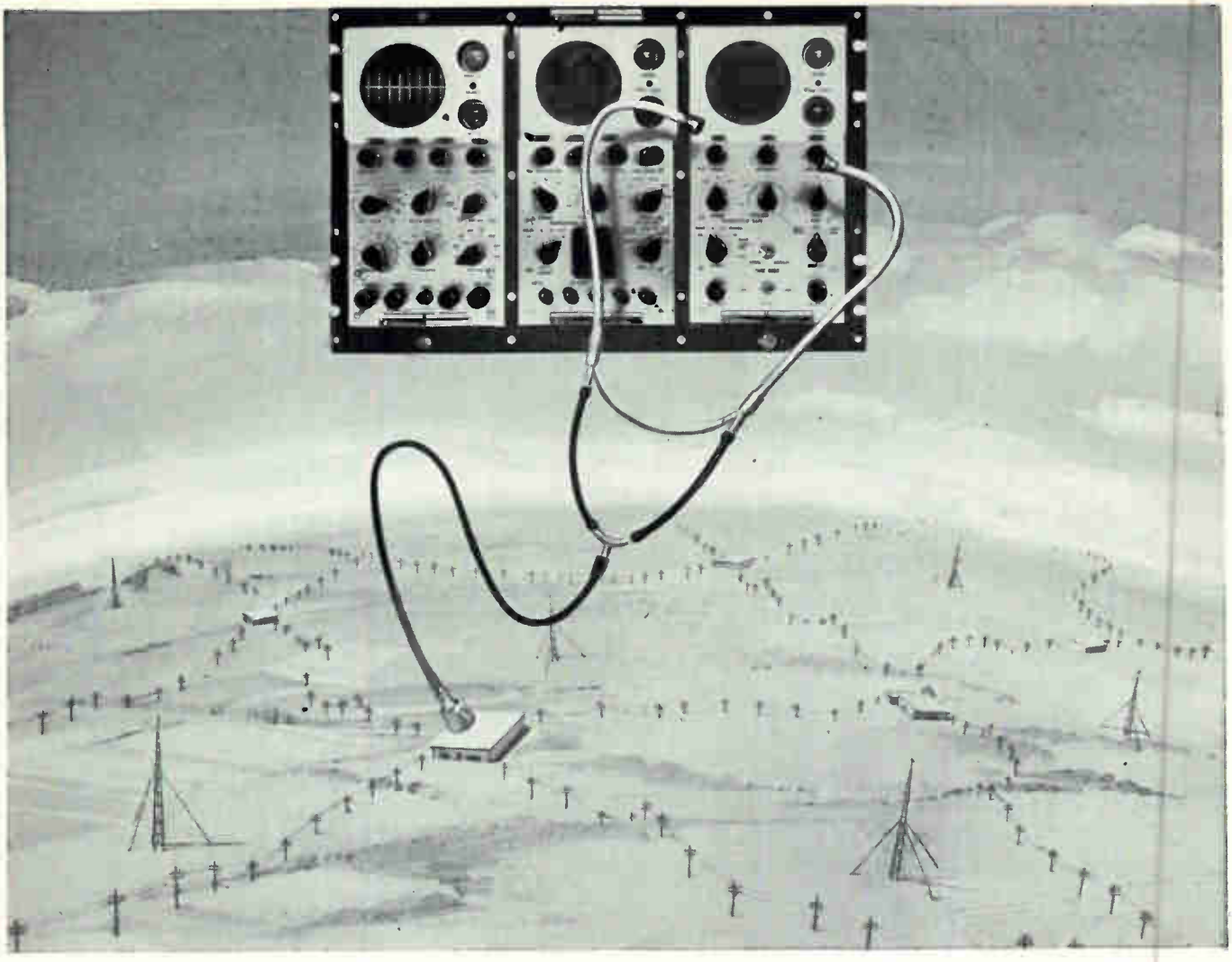
Abroad, the report appears to give official documentation to the propaganda line that the Soviet economy is running rings around the U.S. economy in growth, and that it is Communism a country should choose if it really wants to develop rapidly. Building on a much smaller economic base than the U.S.A., 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.



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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

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.

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.

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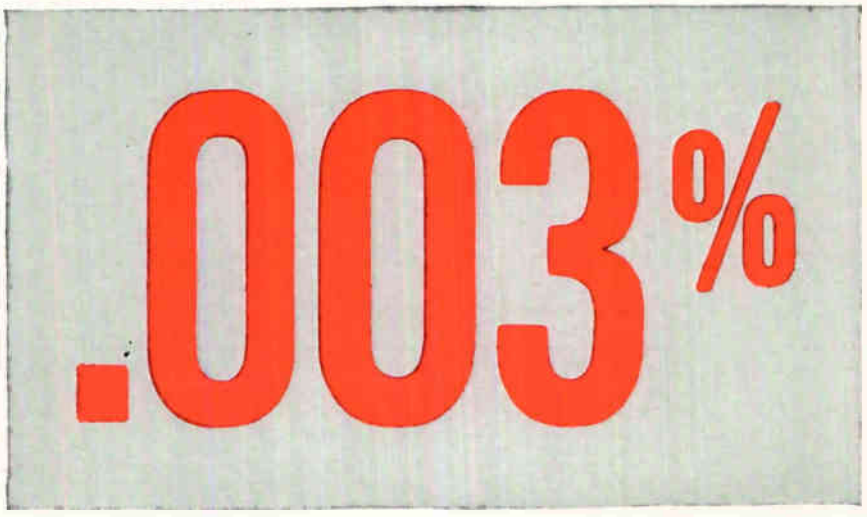

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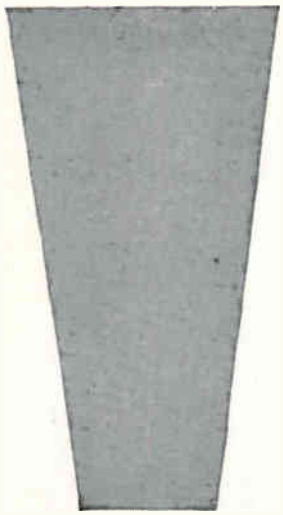

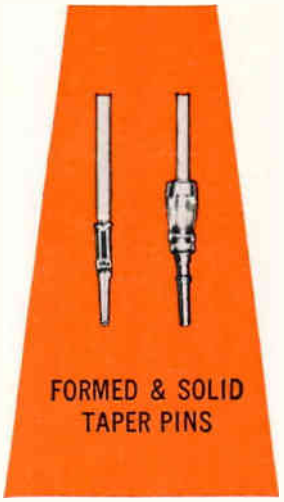

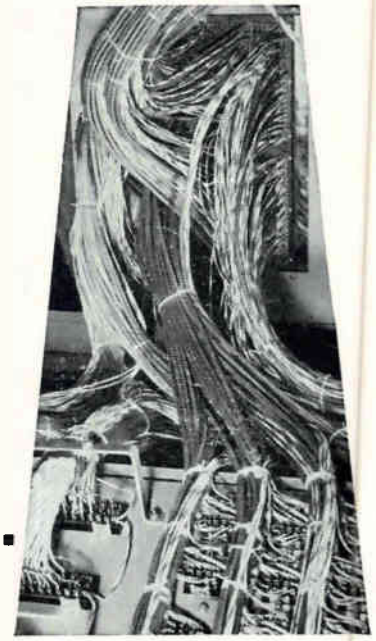

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electronics
July 1, 1960

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

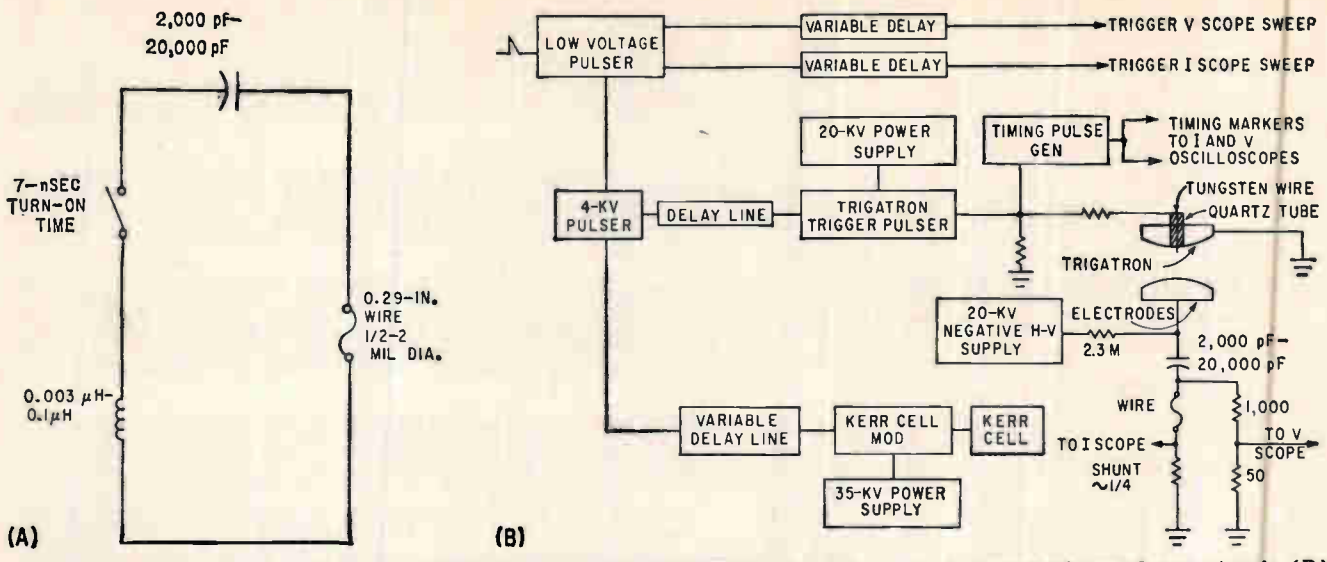


FIG. 1—Basic exploding wire circuit (A) uses switch with 7-nanosecond turn-on time; experimental test circuit (B) includes two traveling-wave oscilloscopes and Kerr cell camera. (See the front cover)

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

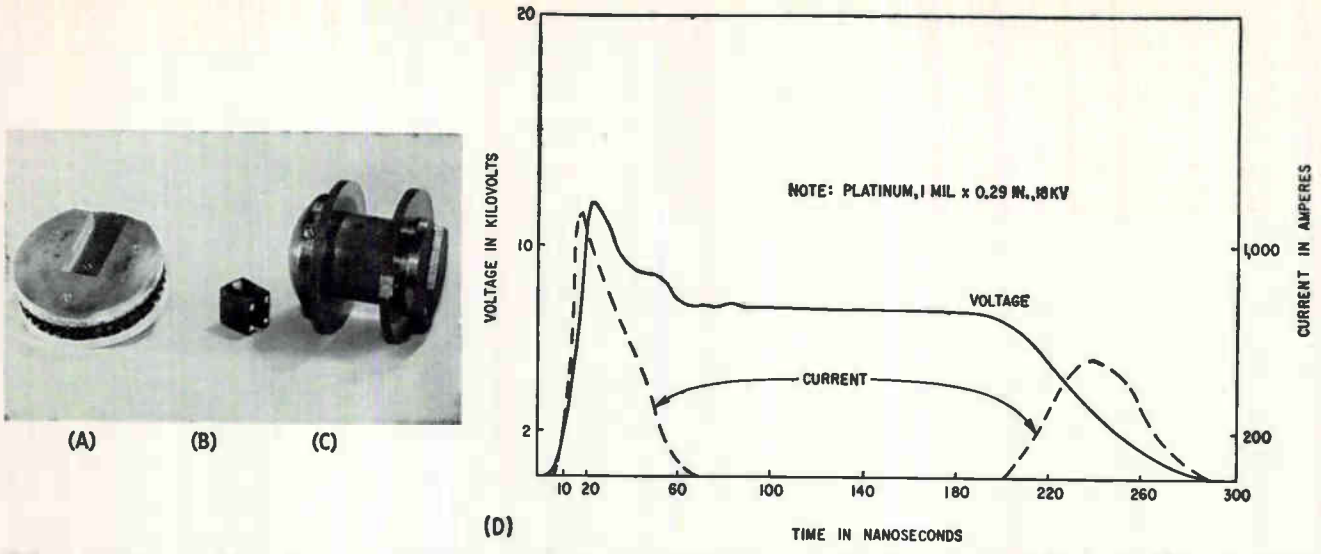


FIG. 2—Trigatron shunt (less coaxial return conductor) is shown in (A), trigatron wire holders in (B); trigatron energy storage unit (C). Current and voltage for an exploded platinum wire are indicated in (D)

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, ½- to 2-mil wire approximately ¼ 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.

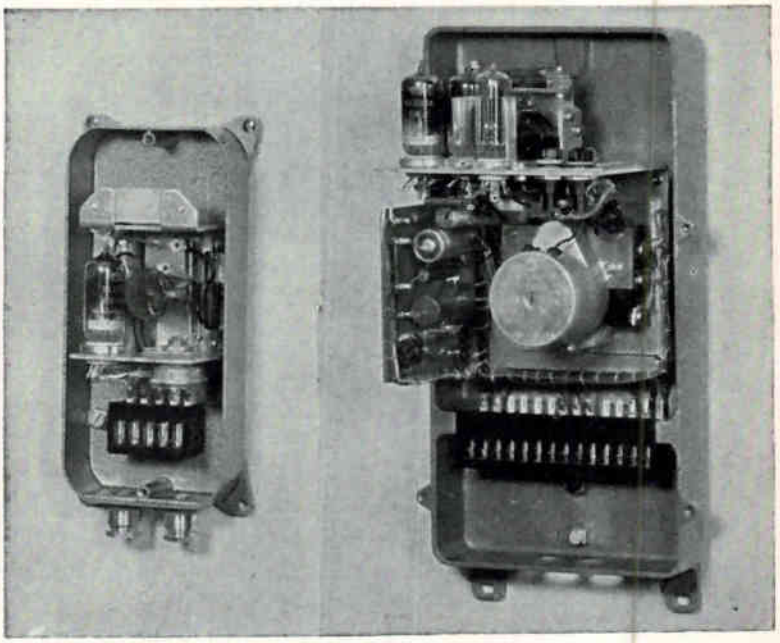
High energy densities can be placed in the wire during the initial conduction period. A typical value of the energy density obtained in an aluminum wire 1 mil in diameter and 0.29 inch long at 18.3 Kv is 11 electron volts per atom (corresponding to an energy input of about 400 millijoules.) These energy 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

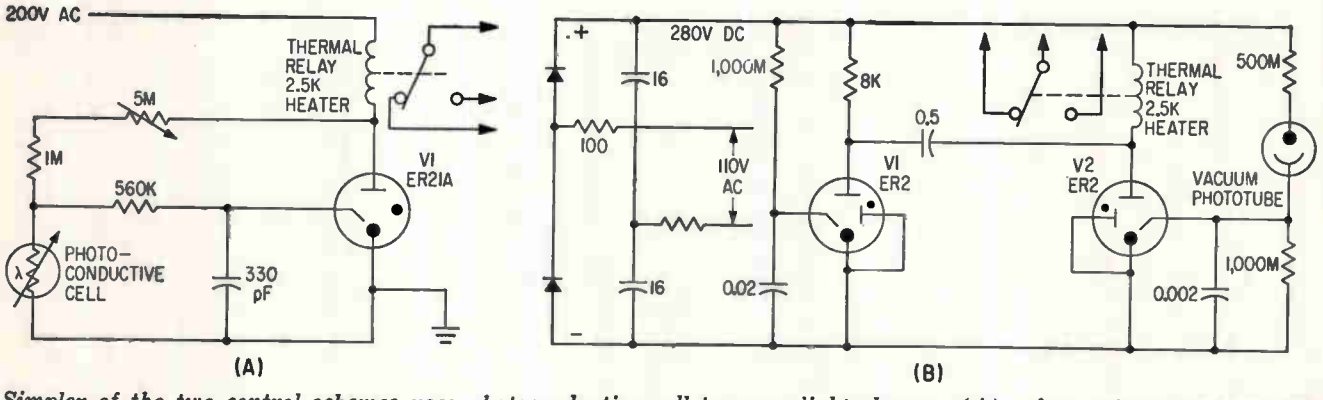
Automatic light control continuously adjusts tunnel illumination so that it equals the ambient light outside, thereby preventing automobile drivers from being temporarily blinded

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)

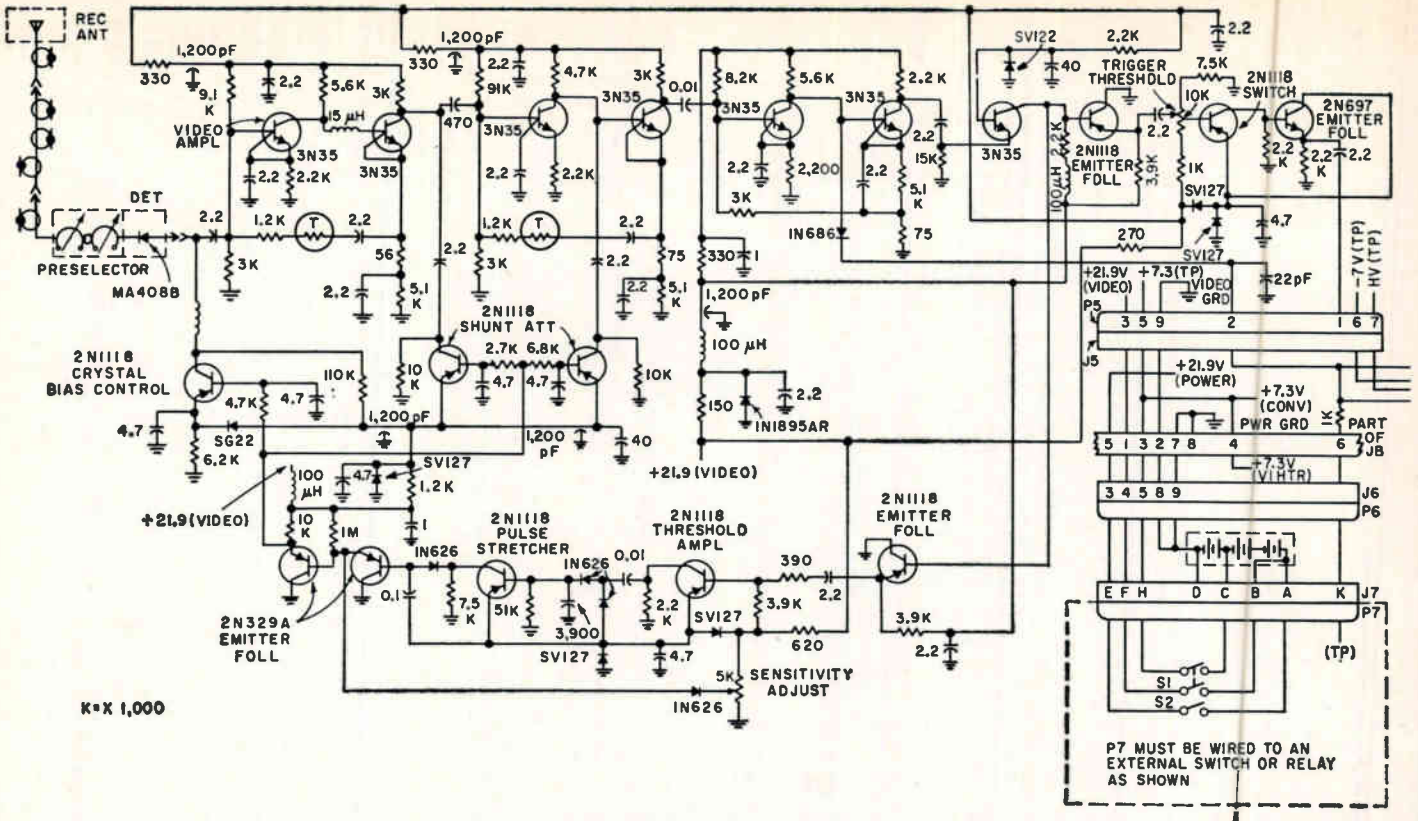


FIG. 1—Complete schematic of the subminiature transponder. Unusual features are the semiconductor modulator and

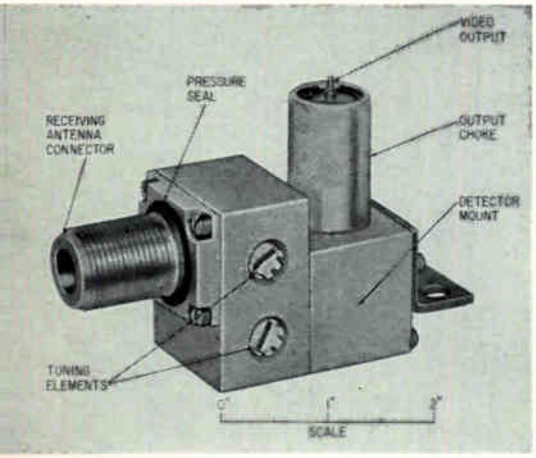


FIG. 2—Preselector and detector mount are an integral unit

Solid-State Modulator

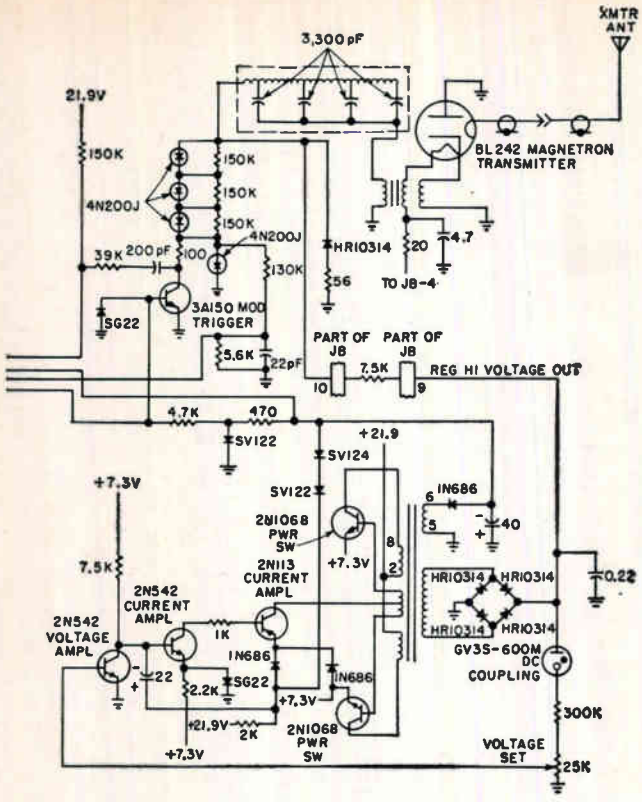
Transponder features a semiconductor modulator whose fast switching time results in an r-f output pulse with extremely fast rise and fall times. Delay stability provides a range accuracy of one yard over a wide range of interrogation signal levels

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

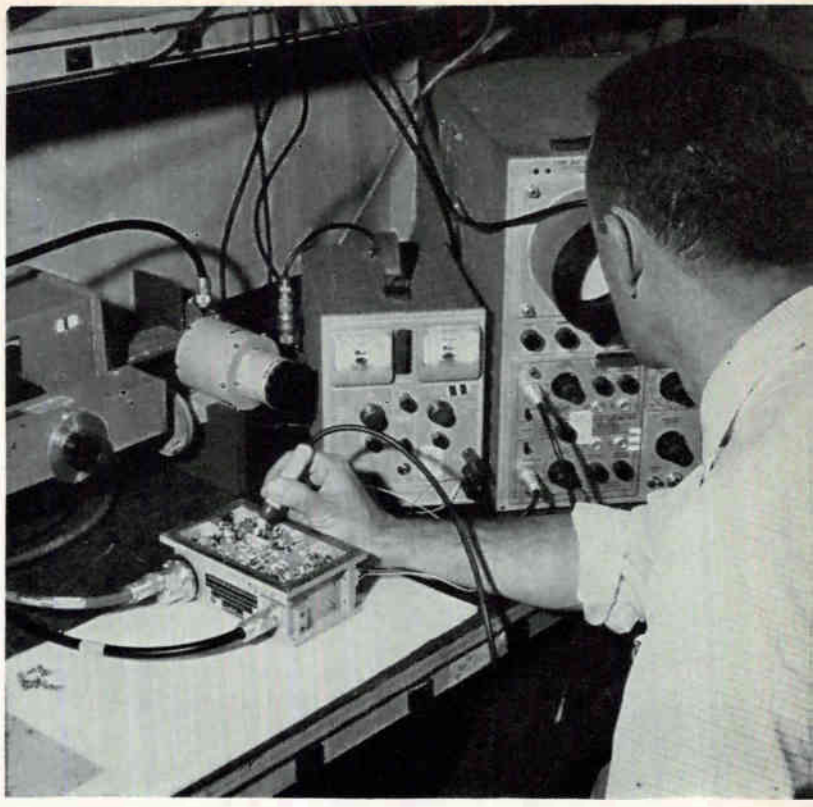
FOR MISSILE TEST firings, one or two radar transponders may be used for tracking. Such range instrumentation, however, does not usually form part of the electronics system of the tactical missile. For this reason, the transponder should be completely self-contained, including primary power supply; furthermore, 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

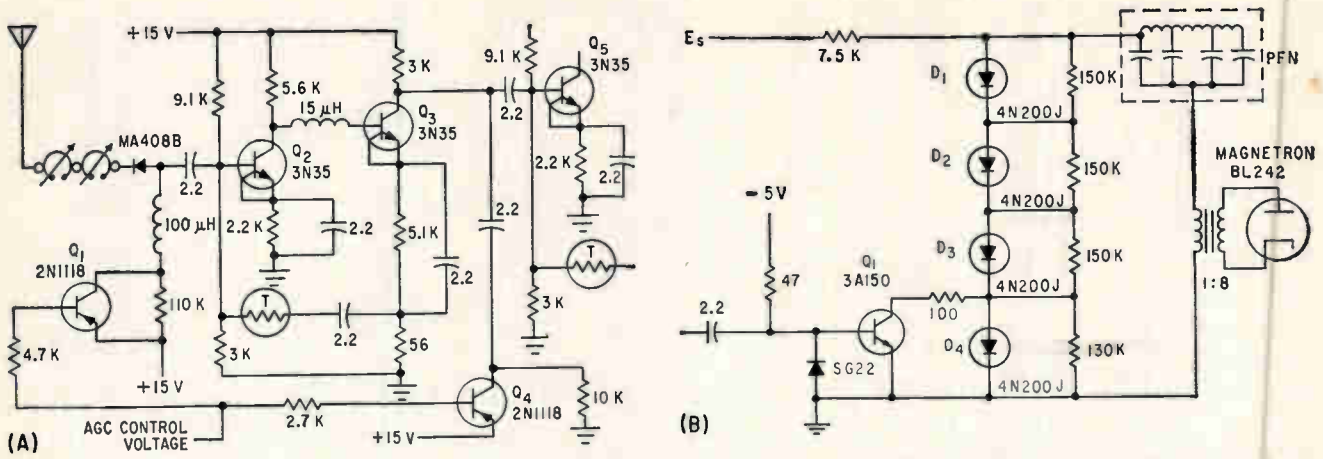


FIG. 3—Enlarged views of typical video and age stages (A), and modulator (B) whose switching action is similar to that of a hydrogen thyratron, but which requires no heater power or warm-up

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

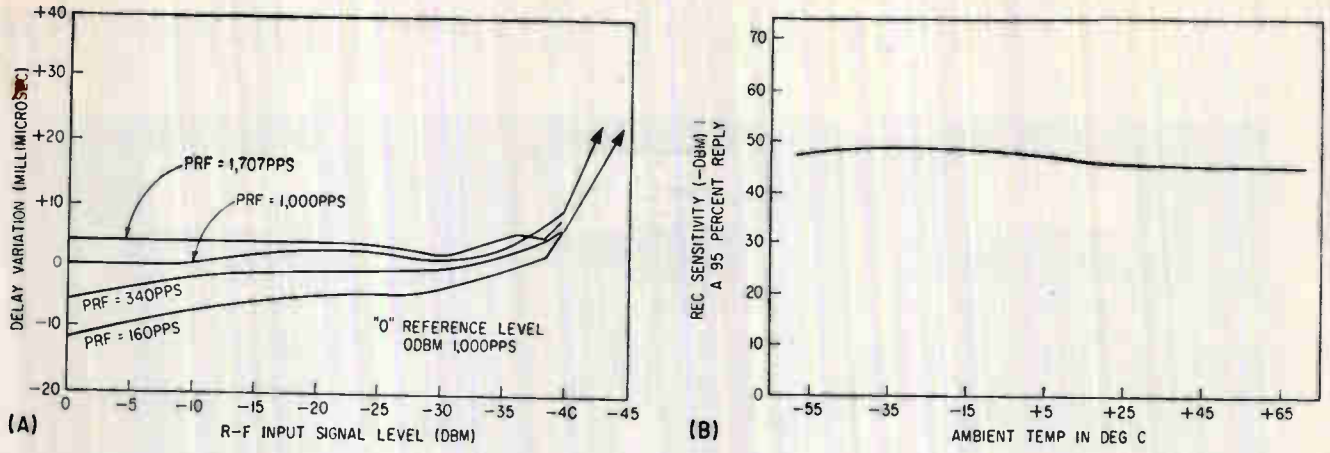


FIG. 4—Delay stability as a function of r-f input signal level for various interrogation rates (A); and receiver sensitivity as a function of temperature (B)

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_1 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

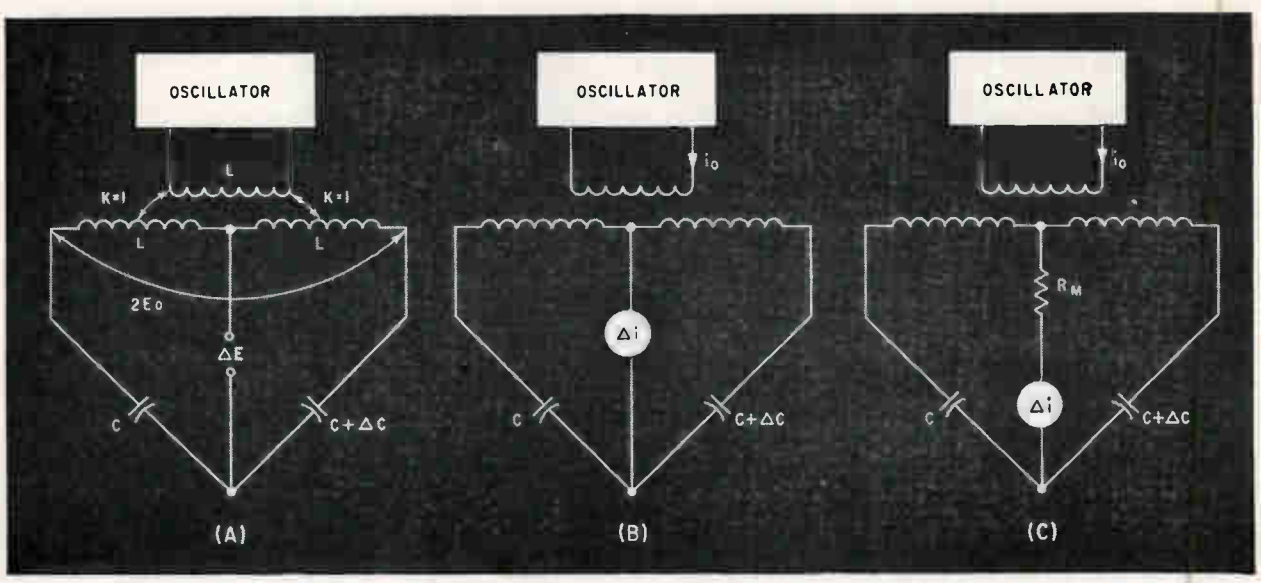


FIG. 1—Basic bridge circuit diagrams for open circuit (A), short circuit (B) and intermediate (C) cases are basis of circuit analysis. Equations for each case are derived in text

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

By GEORGE REVESZ,

Robertshaw-Fulton Controls Co.,
King of Prussia, Pa.

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

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

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

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

for which value the output current is

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

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

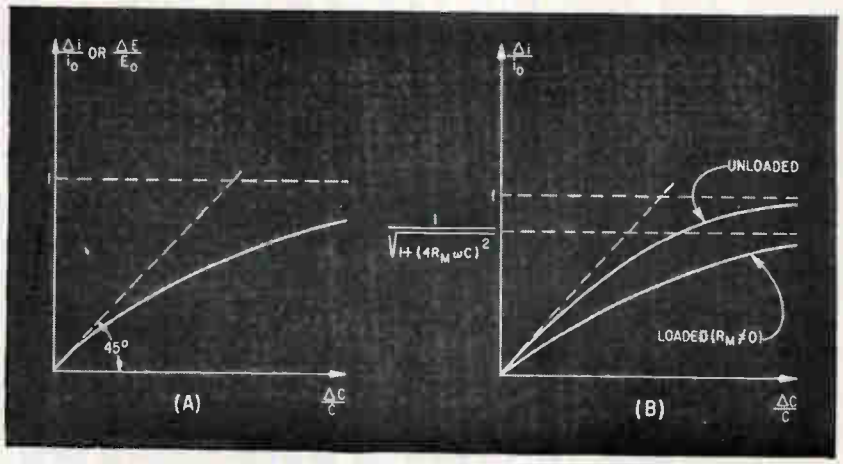


FIG. 2—Curve for no-load and infinite load is shown in (A). Comparison in (B) shows loading effect resulting from meter impedance

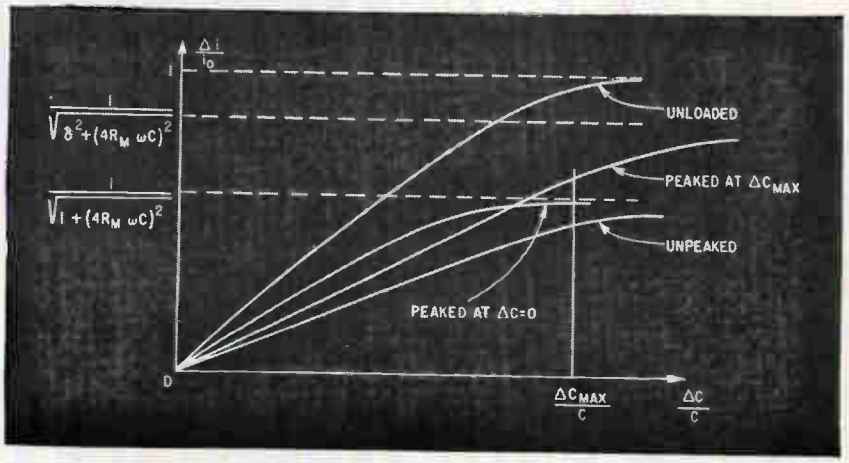


FIG. 3—Effects of loading and peaking on sensitivity and linearity limit design freedom

IMPORTANT PARAMETERS

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

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.

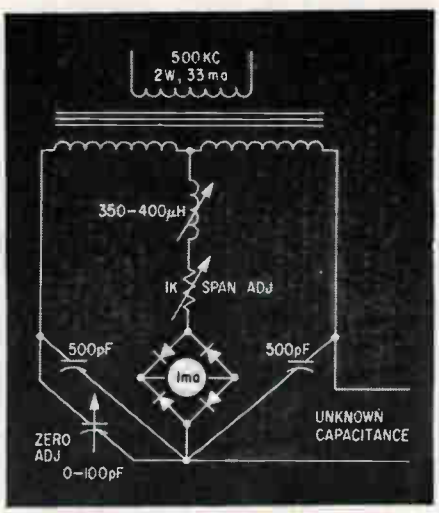


FIG. 4—Resistance of meter in practical circuit shown is 100 ohms

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

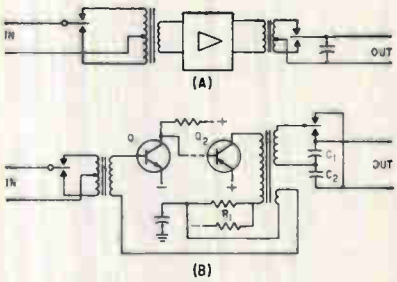


FIG. 1—Conventional chopper amplifier of (A) works well in null type servo but for precise and constant gain, the circuit of (B) is superior

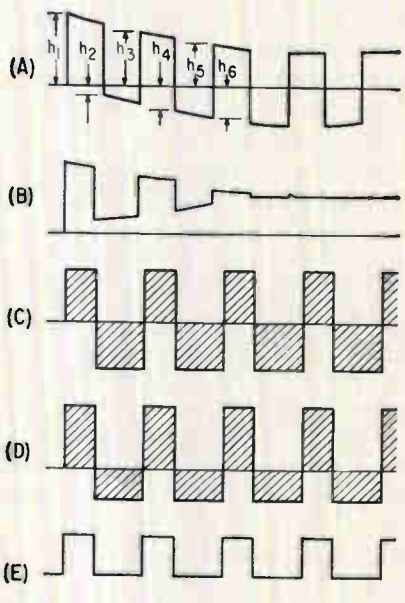


FIG. 2—Transient response of conventional chopper amplifier to a step input (A) is shown in output (B), and the effects of unequal dwell time in (C), (D) and (E)

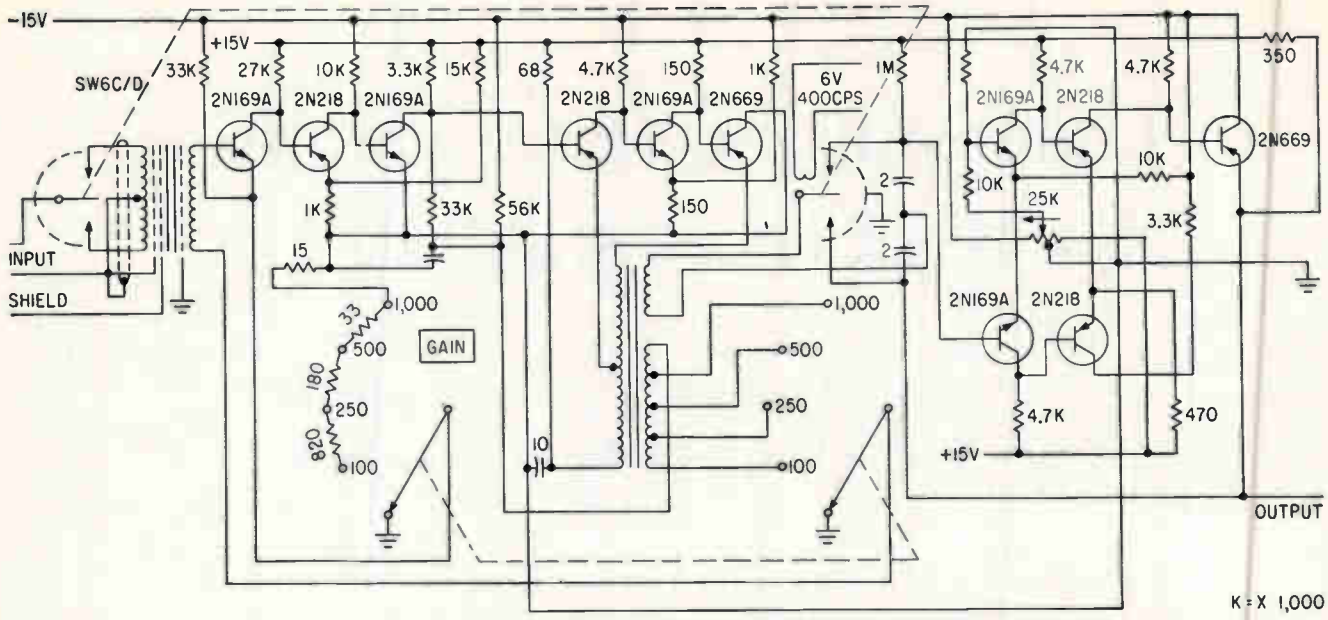


FIG. 3—Transistorized data amplifier has gain stability and linearity of 0.01 percent from 15 to 55 C. Gain is adjusted by changing the amount of feedback

—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 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.

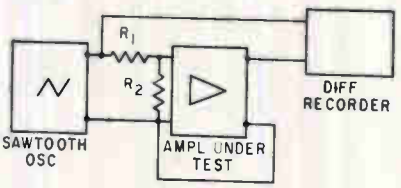


FIG. 4—In test circuit, amplifier makes up gain loss of input network to give straight line output

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	4 to 10 K[d]	4	3–800	150[e]	−3.8 to −4.4	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 −4.4	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 −4.4	4–24	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, 0.245 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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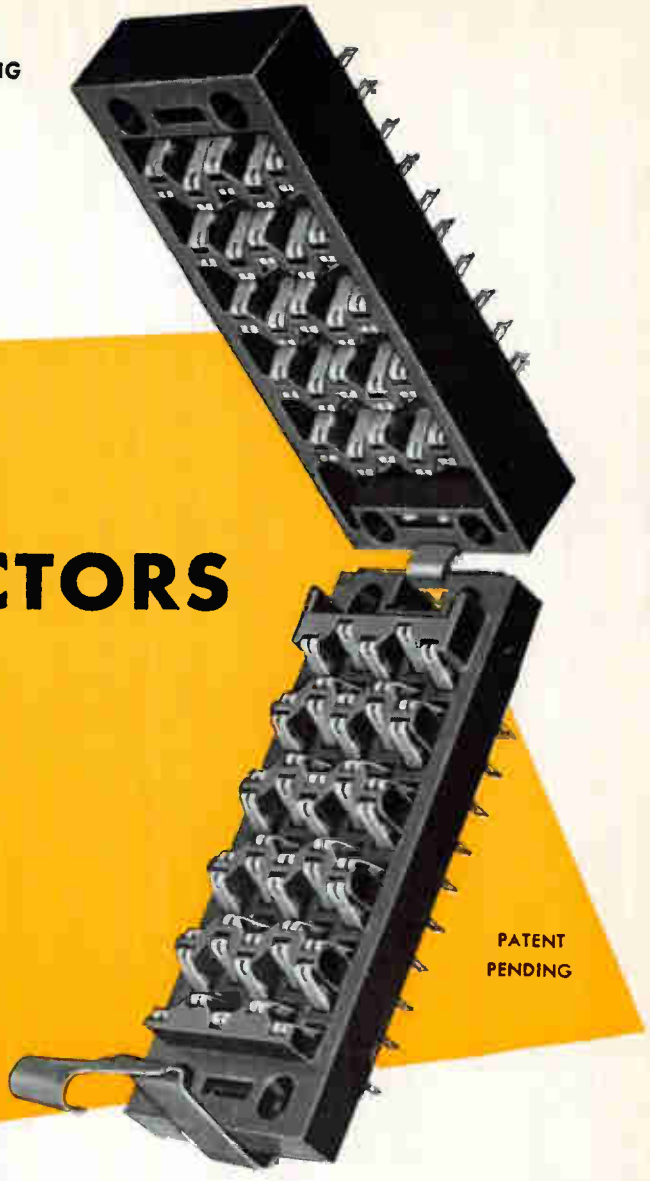

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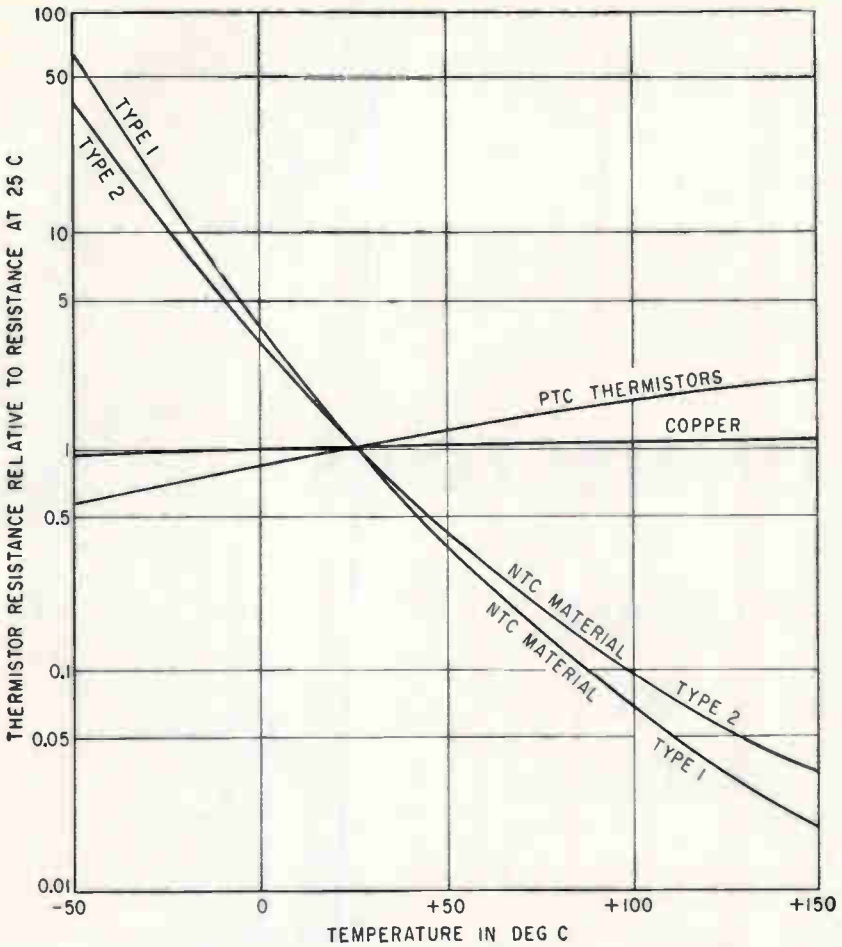

FIG. 1—Variation of thermistor resistance with temperature

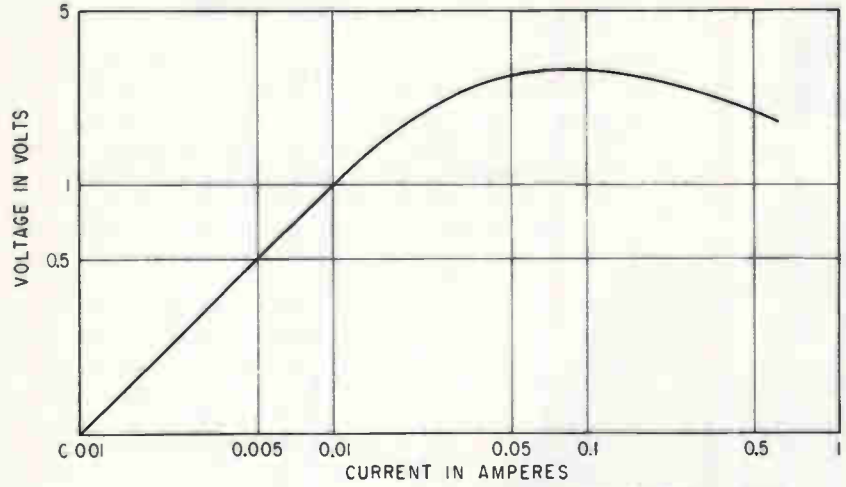

FIG. 2—Static V/I characteristic for typical NTC disk thermistor

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 nonuniformity 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.

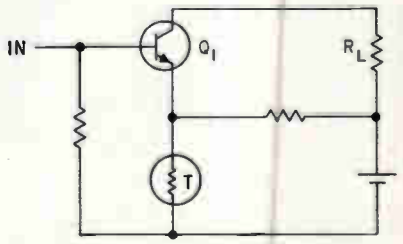

FIG. 3—Temperature compensation with a PTC thermistor

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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

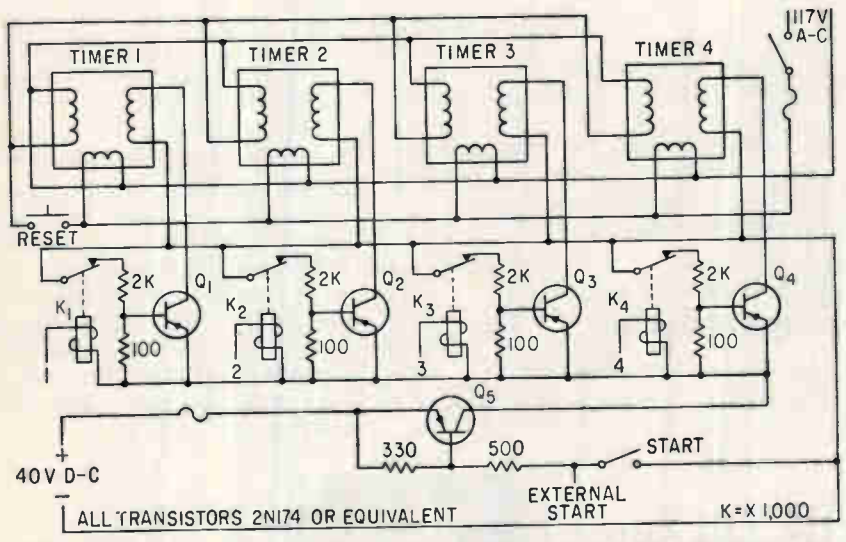

FIG 1—Four simultaneous measurements are provided by transistor control of precision electrical timers

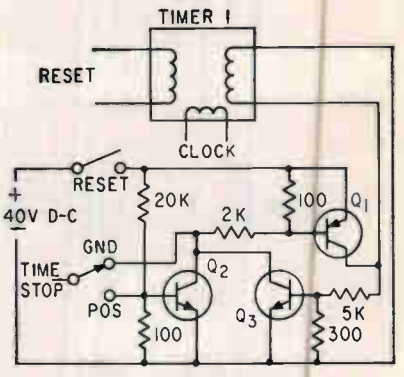

FIG. 2—Transistor switching replaces relays and either polarity start or stop pulses can be used

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_5 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

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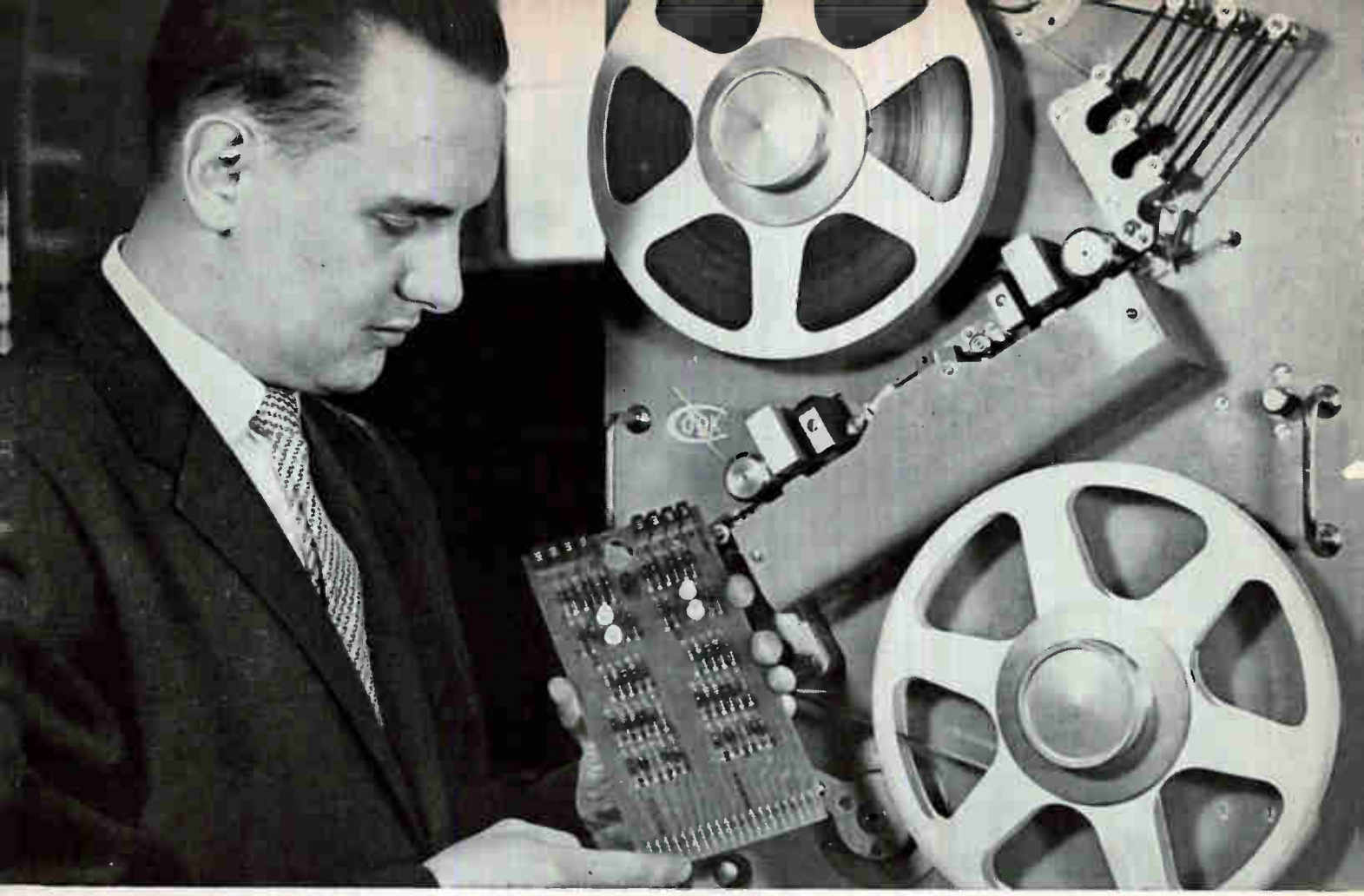

Tung-Sol transistors handle critical switching in COOK ELECTRIC high speed tape transport

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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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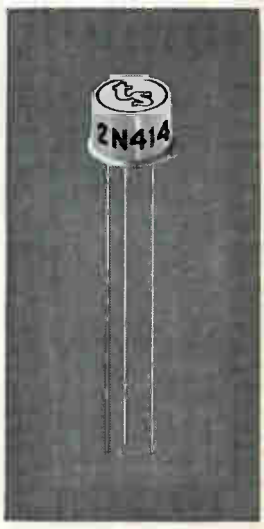

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would behave under unusual conditions like sudden failure of the circulating pumps. Pump failure could seriously damage the reactor if control arrangements were not adequate.

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 fiat 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.

THE UNIVERSAL DIODE

Fairchild FD200, actual size

High Conductance, Ultra Fast Silicon Planar Diode

. . . satisfies all of today's diode requirements and forestalls obsolescence by fulfilling foreseeable future demands for logic, switching and general-purpose applications with these advanced specifications:

- Over 100 mA forward conductance at 1.0 V
- Less than 50 mμsec reverse recovery time
- Capacitance under 5 $\mu\mu$f at 0 V
- 200 V minimum breakdown voltage

RELIABILITY is significantly advanced by the introduction of Fairchild's latest semiconductor state-of-the-art development—the Planar Structure.

UNIFORM CHARACTERISTICS and minimal parameter spreads give unvarying results and consistent performance from every FD200 diode.

IMMEDIATE AVAILABILITY—Call your local distributor or sales office. Complete listing attached. Complete line of Fairchild 1N-types to current specifications complement the FD200.

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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FAIRCHILD SEMICONDUCTOR CORPORATION

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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.

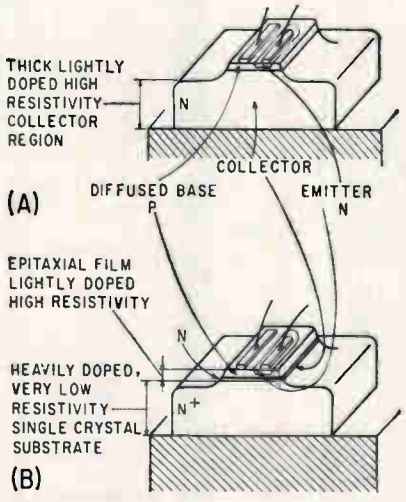
Bell calls these new devices epitaxial diffused transistors. And the diagram shows the new structure (B) compared to the conventional mesa (A).

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.



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

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.

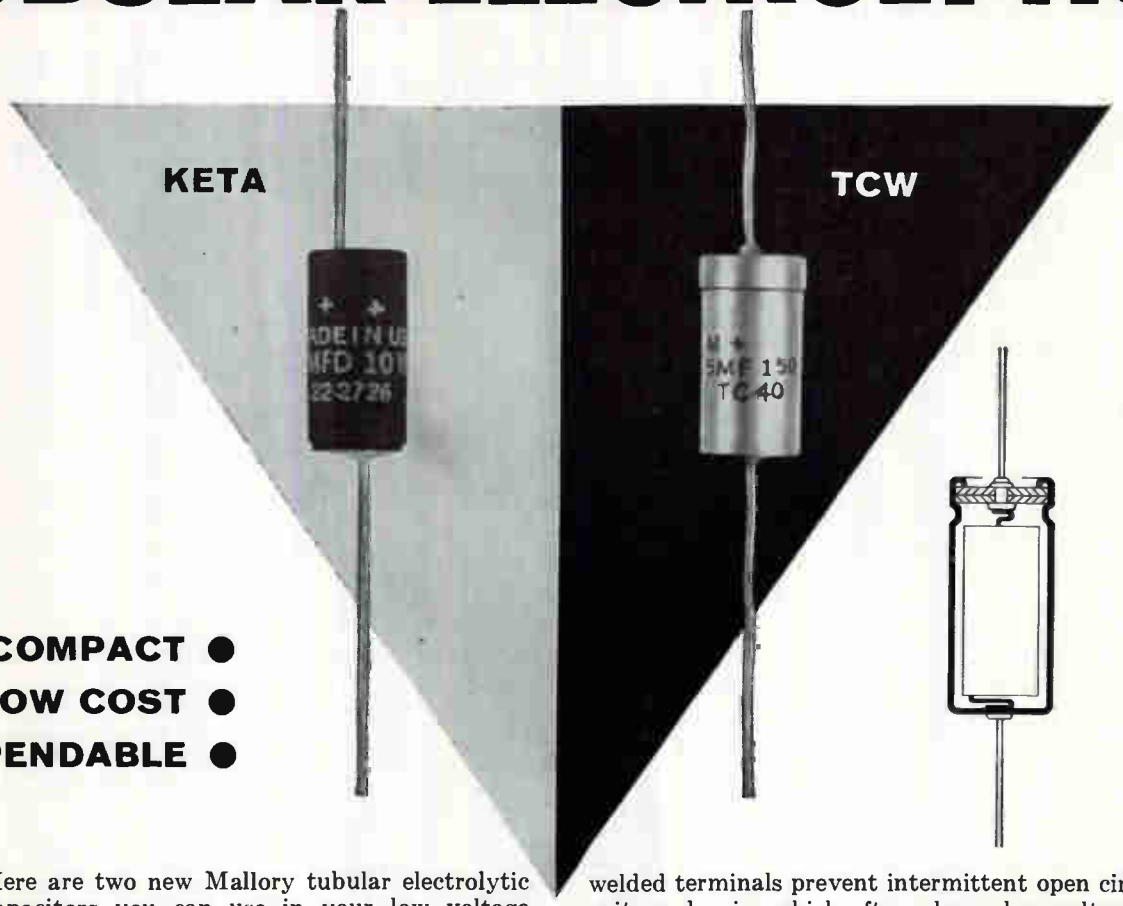
High-Melting Powders

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

For transistorized circuits...

TWO NEW MALLORY TUBULAR ELECTROLYTICS



COMPACT ●
LOW COST ●
DEPENDABLE ●

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	3/8"-5/8"	5/8"-1 13/16"
KETA	1-1400 mfd.	50-3v.	−30 to +65°C	3/16"-5/8"	5/8"-2"

Type KETA available in dual ratings, in 1/2" and 5/8" 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.

Operating at constant speed, the

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.

electronics INDEX
January-June, 1960

Expanded editorial content in *electronics* makes it practical to print the subject and author INDEX every six months. The July 1 issue will contain this valuable 24-page INDEX of technical and technically interpreted business information. Use the REPRINT ORDER FORM on the READER SERVICE CARD to order copies now. Refer to Key No. R-12 when ordering. 1-10 copies cost 50¢ ea.; 11-24 cost 40¢ ea.; 25 or more cost 30¢ ea.

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

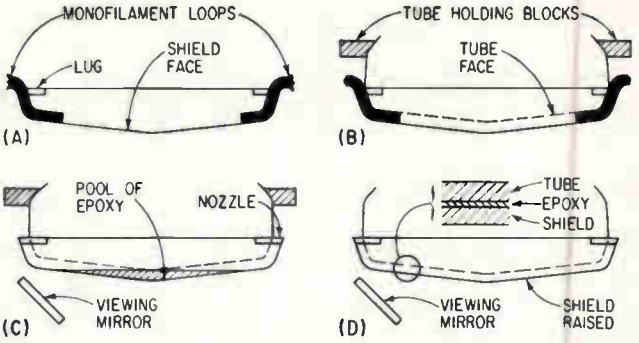


FIG. 1—Fixture provides space between tube and shield. After bonding resin is inserted, shield is raised to complete lamination

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

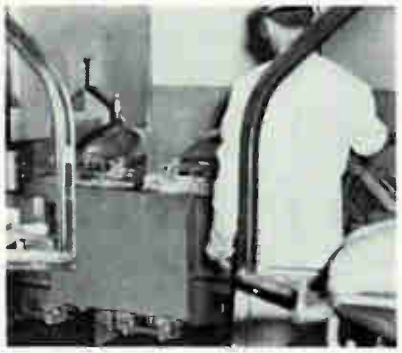
Shields are inspected and cleaned on light tables

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.

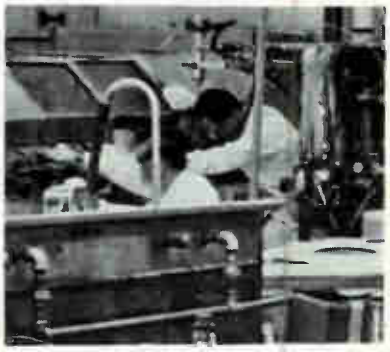
After the shield is positioned, the operator places a frame on the fixture and loads the tube. The frame is equipped with spacers to provide the necessary lateral spacing of the parts and the space between the tube face and shield. A slippery monofilament (Fig. 1A) pulls out, leaving a free air space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

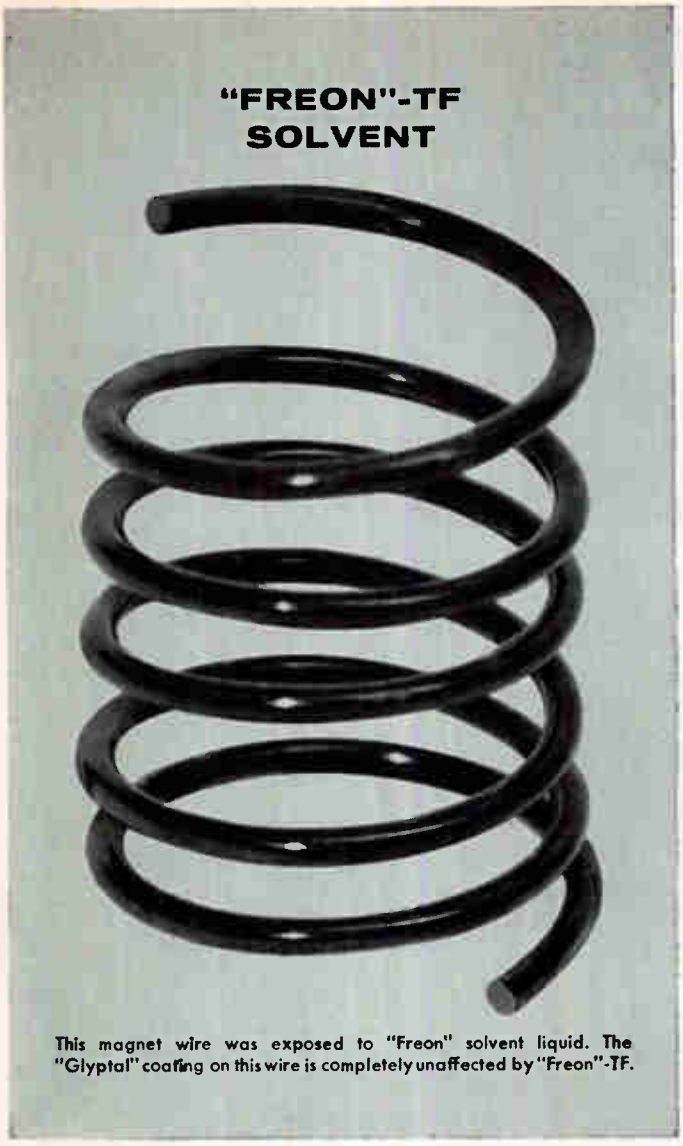
Resin and hardener are piped from supply tanks in an adjoining room and mixed by an automatic dispenser at the filling station. The compound is delivered to a nozzle which fits between the tube and the



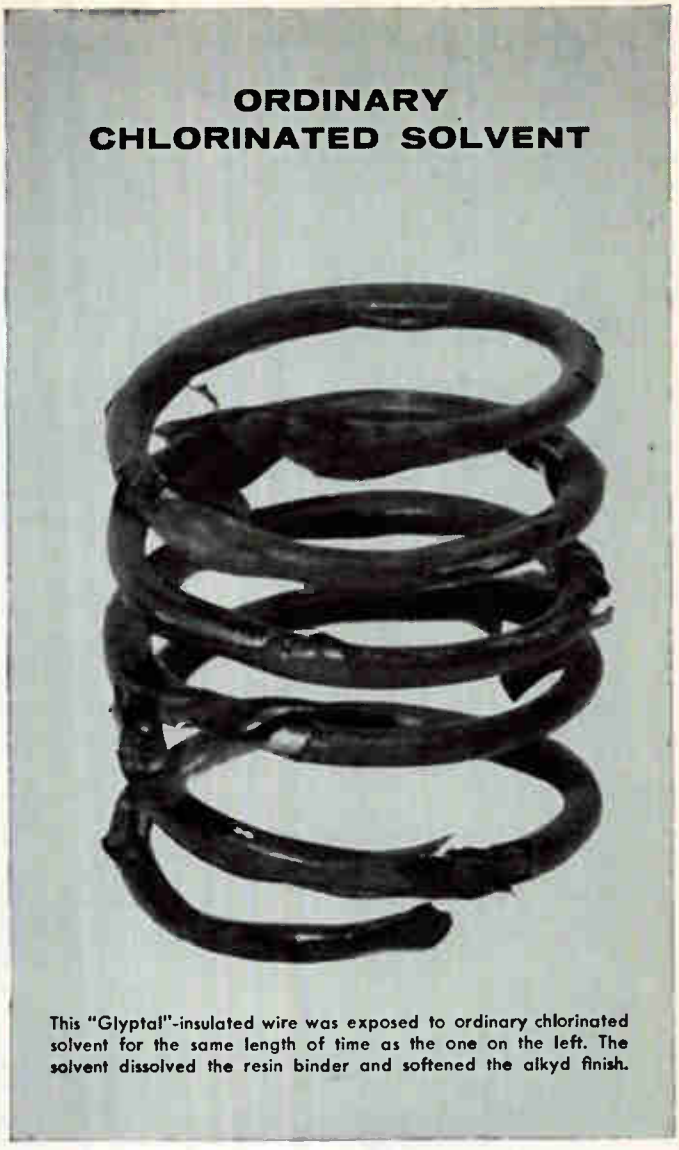
Fixture loading. Assemblies are seen entering preheat oven through the port at left



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



This magnet wire was exposed to "Freon" solvent liquid. The "Glyptal" coating on this wire is completely unaffected by "Freon"-TF.



This "Glyptal"-insulated wire was exposed to ordinary chlorinated solvent for the same length of time as the one on the left. The solvent dissolved the resin binder and softened the alkyd finish.

Comparison with ordinary chlorinated solvent proves:

FREON® solvents won't damage metal, elastomers or plastics . . . are safer for degreasing precision equipment

"Freon" solvents give you an effective and remarkably safe means of cleaning electric motors, ultra-precision mechanical and electronic equipment, and component parts. They minimize swelling of elastomers and plastics . . . will not soften paint, wire coatings or insulators. "Freon" solvents are also non-corrosive to metals without inhibitors. In addition, "Freon" solvents leave no residue when they dry and can be recovered and reused readily.

"Freon" solvents are safe for personnel, too. They are non-explosive and non-flammable. "Freon" is virtually non-toxic. Vapors are odorless and will not cause nausea or headaches.

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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.

Stains on Drawings Cleaned with Camera

DRAWINGS OR SCHEMATICS which have become stained or discolored can be reproduced as clean copies or microfilm by a process recommended by Photostat Corp., Rochester, N. Y. Fresh tracings can also be made at full size or smaller.

The stained drawing is placed on a back-lighted easel and photographed with a 105 mm automatic camera-projector. The backlighting reduces or eliminates the background, while preserving detail. The negative is then projected onto sensitized paper, using the same equipment. The negative or reproduction is used for further copying.

1960 Semi-annual Index to

electronics

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January through June Issues

VOLUME XXXIII

SUBJECT INDEX

Items for which the page reference is marked RD, CM and PT are editorial material published in Research and Development, Components and Materials, and Production Techniques departments, respectively. Designation ERS indicates item is an Electronics Reference Sheet. Designations BE, EN, BTW, MR and PC stand for Business Feature, Electronics Newsletter, Business This Week, Market Research and Picture-with-Caption items respectively.

A

Accelerator, electronic, for boosting speed of conventional electromechanical counters ... TF112 Feb 12
Accelerator, electronic, R&D in France ... SR75 Feb 12
Acoustics, electro-, R&D in Switzerland ... SR75 Feb 12
Active network theory for filter design ... TF88 Jan 15
Ad Hoc study group may propose central organization to administer control over design and procurement of military components ... EN11 May 27
Adder, ceramic-based microminiature for ballistic missile computer ... CM96 Jan 1
Adder circuit, parametron, for digital computers ... TF73 Jun 3
Adhesives, two fast-hardening expoxy bonds introduced for attaching component to circuit boards .. CM116 Jun 24
Advent active communication satellite should have space relay station in operation by 1962, be totally operational by 1964 ... EN11 Jun 24
Afc circuit for controlling local oscillator frequency in transmitter of portable battlefield radar ... TF67 Mar 18
Air suspension helps regulate amplitude of vibratory finishing equipment ... PT106 May 13

AIR TRAFFIC CONTROL
(See also Aviation and Navigation Systems)
Electronic highway guidance system techniques to be used for airport vehicle guidance applications ... BF40 Jun 17
Electronics R&D in air traffic control in England SR75 Feb 12
Europe pushes plans for supranational automatic air traffic control system (SATCO) ... BF40 Apr 22
Experimental simulation of air traffic control data processing central for New York underway ... BF28 Apr 8
FAA 1960 program to concentrate heavily on airtraffic control systems ... BF40 Feb 12
FAA reports five additional megacycles for use of air traffic control systems have been alloted .. EN11 Apr 29
Federal spending on air traffic control for coming fiscal year to increase over last year ... BF32 Jan 29
NBS studies automatic computation methods for determining best possible frequencies for radio transmitters used as road markers on air lanes RD72 Jun 17
Oscilloscope checks operation of memory drum used in air traffic control system ... PC39 Jun 10
Subsection of antenna for 3-D Air Height Surveillance Radar portion of air traffic control to be delivered ... BF29 Apr 8
Two study programs investigate the use of SAGE computer in air traffic control systems ... EN11 May 6

ALARM SYSTEMS
Automatic gas-fume detector alarms, Loran, radiotelephones, direction finders, and depth sounder fish finders make up new $10-million small boat market ... BF30 Jan 22
Light sensor in automatic bomb alarm system now being installed in strategic U. S. cities ... PC45 Apr 8
Nuclear bomb alarm system design to positively identify atomic explosions installed by AF .... BTW11 Apr 8
Remote pulse-coded fault alarm for multihop microwave systems ... TF82 Jan 1
Transistorized high-power sound generating system used to replace mechanical siren alarms TF70 Apr 15
Transistorized radiation monitor sounds alarm when alpha and beta radiation reaches preset level in nuclear-powered Navy vessels ... TF43 Jan 22
Alphanumeric display, electroluminescent, formed by ferroresonant storage and switching circuits ... TF49 Jan 22
Aluminized screens for cathode ray tubes, what's new in ... SR55 Apr 29
Amateur broadcast activities to be supplemented by facsimile and slow-scan tv ... BF48 Feb 12
Ambiguity resolution circuits for precision phase-meter used for c-w and pulsed uhf ... TF54 Mar 4

AMPLIFIERS
Analytical design of transistor push-pull amplifiers ... TF60 Jun 10
Astracon, a small light amplifier tube, increases light-gathering ability of telescopes, permits viewing of high-energy particle tracks ... PC82 Jun 10
Audio and video amplifiers grown from pool of molten semi-conductor materials ... BTW11 Jan 29
Beryllium oxide heat sink solves problem of heat removal from tube anode in r-f telemetry power amplifier ... CM110 May 20
Broadband microwave amplifier uses negative resistance of tunnel diode in combination with nonreciprocal ferrite attentuation ... CM84 Mar 25
Cadmium sulfide field-effect transistor used experimentally as amplifier ... BF42 Mar 18
Cadmium sulphide field-effect phototransistors used successfully in oscillator, multivibrator, amplifier and radiation detector circuits ... EN11 Feb 26
Class-C r-f amplifier using high-power, high-frequency mesa transistors ... CM86 Apr 1
Cross-field amplifier called Circlotron uses magnetron as negative-resistance element ... TF71 Jan 15
D-c transistor amplifier for measurement of low-amplitude long-period surface waves of ocean .. TF85 Jan 1
Design criteria for negative-resistance amplifiers giving low noise and high gain at very high frequencies ... TF110 May 27
Designing vhf transistor amplifier for high-frequency high-power oscillator ... TF52 Jan 8
Determining proper bias and correct circuit impedances for operating tunnel diodes as switches, amplifiers or oscillators ... TF82 Jun 3
Direct record and reproduce transistor amplifiers for wideband magnetic tape instrumentation recorder ... TF44 Jan 8
Electron-beam parametric amplifier operated in synchronous pumping mode improves receiver sensitivity, increases range of coho MTI radar by 50 percent ... RD92 May 13
Fluid amplifier uses gas and liquid pressures instead of voltages ... BF41 Mar 25
Galvanometer-photocell amplifier for industrial hysteresigraph used to measure d-c magnetization and hysteresis of magnetic materials ... TF70 Mar 25
High-voltage amplifiers developed for Canadian pay tv direct wire service ... BF52 Mar 18
Hot and cold constant-impedance loads for measuring noise figure of microwave amplifiers ... RD66 Feb 5
Hybrid low noise and i-f amplifier for portable battlefield radar ... TF67 Mar 18
Indicator triode has fluorescent anode whose illumination is controlled by grid potential for direct data readout ... RF52 Feb 5
Low-noise parametric amplifiers with variable-capacitance diodes expected to start appearing in systems soon ... TF159 Mar 11
Magnetic shift register core-transistor pulse amplifier and blocking oscillator ... TF80 Jan 15
Modern Microwave amplifiers ... SR67 Jun 24
Novel approach to pulse amplifier design reduces standby current, improves gain ... TF64 May 6
Parametric amplifier increases range of S-band radar used to track reentry vehicles ... RD116 Apr 29
Power amplifiers using electro-optical effects handle various combinations of electric, radiactive and thermal power ... TF71 Feb 26
Preamplifier for infrared detector used in rapid scan spectrometer developed to analyze energy radiated during power flight portions of missile trajectory ... TF86 May 20
Reflex klystron amplifier with hybrid T coupling give improved gain and linearity ... TF64 Jun 10
Reflex klystrons used as microwave receiver amplifiers for X-band radars ... TF56 Jan 8
Reflex klystrons used as millimeter wave amplifiers ... TF71 Mar 18
Screen-modulated power amplifier for double-sideband suppressed carrier transmitter ... TF47 Feb 5
Selecting power transistors to give required switching speed gain and current-carrying capacity for solid-state memory driver amplifier TF44 Mar 4
Sense amplifier for expandable random-access solid-state memory ... TF164 Mar 11
Sensitive amplifier for electronic accelerator used to boost speed of conventional electromechanical counters ... TF112 Feb 12
Specially developed diffused-base mesa transistor used in 215 Mc r-f amplifier for tv tuner ... TF64 Apr 8
Superconductor d-c and a-c amplifiers with no zero drift or noise under development ... BF32 Feb 5
Test circuit shows how to accurately measure gain and phase angle characteristics of closed-loop synchro, resolver and computer amplifiers ERS88 May 13
Three-stage silicon transistor amplifier with high-value circuit resistances operates with less than one milliwatt battery drain ... TF106 Apr 29
Transistor amplifier with stable gain for portable transistorized sound level meter ... TF64 Jun 17
Transistorized audio amplifier eliminates large-amplitude low-frequency noise in portable battlefield radar ... TF67 Mar 18
Transistorized high-power amplifiers for sound generating system to replace mechanical siren alarms ... TF70 Apr 15
Transistorized low-pass filter-amplifier for sub-audio frequencies used in missile telemetry .... TF88 Jan 15
Transistorized sense amplifier for Mobile Digital Computer (MOBIDIC) ... TF72 Mar 25
Transistorized servo, switching, and gyro temperature control and signal amplifiers for Able series space exploration probes ... TF60 Jan 29
Transistorized variable gain, d-c and power amplifiers for d-c to a-c inverter ... TF61 Apr 15
Tunnel diode circuit designs open new markets for computer, communications and receiver amplifier applications ... BF36 Feb 26
Tunnel diode microwave oscillator and amplifier circuits reported at 1960 Solid-State Circuits Conference ... TF39 Mar 4
Two transistor voltage amplifiers and latch-type relay provide overload protection for voltmeter .. RD92 Mar 18
Unity-gain isolation amplifier offers high stability and input impedance ... TF66 Feb 26
Vertical and horizontal amplifiers for self-powered transistor oscilloscope ... TF80 Mar 18
What's new in electron tubes for low-noise, small-signal and power amplifiers ... SR55 Apr 29
Wide-and narrow band- feedback amplifiers made from new alloyed-emitter, pnp mesa transistor for low microwave region operation ... RD82 Apr 15
Amplitron, X-band, is microwave tube having large anode-dissipation densities ... TF71 Jan 15
Amplitrons, what's new in ... SR55 Apr 29
Analyzer, transistorized, pulse height-to-time ... TF82 Jan 15
Analyzers, step-van truck with instruments for measuring air pollution developed using ... BF48 Feb 12
Anasthetic device, dental, using stereo sound placed in production ... EN11 May 27
Anemometers, electronic methods for boosting speed of conventional electromechanical counters ... TF112 Feb 12

ANTENNAS
Air Force BMEWS antennas in Arctic near completion ... PC33 Jan 22
Antenna efficiency upped to 70 percent for million-watt transmitter being developed by Navy ... BF41 Jan 29
Broadband log-periodic antennas for monitoring and signal interception, direction finding, satellite tracking, radio astronomy and h-f communications uses ... TF58 Jun 17
Circle diagram for impedance matching transmitter to antenna ... ERS73 Jun 10
Circularly-polarized, high-gain antenna for automatic tracking of Tiros meteorological satellites TF57 Apr 15
Corner reflector antenna offers high-gain, broad frequency response, narrow beam width and low back radiation ... RD82 May 6
Design criteria for electrically short antennas with high radiation efficiency ... TF84 Jun 3
Electronics R&D in directive antennas in England SR75 Feb 12
Elliptically polarized X-band horn antenna has 3-db and 6-db beamwidths of 140 degrees ... TF50 Mar 4
End-fire arrays of high-dielectric ceramic rods give low silhouette and high vertical resolution in uhf region ... TF60 Feb 5
Four-unit rhombic array used to bounce radar signal off sun's outer corona ... BTW11 Feb 12
Frequency scanning antennas for ground mapping or scanning radar systems ... TF70 May 6
Gain and beamwidth of helical antenna obtained with one setting of straightedge on nomograph .. ERS180 Mar 11
Interlacing of two helical antennas improves overall radiation pattern of single helix ... TF99 Apr 29
Large fixed hemisphere and small movable barrel-shaped reflector cut antenna sag for radio telescope use ... RD81 Apr 1
Maneuverable dish radar to scan and track ballistic missiles for BMEWS ... BF47 Mar 18
Missile-borne Ka-band antenna for vhf telemetry system used to eliminate communications blackout resulting from plasma sheath formation during vehicle reentry ... TF105 May 27
Mobile antenna radiating facility for aircraft flight-line testing (RADFAC) ... PC96 Jan 15
Model test range will permit all-weather, interference-free testing of antenna radiation patterns RD64 Jan 8
Modern microwave antennas ... SR67 Jun 24
NASA reports satellite tracking performance is tied to size of antenna ... BF33 Apr 29
Nassau terminus of 186-mile over-the-horizon troposcatter link to Bahamas completed ... PC39 Feb 5
Nomographs for estimating radiation capability low-frequency electrically-short antennas ... ERS86 Mar 18
Noninterfering TV and telemetry transmitter and command receiver antennas for Stratoscope 1 .. TF49 Jun 17
Parallel-plate capacitor antenna for transistorized radio beacon designed to function as aircraft crash position indicator ... TF54 Jan 22
Project Mercury satellite to be tracked by 50 antenna systems ... BF33 Mar 4
Radar test tower determines effect of radomes on antenna radiation ... BF49 Mar 25
Services need inventions in component, transistor, antenna and instrument areas ... BF39 Jan 22
Sixty-foot reflector for 3-axis antenna provides hemispheric coverage of missile and satellite telemetered data ... PC40 Jan 1
Special hurricane-resistant rhombic, curtain and log period antennas being built for Voice of America's new site ... BF34 Feb 19
Spincasting of plastic parabolic radio mirrors may provide antenna surface accuracies presently not practical ... RD96 Jan 15
Subsection of antenna for 3-D Air Height Surveillance Radar portion of air traffic control to be delivered ... BF29 Apr 8
Tracking antenna is towed to site and opened ... PC37 Jan 1
Transmission line analogy for propagation in sandwiches of dielectric sheets and conducting films or grids used in antennas ... ERS100 May 20
Transportable probe tracking facility (antenna and data collector) being tested for ARPA ... BF33 Apr 29

Triangular waveguide antenna is more rigid and easier to construct than large slotted waveguide cross sections ... RD64 Feb 19
Using graphical extension of transform techniques to find spectrum of radar return in presence of antenna scan modulation ... TF68 Apr 1
Antisubmarine telemetering system (Subroc) is given reliability checkout ... PC78 Jan 29
Arithmetic cell using 27 tunnel diodes demonstrates all basic logic circuits including dynamic storage ... TF55 Jan 29
Armatures, bridge circuit measures pulse response of to pinpoint faults during production runs ... TF70 Jun 10
Astracon, a small light amplifier tube, increases light-gathering ability of telescopes, permits viewing of high-energy particle tracks ... PC82 Jun 10
Ataxiameter, electronic, for measuring involuntary bodily movement ... RD78 Jun 10

ATMOSPHERIC STUDIES (See also Meteorology)
Atmospheric duct which traps and propagates radio waves at low loss discovered ... BTW11 Feb 5
Cosmic rays in upper atmosphere to be recorded by 800-lb block of film carried in Project Skyhook balloons ... RD94 Jan 15
Eliminating communication blackout resulting from plasma sheath formation during vehicle reentry using sufficiently high frequency ... TF105 May 27
Galactic noise measured by four-stage sounding rocket ... EN11 Jan 8
Instrumented low-cost Arcas and Loki weather rockets slated for daily firing ... BF43 Apr 29
Radar telescope detects micrometeorites, determines meteor showers are more frequent than previously suspected ... RD106 May 20
Signal transmission through natural ionized layers and ion shields formed by nuclear vehicles, hypersonic reentry vehicles, rocket motor exhausts and nuclear explosions ... TF81 May 20
Study of atmospheric noise needed to develop long-range vlf navigation systems ... RD78 Apr 8
Two Operation Skyhook balloons will study cosmic rays at 18 to 22 mi altitudes ... EN11 Jan 1

AUDIO (See also Stereophonics)
AF studies affect of high intensity sound on human physiological reactions ... PC46 Jun 24
Dental anasthetic device using stereo sound placed in production ... EN11 May 27
Four-track stereo tape recorder and miniature 7-transistor 45-rpm radio-phonograph shown at Japanese Industrial Trade Fair ... EN11 Apr 29
German's market binaural tape for stereo equipment ... BF49 May 13
Hearing aid sales rise 11 percent ... MR28 Mar 18
Japanese to market stereo four-channel tape recorder in U.S. ... EN11 Jan 22
Manufacturers expect continued increase in tv and audio market ... BF39 Feb 5
Miniature capacitor microphone with 15-Kc bandwidth for measurement use, and tv and moving picture studios ... RD80 May 6
National Stereophonic Radio Committee suspends activities ... BF63 Mar 11
New developments in determining unique characteristics of sound ... TF159 Mar 11
Portable transistorized sound level meter for measuring noise ... TF64 Jun 17
Silicon photocells used as detectors in projector optical sound track pickup ... PC68 Jan 8
Sound-canceling microphone makes ordinary voice communication possible in 150-db areas ... PC41 Apr 22
Transistor audio volume compressor for interview tape recorders ... TF62 Jan 8
Transistorized high-power sound generating system used to replace technical siren alarms ... TF70 Apr 15
Wireless eyeglass hearing aid developed ... PC43 May 27
Australia, research and development currently underway in ... SR75 Feb 12
Autocorrelator compares echoes from over-the-horizon radar missile warning system using magnetic-drum receivers ... BF28 Feb 5

AUTOMOBILE ELECTRONICS
Auto company tests energy absorption of materials by measuring impact of steel ball of surface ... PC30 Jun 17
Columbia University studies use of electronic controls in auto traffic safety ... BF60 Mar 11
Electroluminescent devices find expanded market in automotive applications ... BTW11 Jan 29
Electronic highway control using wire loops, guidance cable and transistorized detector demonstrated ... BF40 Jun 17
Generator-regulator for autos uses only semiconductors and resistors ... TF52 Feb 19
Interest in printed motors mounts as electric auto talk is revived ... BTW11 Apr 22
Multi-junction drift-field transistor simplifies design of portable and auto radios ... CM82 Apr 22
NBS' Boulder Labs. mobile field unit to measure interference from generators, power lines, spark plugs and other electrical gear ... BF52 Jun 24
Silicon solar cells power automobile ... PC52 Jun 24
Solar-powered call system gives drivers choice of emergency highway service ... PC53 Jun 3
Soviet remote-controlled farm tractors scheduled to start large-scale tests next year ... EN11 Feb 26
Telemetry technique for studying car behavior developed ... BF42 Mar 18
Transistorized automobile ignition system uses surface-gap spark plugs ... RD82 Mar 25

AVIATION
(See also Air Traffic Control and Navigation Systems)
Airborne early warning blimps to carry largest radar and electronic equipment complex ... EN11 Jan 15
Aircraft identification system used specialized transponders ... PC37 Jan 8
Airliner life rafts being equipped with rescue beacons ... PC52 May 20
Automatic surveying system uses lightbeam projector and profile measuring device to measure airport runway roughness ... TF54 Jun 17
Automatic weather station can be air-lifted to normally inaccessible areas by helicopter ... BF43 May 6
C-w Doppler radar ground velocity system for helicopter permits sonar dunking operations ... PC35 May 27
Electronics R&D in aviation in Australia ... SR75 Feb 12
FAA has raft of big and little plans for 1960 ... BF40 Feb 12
FAA orders test monitoring control equipment to check out VORTAC air navigation system ... EN11 Feb 26
FAA reports five additional megacycles for use of air traffic control systems have been alloted ... EN11 Apr 29
FAA rules out British Decca Mark X hyperbolic system for navigation ... BTW11 Jan 22
Federal spending on aircraft for coming fiscal year to increase over last year ... BF32 Jan 29
Flow rate of jet fuel containing radioactive tracer measured by simultaneously gated oscillator and radiation detector ... TF58 Feb 19
Ground-velocity indicator using c-w Doppler radar developed for helicopters ... EN11 Jan 8
How to determine whether to use visual, infrared or radar aircraft detection in fog or rain ... TF64 Jan 29
Japanese to emphasize development of aviation electronics ... EN11 Feb 12
Mobile antenna radiating facility for aircraft flight-line testing (RADFAC) ... PC96 Jan 15
Navy begins test on UDOFT (Universal Digital Operation Flight Trainer) used to simulate complicated jet flight conditions ... BF44 Apr 15
Plane and vehicle movements monitored by tv system ... BF44 Mar 25
Plug-in type tantalum capacitors for electronic stall control system ... CM98 Jan 1
Portable current-path verifier for aircraft applications identifies individual wires ... PC51 Jan 15
Probes make patterns of airflow around missile nose cone inside hypersonic wind tunnel in color ... BF52 Feb 26
Radiation-operated fuel gage for missiles and aircraft ... RD117 Apr 29
Radioisotope density altimeter is designed for missiles and fast new aircraft ... BF37 Jan 8
Selective calling system for aircraft data links removes necessity of continuously monitoring a communication channel ... TF108 Apr 29
Sixteen colleges in six midwestern states designated as communications network for Midwest Program on Airborne Television instruction ... BF59 May 20
System for tying flight simulator into remote standard ground-controlled intercept radar ... TF86 May 13
Technical aid in civil aviation given to United Arab Republic by FAA ... EN11 Jan 8
Transistorized radio beacon designed to function as aircraft crash position indicator ... TF54 Jan 22
Use of commercial uhf tv sets for reception of tv signals from aircraft for educational purposes discussed at winter meeting of AIEE ... BF28 Feb 19
Voice-visual aircraft communications system (DISCOM) book message transmitted by digital methods scheduled for delivery ... BTW11 Mar 25
Axis-crossing intervals, digital sampler for measurement of for design of weak signal detectors ... TF88 Jun 3

B

Backward-wave oscillator tubes, what's new in ... SR55 Apr 29
Bandpass measurement, two-tube circuit provides accurate, stable intensity marker for oscilloscope over 8 to 22 Mc frequency range for ... TF108 Jun 24
Bankers—their relationship to the Japanese electronics industry ... SR53 May 27
Batch process sequencing and dispensing controls show good progress in Britain ... BF52 May 13

BATTERIES (See also Power Sources and Supplies)
Basic design considerations of silicon solar cells for use as power supplies on satellites ... TF167 Mar 11
Lighter, smaller silver-cadmium portable tv battery capable of more than 2,000 operating hours available ... CM87 Apr 15
Performance ratings of secondary batteries ... TF60 Feb 19
Solar battery used to power Japanese lighthouse has operated successfully for six months ... BF57 May 13

BEACONS
Beacon, elliptically polarized X-band horn antenna with 3-db and 6-db beamwidths of 140 degrees used in ... TF90 Mar 4
Beacon, transistorized radio, designed to function as aircraft crash position indicator ... TF54 Jan 22
Beacon, uhf transponder, in Tiros 1 improves radar data quality, provides horizon-to-horizon coverage ... RD96 May 13
Beacons, rescue, airliner liferafts being equipped with rescue beacons ... PC52 May 20
Beam-pattern design for modern microwave antennas ... SR67 Jun 24
Bearings, ceramic gas, in new gyro reduces drift for space guidance applications ... CM76 Jun 17
Bilingual multiplex system, british, for European broadcasts or conventional stereophonic transmissions ... TF87 Jun 3

BIOPHYSICS (See also Medical Electronics)
Biocurrents in human cells being studied by Soviet Scientist with microelectrode ... EN11 Mar 4
Biological radiation equipment being researched by Syracuse University ... BF53 Feb 12
Computer applications of future will be in retrieving information and studying biological systems ... TF55 Jan 29
Computer calculates turbidimetric assays in automatic microbiological testing ... RD67 Jan 8
Ions affect health and behavior in space, submarines and department stores ... BF45 Feb 26
Mark I perceptron demonstrates ability to learn the alphabet ... BF43 Jun 24
Blood pressure meter, photoelectric, developed by Russians ... RD75 Jun 17
BMEWS detection and communication system, prime contractor get contract awards ... EN11 Feb 26
BMEWS radar to be augmented by Project Midas' heat-seeking missile defense satellite ... BF42 Apr 1
BMEWS rearward communications provided by submarines cable from Greenland to north of North Circle ... BF42 Feb 5
BMEWS to get three maneuverable dish radars to scan and track ballistic missiles ... BF47 Mar 18
Boat loaders, automatic alloy, boost transistor production ... PT122 Jun 24
Boats, transistorized gear for stars at National Motor Boat Show ... BF30 Jan 22
Bolometer using tiny platinum wire developed by Japanese to measure microwave power ... CM88 Apr 1
Bonding components to circuit boards with two newly introduced fast-hardening adhesives ... CM116 Jun 24
Bridge, balanced, and semiconductor diode circuits for one-tube oscillator-mixers in tv and f-m tuners ... TF76 Jan 15
Bridge circuit measures pulse response of armatures to pinpoint faults during production runs ... TF70 Jun 10

BROADCASTING (See also Communications)
A-m/a-m method of stereo broadcasting announced ... EN11 Feb 5
Britain and U.S. government agencies coordinate their time and frequency signal broadcasts ... RD81 Jun 10
British multiplex system for bilingual broadcasts or convention stereophonic transmissions ... TF87 Jun 3
FCC announces status of broadcasting at end of 1959 ... EN11 Jan 15
FCC to evaluate industry groups stereophonic f-m broadcast tests ... BF48 Jun 3
FCC yearend report shows more than 1½ million transmitters now on air in more than 50 services ... BF33 Jan 22
Future of stereophonic radio broadcasting to be determined by Washington this week. ... BF37 Jan 1
Ghana orders $1.68 million worth of shortwave broadcast equipment from British firm. ... EN11 Jan 1
NAB convention to discuss stereophonic and station automation equipment ... BF48 Apr 1
National Stereophonic Radio Committee suspends activities ... BF63 Mar 11
New developments in broadcasting conter around increased station automation ... TF159 Mar 11
Red China gives 50-kw shortwave broadcasting station to Cambodian government ... EN11 Jun 3
Red China tops U.S. in global broadcasting ... BF35 May 27
Regular stereophonic broadcasting to be initiated in Canada ... BF45 Jan 15
Remote transmitter generates control pulses during vertical blanking interval to control TV receiver ... TF79 May 13
Six-month shakedown of instantaneous audiometer used to rate viewing habits in New York City completed ... BF44 Apr 8
Status of broadcasting industry in Japan ... SR53 May 27
Stereo stimulates f-m broadcasters; FCC says standards may be established by fall 1960 ... BF30 Apr 22
Technique for checking calibration of f-m and t-v transmitter percentage-of-modulation monitors ... TF67 Apr 15
Voice of America gets new $25-million site in North Carolina ... BF34 Feb 19
Buffers, non-unity gain, functions for ... TF82 May 13

BUSINESS
(See also Exports, Foreign Electronics, Government, Imports, Management, Marketing, and Market Research)
American and Japanese firms agree to share techniques of design and manufacture of diodes ... BF32 Apr 8
Business data processor reads records prepared in standard business terminology ... EN11 May 13
Changing electronics market develops new patterns of doing business ... SR49 Jan 1
Components manufacturers say total sales were up 23 percent for the year ... BF35 Jun 24
Computers and closed-circuit television are bringing office automation to Mideast banks and oil firms ... EN11 Jul 1
Data processor built around two RCA 501 computers installed in bank ... EN11 Feb 5
Detroit area fast becoming important to electronics industry, particularly in R & D ... BF42 Mar 18
Electronic Manufacturers Association formed in Isreal includes also government and local scientific institutions ... BF53 May 6
Electronics industry will probably get 17 percent of defense budget in ten years ... BF53 Apr 1
Electronics to be third largest U.S. industry by 1965 ... MR24 Jun 17
Florida's new industrial lure: plant-and-house package ... BF30 Jun 10
Guide for measuring new product success record ... MR30 Feb 26
Ions affect health and behavior in space, submarines and department stores ... BF45 Feb 26
Manufacturers give increased attention to developing small computers for small businesses ... BF39 Apr 8
NASA gives $30-million contract for worldwide tracking and communications net for Project Mercury ... BTW11 Feb 5
New business data processing system offers sophistication at moderate price ... BTW11 Apr 15
New data processing system for small business announced ... EN11 Apr 22
New IBM solid-state business data processor ordered by Southern Railway ... EN11 Feb 12
New Mexico's electronics industry now in multi-million dollar bracket through missile development, R&D ... BF41 Apr 15
New trends in finding funds to promote growth of electronic companies ... BF30 Feb 19
Position of U.S. Government and industry on Japanese imports ... SR53 May 27
Self-help plan involving team bidding and establishment of trade association speed industrial growth on Long Island ... BF38 May 6
Tunnel diode factory production announced by U. S. and Japanese firms ... BTW11 Feb 12
Wall street confuses Litton in merger rumor ... BTW11 Apr 15
Wall Street datacenter to be opened in March ... EN11 Jan 1
Washington, D.C. is where firms go to seek an inside track for R & D ... BF34 Apr 22
What exhibitors are saying about forthcoming IRE International Show and Convention ... BF30 Mar 11
Will debate over military policy mean orders or cutbacks? ... BF26 Mar 4
Butterworth low-pass filter transfer functions ... TF82 May 13

C

CABLES
Characteristics and relative cost of coaxial cable and waveguide terminations ... TF50 Jan 8
Fiber optics cable used in closed-circuit tv dental monitor ... RD92 Jan 1

Frame of radiation beams provides nondestructive, continuous method of testing cable insulation.. PT135 May 27
Ions detect pinholes in wire and cable insulation ..... PT77 Feb 5
Molding cable junctions, connectors and terminations with cast-in-place solid elastomers ... PT90 Apr 1
Precision winding machine for submarine cable and capacitor manufacturing ..... PT86 Jun 10
Properties of representative liquid polymers for cold-molding cable systems ..... TF67 May 6
R-f cables and connectors for military applications (See p42, Dec 25, 1959 issue for 1st part of this article) ..... TF90 Jan 1
Submarine cable provides rearward communications for BMEWS from Greenland to north of Arctic Circle..... BF42 Feb 5
Work has starte on submarine telephone cable between Britain and Sweden ..... EN11 Jun 17
Cadmium sulfide photorectifier based on combination of photo-conductor and electret reported at 1960 Solid-State Circuits Conference ..... TF39 Mar 4
Calibration circuit for self-powered transistor oscilloscope ..... TF80 Mar 18
Camera tubes, what's new in..... SR55 Apr 29
Cans of odd shapes made of easily-formed metal by filling simple die with Neoprene plug ..... PT91 Apr 15
Capacitance, measurement engineers cite need for better measurement standards of..... BF53 May 20

CAPACITORS

British approaches to producing capacitors for microminiaturization ..... TF71 Jan 1
Capacitors with plastic wire electrodes and sputtered metal conductors give high temperature advantages..... CM86 Apr 15
Characteristics of precision r-f fixed capacitors ..... TF79 Mar 18
Characteristics of semi-precision paper and plastic film capacitors ..... TF78 Mar 25
Dielectric absorption in capacitors ..... RD78 Jun 10
Experimental current-measuring technique for determining dielectric absorption in capacitors ..... RD90 Mar 18
Ferroelectric capacitor tuning devices for frequency synthesizer gives stable, high-accuracy receiver and transmitters ..... RD122 Feb 12
Miniature capacitor microphone with 15Kc bandwidth for measurement use, and tv and moving picture studios ..... RD80 May 6
More use of tantalum and columbium for capacitors seen at Electrochemical Society meeting ..... EN11 May 20
Nominal-characteristics of electrolytic and general-purpose ceramic capacitors ..... TF173 Mar 11
Plug-in type single-ended tantalum foil capacitors give more capacitance in less space..... CM98 Jan 1
Precision winding machine for submarine cable and capacitor manufacturing ..... PT86 Jun 10
Recent advances in preparing thin film ceramic dielectrics for microminiature capacitors ..... CM96 Jan 1
Self-compensating fixture tests 24 capacitors at a time in an environmental test chamber ..... PT72 Jan 22
Semiconductor resistors and capacitors for microcircuits ..... TF69 May 13
Tantalum capacitor manufacturers look for 20 percent sales increase over 1959 level ..... MR24 Jun 10
What's new in built-in capacitor-type picture tubes SR55 Apr 29
Cathode bowling under severe shock reduced by new cathode base metal ..... CM79 Jun 17
Cathode ray tubes, monoscope-camera system converts computer data into visual form on microfilm. BF11 Feb 26
Cathode ray tubes, Soviet automatic control system checks mass-produced parts using crt scanning technique ..... EN11 Jan 15
Cathode-ray tubes, what's new in ..... SR55 Apr 29
Cathode temperature of commercial tube measured by using magnetic field parallel to retarding potential RD80 Apr 15
Cauer parameters used at specific stopband attenuations makes Zobel filter design procedures straighforward ..... TF96 May 20
Cavity-diode amplifier for modern microwave applications ..... SR67 Jun 24
Cells, human, biocurrents is being studied by Soviet scientist with microelectrode..... EN11 Mar 4

CERAMICS

Ceramic-based microminiature adder for ballistic missile computer..... PC96 Jan 1
Ceramic capacitors, electrolytic and general-purpose, nominal characteristics of ..... TF173 Mar 11
Ceramic filters improve selectivity of multiband communications-type receiver ..... CM84 Feb 26
Ceramic gas bearings in new gyro reduces drift for space guidance applications ..... CM76 Jun 17
End-fire arrays of high-dielectric ceramic rods give low silhouette and high vertical resolution in uhf region..... TF60 Feb 5
Four basic research programs underway to develop ductile ceramic and ionic crystals ..... CM100 Jan 15
NBS discovers a series of ceramic materials that exhibit simultanously both ferroelectric and ferrimagnetic properties..... CM128 Feb 12
Practicality of using small ceramic receiving tubes in thermionic integrated micromodular circuits (TIMMS) ..... CM82 Jun 10
Recent advances in preparing thin film ceramic dielectrics for microminiature capacitors..... CM96 Jan 1
Report on high-temperature ceramics ..... CM116 Jun 24
Cesium cell converter working at high temperatures produces significant amounts of a-c electricity... CM78 Jan 29
Cesium diodes with efficiencies of 15 to 20 percent are expected to be available in two years ..... TF159 Mar 11
Cesium-stream ion engine being contracted for by NASA ..... EN11 Jun 17
Changemaking machine operates by magnetic sensing ..... EN11 Jun 10
Character generator, solid-state, for VIDIAC (Visual Information Display and Control) system . TF55 Jun 10
Charts normalized for frequency provide a rapid solution to twin-T network parameters ..... ERS67 Jun 17
Check handling data processor built around two RCA 501 computers installed in bank..... EN11 Feb 5
Chokes, low-Q iron, simple and effective means of measuring inductance of ..... TF112 Apr 29
Chopper for precision phasemeter used for c-w and pulsed uhf..... TF54 Mar 4
Chrominance circuits for compatible color tv system featuring sequential transmission and using one-line memory in receivers ..... TF57 May 6
Circlotron is crossed-field amplifier using magnetron as negative-resistance element ..... TF71 Jan 15
Circuits breakers, solid-state static power, using silicon-controlled rectifiers have contact rating from milliwatts to milowatts ..... TF114 May 27
Circulators for modern microwave applications..... SR67 Jun 24
Citizens radio, crackdown on Class D looms if users don't toe the line ..... BF28 Jan 8
Citizens radio, self-policing by industries of class D Citizens' Radio being studied..... BF29 Feb 5
Clamp, toggle, makes portable hand punch press... PT73 Mar 4
Classifier, tape target, trains land-oased sonar student operators..... TF65 Mar 25
Clock, atomic, and quarts crystals are subjects of major interest at 14th annual Frequency Control Symposium ..... BF38 Jun 24
Coaxial magnetron oscillators, what's new in..... SR55 Apr 29
Codan (carrier-operated antinoise circuit) of advanced types feature simple design, low power drain, high dependability ..... TF113 May 27
Code circuit, transistorized, for high-power sound generating system used to replace mechanical sound alarms ..... TF70 Apr 15
Coder, eight-function, for remote pulse-coded fault alarm used in multihop microwave systems ..... TF82 Jan 1
Coding circuit for recording output of tv system tracking eye focus points and movements..... TF57 Apr 22
Coil induction heating, opens capsules in predetermined area of dog's gastro-intestinal tract ..... PC29 Jan 1
Coil, low-Q, simple and effective means of measuring inductance of..... TF112 Apr 29
Cold-cathode gas-filled tubes, what's new in ..... SR55 Apr 29
Collector unit sorts ions in double-focusing mass spectrometer..... RD74 Jan 29
Color picture tubes, what's new in ..... SR55 Apr 29

COMMUNICATIONS (See also Broadcasting)

Advent active communications satellite should have space relay station in operation by 1962, be totally operational by 1964 ..... EN11 Jun 24
AF is investigating X-rays as possible means of space communications..... BF45 Feb 12
Applications of modern microwave equipment in radar, communications, computer, remote control and cooking ..... SR67 Jun 24
Atmospheric duct which traps and propagates radio waves at low loss discovered..... BTW11 Feb 5
Automated submarine uses electronic data processing and display to give ship, engineering, communications, weapons, and environmental control ..... BF28 Jan 29
BMEWS detection and communication system prime contractors get contact awards..... EN11 Feb 26
Broadband data link designed to handle information from airborne radar mapper announced..... EN11 Apr 1
Broadband log-periodic antennas for monitoring and signal interception, direction finding, satellite tracking, radio astronomy and h-f communications uses ..... TF58 Jun 17
Communications-nucleus of Japanese electronics industry ..... SR53 May 27
Communications with Polaris submarines not big problem many people think..... BF32 Apr 15
Data communications systems linking distant computers use magnetic tape equipment ..... BF44 Jun 17
Delivery of new single-sideband communications systems for military and commercial market reported ..... BTW11 Mar 18
Designing for space and weight saving with rotary solenoids..... CM66 Mar 4
Double-sideband suppressed carrier modulation technique saves power, permits exalted-carrier detection..... TF47 Feb 5
Electronics R&D in communications in England, France, Italy and Sweden ..... SR75 Feb 12
Eliminating communication blackout resulting from plasma sheath formation during vehicle reentry using sufficiently high frequency..... TF105 May 27
End-fire arrays of high-dielectric ceramic rods give low silhouette and high vertical resolution in uhf region ..... TF60 Feb 5
Experimental progress towards transoceanic communication by means of passive earth satellites reported..... BTW11 Apr 8
FAA reports five additional megacycles for use of Air Traffic control systems have been alloted.. EN11 Apr 29
FAA to use total of 32 direct air-ground communication channels in 1960..... BF40 Feb 12
FCC plans to spend $2 million to find out whether or not uhf can be rejuvenated ..... BF32 Jun 3
Georgia Institute of Technology creates division to study radar and communications ..... BF53 Feb 12
High power pulsed S-band klystron for long-range radar or troposcatter communications..... CM82 Feb 26
Hiring in communications equipment industry up 13 percent..... MR26 Mar 11
Instruments, controls, electron microscopes, advanced communications are features of British Exhibition in New York ..... BF46 Jun 24
International Ordinary Administrative Radio Conference reallocates frequency spectrum and reports new regulations ..... BF33 Feb 19
Irradiation effects on communications-type systems..... TF69 Apr 22
Japanese-made tropospheric scatter communications system used by U.S. forces in Japan .... EN11 Jan 29
Mid-continent link in Army's worldwide communications network now operational..... BF35 Mar 4
Military Affiliate Radio System (MARS) considers facsimile and slow-scan tv as supplement to regular amateur activities ..... BF48 Feb 12
Million-watt transmitter to be completed by year's end for Navy..... BF41 Jan 29
NASA gives $30-million contract for worldwide tracking and communications net for Project Mercury..... BTW11 Feb 5
Nassau terminus of 186-mile over-the-horizon troposcatter link to Bahamas completed ..... PC39 Feb 5
NATO's 4,000-mile tropospheric scatter system Project Ace High to connect all major radar outposts and operational headquarters in Europe..... BF38 Apr 29
Navy experimental moon-relay communications system demonstrated..... EN11 Feb 5
NBS' Boulder Labs. mobile field unit to measure interference from generators, power lines, spark plugs and other electrical gear ..... BF52 Jun 24
New AF-operated facility uses computers and complex communications system to coordinate space surveillance, catalog everything in orbit BF34 Mar 4
New developments in communications..... TF159 Mar 11
New look in data processing to emphasize information transmission by common carrier between computers ..... BF38 May 27
New radar and communications system guard Korea against surprise invasion..... BF40 May 20
Optical-electronic active system for communications, navigation, and tracking and acquisition applications ..... TF71 Jan 15
Pioneer V will be transmitting information over distance of 50 million miles in August, 1960... BF49 Mar 25
Propagation of electromagnetic waves through subsurface of earth being studied for AF..... BTW11 Mar 4
Public facsimile research spreads, faster transmission and privacy are goals..... BF51 Apr 8
Rearward communications for BMEWS provided by submarine cable from Greenland to north of Arctic Circle ..... BF42 Feb 5
Remote Communications Complex (RCC) for SAC's Automatic Combat Control System (SACCS)..... BF36 Mar 25
Satellite astronomical observatory with 50-inch telescope and data communicating systems planned by NSF and NASA..... BTW11 Mar 18
Selective calling system for aircraft data links removes necessity of continuously monitoring a communication channel..... TF108 Apr 29
Selective paging system uses coded transmission for voice intercommunications with up to 45 stations..... TF68 Feb 26
Signal transmission through natural ionized layers and ion shields formed by nuclear vehicles, hypersonic reentry vehicles, rocket motor exhausts and nuclear explosions ..... TF81 May 20
Sixteen colleges in six midwestern states designated as communications network for Midwest Program on Airborne Television Instruction.... BF59 May 20
Sound-canceling microphone makes ordinary voice communication possible in 150-db areas..... PC41 Apr 22
Space communications plans outlined at Armed Forces Communications and Electronics Association's 14th Convention..... BF42 Jun 10
Subsurface propagation of electromagnetic waves being studied ..... PC30 Apr 22
Super-power uhf ceramic-metal tube developed for possible long-range radar missile detection and intercontinental tv..... TF70 Apr 8
Transistorized high-power sound generating alarm system can also carry voice communications... TF70 Apr 15
Transistorized multiplex single-sideband suppressed carrier system capable of handling 600 voice channels announced ..... EN11 Feb 19
Tunnel diode circuit designs open new markets for computer, communications and receiver amplifier applications ..... BF36 Feb 26
Use of sun as huge reflector to relay radio signals between distant points described..... RD115 Jun 24
Voice of America gets new $25-million site in North Carolina..... BF34 Feb 19
Voice-visual aircraft communications system (DISCOM) using canned book message transmitted by digital methods scheduled for delivery BTW11 Mar 25
Comparator, amplitude, for noise suppression factor display unit ..... TF55 Feb 5
Comparator used in automatic fault-finding system for testing battery control center of Hawk Weapons System ..... TF60 Jun 17
Compatible color tv system (French) features sequential transmission of chrominance, uses one-line memory in receiver..... TF57 May 6

COMPONENTS (See also specific components)

Approaches to design and fabrication of microminiaturized digital computer for space applications..... TF95 Apr 29
Avoidance of physical connection between components stressed at Electronic Components Conference..... BF35 May 27
British approaches to microminiaturization..... TF71 Jan 1
Central organization may be set up to administer program for control over design and procurement of military components..... EN11 May 27
Component development in electronics industry of Japan ..... SR53 May 27
Components highlighted at 1960 IRE International Show and Convention ..... BF47 Apr 1
Components manufacturers say total sales were up 23 percent for the year ..... BF35 Jun 24
Components market for 1960 ..... SR49 Jan 1
Components overlooked in R&D aspects of reliability..... BF39 Jan 29
Contour extruded aluminum tubing is being considered for waveguide components with integral flange ..... PT104 Jun 3
Designing for space and weight saving with rotary solenoids..... CM66 Mar 4
Dielectric diodes and triodes to control large amounts of current using thin insulating crystals of cadmium sulphide being developed ..... BTW11 Jan 22
Dollar value of plastics parts produced by electronics companies in 1959 is $250 million, double 1958's $125 million ..... MR24 Jun 24
Drop-feeding and unloading of workpieces on centerless grinder steps up production of synchro shafts..... PT74 Jan 22
Electronics R&D in components in England, Italy, Sweden, Switzerland and Japan ..... SR75 Feb 12
Erasers clean component leads..... PT89 Apr 8
Fit of mating glass parts can be accurately determined by methods known as the water drop and fringe pattern ..... PT106 Jun 3
Government may set minimum wage next year for workers making functional components ..... BTW11 Apr 15
High-thrust propulsion systems to shift critical emphasis in satellite development to component and instruments..... BF48 Apr 29
Japanese Electronics Parts Show indicates trend of manufacturers stepping up efforts to make components ..... BTW11 Mar 18

Labor Department to rule on minimum wages for tube and semiconductor production workers .... BF31 Jan 8
Microminiature modules (MICRAM) with component densities of 2 million units per cu ft being marketed .... BTW11 Mar 25
Microwaves components study of 1958 production issued by Commerce Department's Business and Defense Services Administration .... MR24 Apr 8
Minuteman's guidance and control systems need reliable components for underground storage lasting years .... BF39 Jun 17
Missiles and space continue to account for much government money spent in guidance and componentry research area .... EN11 Jun 3
Mobile controller-recorder programs temperatures to test missile components .... PC34 Jun 17
Modern microwave components .... SR67 Jun 24
Plastic skin packaging for electronic components, wire and circuit board assemblies and electromechanical parts .... PT82 Jan 29
Response of electronic system components and materials to irradiation from nuclear-powered aircraft .... TF69 Apr 22
R-f cables and connectors for military applications (See p42, Dec 25, 1959 issue for 1st part of this article) .... TF90 Jan 1
Respective merits of tubes and transistors discussed at winter meeting of AIEE .... BF28 Feb 19
Selecting R-C values for filters characterized by no output at infinity frequency or zero frequency TF82 May 13
Services need inventions in component, transistor, antenna and instrument areas .... BF39 Jan 22
Simple steps for speeding inspection of small lots of components .... PT72 Feb 19
Slip ring assemblies become major electronics components market, sales rise 25 percent yearly .... MR30 May 13
Solid-State Circuits Conference indicates components may be eliminated by microelectronics .... BF36 Feb 12
Specifications for components in millimeter band CM68 Feb 19
Stackable small parts bins being made of molded plastic .... PT89 Jun 10
Thermoelectric cooling modules for electronic components in R&D stages .... RD68 Feb 5
Three-dimensional x-rays diagnose component failures more readily .... PT74 Jan 22
Transistorized subaudio swept signal generator for testing servos and related equipment and components .... TF67 Apr 22
Two fast-hardening epoxy adhesives introduced for bonding components to circuit boards .... CM116 Jun 24
What designers should know about performance of missile components in dynamic environments .... TF102 Apr 29
Wheel-shaped component carrier in oven makes 150 C tests of silicon diodes .... PT130 Feb 12
Compressor, transistor audio volume, for interview tape-recorders .... TF62 Jan 8

COMPUTERS
(See also Data Processing, Digital Techniques, Logic Circuits, Memories and Registers)
Applications of modern microwave equipment in radar, communications, computer, remote control and cooking .... SR67 Jun 24
Approaches to design and fabrication of microminiaturized digital computer for space applications .... TF95 Apr 29
Automated transistor assembly systems turns out npn alloy junction transistors for computers at rate of 1,8000 per hour .... BTW11 Feb 19
Ballistic missile computer to be delivered for Sky Bolt guidance system .... EN11 May 6
Biasing techniques permit small-area junction germanium diodes to switch microwaves in waveguides or transmission lines .... TF85 Jan 15
Binary transceiver permits computers to talk to each other at 2,400 bits per sec over phone lines .... EN11 Jun 3
British and U.S. computermakers step up sales, promotional and service activities in Europe .... BF34 Jan 8
Ceramic-based microminiature adder for ballistic missile computer .... CM96 Jan 1
Computer and automatic control uses in chemical, petroleum, railroad and broadcast industries discussed at winter meeting of AIEE .... BF28 Feb 19
Computer applications in SAC's Automatic Combat Control System (SACCS) .... BF36 Mar 25
Computer calculates turbidimetric assays in automatic microbiological testing .... RD67 Jan 8
Computer controlled processes still exploratory in Britain .... BF52 May 13
Computer market opens for electroluminescent devices which perform logic and memory functions .... BTW11 Jan 29
Computer system for nuclear radiation alarm .... TF43 Jan 22
Computer technique of patent searching being tested by U.S. Patent Office .... RD124 Feb 12
Computers and closed-circuit television are bringing office automation to Mideast banks and oil firms .... EN11 Jul 1
Controlled-rectifier switch called Transwitch for computers turned off by small negative pulse .... TF71 Jan 15
Data communications systems linking distant computers use magnetic tape equipment .... BF44 Jun 17
Data processor built around two RCA 501 computers installed in bank .... EN11 Feb 5
Digital and analog computermakers seek wide marketing through pricing and design flexibility BTW11 Mar 18
Digital computer for industrial control functions being marketed .... EN11 Jan 8
Digital computers will soon control synthetic-rubber production .... BF35 Jun 10
Drive-sampling core generators precisely defined strobes to give high s/n ratio in digital computer memories .... TF72 Mar 25
Dutch market their first electronic computer which uses transistors and ferrite cores .... BTW11 Feb 12
East Germans show Robotron R-12 electronic computer .... BF37 Mar 18
Eastern Joint Computer Conference indicates computers are heading for 1,000-kc operation and microminiaturized circuits .... TF95 Jan 29
Electron tube tester automatically prepares test data in digital form for computer analysis .... PT74 Feb 5
Electronic equivalent of neuron discussed at winter meeting of AIEE .... BF28 Feb 19
Electronics R&D in computers in France, Italy, Sweden, Israel and Japan .... SR75 Feb 12
Expandable random-access solid-state memories operate over 15 to 55 C temperature range, require only 3 percent supplies .... TF164 Mar 11
FAA installs computers in air traffic control centers .... BF40 Feb 12
Four solid-state computers to form heart of air traffic control data processing central .... BF28 Apr 8
GE sponsors investigation into computer uses of tunnel diodes at University of Arizona .... BF60 Mar 11
Generation, detection and transmission of millimicrosec transients being studied at University of Kansas under Navy grant for Project Jayhawk BF60 Mar 11
Grant given Polytechnical Institute of Brooklyn to set up high speed computer facility .... BF53 Feb 12
Half-amp silicon diodes with 0.3 usec recovery time in volume production for computers .... CM105 Jan 15
Half-inch cube modules holding 12 to 18 components used in reconnaisance drone guidance system, commercial and military computers .... CM123 Apr 29
High-speed repetitive-operation analog computers permit continuous plot displays .... EN11 Feb 19
High-speed transistor switch for computer logic circuit performs at micro-energy levels .... CM98 May 13
Japanese develop new computer logic – high speed parallel adder-accumulator and shifter .... BF36 Apr 15
Large-scale digital computer permits Navy high degree of realism in simulating mock submarine battles .... BF35 Jun 24
Long-range radar, computer with high reliability key units in ground-controlled satellite guidance system .... BF43 May 27
Magnetic element of ferrite composition for storage, switching and logic applications in digital computers has advantage of open flux path, excellent squareness characteristics .... RD104 May 20
Magnetic noncontact shaft-position disk encoder offers high rotational speeds and reliability for computer, control and data logging uses .... RD114 Apr 29
Magnetic thin film dots for computer memories .... PC184 Mar 11
Manufacturers give increased attention to developing small computers for small businesses .... BF39 Apr 8
Manufacturers look for quadrupled digital computer sales over next five years .... MR24 Jun 3
Micrologic elements promise computer miniaturization according to paper given at 1960 Solid-State Circuits Conference .... TF39 Mar 4
Micron-thick permalloy plated onto copper basis of new film logic and memory devices developed in Japan .... EN11 Apr 1
Modification of interceptor and target computers to tie flight simulator into remote standard ground-controlled intercept radar .... TF86 May 15
Monoscope-camera system converts computer data into visual form on microfilm .... BF11 Feb 26
Monoscope tube generates characters for direct readout on a cro or on paper of digital computer output .... TF117 Feb 12
Navigation for hypersonic or space craft aided by computer-directed map projection system under development .... EN11 Jun 3
NBS studies automatic computation methods for determining best possible frequencies for radio transmitters used as road markers on air lanes .... RD72 Jun 17
New AF-operated facility uses computers and complex communications system to coordinate space surveillance, catalog everything in orbit .... BF34 Mar 4
New business data processing system offers sophistication at moderate price .... BTW11 Apr 15
New developments in computers – tunnel triodes and learning systems .... TF159 Mar 11
New look in data processing to emphasize information transmission by common carrier between computers .... BF38 May 27
Noise suppression factor display unit computes and automatically displays ratio of two time-varying quantities .... TF55 Feb 5
Oscilloscope check operation of memory drum used in air-traffic control system .... PC39 Jun 10
Parallel-sequential, single-address, binary, synchronous computer used in UDDFT (Universal Digital Operation Flight Trainer) .... BF44 Apr 15
Parametron logic, register, adder, counter, translator and converter circuits for digital computers .... TF73 Jun 3
Permanent magnet memory unit (Twistor) ready for mass production .... BTW11 Jan 29
Precision turning device for finishing outer-diameters of memory drums .... PT126 Apr 29
Preview of computer sessions for forthcoming IRE International Show and Convention .... BF32 Mar 11
Reciprocal circuit gives output which is inversely proportional to input for use with analog computers and control systems .... TF92 May 20
Rice Institute develops 8,192-word grid tube memory, expect expansion to 32,000 words .... BF59 May 20
Russia's Setun computer using magnetic amplifiers operates on ternary rather than binary code BF11 Feb 26
Sampling oscilloscope permits measurement of computer diode recovery times down to 500 picosec .... TF59 Apr 8
Selecting power transistors to give required switching speed gain and current-carrying capacity in computer switching applications .... TF44 Mar 4
Shaft-position disk encoder design eliminates positional ambiguities .... TF62 Apr 22
Simulator for selecting best possible target among all in-range attackers .... RD76 Jan 29
Six ways to use magnetic core shift register elements .... TF80 Jan 15
Solid-state computer drawing only 100 watts big news at Western Joint Computer Conference .... BF35 May 27
Solid-state computer (STRETCH class) capable of completing 100 billion computations a day is announced .... EN11 May 6
Solid state high-speed printer-plotter prints and plots from computer-prepared magnetic tape .... EN11 Jan 22
Solid-state Univac III has processing speed nine times faster than Univac II .... EN11 May 20
Soviet semiconductor and computer production rates increase .... EN11 Jan 29
Spiral magnetic paths (Twistor) used in digital computer memory .... CM84 Mar 25
Status of computer industry in Japan .... SR53 May 27
STRETCH-class computer capable of completing 100 billion computations a day is announced .... EN11 May 6
Superconductors to find use as components for high-speed switches and memory systems .... BF32 Feb 5
Test circuit shows how to accurately measure gain and phase angle characteristics of closed-loop synchro, resolver and computer amplifiers .... ERS88 May 13
Transistorized digital computer for open-loop control in processing operations .... BTW11 Feb 19
Transistorized function generator eliminated need for d-c amplifier .... TF75 Mar 25
Tunnel diode circuit designs open new markets for computer, communications and receiver amplifier applications .... BF36 Feb 26
Two study programs investigate the use of SAGE computer in air traffic control systems .... EN11 May 6
Varactor diodes available in experimental quantities, used for high-efficiency subharmonic oscillators in microwave computers .... CM131 May 27
West Berlin's Institute for Nuclear Research gets new transistorized computer .... BF31 Jun 10
Conductivity determination of in evaluating three-element semiconductor materials TE103
Conductivity of various chemicals to be studied at University of Cincinnati .... BF60 Mar 11
Conductors, British approaches to producing for microminiaturization .... TF71 Jan 1

CONFERENCES (See also Conventions and Meetings)
Avoidance of physical connection between components stressed at Electronic Components Conference .... BF35 May 27
Control systems, solid-state electronics and electromagnetics featured at Seattle's 7th Regional IRE Conference .... BF39 Jun 10
Eastern Joint Computer Conference indicates computers are heading for 1,000-kc operation and microminiaturized circuits .... TF55 Jan 29
Electronics firms urged at EAI Industrial Electronics Conference to sell systems instead of hardware to industrial customers .... MR22 Jan 22
Electronics probes the universe is theme of 12th Annual National Aeronautical Electronics Conference .... BF45 May 20
Emphasis at Third International Instrument Electronics and Automation Show in Britain is on industrial controls, digital building blocks . BF34 Jun 17
Emphasis on basic scientific progress and discoveries in Conference on Electronic Conductivity in Organic Solids .... RD127 May 27
Forthcoming Solid-State Circuits Conference indicates R & D labs are in tunnel diode race .... BF32 Jan 1
International Federation of Automatic Control Conference to open in Moscow next week .... BF34 Jun 24
International Ordinary Administrative Radio Conference reallocates frequency spectrum and reports new regulations .... BF39 Feb 19
Microelectronics to get special attention at 1960 Solid-State Circuit Conference .... EN11 Jan 29
Microminiaturization discussions dominate Electronic Components Conference .... BF46 May 27
Micro-sized vacuum tubes encapsulated in a solid block reported at 1960 Western Joint Computer Conference .... CM100 Jun 3
New trend towards circuit synthesis rather than circuit analysis noted at Conference on Active Networks and Feedback Systems .... BF44 May 20
Passive, reversible, distributed-coupling transducer introduced at 3rd International Congress on Acoustics .... CM73 Feb 5
Quartz crystals and atomic clocks are subjects of major interest at 14th annual Frequency Control Symposium .... BF38 Jun 24
Recent progress in solid state technology reported at 1960 Solid-State Circuits Conference .... TF39 Mar 4
Russia to host First International Congress on Automatic Control in June .... BF31 Jun 10
Solid-State Circuits Conference indicates microelectronics is moving rapidly out of research phase .... BF36 Feb 12
Solid-state computer drawing only 100 watts big news at Western Joint Computer Conference .... BF35 May 27
Talks on high-frequency standards and calibrations to highlight technical sessions during 1960 Conference on Standards and Electronic Measurements .... BF53 Jun 3
Technique for growing ribbon crystals of semiconductor material described at Solid-State Circuits Conference .... BF36 Feb 12
Technique of vapor-growing high resistivity collector films on a low-resistivity substrate (revealed at IRE-AIEE conference) may have far reaching implications .... EN11 Jun 24
Connectors for military applications (See p42, Dec 25, 1959 issue for 1st part of this article) .... TF90 Jan 1

CONSUMER PRODUCTS (See also specific product)
American-made all-transistor a-m/f-m portable radio being test-marketed .... EN11 Jun 10
British tv and radio manufacturers break all sales records .... EN11 Jan 15
Commerce department forecasts $2.2-Billion consumer market in 1960 .... BTW11 Jan 22
Consumer electronics market for 1960 .... SR49 Jan 1
Electronic oven uses microwave technique for assembly line production of pre-frozen meals in Holland .... BF47 Jun 10
F-m radio set sales to show gain of 50 percent over last year .... MR26 Feb 12
Germans cut prices of radio and tv sets through improved production techniques .... BF49 May 13
India has decided to mass-produce cheap radio receivers (under $25) .... BF52 Jun 24
Japan Electronics Parts Shown featured new consumer products .... BTW11 Mar 18
Japan reopens transistor radio exports under offical controls .... EN11 Jun 3
Japanese company signs contract with U.S. importer for $1.4 million worth of consumer electronic products .... BF30 Jun 17
Japanese Industrial Trade Fair feature consumer items for U.S. market .... EN11 Apr 29
Japanese manufacturers fear their Government will set quota for export of transistor radio to U.S. . BF48 May 6
Japanese radios bought by appliance chain for sale in U.S. .... EN11 Jan 1

Japanese tv set sales increase rapidly ..... EN11 Jan 15
Japan's electronics industry concentrating on production of color tv sets ..... EN11 Jun 24
Manufacturers expect continued increase in tv and audio market ..... BF99 Feb 5
Multi-junction drift-field transistor simplifies design of portable and auto radios ..... CM82 Apr 22
Radio and TV production rise in Austria ..... EN11 Jan 15
Radiophonograph weighing 2.8 lb developed by Japanese ..... EN11 Jan 15
Soviets plan to triple tv set production by 1965... BF Jan 15
Status of consumer products industry in Japan ... SR53 May 27
Transistorized tv receiver with 19-in. screen and rechargeable battery announced ..... EN11 Jun 3
Transistorized tv set to be marketed by Japanese firm during 1960..... EN11 Jan 8
U.S. demand for f-m transistor radios boosts Japanese exports..... EN11 Jan 29

CONTROL CIRCUITS AND SYSTEMS (See also Servomechanisms)
Applications of modern microwave equipment in radar, communications, computer, remote control and cooking ..... SR67 Jun 24
Automated submarine uses electronic data processing and display to give ship, engineering, communications, weapons, and environmental control..... BF28 Jan 29
Automatic control and supervisory system for gas compression station ..... EN11 Jun 10
Automatic control holds voltage across weld constant ..... PT102 Jan 1
Automatic control unit for operating dielectric strength testers ..... PT88 May 6
Automatic fault-finding system for testing battery control center of Hawk Weapons System ..... TF60 Jun 17
Computer and automatic control uses in chemical, petroleum, railroad and broadcast industries discussed at winter meeting of AIEE..... BF28 Feb 19
Control systems, solid-state electronics and electromagnetics featured at Seattle's 7th Regional IRE Conference ..... BF39 Jun 10
Control using voltage constraint and NOR logic improves consistency and reliability of spot welds..... TF48 Feb 19
Designing for space and weight saving with rotary solenoids..... CM66 Mar 4
Digital computer for industrial control functions being marketed..... EN11 Jan 8
Digital computers will soon control synthetic-rubber production ..... BF35 Jun 10
Digital programmer automatically adjusts and controls furnace temperature during preparation of high purity materials ..... RD122 May 27
Electronics R&D in industrial and automatic controls in France, Italy and Japan..... SR75 Feb 12
Emphasis at Third International Instrument Electronics and Automation Show in Britain is on industrial controls, digital building blocks BF34 Jun 17
Five-transistor line voltage regulator uses Zener diodes ..... TF64 Feb 5
Ground based missile roll control system uses photosensitive or infrared detectors..... RD80 Mar 25
Instruments, controls, electron microscopes, advanced communications are features of British Exhibition in New York ..... BF46 Jun 24
International Federation of Automatic Control Conference to open in Moscow next week..... BF34 Jun 24
Low-priced tape-controlled position system with nominal electrical accuracy of one part in 400, 000 shown ..... EN11 May 13
Magnetic noncontact shaft-position disk encoder offers high rotational speeds and reliability for computer, control and data logging uses..... RD114 Apr 29
Minuteman inertial guidance and flight controls get $115-million boost ..... EN11 Jan 8
Minuteman's guidance and control systems need reliable components for underground storage lasting years ..... BF39 Jun 17
Multiplex circuits control robot which performs jobs in dangerously radioactive areas ..... TF46 Jan 22
Pre-punched tape directs numerical machine tool control equipment automatically..... PC37 Mar 18
Production line tester for checking for contact chatter of electromagnetic relays uses thyratron timing circuit..... TF94 May 20
Reciprocal circuit gives output which is inversely proportional to input for use with analog computers and control system..... TF92 May 20
Remote control system for operating balloon-borne TV in Stratoscope I ..... TF49 Jun 17
Remote transmitter generates control pulses during vertical blanking interval to control TV receiver..... TF79 May 13
Rugged ultrasonic transducer with novel vibrating system for indoor and outdoor remote control applications ..... CM128 May 27
Russia to host First International Congress on Automatic Control in June ..... BF31 Jun 10
Shaft-position disk encoder design eliminates positional ambiguities..... TF62 Apr 22
Solid state combustion control system for furnace developed using magnetic amplifiers..... EN11 Jan 15
Solid-state light dimmer weighting 1½ pounds promises to cut industrial power bills by 30 percent ..... BF39 May 27
Soviet automatic control system checks mass-produced parts using crt scanning technique ... EN11 Jan 15
Steering transistor circuits control reversible decade counter generating error signals..... TF86 Jan 1
Stepping relay controls operation of lazy susan used to pace electronic assemblers..... PT76 Feb 5
Survey of United Kingdom's progress in industrial controls..... BF52 May 13
Thyratrons control a milling machine by driving step motors in response to signals from a programmed tape ..... TF174 Mar 11
Transistorized camera control circuit for rocket sled tests..... TF63 Apr 1
Transistorized circuits for guiding Able series space exploration probes..... TF60 Jan 29
Underwater camera flash and film-rewind circuits control picture taking at depth of 6 miles ..... TF62 Apr 8
Controlled rectifier used in adjustable counting and timing circuits operating primarily as frequency dividers ..... TF61 May 6

CONVENTIONS (See also Conferences and Meetings)
Completely passive, balance modulator circuits using thin permalloy film described at 1960 Winter Convention on Military Electronics ..... RD78 Feb 26
Highlights of 1960 IRE International Show and Convention — components, microminiaturization, instruments and production equipment ..... BF47 Apr 1
How to see the IRE International Show and Convention..... BF47 Mar 11
IRE International Show and Convention gives U.S. Firms chance to check activities of foreign competitors ..... BF36 Mar 18
NAB convention to discuss stereophonic and station automation equipment ..... BF48 Apr 1
Preview of technical sessions for forthcoming IRE International Show and Convention..... BF32 Mar 11
Record registration expected for 1960 IRE International Show and Convention, also more technical and applications emphasis ..... BTW11 Mar 11
Space communications plans outlined at Armed Forces Communications and Electronics Association's 14th Convention ..... BF42 Jun 10
Sun-position sensor for establishing coordinate reference system on space vehicle reported at 1960 Winter Convention on Military Electronics. RD62 Mar 4
What exhibitors are saying about forthcoming IRE International Show and Convention..... BF30 Mar 11

CONVERTERS
Americans study Soviet-built heat-to-electricity converter ..... BF48 Apr 1
Analog-to-digital converter grown from pool of molten semiconductor materials ..... BTW11 Jan 29
Cesium cell converter working at high temperatures produces significant amounts of a-c electricity. CM78 Jan 29
Continued emphasis shown on analog-to-digital converters and readouts at IRE Show ..... BF47 Apr 1
Converter for final indicator in noise suppression factor display unit ..... TF55 Feb 5
Data reduction speeded using transistorized pulse-height-to-digital signal converter..... TF58 Jan 8
Experimental converter using tunnel diodes reported at 1960 Solid-State Circuits Conference . TF39 Mar 4
Linear circuits used to obtain precise voltage regulation of output of transistorized d-c to a-c inverter ..... TF61 Apr 15
Monoscope-camera system converts computer data into visual form on microfilm ..... BF11 Feb 26
New developments in direct conversion of heat to electric power without using moving parts ..... TF159 Mar 11
Parallel-to-serial converter for solid-state character generator used in VIDIAC (Visual Information Display and Control) system ..... TF55 Jun 10
Parametron converter circuits for digital computers TF73 Jun 3
Saturating-core multivibrator used as power converter in portable battlefield radar ..... TF67 Mar 18
Single-transistor circuit forms efficient photoflash power converter..... TF57 Jan 22
Thermoelectric generator built which delivers 5 Kw by direct conversion of heat into electricity without major moving parts ..... RD96 Jun 3
Transistorized command converter for attitude-control system in Able series space exploration probes ..... TF60 Jan 29
Transistorized pulse height-to-time converter for earth satellite telemetry system..... TF82 Jan 15
Transmission line analogy for propagation in sandwiches of dielectric sheets and conducting films or grids used in polarization converters ERS100 May 20
What's new in image converters ..... SR55 Apr 29
Convolution integrals, review of and graphical extension of..... TF68 Apr 1

COOLING TECHNIQUES
Batelle Memorial Institute to research cooling techniques ..... CM78 Jun 17
Beryllium oxide heat sink solves problem of heat removal from tube anode in r-f telemetry power amplifier..... CM110 May 20
Low-pressure air most efficient method to cool components during manual soldering of printed circuits..... PT104 May 13
Thermoelectric cooling materials with figure of merit between 4 and 5 expected to be available in two years..... TF159 Mar 11
Thermoelectric cooling modules for electronic components in R&D stage ..... RD68 Feb 5
Thermoelectric cooling now possible using new semiconductor materials ..... CM85 Feb 26
Thermoelectric transistor cooler using Peltier effect gives wide-range temperature control.... TF71 Jan 15

CORES
Current pulse generator for testing ferrite memory cores..... TF80 Jan 1
Dutch market their first electronic computer which uses transistors and ferrite cores..... BTW11 Feb 12
Micro-sized Ferrite-core memory array for data processing system operates under environmental extremes..... CM98 May 13
Multi-aperture configuration simplifies core winding..... CM70 Jan 8
Six ways to use magnetic core shift register elements..... TF80 Jan 15
Corner reflector antenna offers high-gain, broad frequency response, narrow beam bandwidth and low back radiation ..... RD82 May 6
Correlators, polarity coincidence multiplier used as TF67 Jan 29
Cosmic rays at 18 to 22-mi altitudes to be studied by two operation Skyhook balloons ..... EN11 Jan 1
Cosmic rays in upper atmosphere to be recorded by 800-lb block of film carried in Project Skyhook balloons ..... RD94 Jan 15
Countermeasures, chart helps determine effectiveness of radar in presence of jamming ..... TF76 May 6
Countermeasures, elliptically polarized X-band horn antenna has 3-db and 6-db beamwidths of 140 degrees for..... TF50 Mar 4
Countermeasures, invisible electronic shield for baffling radar and radar-guided missiles is reported EN11 May 6
Countermeasures, new applications of modern microwaves in ..... SR67 Jun 24

COUNTERS
Adjustable counting and timing circuits operate primarily as frequency dividers using a controlled rectifier and saturable reactor ..... TF61 May 6
Battery-powered transistorized scale of 64-counter for measuring radioactive tracers improves reliability, reduces cost and weight..... TF74 May 6
Binary counter made by British using micromin-iaturization techniques ..... TF71 Jan 1
Cold-cathode ring-counter drives numerical indicator..... TF80 Apr 1
Electronic methods for boosting conventional electromechanical counter speed ..... TF112 Feb 12
Gas-filled stepping tubes ..... TF46 Feb 19
Parametron counter circuits for digital computers TF73 Jun 3
Semiconducting industrial diamonds may find application as counters of radioactivity ..... RD76 Apr 22
Small BEAM-X switch tube may claim extended market ..... CM126 Feb 12
Steering transistor circuits control reversible decade counter generating error signals ..... TF86 Jan 1
Transistor 7-stage binary counter for pulse-height-to-digital signal converter ..... TF58 Jan 8
Typical semiconductor binary counter for microcircuits ..... TF69 May 13
Tunnel diodes used in binary counters ..... TF55 Jan 29
What's new in counting tubes ..... SR55 Apr 29
Crash position indicator, aircraft, transistorized radio beacon designed to function as ..... TF54 Jan 22

CRYOGENICS
Cryogenic gyro under development; broad capabilities inherent in low-temperature devices spur further studies..... BF32 Feb 5
Cryostat development spurred with increased interest in cryogenic engineering ..... BF32 Feb 5
Recent progress in solid state technology reported at 1960 Solid-State Circuits Conference . TF39 Mar 4
Superconductive gyro called feasible; use seen in subs and space vehicles ..... BTW11 Jan 29
Superconductivity symposium disclosed basic work is still concentrating on cryotron, major problem is fabrication ..... EN11 May 27
Switching and storage circuits are made from crossed film cryotrons deposited on insulating superconductors ..... TF55 Jan 29
Transistorized test set for measuring critical current in superconducting contacts of cryogenic circuits ..... TF52 Jan 22
Crystal-controlled carrier-operated antinoise circuits for receivers feature simple design, low power drain, high dependability ..... TF113 May 27
Crystal specifications for millimeter band ..... CM68 Feb 19
Crystals, quartz, and atomic clocks are subjects of major interest at 14th annual Frequency Control Symposium ..... BF38 Jun 24
Crystals, vhf quartz, improved lapping, polishing and base-plating developed for ..... PT84 Apr 22

D

Dacom, a monoscope-camera system for converting computer data into visual form on microfilm is announced ..... BF11 Feb 26
Damping, built-in, controls violent motion imposed by vibration ..... CM186 Mar 11

DATA PROCESSING
(See also Computers & Information Retrieval)
Automated submarine uses electronic data processing and display to give ship, engineering, communications, weapons, and environmental control ..... BF28 Jan 29
Binary data transceiver permits computers to talk to each other at 2, 400 bits per sec over phone lines ..... EN11 Jun 3
Business data processor reads records prepared in standard business terminology ..... EN11 May 13
Data communications systems linking distant computers use magnetic tape equipment ..... BF44 Jun 17
Data gathering and logging system monitors nuclear radiation levels and weather conditions RD64 Jan 22
Data processor built around two RCA 501 computers installed in bank ..... EN11 Feb 5
Data reduction speeded using transistorized pulse-height-to-digital signal converter ..... TF58 Jan 8
Electronics R&D in data processors in Sweden .. SR75 Feb 12
Expandable random-access solid-states memory for small digital computer used in business applications ..... TF164 Mar 11
Experimental simulation of air traffic control data processing central for New York underway .... BF28 Apr 8
Fivefold increase in data processing sales for 1965 ..... BTW11 Feb 19
High-speed digital plotter cuts time for reducing telemetered data ..... TF41 Jan 8
Indicator triode has fluorescent anode whose illumination is controlled by grid potential for direct data readout ..... TF52 Feb 5
Lab model thermoplastic recording system has radar, ir, information retrieval and data processor applications ..... EN11 Jan 22
Magnetic noncontact shaft-position disk encoder offers high rotational speeds and reliability for computer, control and data logging uses ..... RD114 Apr 29
Manufacturers give increased attention to developing small computers for small businesses ..... BF39 Apr 8
Mark I perceptron demonstrates ability to learn the alphabet ..... BF43 Jun 24
Match-head size tunnel diode holds great promise for missile, satellite and ultra-high-speed data processing applications ..... PC69 Mar 4
Micro-sized ferrite-core memory array for data processing system operates under environmental extremes ..... CM98 May 13
Monoscope-camera system converts computer data into visual form on microfilm ..... BF11 Feb 26
New business data processing system offers sophistication at moderate price ..... BTW11 Apr 15
New data processing system for small business announced ..... EN11 Apr 22
New IBM solid-state business data processor order by Southern Railway ..... EN11 Feb 12
New look in data processing to emphasize information transmission by common carrier between computers ..... BF38 May 27
Noise suppression factor display unit computes and automatically displays ratio of two time-varying quantities ..... TF55 Feb 5

Selective calling system for aircraft data links removes necessity of continuously monitoring a communication channel ..... TF108 Apr 29
Shaft-position disk encoder design eliminates positional ambiguities ..... TF62 Apr 22
Six ways to use magnetic core shift register elements ..... TF80 Jan 15
Small BEAM-X switch tube converts information rapidly from one form to another ..... CM126 Feb 12
Solid-state character generator (VIDIAC-visual information display and control) for data processing system developed ..... EN11 Apr 29
Traffic Control Center (TCC) and Data Processing Subsystem (DPSS) for SAC'S Automatic Combat Control System (SACCS) ..... BF36 Mar 25
Wall Street datacenter to be opened in March ..... EN11 Jan 1
Decoder, eight-function, for remote pulse-coded fault alarm used in multihop microwave systems .. TF82 Jan 1
Decoder, transistorized, for selective calling system used with aircraft data links ..... TF108 Apr 29
Decoding and deflection circuit for monoscope tube character generator used as digital computer read-out device ..... TF117 Feb 12
Deflection and decoding circuit for monoscope tube character generator used as digital computer read-out device ..... TF117 Feb 12
Delay devices for modern microwave applications .. SR67 Jun 24
Demineralizer, recirculating, for making water virtually free of particulate matter, dissolved solids and gases ..... PT132 May 27
Demodulator, transistorized, for selective calling system used with aircraft data links ..... TF108 Apr 29
Demodulator, transistorized f-m, for tape target classifier used to train land-based sonar student operators ..... TF65 Mar 25
Demodulators for linear differential transformers.... ERS92 Jun 3
Demodulators, transistorized, for attitude-control .. system in Able series space exploration probes .. TF60 Jan 29
Dental anesthetic device using stereo sound placed in production ..... EN11 May 27
Depth indicator, portable transistorized, for locating fish doesn't need crt ..... TF50 Feb 5
Destriau effect, definition of ..... TF71 Feb 26

DETECTORS

Automatic gas-fume detector alarms Loran, radiotelephones, direction finders, and depth sounder fish finders make up new $10-million small boat market ..... BF30 Jan 22
Cadmium sulfide field-effect transistor used experimentally as radiation detector ..... BF42 Mar 18
Cadmium sulphide field-effect phototransistors used successfully in oscillator, multivibrator, amplifier and radiation detector circuits..... EN11 Feb 26
Characteristics of thermal, photoconducting photovoltaic and photoelectromagnet infrared detectors..... TF72 Apr 1
Digital sampler for measurement of axis-crossing intervals for design of weak signal detectors... TF88 Jun 3
Electronic highway control using wire loops, guidance cable and transistorized detector demonstrated..... BF40 Jun 17
Flow rate of jet fuel containing radioactive tracer measured by simultaneously gated oscillator and radiation detector ..... TF58 Feb 19
Ground based missile roll control system uses photosensitive or infrared detectors ..... RD80 Mar 25
How to determine whether to use visual, ir or radar detection in fog or rain ..... T64 Jan 29
Phase detector for precision phasemeter used for c-w and pulsed uhf ..... TF54 Mar 4
Photocell detection circuit for inspecting transistors assembled by fully automatic electromechanical machine ..... TF57 Mar 25
Polarity coincidence multiplier detects weak low-frequency signal in high-noise background..... TF67 Jan 29
Principle of proximity detectors used in electronic wire gage for nondestructive measurement of wire thickness ..... TF109 Feb 12
Probe-type detector for checking for presence of gas shown at IRE Show ..... BF47 Apr 1
Rapid scan spectrometer detects and analyzes infrared energy radiated during power flight portions of missile trajectory ..... TF86 May 20
Sensitive flaw detector system overcomes noise problem of photomultipliers to find defects of paper ..... TF64 Apr 15
Servo detector for automatic survey system used to measure roughness of airport runways ..... TF54 Jun 17
Silicon photocells used as detectors in projector optical sound track pickup ..... PC68 Jan 8
Silicon pn junctions used as particle detectors... RD74 Apr 22
Solid-state radiation detector made of doped silicon gives new speed and accuracy to particle analysis ..... BTW11 Feb 5
Step-van truck with instruments for measuring air pollution developed ..... PC48 Feb 12
Three infrared and visual detectors under development may change design concepts in advanced military and industrial equipment ..... EN11 May 27
Transistorized boxcar detector for portable battlefield radar ..... TF67 Mar 18
Transistorized peak amplitude detector for tape target classifier used to train land-based sonar student operators ..... TF65 Mar 25
Transistorized radiation monitor sounds alarm when alpha and beta radiation reaches preset level in nuclear-powered Navy vessels..... TF43 Jan 22
Uncooled indium-antimonide photoelectromagnetic detector responds to long infrared wavelengths. TF62 Mar 25
Undersea oil lines detected by metal locator which generates electromagnetic field ..... BF57 Jan 15
What's new in radiation detecting tubes ..... SR55 Apr 29
X-ray detector being built to find troubles in high-voltage mercury-arc tubes ..... RD87 Mar 25
DEW line, radar target simulator to train operators for ..... PC64 Jan 8

DIELECTRICS

Automatic control unit for operating dielectric strength testers..... PT88 May 6
British approaches to producing conductors for microminiaturization ..... TF71 Jan 1
Dielectric absorption in capacitors ..... RD78 Jun 10
Dielectric absorption in capacitors determined by experimental current-measuring technique ..... RD90 Mar 18
Dielectric conductivity of materials increases as function of gamma dose rate ..... TF69 Apr 22
Dielectric diodes and triodes to control large amounts of current using thin insulating crystals of cadmium sulphide being developed .... BTW11 Jan 22
End-fire arrays of high-dielectric ceramic rods give low silhouette and high vertical resolution in uhf region ..... TF60 Feb 5
High-purity silicon dielectric for potting transistors is nonmelting and greaselike ..... CM84 Apr 15
Recent advances in preparing thin film ceramic dielectrics for microminiature capacitors ..... CM96 Jan 1
Temperature-insensitive solid-state dielectric diodes and triodes ..... TF59 Feb 26
Transmission line analogy for propagation in sandwiches of dielectric sheets and conducting films or grids used in antennas ..... ERS100 May 20

DIGITAL TECHNIQUES

(See also Computers, Data Processing, Logic Circuits, Memories, Pulse Techniques & Registers)

Data reduction speeded using transistorized pulse-height-to-digital signal converter..... TF58 Jan 8
Digital oscilloscope for direct readout of amplitudes and waveforms announced ..... EN11 Feb 5
Digital programmer automatically adjusts and controls furnace temperature during preparation of high-purity materials ..... RD122 May 27
Digital sampler for measurement of axis-crossing intervals for design of weak signal detectors .. TF88 Jun 3
Digital system for controlling robot which performs jobs in dangerously radioactive areas ... TF46 Jan 22
Electron tube tester automatically prepares test data in digital form for computer analysis ..... PT74 Feb 9
Emphasis at Third International Instrument . Electronics and Automation Show in Britain is on industrial controls, digital building blocks.. BF34 Jun 17
High-speed digital plotter cuts time for reducing telemetered data ..... TF41 Jan 8
Monoscope tube generates characters for direct readout on a cro or on paper of digital computer output ..... TF117 Feb 12
Navy begins test on UDOFT (Universal Digital Operation Flight Trainer) used to simulate complicated jet flight conditions ..... BF44 Apr 15
Oscilloscope with direct digital readout of amplitude and duration of pulse signals reduce operator errors, cut measurement time ..... BF30 Mar 4
Polarity coincidence multiplier detects weak low-frequency signal in high-noise background..... TF67 Jan 29
Sampling attachment for conventional oscilloscopes can resolve rise times of 1/3 nanosec with repetition rates up to 50 Kc ..... TF96 Jun 24
Thyratrons control a milling machine by driving step motors in response to signals from a programmed tape ..... TF174 Mar 11
Transistorized slicer measures amplitude probability density functions ..... TF70 Jan 29
Voice-visual aircraft communications system (DISCOM) using canned book message transmitted by digital methods scheduled for delivery BTW11 Mar 25

DIODE CIRCUITS

Balanced-bridge and semiconductor diode circuits for one-tube oscillator-mixers in tv and f-m tuners ..... TF76 Jan 15
Biasing techniques permit small-area junction germanium diodes to switch microwaves in waveguides or transmission lines ..... TF85 Jan 15
Magnetic shift rebistar current-operated voltage-controlled and wide-width core-diode elements . TF80 Jan 15
Tunnel diode logic circuits--modes of operation and effect of circuit component tolerances..... TF103 Jun 24

DIODES

Accurate and stable pulse height discriminator uses forward-biased shunt diode in input circuit TF89 May 20
American and Japanese firms agree to share techniques of design and manufacture of diodes.... BF32 Apr 8
British approaches to producing flat-plate diodes for microminiaturization ..... TF71 Jan 1
Cesium diodes with efficiencies of 15 to 20 percent are expected to be available in two years. TF159 Mar 11
Color code standards for designating semiconductor diode and rectifier types adopted.... CM83 Apr 22
Gallium arsenide diodes with low noise figures at 10, 16 and 24 kmc and upper operating temperature of 300 C developed ..... EN11 Jan 1
Gallium phosphide diodes and switching devices withstand 1,500 C ..... CM71 Jan 8
Germanium diffused base transistor with open circuit base connection serves as inductive negative resistance diode in microcircuits .... TF60 Apr 22
Half-amp silicon diodes with 0.3 usec recovery time in volume production for computers..... CM105 Jan 15
Sampling oscilloscope permits measurement of computer diode recovery times down to 500 picosec ..... TF59 Apr 8
Temperature-insensitive solid-state dielectric diodes and triodes..... TF59 Feb 26
Tunnel diode circuit designs open new markets for computer, communications and receiver amplifer applications ..... BF36 Feb 26
Use of gallium phosphide in point-contact devices points to development of gallium phosphide diodes ..... CM108 May 20
Varactor diodes available in experimental quantities, used for high-efficiency subharmonic oscillators in microwave computers..... CM131 May 27
Wheel-shaped component carrier in oven makes 150 C tests of silicon diodes ..... PT130 Feb 12
Direction finders, together with automatic gas-fume detector alarms, Loran, radiotelephones, and depth sounder fish finders make up new $10-million small boat market ..... BF30 Jan 22
Direction finding, broadband log-periodic antennas for ..... TF58 Jun 17
DISCOM (digital selective communications) for sending canned messages from aircraft scheduled for delivery ..... BTW11 Mar 25
Discriminator, accurate and stable pulse height, uses forward-biased shunt diode in input circuit.. TF89 May 20
Discriminator circuit measures carrier frequency deviation caused by wow and flutter in tape recorder ..... TF100 Jun 24
Disk encoder, magnetic noncontact shaft-position disk, offers high rotational speeds and reliability for computer, control and data logging uses ..... RD114 Apr 29
Disk encoder, shaft-position, design eliminates positional ambiguities of ..... TF62 Apr 22

DISPLAYS

(See also Indicators, Monitors, Readout Devices, Registers & Storage Devices)

Automated submarine uses electronic data processing and display to give ship, engineering, communications, weapons, and environmental control ..... BF28 Jan 29
Cold-cathode ring-counter drives numerical indicator ..... TF80 Apr 1
Continued emphasis shown on analog-to-digital converters and readouts at IRE Show ..... BF47 Apr 1
Electroluminescent devices find expanded market in general informational display applications .. BTW11 Jan 29
Ferroresonant storage and switching circuits combined with alpha-numeric indicator form electroluminescent typewriter..... TF49 Jan 22
Gas-filled stepping tubes ..... TF46 Feb 19
High-speed repetitive-operation analog computers permit continous plot displays ..... EN11 Feb 19
Indicator triode has fluorescent anode whose illumination is controlled by grid potential for direct data readout ..... RD52 Feb 5
Monoscope tube generates characters for direct readout on a cro or on paper of digital computer output ..... TF117 Feb 12
Noise suppression factor display unit computes and automatically displays ratio of two time-varying quantities..... TF55 Feb 5
Small BEAM-X switch tube may claim extended market ..... CM126 Feb 12
Solid-state character generator (VIDIAC-visual information display and control) for data processing system developed..... EN11 Apr 29
Solid-state character generator for VIDIAC (Visual Information Display and Control) System..... TF55 Jun 10
Visual display system for SAC's Automatic Combat Control System (SACCS) ..... BF36 Mar 25
What's new in cathode-ray, storage, counting tubes ..... SR55 Apr 29
Distance measuring equipment, use of selective calling system for data link in high-density traffic TF108 Apr 29
Distributed-constant semiconductor R-C networks for microcircuits ..... TF69 May 13
Distributor circuits, electronic, for teleprinter developed in Japan and India ..... BF31 Jun 10
Distributors place in 1960 electronics sales market . SR49 Jan 1
Dividers, designing frequency-independent current types ..... ERS74 Apr 8
Doppler principles involved in designing portable radar for detecting enemy movements during battlefield deployment ..... TF67 Mar 18
Dosimetry, needle glass fluoresces in proportion to radiation received..... TF74 Mar 18
DPSS (Data Processing Subsystem) for SAC's Automatic Combat Control System (SACCS) ..... BF36 Mar 25
Drafting procedures being streamlined to expedite R&D production ..... PT98 Mar 18
Drilling, electron beam metalworking equipment for PT86 Feb 26
Driver for expandable random-access solid-state memory ..... TF164 Mar 11

E

Earth, propagation of electromagnetic waves through subsurface of earth being studied for AF..... BTW11 Mar 4
Earth, rotation of measured by precision Atlas guidance system ..... EN11 Jun 17

EDUCATION (See also Manpower)

Company combats shortage of semiconductor engineers by giving series of in-depth, 13-week courses..... BF44 Jun 17
Doctoral program in engineering and physical sciences to be developed at Arizona State University ..... BF53 Feb 12
Electronics R&D in education in Italy and Switzerland ..... ST75 Feb 12
Engineering education discussed at winter meeting of AIEE ..... BF28 Feb 19
Guggenehim Fellowship winner works in Britain's Atomic Energy Research Establishment ..... PC39 Jun 24
Minnesota governor indicates expanding universities, skilled manpower and favorable financial climate stimulates area's growth ..... BF30 Jun 17
Project Vanguard annual graduate fellowship established at Johns Hopkins..... BF59 May 20
Sixteen colleges in six midwestern states designated as communications network for Midwest Program on Airborne Television Instruction.... BF59 May 20
Transistormen give financial aid to support Stanford solid-state research ..... BF45 Jan 1
Two-ton magnetic unit studied by members of JETS (Junior Engineering Tech Society) ..... PC48 May 6
Use of commercial uhf tv sets for reception of tv signals from aircraft for educational purposes discussed at winter meeting of AIEE ..... BF28 Feb 19
Electret combined with photoconductor form photorectifier according to paper given at 1960 Solid-State Circuits Conference ..... TF39 Mar 4
Electrical, magnetic and optical properties of solid state phenomena to be studied in RCA's proposed research laboratory in Japan ..... EN11 Jun 24
Electroacoustics R&D in Switzerland ..... SR75 Feb 12
Electrode effects on the conductivity of organic hydrocarbons reported at Conference on Electronic Conductivity in Organic Solids..... RD127 May 27

ELECTROLUMINESCENT DEVICES

(See also Displays)

Electroluminescent device output to increase for a wide variety of military and civilian markets BTW11 Jan 29
Ferroresonant storage and switching circuits combined with alphanumeric indicator form electroluminescent typewriter..... TF49 Jan 22
Increased production, marketing activity forecast for electroluminescent devices..... BTW11 Apr 1
Power amplifiers using electro-optical effects handle various combination of electric, radioactive and thermal power..... TF71 Feb 26

What's new in electroluminescent displays for cathode ray tubes ... SR55 Apr 29
Electrolytic recording used in high-speed digital plotter ... TF41 Jan 8
Electromechanical assembler of alloy-junction transistors is fully automatic ... TF57 Mar 25
Electrometer and photomultiplier measure fluorescence of glass dosimetry needle to determine radiation exposure in human body ... TF74 Mar 18
Electron beam device accurately drills small holes in evaporating masks used in microminiaturization TF71 Jan 15
Electron beam metalworking equipment for use in surface treating, welding, milling or drilling ... PT86 Feb 26
Electron bombardment used to make plastic type transistors by Soviet scientist ... EN11 Jan 1
Electronic shield for baffling radar and radar-guided missiles is reported ... EN11 May 6
Electronics Research & Development Around the World - Australia, England, France, Israel, Italy, Japan, Sweden and Switzerland ... SR93 Feb 12
Electroplating, techniques for solving tin-nickel plating problems ... PT86 Feb 26
Electrostatic analyzer for double-focusing mass spectrometer ... RD74 Jan 29
Electrostatic focusing of cathode ray tubes ... SR55 Apr 29
Encapsulant remains serviceable despite continuous exposure to 60 to 250 C temperature ... CM84 Apr 15
Encoder, magnetic noncontact shaft-position disk, offers high rotational speeds and reliability for computer, control and logging data uses ... RD114 Apr 29
Encoder, shaft-position disk, design eliminates positional ambiguities of ... TF62 Apr 22
England — research and development currently underway in ... SR75 Feb 12
Environmental control, automated submarine uses electronic data processing and display to give ... BF28 Jan 29
Environmental forecasts could double effectiveness of undersea fleet according to oceanographic research findings ... BF36 Jan 22
Environmental testing device materials tested at-460F ... PC39 Jan 29
Environmental testing self-compensating fixture tests 24 capacitors at a time in an environmental test chamber ... PT72 Jan 22
Environmental unit, mobile, uses controller-recorder to program temperature during test of missile components ... PC34 Jun 17
Environments, dynamic, what designers should know about performance of missile components in. TF102 Apr 29
Epitaxial technique (vapor-growing high resistivity collector films on low-resistivity substrate) revealed at IRE-AIEE conference may have far reaching implications ... EN11 Jun 24
ETL (Etching by Transmitted Light) technique improves fabrication of micro-alloy diffused base transistors (MADT) ... BTW11 Apr 1
Ettingshausen effect, definition of ... TF71 Feb 26
Evaporating masks, electron beam device accurately drills holes in ... TF71 Jan 15
Evaporation machine used by British to produce microminiature circuits ... TF71 Jan 1

EXHIBITIONS

French and British instrument companies to hold exhibitions in Moscow ... EN11 Mar 4
German Industries Fair of 1960 shows German electronics comes of age ... BF49 May 13
Hungarian automatic telephone-answering tape recorder shown at Leipzig Fair ... BF47 May 27
Instruments, controls, electron microscopes, advanced communications are features of British Exhibition in New York ... BF46 Jun 24
Next year's World Trade Fair exhibitors to put more stress on science and technology ... BF46 May 27
Transistorized gear stars at National Motor Boat Show ... BF30 Jan 22

EXPORTS (See also Business)

American exports of precision instruments in 1959 up $7 million over 1958 ... EN11 Mar 11
Electronics industry exports for 1959 are $415 million, down 3% percent from 1958 ... MR26 May 6
Export Control Act extension in 1960 likely ... BF28 Jan 1
Export picture for electronics industry in 1960 ... SR49 Jan 1
Japan boosts tv set output for export ... BF48 Feb 26
Japan reopens transistor radio exports under official controls ... EN11 Jun 3
Japanese manufacturers fear their Government will set quota for export of transistor radio to U.S. . BF48 May 6
Japan's export picture ... SR53 May 27
One Company's approach to beefing up electronics export trade ... EN11 Apr 29
Eye, electronic tonometer detects glaucoma by measuring pressure in ... TF115 Feb 12

F

Fabrication techniques for semiconductor networks used in microcircuits ... TF69 May 13
Faceplate improvement of cathode ray tubes ... SR55 Apr 29
Facsimile now considered as supplement to regular civilian amateur activities ... BF48 Feb 12
Facsimile research spreads, faster transmission and privacy are goals ... BF51 Apr 8
Facsimile systems, U.S. Weather Bureau completing installation of advanced, high-speed recording equipment for high-altitude weather map network.. BF49 May 6
FAST (flight advisory service test) portion of Project Trailsmoke to operationally evaluate use of SAGE computer for air traffic control use ... EN11 May 6
Fathometer, portable transistorized, for locating fish doesn't need crt ... TF50 Feb 5
Feed, auto-track, for circularly-polarized, high-gain antenna for tracking Tiros meterological satellite ... TF57 Apr 15
Feedback circuit design for high-frequency, high power transistor oscillator ... TF52 Jan 8
Ferrite devices for modern microwave applications SR67 Jun 24
Ferrites, broadband microwave amplifier uses negative resistance of tunnel diode in combination with nonreciprocal ferrite attenuation ... CM84 Mar 25
Ferrites, devices, Dutch market their first electronic computer which uses transistors and ferrite cores. BTW11 Feb 12
Ferrites, magnetic element of ferrite composition for storage, switching and logic applications in digital computers has advantage of open flux path, excellent squareness characteristics ... RD104 May 20
Ferrites, micro-sized ferrite-core memory array for data processing system operates under environmental extremes ... CM98 May 13

FERROELECTRIC AND FERROMAGNETIC DEVICES

Completely passive, balance modulator circuits using thin permalloy film described at 1960 Winter Convention on Military Electronics ... RD78 Feb 26
Electronics R&D in ferromagnetism in Israel ... SR75 Feb 12
Ferroelectric capacitor tuning devices for frequency synthesizer gives stable, high-accuracy receiver and transmitters ... RD122 Feb 12
NBS discovers a series of ceramic materials that exhibit simultaneously both ferroelectric and ferrimagnetic properties ... CM128 Feb 12
Ferroresonant storage and switching circuits combined with alphanumeric indicator form electroluminescent typewriter ... TF49 Jan 22

FILTERS

Ceramic filters improve selectivity of multiband communications-type receiver ... CM84 Feb 26
Charts normalized for frequency make it easy to determine network component values for frequency-rejection filters ... ERS67 Jun 17
Etched-board transmission line input bandpass filter for uhf f-m receiver of camera control system used in rocket sled tests ... TF63 Apr 1
Graphical extension of transform techniques clarifies operation of carrier elimination filter .. TF68 Apr 1
Multichannel filters for modern microwave applications ... SR67 Jun 24
Procedure for designing Zobel filters made straightforward by use of Cauer parameters for specified stopband attenuation ... TF96 May 20
Selecting R-C values for filters characterized by no output at infinity frequency or zero frequency TF82 May 13
Transistorized low-pass filter-amplifier for sub-audio frequencies used in missile telemetry ... TF88 Jan 15
Tuning forks used as high-Q resonant elements for audio-frequency narrow-band electro-mechanical filters ... CM108 May 20
Fishing, portable transistorized depth indicator for. TF50 Feb 5
Fixture, self-compensating, tests 24 capacitors at a time in an environmental test chamber ... PT72 Jan 22
Fixtures, multipurpose, for fabricating bulky electronic equipment shelters and consoles ... PT102 May 13
Flash tube circuit for investigating possibilities of using plasma to propel space vehicles ... TF66 Jun 10
Flip-flop circuit uses indicator triode with fluorescent anode whose illumination is controlled by grid potential ... TF52 Feb 5
Flip-flops using tunnel diodes reported at 1960 Solid-State Circuits Conference ... TF39 Mar 4
Flow rate measurement of a variety of fluids made by detecting nuclear magnetic resonance ... TF77 Apr 1
Fluorescent lamps in British railway coaches operate from transistorized inverter power by 24-v battery. TF58 Feb 5
Focusing techniques for linear-beam microwave tubes ... SR55 Apr 29
Fog, how to determine whether to use visual, ir or radar detection in ... TF64 Jan 29

FOREIGN ELECTRONICS

(See also Business, Exports & Imports)

American and Japanese firms agree to share techniques of design and manufacture of diodes BF32 Apr 8
Americans study Soviet-built heat-to-electricity converter ... BF48 Apr 1
Biocurrents in human cells being studied by Soviet Scientist with microelectrode ... EN11 Mar 4
Britain and U.S. government agencies coordinate their time and frequency signal broadcasts. ... RD81 Jun 10
British and U.S. computermakers step up sales, promotional and service activities in Europe ... BF34 Jan 8
British approaches to microminiaturization ... TF71 Jan 1
British electronics boom continues ... BF37 Mar 18
British multiplex system for bilingual broadcasts or convention stereophonic transmissions ... TF87 Jun 3
British tv and radio manufacturers break all sales records ... EN11 Jan 15
Computers and closed-circuit television are bringing office automation to Mideast banks and oil firms ... EN11 Jul 1
Counterattacks to petion for import curbs on Japanese transistors are registered in Washington ... BF42 Jan 15
Czechoslovakian transistor cardio-tachometer in use ... BF28 Jan 1
Dutch market their first electronic computer which uses transistors and ferrite cores ... BTW11 Feb 12
East Germans expect $175 million sales from western customers, publicize a-c voltmeter and Robtron computer ... BF37 Mar 18
Electronic distributor circuits for teleprinter developed in Japan and India ... BF31 Jun 10
Electronic Manufacturing Association formed in Israel, Includes also government and local scientific institutions ... BF53 May 6
Electronic oven uses microwave technique for assembly line production of pre-frozen meals in Holland ... BF47 Jun 10
Electronics in Japan -background of industry, products and practices, research and engineering, and marketing and export ... SR53 May 27
Electronics research and development around the world ... SR75 Feb 12
Emphasis at Third International Instrument Electronics and Automation Show in Britain is on industrial controls, digital building blocks .... BF34 Jun 17
English radars being ordered by and going on tour to other European countries ... BF53 Mar 11
Europe pushes plans for supranational automatic air traffic control system (SATCO) ... BF40 Apr 22
Export-import picture for electronics industry in 1960 ... SR49 Jan 1
FAA rules out British Decca Mark X hyperbolic system for navigation ... BTW11 Jan 22
Five different electronic firms in five European countries to produce Hawk air defense guided missile ... BF33 May 6
French and British instrument companies to hold exhibitions in Moscow ... EN11 Mar 4
French compatible color tv system features sequential transmission of chrominance, uses one-line memory in receiver ... TF57 May 6
French President DeGaulle impressed with range of test instruments made by manufacturer ... EN11 May 13
French President DeGaulle impressed with range of test instruments made by manufacturer ... PC37 May 13
German Industries Fair of 1960 shows German electronics comes of age ... BF49 May 13
Ghana orders $1.68 million worth of shortwave broadcast equipment from British firm ... EN11 Jan 1
Guggenheim Fellowship winner works in Britain's Atomic Energy Research Establishment ... PC39 Jun 24
Hungarian automatic telephone-answering tape recorder shown at Leipzig Fair ... BF47 May 27
Industrial diamonds with semiconducting properties made in South Africa ... RD76 Apr 22
Instrument fault in orientation system causes Soviet spaceship backfire ... EN11 Jun 10
Instrument manufacture in India has more than trebled in value in last three years ... BF52 Jun 24
Instruments, controls, electron microscopes, advanced communications are features of British Exhibition in New York ... BF46 Jun 24
International cooperation in geophysics put on permanent basis ... EN11 Jan 8
International Federation of Automatic Control Conference to open in Moscow next week ... BF34 Jun 24
International Ordinary Administrative Radio Conference reallocates frequency spectrum and reports new regulations ... BF33 Feb 19
IRE International Show and Convention gives U.S. Firms chance to check activities of foreign competitors ... BF36 Mar 18
Israel to make a decision for or against establishing nation-wide tv net in 1960 ... BF31 Jan 22
Japan adopts American NTSC standards to pave way for marketing transistorized color, and black and white tv set in U.S. ... BF27 Jan 22
Japan boosts tv set output for export ... PC48 Feb 26
Japan Electronics Parts Shown featured new consumer products ... BTW11 Mar 18
Japan reopens transistor radio exports under official controls ... EN11 Jun 3
Japanese black-and-white and color tv sets arriving in quantity in U.S. ports ... BF32 Apr 29
Japanese Company signs contract with U.S. importer for $1.4 million worth of consumer electronic products ... BF30 Jun 17
Japanese develop new computer logic — high-speed parallel adder-accumulator and shifter ... BF36 Apr 15
Japanese exports to U.S. rose from 22 million in 1958 to 76 million in 1959 ... MR26 Apr 29
Japanese Industrial Trade Fair feature consumer items for U.S. market ... EN11 Apr 29
Japanese-made tropospheric scatter communications system used by U.S. forces in Japan .... EN11 Jan 29
Japanese manufacturers fear their government will set quota for export of transistor radio to U.S. ... BF48 May 6
Japanese radios bought by appliance chain for sale in U.S. ... EN11 Jan 1
Japanese to emphasize development of crt tubes for color tv, video tape recorders, aviation and medical electronics and microwave tubes ... EN11 Feb 12
Japanese to market stereo 4-channel tape recorder in U.S. ... EN11 Jan 22
Japanese tv set sales increase rapidly ... EN11 Jan 15
Japanese young women electronics production workers: a close-up ... BF36 Apr 1
Japan's electronics industry concentrating on production of color tv sets ... EN11 Jun 24
Leo Esaki joins IBM as resident consultant ... EN11 Feb 5
Low-grade silicon in demand in Europe ... CM68 Jan 8
Micron-thick permalloy plated onto copper basis of new thin film logic and memory devices developed in Japan ... EN11 Apr 1
More U.S. gear going into second generation of British missiles ... BF32 Mar 25
Nassau terminus of 186-mile over-the-horizon troposcatter link to Bahamas completed ... PC39 Feb 5
NATO's 4,000-mile tropospheric scatter system Project Ace High to connect all major radar outposts and operational headquarters in Europe .. BF38 Apr 29
New radar and communications system guard Korea against surprise invasion ... BF40 May 20
One company's approach to beefing up electronics export trade ... EN11 Apr 29
Over 1,000 British design engineers crowd one-day special symposium on Electronic Equipment Reliability ... BF34 Jun 10
Patent protection in Russia obtainable only by applying for Russian patents ... EN11 Jan 8
Pay tv in Canada uses direct wire to give choice of three channels to viewers ... BF52 Mar 18
Plastic type transistor developed by Soviet Scientist ... EN11 Jan 1
Producing germanium from flue dusts of certain kinds of coal ... CM121 Jun 24
Proton synchrotron of European Organization for Nuclear Research in operation ... EN11 Jan 1
Radio and TV production rise in Austria ... EN11 Jun 10
Radiophonograph weighing 2.8 lb developed by Japanese ... EN11 Jan 15
RCA to open research laboratory in Japan, will study solid-state phenomena ... EN11 Jun 24
Red China gives 50-Kw shortwave broadcasting station to Cambodian government ... EN11 Jun 3
Red China tops U.S. in global broadcasting ... BF35 May 27
Regular stereophonic broadcasting to be initiated in Canada ... BF45 Jan 15
Report on semiconductive plastics — in U.S.S.R. and in U.S.A. ... CM68 Jan 22
Russia to host First International Congress on Automatic Control in June ... BF31 Jun 10
Russians develop photoelectric blood pressure meter ... RD75 Jun 17
Russia's Setun computer using magnetic amplifiers operates on ternary rather than binary code .... BF11 Feb 26
Solar battery used to power Japanese lighthouse has operated successfully for six months ... BF57 May 13
Soviet Academy of Sciences changing some of its research approaches ... BF43 Apr 1
Soviet automatic control system checks mass-produced parts using crt scanning techniques .. EN11 Jan 15

Soviet exhibit at 1960 Leipzig trade fair focused on new electronic instrument, automation and space ... EN11 Mar 11
Soviet microwave research ... SR67 Jun 24
Soviet remote-controlled farm tractors scheduled to start large-scale tests next year ... EN11 Feb 26
Soviet semiconductor and computer production rates increase ... EN11 Jan 29
Soviets plan to triple tv set production by 1965... BF51 Jan 15
Soviets plan whole new series of artificial satellites ... BF57 May 13
Soviets report method of drawing wires of 1 or 2 microns in diameter ... PT100 Mar 18
Spider-web 142-ft radio telescope built in Scotland to study aurora ... PC52 May 13
Survey of United Kingdom's progress in industrial controls ... BF52 May 13
Technical aid in civil aviation given to United Arab Republic by FAA ... EN11 Jan 8
Technical details of Soviet spaceship launched May 16 beginning to leak out ... EN11 Jun 3
Thailand, Laos and Vietnam to have telecommunication network for radio and tv ... BF29 Jan 1
Tiny platinum wire is heart of Japanese bolometer mount for measuring microwave power ... CM88 Apr 1
Transistorized inverters working at 1,250 cps power 40-watt fluorescent lamp off 24-v battary in British railway coaches ... TF58 Feb 5
Transistorized tv set to be marketed by Japanese firm during 1960 ... EN11 Jan 8
Tunnel diode factory production announced by U.S. and Japanese firms ... BTW11 Feb 12
Two American electronic men who toured Russia
U. S. demand for f-m transistor radios boosts Japanese exports ... EN11 Jan 29
impressed with Soviet scientific education and research ... BTW11 Apr 8
U.S. electron tubes and semiconductors of specialized types and advanced designs in demand abroad ... BF48 Feb 26
U. S. headstart over Russia in microminiaturization seen as future space asset ... BTW11 Apr 8
U.S. National Television Standards formally okayed by Japan's Electrowave Control Council EN11 Jun 17
U. S. to help Canada launch first satellite for studying ionosphere and galactic noise ... BF61 Mar 18
USSR claims to have made transistors from plastic fiber using bombardment techniques ... BF26 Jan 22
West Berlin's Institute for Nuclear Research gets new transistorized computer ... BF31 Jun 10
Wire-guided missiles developed in Europe being appraised by Army ... BF38 Jan 15
Work has starte on submarine telephone cable between Britain and Sweden ... EN11 Jun 17
Fourier integrals, review of ... TF68 Apr 1
France — research and development currently underway in ... SR75 Feb 12
Frequency and time signal broadcasts being coordinated by Britain and U.S. ... RD81 Jun 10
Frequency divider using tunnel diode reported at 1960 Solid-State Circuits Conference ... TF39 Mar 4
Frequency-independent current dividers, design of.. ERS74 Apr 8
Frequency modulating a resonant circuit using reactance switching technique ... TF74 Feb 26
Frequency standards, quarts crystals and atomic clocks are subjects of major interest at 14th annual Frequency Control Symposium ... BF38 Jun 24
Fuel cell power supply for Marine and Army portable field radar to be delivered ... EN11 Apr 29
Fuel cells, ion-membrane, used in portable power pack under development for Marine and Army ... PC53 May 6
Fuel gage, radiation-operated, for missiles and aircraft ... RD117 Apr 29
Function generator using transistors eliminates need for d-c amplifier ... TF75 Mar 25
Functional-transformation methods — review of Fourier and convolution integrals and graphical extension of convolution technique ... TF68 Apr 1
Fungus-proofing of plug-in circuit cards speeded using completed chassis as dipping fixtures ... PT93 Apr 1
Furnace, solid state system developed using magnetic amplifiers controls combustion in ... EN11 Jan 15
Fuzes, analyzing sensitivity of using steel marble as moving short circuit ... PC48 Apr 29

G

Gallium phosphide diodes and switching devices withstand 1,500 C ... CM71 Jan 8
Gas chromatography featured at Instrument Society of America Meeting ... BF47 Jun 24
Gas compression station, automatic control and supervisory system for ... EN11 Jun 10
Gas-filled tubes, what's new in ... SR55 Apr 29
Gas-floated ceramic bearings in new gyro reduces drift for space guidance applications ... CM76 Jun 17
GATES
Diode AND gate for transistorized slicer used to measure amplitude probability density functions TF70 Jan 29
Transistorized audio selection gate for tape target classifier used to train land-based sonar student operators ... TF65 Mar 25
Transistorized gating stage for sense amplifier used in Mobile Digital Computer (MOBIDIC).... TF72 Mar 25
Tunnel diodes used in single-ended and balanced or symmetrical threshold gates.... TF55 Jan 29
GENERATORS
Choosing transistors for monostable multivibrators used as variable delay generators.... ERS58 Jan 22
Combination flip-flop and bootstrap sweep generator gives same type waveforms as phantastrons ... TF177 Mar 11
Current pulse generator for testing ferrite memory cores ... TF80 Jan 1
Experimental magnetohydrodynamic generator produces 2 1/2 kw, runs for four minutes ... EN11 Mar 25
Experimental solid-state generator for converting pulsed d-c magnetic fieids into microwave radiation has been built ... EN11 Feb 19
Gating pulse generator for circuit used to reduce interference from other stations during ionospheric sounding ... TF118 May 27
Generator-regulator for autos uses only semiconductors and resistors ... TF52 Feb 19
Magnetohydrodynamics power plant generators offering high-efficiency output being studied ... RD92 Jan 1
Modern microwave generators ... SR67 Jun 24
Monoscope tube generates characters for direct readout on a cro or on paper of digital computer output ... TF117 Feb 12
NBS' Boulder Labs. mobile field unit to measure interference from generators, power lines, spark plugs and other electrical gear ... BF52 Jun 24
Precision R-C frequency generator uses controlled phase-shift network in feedback loop to get high degree of stability ... TF76 Apr 15
Range gate generator for portable battlefield radar ... TF67 Mar 18
Researchers demonstrate experimental photogenerator for converting solar energy by photoelectric emission ... EN11 May 27
Solid-state character generator (VIDIAC-visual information display and control) for data processing system developed ... EN11 Apr 29
Solid-state character generator for VIDIAC (Visual Information Display and Control) System.... TF55 Jun 10
Sweep generator for self-powered transistor oscilloscope ... TF80 Mar 18
Thermoelectric generator built which delivers 5 Kw by direct conversion of heat into electricity without major moving parts ... RD96 Jun 3
Transistor gate generator for puse-height-to-digital signal converter ... TF58 Jan 8
Transistorized function generator eliminates need for d-c amplified ... TF75 Mar 25
Transistorized high-power sound generating system used to replace mechanical siren alarms ... TF70 Apr 15
Transistorized precision multiple-range sweep generator for airborne radar system ... TF92 Jan 15
Transistorized pulse generator for synchronizing events in zero-gradient synchrontron ... TF63 Jun 10
Transistorized subaudio swept signal generator for testing servos and related equipment and components ... TF67 Apr 22
Two-tube generator provides accurate, stable intensity marker for oscilloscope over 8 to 22 Mc frequency range for bandpass measurements TF108 Jun 24
Geophysics, international cooperation put on permanent basis ... EN11 Jan 8
Glass parts, fit of, can be accurately determined by methods known as the water drop and fringe pattern ... PT106 Jun 3
Glaucoma detector with electronic tonometer which measures pressure within eyeball ... TF115 Feb 12
Goniometer, immersion, for measuring ultrasonic velocity in different media ... RD112 Jun 24
GOVERNMENT
(See also Business, Management & Military Electronics)
Britain and U.S. government agencies coordinate their time and frequency signal broadcasts.... RD81 Jun 10
Central organization may be set up to administer program for control over design and procurement of military components ... EN11 May 27
Computer technique of patent searching being tested by U. S. Patent Office ... RD124 Feb 12
Crackdown on Class D Citizens Radio looms if users don't toe the line ... BF28 Jan 8
Export Control Act extension in 1960 likely.... BF28 Jan 1
FAA has raft of big and little plans for 1960.... BF40 Feb 12
FAA orders test monitoring control equipment to check out VORTAC air navigation system .... EN11 Feb 26
FAA reports five additional megacycles for use of air traffic control systems have been alloted... EN11 Apr 29
FAA rules out British Decca Mark X hyperbolic system for navigation ... BTW11 Jan 22
FCC announces status of broadcasting at end of 1959 ... EN11 Jan 15
FCC plans to spend $2 million to find out whether or not uhf TV can be rejuvenated ... BF32 Jun 3
FCC to evaluate industry groups stereophonic f-m broadcast tests ... BF48 Jun 3
FCC yearend report shows more than 1 1/2 million transmitters now on air in more than 50 services ... BF33 Jan 22
Federal spending for coming fiscal year to hold close to last year's figures ... BF32 Jan 29
Federal spending on R & D to surpass $15 billion in 1960 ... BF40 Jan 29
Future of stereophonic radio broadcasting to be determined by Washington this week . ... BF37 Jan 1
Government may set minimum wage next year for workers making functional components ... BTW11 Apr 15
Government relationship to research and engineering activities in Japan ... SR53 May 27
Hector R. Skifter resigns from Defense Research and Engineering (Air Defense) ... BTW11 Apr 15
Labor Department to hold hearing on minimum wage for electronic component parts plants selling to government ... BF44 Mar 25
Labor Department to rule on minimum wages for tube and semiconductor production workers .... BF31 Jan 8
Microwaves components study of 1958 production issued by Commerce Department's Business and Defense Services Administration ... MR24 Apr 8
Missiles and space continue to account for much government money spent in guidance and componentry research area ... EN11 Jun 3
NASA gives $30-million contract for worldwide tracking and communications net for Project Mercury ... BTW11 Feb 5
NASA plans to spend 12-15 billion dollars on space exploration over next 10 years ... EN11 Feb 26
NASA seeks supplemental 1960 funds of $19 million to spur man-in-space program ... BTW11 Mar 11
National Research Council urges government to give high priority to development of material... CM85 Apr 8
NBS' Boulder Labs. mobile field unit to measure interference from generators, power lines, spark plugs and other electrical gear ... BF52 Jun 24
NBS studies automatic computation methods for determining best possible frequencies for radio transmitters used as road markers on air lanes . RD72 Jun 17
Pay tv to get three-year, $10 million test if FCC approves ... BTW11 Apr 15
Project Defender, a study program to find tomorrow's space defense, to use pincushion radar ... BF42 Feb 26
Radio amateur licenses jump 285 percent in 12 years. Amateur radio licenses jump 286 percent in 12 years ... EN11 Mar 11
Recommendations on role of Department of Commerce in science and technology ... EN11 Apr 22
Self-policing by industries of class D Citizens' Radio being studied ... BF29 Feb 5
Stereo stimulates f-m broadcasters; FCC says standards may be established by fall 1960.... BF30 Apr 22
U.S. Information Agency needs engineers to keep Voice of America's Greenville installation going EN11 Jun 10
U. S. Weather Bureau completing installation of advanced, high-speed facsimile recording equipment for high altitude weather map network BF40 May 6
West Coast manufacturer urges government give Q awards for production ... BF40 Jan 1
Will debate over military policy mean orders or cutbacks? ... BF26 Mar 4
WWV adds experimental standard time code to regular broadcasts for simultaneous observations at widely separated locations ... RD114 Jun 24
Gudden-Pohl effect, definition of ... TF71 Feb 26
GUIDANCE SYSTEMS
(See also Navigation Systems & Missiles)
Ceramic gas bearings in new gyro reduces drift for space guidance applications ... CM76 Jun 17
Command guidance system developed for Titan ICBM guides Tiros into preselected circular orbit ... PC40 Jun 3
Electronic highway control using wire loops, guidance cable and transistorized detector demonstrated ... BF40 Jun 17
Half-inch cube modules holding 12 to 18 components used in reconnaisance drone guidance system, commercial and military computers.... CM73 Apr 29
Invisible electronic shield for baffling radar and radar guided missiles is reported ... EN11 May 6
Long-range radar, computer with high reliability key units in ground-controlled satellite guidance system ... BF33 May 27
Minuteman inertial guidance and flight controls get $115-million boost ... EN11 Jan 8
Minuteman's guidance and control systems need reliable components for underground storage lasting years ... BF39 Jun 17
Missiles and space continue to account for much government money spent in guidance and componentry research area ... EN11 Jun 3
Navy's Corvus carrier aircraft missile, with passive radar guidance, gets contract push.... BTW11 Mar 11
Precision Atlas guidance system recently used to measure rotation of earth ... EN11 Jun 17
Soviet remote-controlled farm tractors scheduled to start large scale tests next year ... EN11 Feb 26
Steel marble used as moving short circuit to analyze sensitivity of fuzes used in guidance and detonation missiles ... PC48 Apr 29
Superconductive gyro called feasible; use seen in subs and space vehicles ... BTW11 Jan 29
Gyraline is d-c controlled attenuator used to vary L-band maser pump power in radiometer ... TF71 Jan 15
Gyro reference assembly for attitude-control system in Able series space exploration probes .. TF60 Jan 29
Gyro, superconductive, called feasible; use seen in subs and space vehicles ... BTW11 Jan 29
Gyro uses ceramic gas bearings to reduce drift for space guidance applications ... CM76 Jun 17
Gyroelectric plasma circuit used as an oscillator to generate microwave energy at 2,000 Mc.... BTW11 Mar 4
Gyros, cryogenic, with extremely low drift rate under development ... BF32 Feb 5

H

Hall effect, coefficient determination of in evaluating three-element semiconductor materials ... TF103 Feb 12
Hall effect, definition of ... TF71 Feb 26
Hall probe speeds cyclotron design ... RD80 Apr 8
Harmonic generators for modern microwave applications ... SR67 Jun 24
Harnesses wrapped in shrunken polyethylene tubing. PT86 Apr 8
Hawk Weapons System, automatic fault-finding system for testing battery control center of ... TF60 Jun 17
Hearing aids, comparison between 4 1/2-lb 1937 type and new wireless eyeglass type ... PC43 May 27
Heart pulse rate measured and recorded with transistor cardio-tachometer in Czechoslovakia... BF28 Jan 1
Heat control circuit using voltage constraint and NDR logic improves consistency and reliability of spot welds ... TF48 Feb 19
Heating, new applications of modern microwaves in SR67 Jun 24
Helical antennas interlaced to improve overall radiation pattern of single helix ... TF99 Apr 29
Henri de France method of compatible color tv system features sequential transmission of chrominance, uses one-line memory in receiver... TF57 May 6
Hermetical sealing of container done conveniently with umbilical tubing ... PT91 Mar 25
Highway control, electronic, using wire loops, guidance cable and transistorized detector demonstrated ... BF40 Jun 17
Hybrid of tubes and transistors cut power requirements of portable battlefield radar ... TF67 Mar 18
Hydrogen thyratrons, what's new in ... SR55 Apr 29
Hydrophones, material and backing-plate selection for sonar transducer design ... TF62 Feb 26
Hypersonics, new developments in ... TF59 Mar 11
Hypervelocity work aided by use of electrically exploded wires ... CM97 Mar 18
Hysteresigraph, industrial, uses d-c integrating technique to measure d-c magnetization and hysteresis of magnetic materials ... TF70 Mar 25

I

Identification system, automation, bubbling in Britain ... BF52 May 13
Ignition system, transistorized, for automobiles uses surface-gap spark plug ... RD82 Mar 25
Ignitrons, welding control, what's new in ... SR55 Apr 29
Image othicons and converters, what's new in.... SR55 Apr 29

Impedance matching transmitter to antenna using circle diagrams ... ERS73 Jun 10

IMPORTS (See also Business, Exports & Foreign Electronics)
- Counterattacks to petition for import curbs on Japanese Company signs contract with U.S. importer for $1.4 million worth of consumer electronic products ... BF30 Jun 17
- Import picture for electronics industry in 1960 ... SR49 Jan 1
- IRE International Show and Convention gives U.S. Firms chance to check activities of foreign competitors ... BF36 Mar 18
- Japan adopts American NTSC standards to pave way for marketing transistorized color, and black and white tv set in U.S. ... BF27 Jan 22
- Japanese black-and-white and color tv sets arriving in quantity in U.S. ports ... BF32 Apr 29
- Japanese exports to U.S. rose from 22 million in 1958 to 76 million in 1959 ... MR26 Apr 29
- Japanese radios bought by appliance chain for sale in U.S. ... EN11 Jan 1
- Japanese to market stereo 4-channel tape recorder in U.S. ... EN11 Jan 22
- Japanese transistors are registered in Washington ... BF42 Jan 15

Increductor tuning devices for frequency synthesizer gives stable, high-accuracy receiver and transmitters ... RD122 Feb 12

INDICATORS
(See also Displays, Electroluminescent Devices, Indicators, Readout Devices & Registers)
- Cold-cathode ring-counter drives numerical indicator ... TF80 Apr 1
- Ferroresonant storage and switching circuits combined with alphanumeric indicator form electroluminescent typewriter ... TF49 Jan 22
- Gas-filler stepping tubes ... TF46 Feb 19
- Ground-velocity indicator using c-w Doppler radar developed for helicopters ... EN11 Jan 8
- Indicator triode has fluorescent anode whose illumination is controlled by grid potential for direct data readout ... TF52 Feb 5
- Monoscope tube generates characters for direct readout on a cro or on paper of digital computer output ... TF117 Feb 12
- Photographically-sensitized metal sheet makes custom labels for instrument and test equipment panels ... PT100 Jan 1
- Portable transistorized depth indicator for locating fish doesn't need crt ... TF50 Feb 5
- Reversible decade counter used eight-digit transistor-Nixie readout circuit ... TF86 Jan 1
- Small revolving globe for use by astronaut indicates position of orbiting capsule over earth ... RD85 Apr 1
- Transistor reverse-biasing technique raises breakdown point for switching indicator tubes ... TF48 Jan 8
- Transistorized radio beacon designed to function as aircraft crash position indicator ... TF54 Jan 22
- Wow-flutter indicator for precise measurement of tape recorder performance ... TF100 Jun 24

Inductance, circuit, technique for simply and accurately measuring ... ERS58 Mar 4

Inductance, measurement engineers cite need for better measurement standards of ... BF53 May 20

Inductance, simple and effective means of measuring in low-Q iron chokes ... TF112 Apr 29

Induction heating coil opens capsules in predetermined area of dog's gastro-intestinal tract ... PC29 Jan 1

INFORMATION RETRIEVAL (See also Data Processing)
- Computer applications of future will be in retrieving information and studying biological systems ... TF55 Jan 29
- Input geared to unambiguous restricted English main advance of fact-compiler concept Western Joint Computer Conference hears ... BF35 May 27
- Lab model thermoplastic recording system has radar, ir, information retrieval and data processor applications ... EN11 Jan 22
- Mark I perceptron demonstrates ability to learn the alphabet ... BF43 Jun 24

INFRARED
- Characteristics of thermal, photoconducting photovoltaic and photoelectromagnet infrared detectors ... TFB72 Apr 1
- Controlled environment for infrared studies made possible with 86-ft tunnel ... BF61 Mar 18
- Determination of infrared absorption in evaluating three-element semiconductors ... TF103 Feb 12
- Ground based missile roll control system uses photosensitive or infrared detectors ... RD80 Mar 25
- Growth foreseen in next two years in infrared maser field ... TF159 Mar 11
- How to determine whether to use visual, ir or radar detection in fog or rain ... TF64 Jan 29
- Lab model thermoplastic recording system has radar, ir, information retrieval and data processor applications ... EN11 Jan 22
- Rapid scan spectrometer detects and analyzes infrared energy radiated during power flight portions of missile trajectory ... TF86 May 20
- Three infrared and visual detectors under development may change design concepts in advanced military and industrial equipment ... EN11 May 27
- Uncooled indium-antimonide photoelectromagnetic detector responds to long infrared wavelengths ... TF62 Mar 25

Injected-beam forward-wave amplifiers and backward-wave electronically tunable oscillators, what's new in ... SR55 Apr 29

Inspection automation machine lagging in Britain ... BF52 May 13

Instrumentation for exploring the oceans ... TF62 Apr 8

INSTRUMENTS (See also specific instrument)
- Air transportable nuclear reactor now in instrumentation state ... EN11 Jan 1
- American exports of precision instruments in 1959 up $7 million over 1958 ... EN11 Mar 11
- Automatic spectroscopic system for determining the spectral response of electro-optical materials ... TF66 Apr 1
- Automatic surveying system uses lightbeam projector and profile measuring device to measure airport runway roughness ... TF54 Jun 17
- Battery-powered transistorized scale-of-64 counter for measuring radioactive tracers improves reliability, reduces cost and weight ... TF74 May 6
- Biocurrents in human cells being studied by Soviet Scientist with microelectrode ... EN11 Mar 4
- Biomedical space flight instrumentation system tested on racing car crews ... RD185 Mar 11
- Bridge circuit measures pulse response of armatures to pinpoint faults during production runs ... TF70 Jun 70
- Current pulse generator for testing ferrite memory cores ... TF80 Jan 1
- D-c transistor amplifier for measurement of low-amplitude long-period surface waves of ocean ... TF85 Jan 1
- Digital oscilloscope for direct read-out of amplitudes and waveforms announced ... EN11 Feb 5
- Digital sampler for measurement of axis-crossing intervals for design of weak signal detectors ... TF88 Jun 3
- Double focusing mass spectrometer going into satellite to measure elements in the exosphere ... RD81 Feb 26
- Double-focusing mass spectrometer measures relative amounts and weights of atoms ... RD74 Jan 29
- East Germans publicize a-c voltmeter ranging from 6 mv to 600 mv ... BF37 Mar 18
- Electrical stroboscope displays pulses with rise times of 10-10 sec ... RD81 Apr 1
- Electroluminescent devices find expanded market in instrument face applications ... BTW11 Jan 29
- Electronic ataxiameter for measuring involuntary bodily movement ... RD78 Jun 10
- Electronic methods for boosting conventional electromechanical counter speed ... TF112 Feb 12
- Electronic tonometer detects glaucoma by measuring pressure within eyeball ... TF115 Feb 12
- Electronic wire gage for nondestructive measurement of wire thickness ... TF109 Feb 12
- Electronics R & D in instruments in Italy and Sweden ... SR75 Feb 12
- Emphasis at Third International Instrument Electronics and Automation Show in Britain is on industrial controls, digital building blocks ... BF34 Jun 17
- Experimental current-measuring technique for determining dielectric absorption in capacitors ... RD90 Mar 18
- Flow rate of jet fuel containing radioactive tracer measured by simultaneously gated oscillator and radiation detector ... TF58 Feb 19
- French and British instrument companies to hold exhibitions in Moscow ... EN11 Mar 4
- French President DeGaulle impressed with range of test instruments made by manufacturer ... EN11 May 13
- French President DeGaulle impressed with range of test instruments made by manufacturer ... PC37 May 13
- Gas chromatography featured at Instrument Society of America Meeting ... BF47 Jun 24
- High-thrust propulsion systems to shift critical emphasis in satellite development to component and instruments ... BF48 Apr 29
- Hot and cold constant-impedance loads for measuring noise figure of microwave amplifiers ... RD66 Feb 5
- Immersion goniometer for measuring ultrasonic velocity in different media ... RD112 Jun 24
- Industrial hysteresigraph uses d-c integrating technique to measure d-c magnetization and hysteresis of magnetic materials ... TF70 Mar 25
- Instrument fault in orientation system causes Soviet spaceship backfire ... EN11 Jun 10
- Instrument manufacture in India has more than trebled in value in last three years ... BF52 Jun 24
- Instruments, controls, electron microscopes, advanced communications are features of British Exhibition in New York ... BF46 Jun 24
- Instruments highlighted at 1960 IRE International Show and Convention ... BF47 Apr 1
- Low-temperature research program to provide higher-precision thermometry being expanded ... RD98 Jun 3
- Magnetic tape instrumentation recorder has extended bandwidth to accommodate new heads ... TF44 Jan 8
- Magnetometer computes and measures magnetic field components of lake ... PC33 May 6
- Mass spectrometer measures quantity of helium escaping in electron tube manufacture ... TF74 Apr 1
- Measurement engineers cite need for better measurement standards of inductance and capacitance ... BBF53 May 20
- Measurement techniques for evaluating ultrapure refractory materials ... TF71 Jan 15
- Measuring circuit for simple and effective determining inductance of low-Q iron chokes ... TF112 Apr 29
- Measuring flow rates of a variety of fluids by detecting nuclear magnetic resonance ... TF77 Apr 1
- Measuring switching speed of thin magnetic films using strip transmission line ... TF79 Jun 3
- Milliammeter sorts look-alike metals using thermoelectric effect to detect polarity ... PT72 Jan 8
- Millipore filter tape instrument monitors high-purity water ... PT125 Jun 24
- Miniaturized all-weather radiometric sextant developed for submarine use ... EN11 Jan 15
- Modern microwave instruments ... SR67 Jun 24
- New applications of modern microwaves in medical research and spectroscopy ... SR67 Jun 24
- Noise suppression factor display unit computes and automatically displays ratio of two time-varying quantities ... TF55 Feb 5
- Nuclear instrument shipments for 1958 rise 33 percent over those of 1957 ... MR22 Feb 19
- Oscilloscope and oscillograph market will increase 50 percent between 1960 and 1962 ... MR24 Feb 5
- Oscilloscope checks operation of memory drum used in air-traffic control system ... BF39 Jun 10
- Oscilloscope with direct digital readout of amplitude and duration of pulse signals reduce operator errors, cut measurement time ... BF30 Mar 4
- Peak voltmeter uses transistorized flip-flop comparison and adjustment circuit to charge storage capacitor during substantial part of interpulse interval ... TF57 Jun 17
- Phasemeter measures two signals in 100 to 520 Mc band with 0.2 degree for c-w and 0.5 degree for pulsed uhf ... TF54 Mar 4
- Photographic system records electromagnetic radiation from lightning (sferics) propagated over long distances ... RD64 Mar 4
- Photographically-sensitized metal sheet makes custom labels for instrument and test equipment panels ... PT100 Jan 1
- Photomultiplier and electrometer measure fluorescence of glass dosimetry needle to determine radiation exposure in human body ... TF74 Mar 18
- Polarity coincidence multiplier detects weak low-frequency signal in high-noise background ... TF67 Jan 29
- Portable current-path verifier for aircraft applications identifier individual wires ... PC51 Jan 15
- Portable transistorized depth indicator for locating fish doesn't need crt ... TF50 Feb 5
- Portable transistorized sound level meter for measuring noise ... TF64 Jun 17
- Pulsed x-ray pencil beam gages thickness of hot and cold rolled metals ... PC62 Jan 22
- Radiation-operated fuel gage for missiles and aircraft ... RD117 Apr 29
- Radioisotope density altimeter is designed for missiles and fast new aircraft ... BF37 Jan 8
- Radiometer measures noise radiated from plasma at low power levels ... TF159 Mar 11
- Rapid scan spectrometer detects and analyzes infrared energy radiated during power flight portions of missile trajectory ... TF86 May 20
- Reversible decade counter for measuring temperature, pressure and the like ... TF86 Jan 1
- Russians develop photoelectric blood pressure meter ... RD75 Jun 17
- Self-powered transistor oscilloscope has response from d-c to over 5 Mc ... TF80 Mar 18
- Services need inventions in component, transistor, antenna and instrument areas ... BF39 Jan 22
- Sharp resonances located using precision R-C oscillator with high degree of stability ... TF76 Apr 15
- Solid-state radiation detector made of doped silicon gives new speed and accuracy to particle analysis ... BTW11 Feb 5
- Soviet exhibit at 1960 Leipzig trade fair focused on new electronic instrument, automation and space ... EN11 Mar 11
- Status of industrial instrument business in Japan ... SR53 May 27
- Step-van truck with instruments for measuring air pollution developed ... PC48 Feb 12
- Strain sensing element of whisker size and high strength gives 50 times greater sensitivity than present metallic devices ... BF11 Feb 26
- Talks on high-frequency standards and calibrations to highlight technical sessions during 1960 Conference on Standards and Electronic Measurements ... BF53 Jun 3
- Technique for checking calibration of f-m and t-v transmitter percentage-of-modulation monitors ... TF67 Apr 15
- Technique for simply and accurately measuring circuit inductance uses only scope with calibrated sweep velocities ... ERS58 Mar 4
- Test instrument sales to both industry and military rise fast ... MR26 Jan 15
- Tiny platinum wire is heart of Japanese bolometer mount for measuring microwave power ... CM88 Apr 1
- Transistorized slicer measures amplitude probability density functions ... TF70 Jan 29
- Transistorized subaudio swept signal generator for testing servos and related equipment and components ... TF67 Apr 22
- Two transistor voltage amplifiers and latchtype relay provide overload protection for voltmeter ... RD92 Mar 18
- Two-tube generator provides accurate, stable intensity marker for oscilloscope over 8 to 22 Mc frequency range for bandpass measurements ... TF108 Jun 24
- Ultrafast spectrometer for analyzing chemical reactions occurring on 0.1 millisec developed ... BF42 Mar 18
- Ultrasonic flowmeter uses two crystal transducers for common-path beam-direction to eliminate temperature errors ... RD78 Apr 22
- Ultrasonic resonance thickness gage measures missile radomes and nose cones ... PC86 Feb 26
- Undersea oil lines detected by metal locator which generates electromagnetic field ... BF57 Jan 15
- Unique instrumentation for investigating possibilities of using plasma to propel space vehicles ... TF66 Jun 10
- University of California Lick observatory to construct nebular spectrograph for collecting information on motions of gaseous nebulae ... BF60 Mar 11
- Use of stroboscope principle for nano and picosecond oscilloscopes described ... EN11 May 27
- What's new in cathode ray tubes for oscillography ... SR55 Apr 29
- X-ray analytical instrumentation to find expanding market ... BF53 May 6

INSULATORS
- Dielectric diodes and triodes to control large amounts of current using thin insulating crystals of cadmium sulphide being developed ... BTW11 Jan 22
- Frame of radiation beams provides nondestructive, continuous method of testing cable insulation ... PT135 May 27
- Ions detect pinholes in wire and cable insulation ... PT77 Feb 5
- Solventless silicone resin for high-temperature insulation now commercially available ... CM118 Jun 24
- Spray-on insulator dissipates heat and controls temperature on outside of space capsules ... CM105 Jan 15
- Teflon coated wire eliminates failure under corona stress ... CM80 Jan 29
- Temperature-insensitive solid-state dielectric diodes and triodes ... TF59 Feb 26

Integrator for transistorized slicer used to measure amplitude probability density functions ... TF70 Jan 29

Integrator, logarithmic, for nuclear radiation atarm ... TF43 Jan 22

Interference from other stations reduced during ionospheric sounding by circuit which separates desired pulses from unwanted tone signals ... TF118 May 27

Interference from generators, power lines, spark plugs and other electrical gear to be measured by NBS' Boulder Labs mobile field unit ... BF52 Jun 24

INVERTERS
- Inverter for transistorized slicer used to measure amplitude probability density function ... TF70 Jan 29
- Transistorized Inverter for Mobile Digital Computer (MOBIDIC) ... TF72 Mar 25
- Transistorized inverters working at 1,250 cps power 40-watt fluorescent lamp off 24-v battery in British railway coaches ... TF58 Feb 5
- Tunnel diodes used in inverter configuration ... TF55 Jan 29
- Typical semiconductor inverter for microcircuit ... TF69 May 13

Ion engine using cesium stream being contracted for by NASA ... EN11 Jun 17

Ionization, transmission of signals through natural layers and through shields formed by nuclear vehicles, hypersonic reentry vehicles, rocket motor exhausts and nuclear explosion ... TF81 May 20

Ionospheric sounding, circuit reduces interference from other stations by separating desired pulses from unwanted tone signals ... TF118 May 27

Isolators for modern microwave applications ... SR67 Jun 24

ions reported to affect health and behavior ..... BF45 Feb 26
Isolation amplifier, unity-gain, offers high stability and input impedance ..... TF66 Feb 26
Israel -- research and development currently underway in ..... SR75 Feb 12
Italy -- research and development currently underway in ..... SR75 Feb 12

J

Jamming chart helps determine effectiveness of radar in presence of ..... TF76 May 6
Japan (See Foreign Electronics)
JETS, Junior Engineering Tech Society, studied two-ton magnetic unit ..... PC48 May 6

K

Keyer, phase-shift, for double-sideband suppressed carrier transmitter ..... TF47 Feb 5
KLYSTRONS
Klystron amplifiers for modern microwave applications ..... SR67 Jun 24
Klystron, high-power S-band klystron, for long-range radar or troposcatter communications ..... CM82 Feb 26
Novel handling techniques for producing super-power klystron over 10 feet tall ..... PT192 Mar 11
Reflex klystron amplifier with hybrid T coupling give improved gain and linearity ..... TF64 Jun 10
Reflex klystrons used as microwave receiver amplifiers for X-band radars ..... TF56 Jan 8
Reflex klystrons used as millimeter wave amplifiers ..... TF71 Mar 18
Ultra-clean electron gun promises greater power rating, longer life for radar klystrons ..... EN11 Mar 25
What's new in megawatt and high-power c-w klystrons ..... SR55 Apr 29

L

Laminate with properties of Teflon and glass ideal wave applications ..... CM79 Jun 17
for high-temperature printed circuits and micro-
Lamps, incandescent, now available as pin-sized units ..... CM86 Apr 15
Latch circuit using saturable reactor is high-speed, low-cost and simple ..... RD66 Jan 8
Life, operating, extension of in receiving type electron tubes being researched ..... SR55 Apr 29
Light dimmer, solid-state, weighing 1 1/2 pounds promises to cut industrial power bills by 30 percent BF39 May 27
Lightning and earth's magnetic field being studied to develop long-range vlf navigation systems ..... RD78 Apr 8
Lightning discharges to be studied by University of Arizona ..... BF60 Mar 11
Lightning photographed by intermittent recorder .... RD64 Mar 4
Littrow mirror system for monochromator of rapid scan spectrometer used to detect and analyze infrared energy raidated during power flight portions of missile trajectory ..... TF86 May 20

LOGIC CIRCUITS
(See Also Digital Techniques)
Flip-flop uses indicator triode with fluorescent anode whose illumination is controlled by grid potential ..... TF52 Feb 5
High-speed transistor switch for computer logic circuit performs at micro-energy levels ..... CM98 May 13
Japanese develop new computer logic -- high speed parallel adder-accumulator and shifter ... BF36 Apr 15
Magnetic element of ferrite composition for storage, switching and logic applications in digital computers has advantage of open flux path, excellent squareness characteristics ..... RD104 May 20
Mark I perceptron demonstrates ability to learn the alphabet ..... BF43 Jun 24
Micron-thick permalloy plated onto copper basis of new thin film logic and memory devices developed in Japan ..... EN11 Apr 1
Parametron logic circuits for digital computers ..... TF73 Jun 3
Tunnel diode logic circuits--modes of operation and effect of circuit component tolerances .... TF103 Jun 24
Tunnel diodes used in EXCLUSIVE-OR and SUM circuits and flip-flops ..... TF55 Jan 29
Typical semiconductor logic block, and gate and NOR for microcircuits ..... TF69 May 13
Lossev effect, definition of ..... TF71 Feb 26
Low-noise devices used with modern microwave equipment ..... SR67 Jun 24

M

Machine tool control shows little penetration in Britain ..... BF52 May 13
Machine tools controlled by thyratrons driving step motors in response to signals from a programmed tape ..... TF174 Mar 11

MAGNETICS (See also Thin Films)
Changemaking machine operates by magnetic sensing ..... EN11 Jun 10
Control systems, solid-state electronics and electromagentics featured at Seattle's 7th Regional IRE Conference ..... BF39 Jun 10
Current pulse generator for testing ferrite memory cores ..... TF80 Jan 1
Data communications systems linking distant computers use magnetic tape equipment ..... BF44 Jun 17
Earth's magnetic field and lightning being studied to develop long-range vlf navigation systems .. RD78 Apr 8
Electronics R&D in magnetics in Italy ..... SR75 Feb 12
Experimental solid-state generator for converting pulsed d-c magnetic fields into microwave radiation has been built ..... EN11 Feb 19
Flexible Mylar magnetic disk memory unit stores 50,000 to 60,000 bits ..... TF55 Jan 29
Industrial hysteresigraph uses d-c integrating technique to measure d-c magnetization and hysteresis of magnetic materials ..... TF70 Mar 25
Magnetic analyzer for double-focusing mass spectrometer ..... RD74 Jan 29
Magnetic element of ferrite composition for storage, switching and logic applications in digital computers has advantage of open flux path, excellent squareness characteristics ..... RD104 May 20
Magnetic, noncontact shaft position disk encoder offers high rotational speeds and reliability for computer, control and data logging uses ..... RD114 Apr 29
Magnetic recording of color television using time-correction circuits to reproduce hues faithfully TF76 Jan 1
Magnetic resonance, nuclear, discussed at Instrument Society of America Meeting ..... BF47 Jun 24
Magnetic spot-welding electrodes hold small parts to be welded to sheet or strip material ..... PT88 Apr 15
Magnetometer computes and measures magnetic field components of lake ..... PC33 May 6
Measuring cathode temperature of commercial tubes by using magnetic field parallel to retarding potential ..... RD80 Apr 15
Measuring flow rates of a variety of fluids by detecting nuclear magnetic resonance ..... TF77 Apr 1
Measuring switching speed of thin magnetic films using strip transmission line ..... TF79 Jun 3
Miniature magnetic head for high-density memory drum consists of coil wound over four-layer core TF55 Jan 29
NBS discovers a series of ceramic materials that exhibit simultaneously both ferroelectric and ferrimagnetic properties ..... CM128 Feb 12
Optical-electronic magnetometer control attitude of vehicles in space ..... TF55 Apr 8
Permanent magnet memory unit (Twistor) ready for mass production ..... BTW11 Jan 29
Project Madre to use magnetic-drum receivers to autocorrelate echoes from over-the-horizon radar Missile warning system ..... BF28 Feb 5
RCA to open research laboratory in Japan to study electrical, magnetic and optical properties of solid-state phenomena ..... EN11 Jun 24
Recent progress in solid state technology reported at 1960 Solid-State Circuits Conference ..... TF39 Mar 4
Semiconductor wafer Hall probe in magnetic field plotting system speeds cyclotron design ..... RD80 Apr 8
Six ways to use magnetic core shift register elements ..... TF80 Jan 15
Spiral magnetic paths (Twistor) used in digital computer memory ..... CM84 Mar 25
Superconducting electromagnets being explored for use with masers and in solid-state research requiring cryogenic temperatures and a magnetic field ..... EN11 May 20
Transfluxor (magnetic-electronic) oscillator retains last frequency setting many hours after control signal removal ..... TF48 Mar 4
Two-ton magnetic unit studied by members of JETS (Junior Engineering Tech Society) ..... PC48 May 6
Uncooled indium-antimonide photoelectromagnetic detector responds to long infrared wavelengths TF62 Mar 25
Value of thin magnetic films in computer memory systems being explored by Case Institute of Technology ..... BF53 Feb 12

MAGNETOHYDRODYNAMICS
(See also Plasma Physics)
Experimental magnetohydrodynamic generator produces 2½ kw, runs for four minutes ..... EN11 Mar 25
Magnetohydrodynamics power plant generators offering high-efficiency output being studied ... RD92 Jan 1
Magnetohydrodynamics symposium of AIEE points up electronics industry's growing interest in plasma research ..... EN11 Mar 4
Magnetohydrodynamics takes on new significance to electronics industry ..... BF52 Mar 11
New developments in direct conversion of heat to electric power without using moving parts ..... TF159 Mar 11
Magnetometer computes and measures magnetic field components of lake ..... PC33 May 6
Magnetometer, optical-electronic, controls attitude of vehicles in space ..... TF55 Apr 8

MAGNETRONS
Crossed-field amplifier called Circlotron uses magnetron as negative-resistance element ..... TF71 Jan 15
Experimental magnetrons for 32, 12, 8 and 4 mm wavelengths give peak outputs of 1,100 70, 80, and 40 kw, respectively ..... CM96 Mar 18
Magnetron with 25-kw peak power at 35-kmc developed for surface detecti on radar set ..... EN11 Jan 15
What's new in magnetron oscillators ..... SR55 Apr 29

MANAGEMENT
(See also Government, Manpower, Marketing, and Market Research)
Automatic teaching machine (Tutor) simulates complex electronic gear, speeds development of technical personnel ..... BF39 Apr 22
Company combates shortage of semiconductor engineers by giving series of in-depth, 13-week courses ..... BF44 Jun 17
Defense Department urges extensive changes in management of military electronic parts specs.. BF31 Apr 22
Do's and don'ts of hiring engineers and scientists BF40 Mar 11
Electronics to be third largest U.S. industry by 1965 ..... MR24 Jun 17
Government may set minimum wage next year for workers making functional components ..... BTW11 Apr 15
Guide for measuring new product success record .. MR30 Feb 26
Labor Department to hold hearing on minimum wage for electronic component parts plants selling to government ..... BF44 Mar 25
Labor Department to rule on minimum wages for tube and semiconductor production workers .... BF31 Jan 8
Mass recruitment of electronics engineers by industry firms is on way down according to reports ..... BF40 Jun 3
Selective paging system uses coded transmission for voice intercommunications with up to 45 stations ..... TF68 Feb 26
Self-help plan involving team bidding and establishment of trade association speeds industrial growth on Long Island ..... BF38 May 6
Survey shows that field engineers resign jobs because not enough management experience is gained ..... BF52 May 20
West Coast manufacturer urges government give Q awards for production ..... BF40 Jan 1

MANPOWER (See also Education and Management)
Automatic teaching machine (Tutor) simulates complex electronic gear, speeds development of technical personnel ..... BF39 Apr 22
Company combates shortage of semiconductor engineers by giving series of in-depth, 13-week courses ..... BF44 Jun 17
Do's and dont't of hiring engineers and scientists BF40 Mar 11
Florida's new industrial lure: plant-and-house package ..... BF30 Jun 10
Government may set minimum wage next year for workers making functional components ..... BTW11 Apr 15
Guggenheim Fellowship winner works in Britain's Atomic Energy Research Establishment ..... PC39 Jun 24
Importance of Japan's manpower in her rising electronics industry ..... SR53 May 27
Japanese young women electronics production workers: a close-up ..... BF30 Apr 1
Labor Department to hold hearing on minimum wage for electronic component parts plants selling to government ..... BF44 Mar 25
Labor Department to rule on minimum wages for tube and semiconductor production workers .... BF31 Jan 8
Manpower distribution of electronic industry personnel-1959 ..... SR49 Jan 1
Mass recruitment of electronics engineers by industry firms is on way down according to reports ..... BF40 Jun 3
Minnesota Governor indicates expanding universities, skilled manpower and favorable financial climate stimulates area's growth ..... BF30 Jun 17
Survey shows that field engineers resign jobs because not enough management experience is gained ..... BF52 May 20
U.S. forms plan to hire 44 percent more EE graduates in 1960 than in 1959 ..... BF39 Jun 24
U.S. Information Agency needs engineers to keep Voice of America's Greenville installation going EN11 Jun 10
What exhibitors are saying about recruiting at forthcoming IRE International Show and Convention ..... BF30 Mar 11
Maps of ground terrain made from air with side-looking all-weather radar ..... BF49 Apr 15
Marker generator provides accurate, stable intensity marks for oscilloscope over 8 to 22 Mc frequency band for bandpass measurements ..... TF108 Jun 24

MARKETING (See also Market Research and Sales)
Automatic gas-fume detector alarms, Loran, radio telephones, direction finders, and depth sounder fish finders make up new $10-million small boat market ..... BF30 Jan 22
British and U.S. computermakers step up sales, promotional and service activities in Europe ... BF34 Jan 8
Commerce department forecasts $2.2-Billion consumer market in 1960 ..... BTW11 Jan 22
Delivery of new single-sideband communications systems for military and commercial market reported ..... BTW11 Mar 18
Digital and analog computermakers seek wide marketing through pricing and design flexibility BTW11 Mar 18
Digital computer for industrial control functions being marketed ..... EN11 Jan 8
Dutch market their first electronic computer which uses transistors and ferrite cores ..... BTW11 Feb 12
Electroluminescent devices output to increase for a wide variety of military and civilian markets BTW11 Jan 29
Electronics market for 1960 ..... SR49 Jan 1
EMI Electronics of England expands marketing of computers in U.S. ..... BF36 Mar 18
Increased production, marketing activity forecast for electroluminescent devices ..... BTW11 Apr 1
Japan adopts American NTSC standards to pave way for marketing transistorized color, and black and white tv set in U.S. ..... BF27 Jan 22
Japanese Industrial Trade Fair feature consumer items for U.S. market ..... EN11 Apr 29
Japanese to market stereo 4-channel tape recorder in U.S. ..... EN11 Jan 22
Low-grade silicon in demand in Europe ..... CM68 Jan 8
Manufacturers expect continued increase in tv and audio market ..... BF39 Feb 5
Manufacturers give increased attention to developing small computers for small businesses ..... BF39 Apr 8
Marketing techniques of electronics industry in Japan ..... SR53 May 27
Microminiature modules (MICRAM) with component densities of 2 million units per cu ft being marketed ..... BTW11 Mar 25
New business data processing system offers sophistication at moderate price ..... BTW11 Apr 15
One company's approach to beefing up electronics export trade ..... EN11 Apr 29
Self powered portables, more color sets and additional remote control models focal points of 1960 TV market ..... BF44 May 13
Transistorized tv set to be marketed by Japanese firm during 1960 ..... EN11 Jan 8
Tunnel diode circuit designs open new markets for computer, communications and receiver amplifier applications ..... BF36 Feb 26
Tunnel diode factory production announced by U.S. and Japanese firms ..... BTW11 Feb 12
U.S. electron tubes and semiconductors of specialized types and advanced designs in demand abroad ..... BF48 Feb 26
U.S. forms plan to hire 44 percent more EE graduates in 1960 than in 1959 ..... BF39 Jun 24
X-ray analytical instrumentation to find expanding market ..... BF53 May 6

MARKET RESEARCH (See also Marketing and Sales)
Color tv sales to rise $10 million in 1960 ..... MR24 Apr 22
Dollar value of plastics parts produced by electronics companies in 1959 is $250 million, double 1958's $125 million ..... MR24 Jun 24
Electronics firms urged at EAI Industrial Electronics Conference to sell systems instead of hardware to industrial customers ..... MR22 Jan 22
Electronics industry exports for 1959 are $415 million, down 3 percent from 1958 ..... MR26 May 6
Electronics to be third largest U.S. industry by 1965 ..... MR24 Jun 17
F-m radio set sales to show gain of 50 percent over last year ..... MR26 Feb 12

Guide for measuring new product success record MR30 Feb 26
Hearing aid sales will increase by 11 percent in 1960 MR28 Mar 18
Hiring in communications equipment industry up 13 percent MR26 Mar 11
Industrial products to reach $8-10 billion sales MR26 Apr 15
Japanese exports to U.S. rose from 22 million in 1958 to 76 million in 1959 MR26 Apr 29
Magnetic tape sales to increase by 30 to 35 percent on 1959 in 1960 MR22 Jan 8
Manufacturers look for quadrupled digital computer sales over next five years MR24 Jun 3
Microwaves components study of 1958 production issued by Commerce Department's Business and Defense Services Administration MR24 Apr 8
Military marketing strategy MR26 Mar 25
Nuclear instrument shipments for 1958 rise 33 percent over those of 1957 MR22 Feb 19
Oscilloscope and oscillograph market will increase 50 percent between 1960 and 1962 MR24 Feb 5
Preliminary statistics indicate tube shipments increased 145 percent between 1954 and 1958 MR22 Mar 4
Replacement parts, repairs and modifications to cost military $900 this year MR30 Apr 1
Retail sales of tv sets will rise 60 to 70 percent higher in 1970 MR26 May 27
Silicon controlled rectifier dollar sales to double in 1960 MR22 Jan 1
Slip ring assemblies become major electronics components market, sales rise 25 percent yearly MR30 May 13
Tantalum capacitor manufacturers look for 20 percent sales increase over 1959 level MR24 Jun 10
Test instrument sales to both industry and military rise fast MR26 Jan 15
Ultrasonic cleaning equipment sales to be up 30 percent over next five years MR28 May 20
Year 1960 to see increased semiconductor sales, maintenance of high level 1959 electron tube sales MR24 Jan 29
Mars, MIT interplanetary space probe to take photographs of 40 percent of surface of BF49 May 20

MASERS
Army announces development of 25-lb ruby maser EN11 Apr 22
D-c controlled attenuator called Gyraline varies L-band maser pump power in radiometer TF71 Jan 15
Search for new materials plays key role in maser development TF159 Mar 11
Superconducting electromagnets being explored for use with masers and in solid-state research requiring cryogenic temperatures and a magnetic field EN11 May 20
Mass spectrometer, double focusing, going into satellite to measure elements in the exosphere RD81 Feb 26
Mass spectrometer tests tightness of seals TF74 Apr 1

MATERIALS
(See also Ceramics, Dielectries, Insulators, Plastics, Superconductors and Thermoplasties)
Auto Company tests energy absorption of materials impact of steel ball of surface PC30 Jun 17
Automatic spectroscopic system for determining the spectral response of electro-optical materials TF66 Apr 1
Beryllium oxide heat sink solves problem of heat removal from tube anode in r-f telemetry power amplifier CM110 May 20
Defense Department considers establishment of information center on ceramic materials to aid research EN11 May 13
Device materials tested at-460F PC39 Jan 29
Dielectric diodes and triodes to control large amounts of current using thin insulating crystals of cadmium sulphide being developed BTW11 Jan 22
Digital programmer automatically adjusts and controls furnace temperature during preparation of high purity materials RD122 May 27
Emphasis on basic scientific progress and discoveries in Conference on Electronic Conductivity in Organic Solids RD127 May 27
Epoxy resins for encapsulation display novel structure, reactivity and curing characterisitcs CM71 Feb 19
Four basic research programs underway to develop ductile ceramic and ionic crystals CM100 Jan 15
Gallium phosphide diodes and switching devices withstand 1,500 C CM71 Jan 8
Gas plasma gun sprays materials with high melting points onto materials with relatively low melting points PT77 Feb 5
Germanium used in new alloy for brazing stainless steel PT127 Apr 29
Germans develop world's purest silicone, and continous process for making pure crystallized silicon BF49 May 13
Gold-antimony alloy gives more even control of semiconductor doping CM71 Jan 22
High degree of piezoelectricity in zinc oxide and cadmium sulfide has been discovered BF52 Jun 24
High-purity tungsten now easily plated on metal surface using vapor deposition process CM85 Jun 10
How built-in damping controls violent motion imposed by vibration CM186 Mar 11
Immersion gonlometer for measuring ultrasonic velocity in different media RD112 Jun 24
Knitted metal mesh protects electronic equipment from shock and vibration CM94 Mar 18
Laminate with properties of Teflon and glass ideal for high-temperature printed circuits and microwave applications CM79 Jun 17
Low-grade silicon in demand in Europe CM68 Jan 8
Material and backing-plate selection for sonar transducer design TF62 Feb 26
Materials for potting base of electron tubes CM84 May 6
Materials hold key to development of electron tubes capable of reliable performance at high ambient temperatures CM118 Apr 29
Materials progress in transistor potting, high-tensile strength polyethylene and plastic laminates reported CM84 Apr 15
Materials research activity in Japan SR53 May 27
Measurement techniques for evaluating ultrapure refractory materials TF71 Jan 15
Methods of metallizing ceramics for brazing into ceramic-metal assemblies CM86 May 6
More use of tantalum and columbium for capacitors seen at Electrochemical Society meeting EN11 May 20
National Research Council urges government to give high priority to development of material CM85 Apr 8
NBS discovers a series of ceramic materials that exhibit simultaneously both ferroelectronic and ferrimagnetic properties CM128 Feb 12
New cathode base metal for tubes greatly improves microphonics and resistance to cathode bowing under severe shock CM79 Jun 17
Paper-base phenolic laminate provides flame retardance with excellent cold punching characteristics CM103 Jun 3
Predicting possible three-element semiconductor materials TF103 Feb 12
Producing germanium from flue dusts of certain kinds of coal CM121 Jun 24
Production of large ceramic pieces to serve as circuit boards reported CM87 May 6
Report on high-temperature ceramics CM116 Jun 24
Response of electronic system components and materials to irradiation from nuclear-powered aircraft TF69 Apr 22
Review of uranium compounds suggests some may posses semiconductive properties of interest in high-temperature applications CM130 May 27
Scientists grow single crystals of transparent gallium phosphide experimentally EN11 May 13
Search for new materials plays key role in maser development TF159 Mar 11
Solventless silicone resin for high-temperature insulation now commercially available CM118 Jun 24
Special machining techniques for forming pure tungsten into intricate shapes CM87 May 6
Spray-on insulator dissipates heat and controls temperature on outside of space capsules CM105 Jan 15
Teflon coated wire eliminates failure under corona stress CM80 Jan 29
Thermoelectric cooling now possible using new semiconductor materials CM85 Feb 26
Two fast-hardening epoxy adhesives introduced for bonding components to circuit boards CM116 Jun 24
Use of gallium phosphide in point-contact devices points to development of gallium phosphide diodes CM108 May 20
What's new in photocathode materials SR55 Apr 29
Measurement engineers cite need for better measurement standards of inductance and capacitance BF53 May 20
Mechanical environment and assembly of receiving-type electron tubes SR55 Apr 29

MEDICAL ELECTRONICS (See also Biophysics)
AF studies affect of high intensity sound on human physiological reactions PC46 Jun 24
Artificial neuron designed as component for studying self-organizing systems reported at 1960 Solid-State Circuits Conference TF39 Mar 4
Biocurrents in human cells being studied by Soviet Scientist with microelectrode EN11 Mar 4
Biomedical space flight instrumentation system tested on racing car crews RD185 Mar 11
Closed-circuit tv for monitoring dental surgery and for assisting in diagnosis being studied RD92 Jan 1
Computer calculates turbidimetric assays in automatic microbiological testing RD67 Jan 8
Cryogenic electron microscope of future may give man his first view of atom BF32 Feb 5
Czechoslovakian transistor cardio-tachometer in use BF28 Jan 1
Dental anesthetic device using stereo sound placed in production EN11 May 27
Electronic ataxiameter for measuring involuntary bodily movement RD78 Jun 10
Electronic equivalent of neuron discussed at winter meeting of AIEE BF28 Feb 19
Electronic tonometer detects glaucoma by measuring pressure within eyeball TF115 Feb 12
Electronics R&D in medicine in Sweden and Israel SR75 Feb 12
Hearing aid sales rise 11% MR28 Mar 18
Induction heating coil opens capsules in predetermined area of dog's gastro-intestinal tract PC29 Jan 1
Ions affect health and behavior in space, submarines and department stores BF45 Feb 26
Japanese to emphasis development of medical electronics EN11 Feb 12
Low-energy short-lived radioisotope samarium-153 produces high quality diagnostic radiograms BF42 Mar 18
Measuring flow rate of blood externally by detecting nuclear magnetic resonance TF77 Apr 1
Mutual aid between electronics and medical men seen essential to medical research TF159 Mar 11
New applications of modern microwaves in medical research and spectroscopy SR67 Jun 24
Photomultiplier and electrometer measure fluorescence of glass dosimetry needle to determine radiation exposure in human body TF74 Mar 18
Preview of medical electronics sesslons for forthcoming IRE International Show and Convention BF32 Mar 11
Russians develop photoelectric blood pressure meter RD75 Jun 17
Semiconducting industrial diamonds may find application as highly sensitive thermometers RD76 Apr 22
Solid-state radiation detector made of doped silicon used in surgical probe for cancer treatment control BTW11 Feb 5
Status of medical electronics in Japan SR53 May 27
Television tracking system records eye focus points and movements TF57 Apr 22
University of California probes new ways to use radiation in brain study BF53 Feb 12
Wireless eyeglass hearing aid developed PC43 May 27

MEETINGS (See also Conferences and Conventions)
Advanced research projects discussed at Northeast Electronics Research and Engineering Meeting TF71 Jan 15
Gas chromatography featured at Instrument Society of America Meeting BF47 Jun 24
Magnetohydrodynamics symposium of AIEE points up electronics industry's growing interest in plasma research EN11 Mar 4
Marine experts at AIEE winter meeting indicate sophisticate electronic gear on ships may mean more solid-state power supplies EN11 Feb 12
More use of tantalum and columbium for capacitors seen at Electrochemical Society meeting EN11 May 20
Non-newtonian color optics being used in color-reception system using two monochrome tubes shown at regional meeting of Society of Photographic Scientists and Engineers EN11 Jun 24
Sixth annual symposium on Reliability and Quality Control BF39 Jan 29
Superconductivity symposium disclosed basic work is still concertrating on cryotron, major problem is fabrication EN11 May 27
Tube-transistor comparisons, microelectronics, space electronics, computer applications and engineering education discussed at winter meeting of AIEE BF28 Feb 19

MEMORIES
(See also Computers, Cores, Data Processing, Digital Techniques, Storage Devices and Thin Films)
Current pulse generator for testing ferrite memory cores TF80 Jan 1
Drive-sampling core generators precisely defined strobes to give high s/n ratio in digital computer memories TF72 Mar 25
Expandable random-access solid-state memories operate over 15 to 55 C temperature range, require only 3 percent supplies TF164 Mar 11
Flexible Mylar magnetic disk memory unit stores 50,000 to 60,000 bits TF55 Jan 29
Information stored in form of acoustic energy in quartz delay line TF159 Mar 11
Magnetic thin films dots for computer memories PC184 Mar 11
Mark I perceptron demonstrates ability to learn the alphabet BF43 Jun 24
Micro-sized ferrite-core memory array for data processing system operates under environmental extremes CM98 May 13
Micron-thick permalloy plated onto copper basis of new thin film logic and memory devices developed in Japan EN11 Apr 1
Miniature high-density memory drum stores 300,000 bits TF55 Jan 29
Oscilloscope check operation of memory drum used in air-traffic control system BF39 Jun 10
Permanent magnet memory unit (Twistor) ready for mass production BTW11 Jan 29
Precision turning device for finishing outer-diameters of memory drums PT126 Apr 29
Rice Institute develops 8, 192-word grid tube memory, expect expansion to 32,000 words BF59 May 20
Spiral magnetic paths (Twistor) used in digital computer memory CM84 Mar 25
Superconductors to find use as components for high-speed switches and memory systems BF32 Feb 5
Mercury pool tubes, what's new in SR55 Apr 29
Metal locator detects undersea oil lines BF57 Jan 15
Metals that look alike are sorted by milliammeter using thermoelectric effect to detect polarity PT72 Jan 8
Meteor showers found to be more frequent than previously suspected by use of radar telescope capable of detecting micrometeorites RD106 May 20

METEOROLOGY (See also Atmospheric Studies)
Automatic weather station can be air-lifted to normally inaccessible areas by helicopter BF43 May 6
Circularly-polarized, high-gain antenna for automatic tracking of Tiros meteorological satellites TF57 Apr 15
Data gathering and logging system monitors nuclear radiation levels and weather conditions RD64 Jan 22
Electronics R&D in weather aids in Australia SR75 Feb 12
Instrumented low-cost Arcas and Loki weather rockets slated for daily firing BF43 Apr 29
Side-looking radar makes all-weather air maps of ground terrain BF49 Apr 15
Tiros transmits data with two 33-ounce off-the-shelf f-m telemetry transmitters BTW11 Apr 15
U.S. Weather Bureau completing installation of advanced, high-speed facsimile recording equipment for high-altitude weather map network BF49 May 6
Meter, photoelectric blood pressure, developed by Russians RD75 Jun 17
Meter, portable transistorized sound level, for measuring noise TF64 Jun 17
Meters, percentage-of-modulation, for f-m and t-v transmitters, technique for checking calibration of TF67 Apr 15
MICRAM (microminiature individual components reliable assembled modules) are being marketed BTW11 Mar 25
Microfilm, monoscope system converts computer data into visual form on BF11 Feb 26

MICROMINIATURIZATION
(See also Printed Circuits and Thin Films)
Approaches to design and fabrication of microminiaturized digital computer for space applications TF95 Apr 29
British approaches to microminiaturization TF71 Jan 1
Ceramic-based microminiature adder for ballistic missile computer PC96 Jan 1
Circuits grown form pool of molten semiconductor materials BTW11 Jan 29
Eastern Joint Computer Conference indicates computers are heading for 1,000-kc operation and microminiaturized circuits TF55 Jan 29
Electron beam device accurately drills small holes in evaporating masks used in microminiaturization TF71 Jan 15
Germanium diffused base transistor with open circuit base connection serves as inductive negative resistance diode in microcircuits TF60 Apr 22
Half inch cube modules holding 12 to 18 components used in reconnaisance drone guidance system, commercial and military computers CM123 Apr 29
Microelectronics discussed at winter meeting of AIEE BF28 Feb 19
Microelectronics to get special attention at 1960 Solid-State Circuit Conference EN11 Jan 29
Microminiature modules (MICRAM) with component densities of 2 million units per cu ft being marketed BTW11 Mar 25
Microminiature tube circuits featuring nuclear radiation resistance offered at IRE International Show and Convention BTW11 Apr 1
Microminiaturization discussions dominate Electronic Components Conference BF46 May 27
Microminiaturization highlighted at 1960 IRE International Show and Convention BF47 Apr 1
Micro-sized vacuum tubes encapulated in a solid block reported at 1960 Western Joint Computer Conference CM100 Jun 3

New developments in microminiaturization ..... TF199 Mar 11
New triple-diffused npn silicon mesa devices designed for low-power high-speed switches shrunk to pico size ..... CM82 Apr 8
Practicality of using small ceramic receiving tubes in thermionic integrated micromodular circuits (TIMMS) ..... CM82 Jun 10
Recent advances in preparing thin film ceramic dielectrics for microminiature capacitors ..... CM96 Jan 1
Recent progress in solid state technology reported at 1960 Solid-State Circuits Conference ..... TF39 Mar 4
Selective diffusion and shaping of semiconductors to form complete circuits cuts size and weight, improves reliability ..... TF69 May 13
Series of papers on thin films presented in IBM Journal ..... CM78 Jun 17
Solid-State Circuits Conference indicates microelectronics is moving rapidly out of research phase ..... BF36 Feb 12
U.S. headstart over Russia in microminiaturization seen as future space asset ..... BTW11 Apr 8
Microphone, miniature capacitor, with 15Kc bandwidth for measurement use, and tv and moving picture studios ..... RD80 May 6
Microphone, sound-canceling, makes ordinary voice communication possible in 150-db areas ..... PC41 Apr 22
Microphonics in tubes reduced by new cathode base metal ..... CM79 Jun 17
Microscope, cryogenic electron, of future may give man his first view of atom ..... BF32 Feb 5
Microscopes, electron, are one of features at British Exhibition in New York ..... BF46 Jun 24

MICROWAVE SYSTEMS & DEVICES (See also specific headings)
Alloyed-emitter, pnp mesa transistor operates in low microwave region and is mounted in coaxial shell ..... RD82 Apr 15
Biasing techniques permit small-area junction germanium diodes to switch microwave in waveguides or transmission lines ..... TF85 Jan 15
Broadband microwave amplifier uses negative resistance of tunnel diode in combination with nonreciprocal ferrite attentuation ..... CM84 Mar 25
Characteristics and relative cost of coaxial cable and waveguide terminations ..... TF50 Jan 8
Compact hybrid microwave mixer for airborne radar receiver is now available ..... CM70 Feb 5
Corner reflector antenna offers high-gain, broad-frequency response, narrow beam width and low back radiation ..... RD82 May 6
Crossed-field amplifier called Circlotron uses magnetron as negative-resistance element ..... TF71 Jan 15
Eastern Joint Computer Conference indicates computers are heading for 1,000-Mc operation and microminiaturized circuits ..... TF55 Jan 29
Electronic oven uses microwave technique for assembly line production of pre-frozen meals in Holland ..... BF47 Jun 10
Elliptically polarized X-band horn antenna has d-db and 6-db beamwidths of 140 degrees ..... TF50 Mar 4
End-fire arrays of high-dielectric ceramic rods give low silhouette and high vertical resolution in uhf region ..... TF60 Feb 5
Experimental magnetrons for 32, 12, 8 and 4 mm wavelengths give peak outputs of 1, 100, 70, 80 and 40 kw, respectively ..... CM96 Mar 18
Experimental solid-state generator for converting pulsed d-c magnetic fields into microwave radiation has been built ..... EN11 Feb 19
Hot and cold constant-impedance loads for measuring noise figure of microwave amplifiers RD66 Feb 5
Japanese to emphasize development of microwave tubes ..... EN11 Feb 12
Laminate with properties of Teflon and glass ideal for high-temperature printed circuits and microwave applications ..... CM79 Jun 17
Microwave components and measuring instruments receive much attention at 1960 IRE International Show and Convention ..... BF47 Apr 1
Microwave components study of 1958 production issued by Commerce Department's Business and Defense Services Administration ..... MR24 Apr 8
Microwave data link transmits output of side-looking, all-weather terrain mapping radar to ground film recorder ..... BF49 Apr 15
Microwave links for Japanese television distribution ..... SR53 May 27
Microwave tube called X-Band amplitron has large anode-dissipation densities ..... TF71 Jan 15
Modern microwaves--applications, antennas, generators, amplifiers, components and test equipment ..... SR67 Jun 24
Monopulse tracking radars compared with sequential lobing and conical scan techniques ... TF51 Apr 22
New developments in line-of-sight and over-the-horizon systems ..... TF159 Mar 11
Phasemeter measures two signals in 100 to 520 Mc band with 0.2 degree for c-w and 0.5 degree for pulsed uhf ..... TF54 Mar 4
Plasma circuit used as an oscillator to generate microwave energy at 2,000 Mc ..... BTW11 Mar 4
Reflex klystrons used as microwave receiver amplifiers for X-band radars ..... TF56 Jan 8
Reflex klystrons used as millimeter wave amplifiers ..... TF71 Mar 18
Remove pulse-coded fault alarm for multihop microwave systems ..... TF82 Jan 1
Rutgers University probes various microwave areas ..... BF53 Feb 12
Specifications for components in millimeter band CM68 Feb 19
Super-power uhf ceramic-metal tube developed for possible long-range radar missile detection and intercontinental tv ..... TF70 Apr 8
Thailand, Laos and Vietnam to have telecommunication network for radio and tv ..... BF29 Jan 1
Tiny platinum wire is heart of Japanese bolometer mount for measuring microwave power ..... CM88 Apr 1
Triangular waveguide antenna is more rigid and easier to construct than large slotted waveguide cross sections ..... RD64 Feb 19
Varactor diodes available in experimental quantities, used for high-efficiency subharmonic oscillators in microwave computers ..... CM131 May 27
What's new in electron tubes for low noise, small-signal and power amplifiers ..... SR55 Apr 29
What's new in linear-beam and crossed field type microwave tubes ..... SR85 Apr 29
Midwest Program on Airborne Television Instruction, sixteen colleges in six midwestern states designated as communications network for ..... BF59 May 20
Military Affiliate Radio System (MARS) considers facsimile and slow-scan tv as supplement to regular amateur activities ..... BF48 Feb 12

MILITARY ELECTRONICS (See also specific headings)
Acknowledgement by U.S. of recon operation drops cloak from a big and growing area of electronics industry ..... BF34 May 27
AF develops translator for converting Russian into English at 35 words a second ..... EN11 May 20
AF is investigating X-rays as possible means of space communication ..... BF45 Feb 12
AF studies affect of high intensity sound on human physiological reactions ..... PC46 Jun 24
Airborne early warning blimps to carry largest radar and electronic equipment complex ..... EN11 Jan 15
Army announces development of 25-lb ruby maser EN11 Apr 22
ARPA contracts awarded to study ways of nullifying attack by nuclear-armed vehicles entering earth's atmosphere from outer space .. BF36 May 13
Automated submarine uses electronic data processing and display to give ship, engineering, communications, weapons and environmental control ..... BF28 Jan 29
BMEWS detection and communication system prime contractors get contract awards ..... EN11 Feb 26
Central organization may be set up to administer program for control over design and procurement of military components ..... EN11 May 27
Defense Department urges extensive changes in management of military electronic parts specs.. BF31 Apr 22
Delivery of new single-sideband communications systems for military and commercial market reported ..... BTW11 Mar 18
Department of Defense pushing program to find out more about radar signatures for ICBM's ..... EN11 Jun 17
Electron sealing process using optically-ground and mated glass stem and envelopes to extend military tube life ..... EN11 May 6
Electronics industry will probably get 17 percent of defense budget in ten years ..... BF53 Apr 1
Electronics R&D in the military in Italy ..... SR75 Feb 12
Equations and charts for determining range parameters of active and passive sonar systems ... TF41 Feb 19
FAA has raft of big and little plans for 1960 .... BF40 Feb 12
Federal spending for coming fiscal year to hold close to last year's figures ..... BF32 Jan 29
Fifty-pound Doppler radar detects and accurately locates moving vehicles and men to trace battlefield deployment ..... TF67 Mar 18
Fuel cell power supply for Marine and Army portable field radar to be delivered ..... EN11 Apr 29
Generation, detection and transmission of millimicrosec transients being studied at University of Kansas under Navy grant for Project Jayhawk BF60 Mar 11
Ions affect health and behavior in space, submarines and department stores ..... BD45 Feb 26
Japanese-made tropospheric scatter communications system used by U.S. forces in Japan .... EN11 Jan 29
Large-scale digital computer permits Navy high degree of realism in simulating mock submarine battles ..... BF35 Jun 24
Long-range 3-D target finding radar installed .... PC42 Jun 10
Major use of tunnel diodes seen in industrial and military electronics ..... TF159 Mar 11
Mid-continent link in Army's worldwide communications network now operational ..... BF35 Mar 4
Military electronics market for 1960 ..... SR49 Jan 1
Military marketing strategy ..... MR26 Mar 25
Military to get mobile, high-power folding radar assembly ..... PC34 Jun 10
Military weapon system development stresses too much breakthough research, too many unit cost compromises ..... BF39 Jan 29
Million-watt transmitter to be completed by year's end for Navy ..... BF41 Jan 29
Missile-impact locating system (MILS) developed for Navy uses oceanographic sound-ranging techniques ..... EN11 Jun 17
More U.S. gear going into second generation of British missiles ..... BF32 Mar 25
Navy begins test on UDOFT (Universal Digital Operation Flight Trainer) used to simulate complicated jet flight conditions ..... BF44 Apr 15
Navy experimental moon-relay communications system demonstrated ..... EN11 Feb 5
Navy survey predicts end equipment sales up $1.3 billion in 1960 ..... EN11 May 13
Navy's Corvus carrier aircraft missile, with passive radar guidance, gets contract push ... BTW11 Mar 11
Navy's surface warships to get new dual-purpose guided missile system called Typhon ..... BF49 Apr 29
New AF-operated facility uses computers and complex communications system to coordinate space surveilance, catalog everything in orbit BF34 Mar 4
Nuclear bomb alarm system design to positively identify atomic explosions installed by AF .... BTW11 Apr 8
Oceanographic research indicates undersea fleet effectiveness could be doubled by environmental forecasts ..... BF36 Jan 22
Portable power-pack using 30 ion-membrance fuel cells under development for Marine and Army .. PC53 May 6
Project Defender, a study program to find tomorrow's space defense, to use pincushion radar ..... BF42 Feb 26
Project Madre to use magnetic-drum receivers to autocorrelate echoes form over-the-horizon radar missile warning system ..... BF28 Feb 5
Project Midas heat-seeking missile defense satellite to work with BMEWS radar ..... BF42 Apr 1
Project Tepee detects both missile launchings and nuclear explosions using over-the-horizon radar BF28 Feb 5
Propagation of electromagnetic waves through subsurface of earth being studied for AF ..... BTW11 Mar 4
Prototype of SAC's Automatic Combat Control System (SACCS) being set up ..... BF36 Mar 25
R&D costs for Army's Nike-Zeus anti-missile pass $½ billion ..... PC45 Jan 15
Radar warning system that gives 3-dimensional information can be airlifted to site ..... EN11 Jan 1
Rapid scan spectrometer detects and analyzes infrared energy radiated during power flight portions of missile trajectory ..... TF86 May 20
Rearward communications for BMEWS provided by submarine cable from Greenland to north of Arctic Circle ..... BF42 Feb 5
Remote Underwater Manipulator (RUM), a converted Ontos tank, uses TV guide for exploring, installing and removing fixed sonar gear ..... BF31 Jun 17
Replacement parts, repairs and modifications to cost military $900 this year ..... MR30 Apr 1
R-f cables and connectors for military applications (See p42, Dec 25, 1959 issue for 1st part of this article) ..... TF90 Jan 1
Role of electronics in Japan's defense set up ..... SR53 May 27
Search radar facility built by Air Force to provide defense against airborne vehicles ..... PC45 Jan 1
Services need inventions in component, transistor, antenna and instrument areas ..... BF39 Jan 22
Simulator for selecting best possible target among all in-range attackers ..... RO76 Jan 29
Sonobuoys and repair kits bought by Navy for antisubmarine warfare ..... EN11 Jan 15
Telemetry transmitter for ICBM operates through ionized plasma around re-entry missile ..... BTW11 Feb 12
Three infrared and visual detectors under development may change design concepts in advanced military and industrial equipment ..... EN11 May 27
Titan flight test program will use pulse-code-modulation telemetry system ..... BTW11 Mar 4
Transistorized radiation monitor sounds alarm when alpha and beta radiation reaches preset level in nuclear-powered Navy vessels ..... TF43 Jan 22
Transistorized receiver in model ship helps Navy trainees to study ship-handling problems ..... PC43 Apr 29
Where Polaris stands today -- ELECTRONICS visits Navy's first ballistic missile assembly installation ..... BF32 Apr 15
• Will debate over military policy mean orders or cutbacks? ..... BF26 Mar 4
Wire-guided missiles developed in Europe being appraised by Army ..... BF38 Jan 15
Milliammeter sorts look-alike metals using thermoelectric effect to detect polarity ..... PT72 Jan 8
Millimeter components, specifications for ..... CM68 Feb 19
Millimeter wave amplifiers made from reflex klystrons ..... TF71 Mar 18
Millimeter wavelength pulsed magnetrons develop high power ..... CM96 Mar 18
Millimeter waves research promises communications applications ..... TF159 Mar 11
Milling, electron beam metalworking equipment for PT86 Feb 26
MILS (missile-impact locating system) developed for Navy uses oceanographic sound-ranging techniques ..... EN11 Jun 17
Miniature gas-filled stepping tubes for counters operating up to 1Mc ..... TF46 Feb 19
Minuteman's guidance and control systems need reliable components for underground storage lasting years ..... BF39 Jun 17

MISSILES (See also Military Electronics)
Accurate pulse-code modulation system for missile telemetering being built ..... EN11 Jan 1
Automatic fault-finding system for testing battery control center of Hawk Weapons System ..... TF60 Jun 17
BMEWS detection and communication system prime contractors get contract awards ..... EN11 Feb 26
Ceramic-based microminiature adder for ballistic missile computer ..... CM96 Jan 1
Department of Defense pushing program to find out more about radar signatures for ICBM's ..... EN11 Jun 17
Eliminating communication blackout resulting from plasma sheath formation during vehicle reentry using sufficiently high frequency ..... TF105 May 27
Federal spending on missiles for coming fiscal year to level off ..... BF32 Jan 29
Five different electronic firms in five European countries to produce Hawk air defense guided missile ..... BF33 May 6
Galactic noise measured by 4-stage sounding rocket ..... EN11 Jan 8
Ground based missile roll control system uses photosensitive or infrared detectors ..... RO80 Mar 25
Invisible electronic shield for baffling radar and radar-guided missiles is reported ..... EN11 May 6
Maneuverable dish radar to scan and track ballistic missiles for BMEWS ..... BF47 Mar 18
Match-head size tunnel diode holds great promise for missile satellite and ultra-high-speed data processing applications ..... PC69 Mar 4
Million-watt transmitter being developed will detect missile launchings by detecting echoes from ionized trails ..... BF41 Jan 29
Miniature tv camera system transmitted high-resolution pictures from Redstone missile ..... BTW11 Mar 25
Minuteman inertial guidance and flight controls get $115-million boost ..... EN11 Jan 8
Minuteman's guidance and control systems need reliable components for underground storage lasting years ..... BF39 Jun 17
Missile-impact locating system (MILS) developed for Navy uses oceanographic sound-ranging techniques ..... EN11 Jun 17
Missile telemeter-radio interference: Cause and cure ..... BF24 Jan 8
Missile tracking ship to get more radar measuring equipment ..... EN11 Jan 1
Missiles and space continue to account for much government money spent in guidance and componentry research area ..... EN11 Jun 3
Mobile controller-recorder programs temperatures to test missile components ..... PC34 Jun 17
More U.S. gear going into second generation of British missiles ..... BF32 Mar 25
Navy's Corvus carrier aircraft missile, with passive radar guidance, gets contract push ... BTW11 Mar 11
Navy's surface warships to get new dual-purpose guided missile system called Typhon ..... BF49 Apr 29
New Mexico's electronics industry now in multi-million dollar bracket through missile development, R&D ..... BF41 Apr 15
Nonablative nose cone to be used to determine effects of plasma sheath on radio signals ..... RD66 Feb 5

Participants in Sixth National Flight Test Instrumentation Symposium hear that U.S. is far ahead of Soviets in ballistic missile and satellite fields ... BF53 Jun 3
Precision Atlas gruidance system recently used to to measure rotation of earth ... EN11 Jun 17
Probes make patterns of airflow around missile nose cone inside hypersonic wind tunnel in color ... BF52 Feb 26
Project Defender, a study program to find tomorrow's space defense, to use pincushion radar ... BF42 Feb 26
Project Madre to use magnetic-drum receivers to autocorrelate echoes from over-the-horizon radar missile warning system ... BF28 Feb 5
Project Tepee detects both missile launchings and nuclear explosions using over-the-horizon radar ... BF28 Feb 5
Propagation of electromagnetic waves through subsurface of earth being studied for possible use as missile communication network by AF ... BTW11 Mar 4
R&D costs for Army's Nike-Zeus anti-missile pass $½ billion ... PC45 Jan 15
Radar transmitter for anti-missile Zeus being tested ... BF34 May 27
Radar view of atlas ICBM ... BF45 Feb 26
Radiation-operated fuel gage for missiles and aircraft ... RD117 Apr 29
Radioisotope density altimeter is designed for missiles and fast new aircraft ... BF37 Jan 8
Rapid scan spectrometer detects and analyzes infrared energy radiated during power flight portions of missile trajectory ... TF86 May 20
Rearward communications for BMEWS provided by submarine cable from Greenland to north of Arctic Circle ... BF42 Feb 5
Signal transmission through natural ionized layers and ion shields formed by nuclear vehicles, hypersonic reentry vehicles, rocket motor exhausts and nuclear explosions ... TF81 May 20
Sixty-ft reflector for 3-axis antenna provides hemispheric coverage of missile and satellite telemetered data ... PC40 Jan 1
Steel marble used as moving short circuit to analyze sensitivity of fuzes used in guidance and detonation missiles ... PC48 Apr 29
Super-power uhf ceramic-metal tube developed for possible long-range radar missile detection and intercontinental tv ... TF70 Apr 8
Telemetry transmitter for ICBM operates through ionized plasma around re-entry missile ... BTW11 Feb 12
Titan flight test program will use pulse-code-modulation telemetry system ... BTW11 Mar 4
Transistorized circuits for guiding Able series space exploration probes ... TF60 Jan 29
Ultrasonic resonance thickness gage measures missile radomes and nose cones ... PC86 Feb 26
Waveguide 2,200 ft long delivered to AF missile center ... EN11 Jan 1
What designers should know about performance of missile components in dynamic environments ... TF102 Apr 29
Where Polaris stands today — ELECTRONICS visits Navy's first ballistic missile assembly installation ... BF32 Apr 15
Will debate over military policy mean orders or cutbacks? ... BF26 Mar 4
Wire-guided missiles developed in Europe being appraised by Army ... BF38 Jan 15
Mixer circuit for comparator used in automatic fault-finding system for testing battery control center of Hawk Weapons System ... TF60 Jun 17
Mixer, compact hybrid microwave, for airborne radar receiver is now available ... CM70 Feb 5
Mixer, tv tuner, specially developed diffused-base mesa transistor used in ... TF64 Apr 8
MOBIDIC used drive-sampling core to generate precisely defined strobes to solve noise problems ... TF72 Mar 25
Modulation and remodulation problems solvable using graphical extension of transfor techniques ... TF68 Apr 1

MODULATORS
Completely passive, balanced modulator circuits using thin permalloy film described at 1960 Winter Convention on Military Electronics ... RD78 Feb 26
Frequency modulating a resonant circuit using reactance switching technique ... TF74 Feb 26
Phase-shift modulator for double-sideband suppressed carrier transmitter ... TF47 Feb 5
Power tubes for pulse modulators ... SR55 Apr 29
Pulse-position modulator used in vhf telemetry system for eliminating communication blackout from plasma sheath formation during vehicle reentry ... TF105 May 27
Telemetry transmitter for investigating Van Allen radiation belt uses novel transistorized phase modulator circuit ... TF68 May 6
Transistorized f-m modulator for tape target classifier used to train land-based sonar student operators ... TF65 Mar 25
Modules, half-inch cube holding 12 to 18 components used in reconnaisance drone guidance system, commercial and military computers ... CM123 Apr 29
Modules in battery control center of Hawk Weapons System tested by automatic fault-finding system ... TF60 Jun 17
Modules, peg board type pallet permits connections to be dip soldered ... PT192 Mar 11
Modules, thermoelectric cooling of, for electronics components in R&D stage ... RD68 Feb 5

MONITORS
(See also Displays, Indicators and Readout Devices)
Closed-circuit tv for monitoring dental surgery and for assisting in diagnosis being studied ... TD92 Jan 1
Closed-circuit tv monitors quality during production of mesa transistors ... PT86 Apr 8
Data gathering and logging system monitors nuclear radiation levels and weather conditions ... RD64 Jan 22
Ground station monitoring circuit for slow-scan TV chain used with Stratoscope I ... TF49 Jun 17
Millipore filter tape instrument monitors high-purity water ... PT125 Jun 24
Monitoring production flow items gets good start in Britain ... BF52 May 13
Plane and vehicle movements monitored by tv system ... BF44 Mar 25
Pulsed x-ray pencil beam gages thickness of hot and cold rolled metals ... PC62 Jan 22
Selective calling system for aircraft data links removes necessity of continuously monitoring a communication channel ... TF108 Apr 29
Step-van truck with instruments for measuring air pollution developed ... BF48 Feb 12
Technique for checking calibration of f-m and t-v transmitter percentage-of-modulation monitors ... TF67 Apr 15
Transistorized monitor developed to test electrical contacts under shock and vibration conditions ... RD78 Apr 8
Translstorized radiation monitor sounds alarm when alpha and beta radiation reaches preset level in nuclear-powered Navy vessels ... TF43 Jan 22
Monochromator, rapid scan, for spectrometer used to detect and analyze infrared energy radiated during power flight portions of missile trajectory ... TF86 May 20
Monochromator system automatic for determining the spectral response of electro-optical materials ... TF66 Apr 1
Monoscope-camera system converts computer data into visual form on microfilm ... BF11 Feb 26
Monoscope tube generates characters for direct readout on a cro or on paper of digital computer output ... TF117 Feb 12
Moon relay communications system kicks off Armed Forces Communications and Electronics Association's 14th Convention ... BF42 Jun 10
Morphology of 27 possible electro-optical power amplifiers ... TF71 Feb 26
Motors, printed-circuit, answers to questions about ... CM80 Apr 22
Motors, printed, interest in mounts as electric auto talk is revived ... BTW11 Apr 22
Motors, step, drive milling machine via thyratron-controlled signals from a programmed tape ... TF174 Mar 11
Mount, floating, for uhf triodes ... CM68 Jan 8
Multiplex circuits control robot which performs jobs in dangerously radioactive areas ... TF46 Jan 22
Multiplex system, British, for billingual broadcasts or conventional stereophonic transmissions ... TF87 Jun 3

MULTIPLIERS
Photomultiplier and electrometer measure fluorescence of glass dosimetry needle to determine radiation exposure in human body ... TF74 Mar 18
Polarity coincidence multiplier detects weak low-frequency signal in high-noise background ... TF67 Jan 29
Q multiplier used as oscillator in electronic wire gage for nondestructive measurement of wire thickness ... TF109 Feb 12
Specifications of frequency multiplier used in millimeter band ... CM68 Feb 19
What's new in multiplier phototubes ... SR55 Apr 29
experimentally as multivibrator ... BF42 Mar 18

MULTIVIBRATORS
Cadmium sulfide field-effect transistor used
Choosing transistors for monostable multivibrators used as variable delay generators ... ERS58 Jan 22
Cadmium sulphide field-effect phototransistors used successfully in oscillator, multivibrator, amplifier and radiation detector circuits ... EN11 Feb 26
Graphical method of solving sweep oscillator multivibrator instability problems encountered in tv receivers ... TF55 Feb 19
Insuring stability in precision time delay multivibrators used in radar and industrial electronics ... TF73 Apr 8
Multivibrators grown from pool of molten semiconductor materials ... BTW11 Jan 29
Saturating-core multivibrator used as power converter in portable battlefield radar ... TF67 Mar 18
Starter multivibrator for coding circuit used to record output of tv system tracking eye focus points and movements ... TF57 Apr 22
Trigger multivibrator for self-powered transistor oscilloscope ... TF80 Mar 18
Music synthesizer potential for forming new music being investigated by Joint Columbia University-RCA project ... BF60 Mar 11
Mutators, or power amplifiers, for handling various combination of electric, radioactive and thermal power ... TF71 Feb 26
Mylar magnetic disk memory unit stores 50,000 to 60,000 bits ... TF55 Jan 29

N

NAVIGATION SYSTEMS
(See also Air Traffic Control, Aviation and Guidance Systems)
Automatic gas-fume detector alarms, Loran, radiotelephones, direction finders, and depth sounder fish finders make up new $10-million small boat market ... BF30 Jan 22
Electronics R & D in navigation systems in France ... SR75 Feb 12
FAA 1960 program to concentrate heavily on air navigation facilities ... BF40 Feb 12
FAA orders test monitoring control equipment to check out VORTAC air navigation system ... EN11 Feb 26
FAA rules out British Decca Mark X hyperbolic system for navigation ... BTW11 Jan 22
Optical-electronic active system for communications, navigation, and tracking and acquisition applications ... TF71 Jan 15
Precipitation static eliminated from airborne radio and navigation equipment by sharp tungsten pins ... RD96 Jun 3
Study of atmospheric noise needed to develop long-range vlf navigation systems ... RD78 Apr 8
Navigation for hypersonic or space craft aided by computer-directed map projection system under development ... EN11 Jun 3
Negative resistance elements, use of in active circuit synthesis ... BF44 May 20
Neon lamp on rotating arm of constant speed motor replace crt in portable transistorized depth indicator ... TF50 Feb 5
Nemst effect, definition of ... TF71 Feb 26
Network, twin-T, charts normalized for frequency provide rapid solution to parameters for ... ERS67 Jun 17
Networks, semiconductor for microelectronics
Networks synthesis rather than analysis stressed at Conference on Active Network and Feedback Systems ... BF44 May 20
Neuron model and electronic equivalent discussed at winter meeting of AIEE ... BF28 Feb 19
Nixies switched by means of Trixies which use transistor reverse-biasing technique to raise breakdown point ... TF48 Jan 8
Noise, digital sampler for measurement of axis-crossing intervals for theoretical studies of ... TF88 Jun 3
Noise, effect of on range parameters of active and passive sonar ... TF41 Feb 19
Noise figure measurement of microwave amplifiers uses hot and cold constant-impedance loads ... RD66 Feb 5
Noise measurement, portable transistorized sound lever meter for ... TF64 Jun 17
Noise problems in digital computer memories solved using drive-sampling core to generate precisely defined strobes ... TF72 Mar 25
Noise problems of photomultipliers solved by sensitive flaw detector for finding defects in paper ... TF64 Apr 15
Noise suppression factor display unit computes and automatically displays ratio of two time-varying quantities ... TF55 Feb 5
Nomograph gain and beamwidth of helical antenna obtained with one setting of straightedge on ... ERS180 Mar 11
Nomographs for estimating radiation capability low-frequency electically-short antennas ... ERS86 Mar 18

NUCLEONICS (See also Radiation)
Accurate and stable pulse height discriminator for nuclear physics work ... TF89 May 20
Air transportable nuclear reactor now in instrumentation stage ... EN11 Jan 1
Applications of ignitrons in nuclear fields ... SR55 Apr 29
Astracon, a small light amplifier tube, increases light-gathering ability of telescopes, permits viewing of high-energy particle tracks ... PC82 Jun 10
Battery-powered transistorized scale-of-64 counter for measuring radioactive tracers, improves reliability, reduces cost and weight ... TF74 May 6
Cadmium sulfide field-effect transistor used experimentally as radiation detector ... BF42 Mar 18
Cesium cell converter working at high temperatures produces significant amounts of a-c electricity ... CM78 Jan 29
Data gathering and logging system monitors nuclear radiation levels and weather conditions ... RD64 Jan 22
Double-focusing mass spectrometer measures relative amounts and weights of atoms ... RD74 Jan 29
Electronics R & D in nuclear energy in France and Israel ... SR75 Feb 12
Generation, detection and transmission of millimicrosec transients being studied at University of Kansas under Navy grant for Project Jayhawk ... BF60 Mar 11
Light sensor in automatic bomb alarm system now being installed in strategic U. S. cities ... PC45 Apr 8
Measuring flow rates of a variety of fluids by detecting nuclear magnetic resonance ... TF77 Apr 1
Microminiature tube circuits featuring nuclear radiation resistance offered at IRE International Show and Convention ... BTW11 Apr 1
Multiplex circuits control robot which performs jobs in dangerously radioactive areas ... TF46 Jan 22
Nuclear bomb alarm system design to positively identify atomic explosions installed by AF ... BTW11 Apr 8
Nuclear-fueled power plant using magnetohydrodynamic generators being studied ... RD92 Jan 1
Nuclear instrument shipments for 1958 rise 33 percent over those of 1957 ... MR22 Feb 19
Project Tepee detects both missile launchings and nuclear explosions using over-the-horizon radar. BF28 Feb 5
Proton synchrotron of European Organization for Nuclear Research in Operation ... EN11 Jan 1
Quartz crystals and atomic clocks are subjects of major interest at 14th anual Frequency Control Symposium ... BF38 Jun 24
Radar field causes continuous discharge in bulb with gas of reduced pressure ... PC83 Apr 15
Radiation-operated fuel gage for missiles and aircraft ... RD117 Apr 29
Response of electronic system components and materials to irradiation from nuclear-powered aircraft ... TF69 Apr 22
Semiconducting industrial diamonds may find application as counters of radio-activity ... RD76 Apr 22
Semiconductor wafer Hall probe in magnetic field plotting system speeds cyclotron design ... RD80 Apr 8
Signal transmission through natural ionized layers and ion shields formed by nuclear vehicles, hypersonic reentry vehicles, rocket motor exhausts and nuclear explosions ... TF81 May 20
Silicon-carbide rectifier that withstand 500 C and in useable in nuclear environments ... CM94 Mar 18
Silicon pn junctions used as particle detectors ... RD74 Apr 22
Solid-state radiation detector made of doped silicon gives new speed and accuracy to particle analysis ... BTW11 Feb 5
Transistorized pulse generator for synchronizing events in zero-gradient synchrontron ... TF63 Jun 10
Transistorized radiation monitor sounds alarm when alpha and beta radiation reaches present level in nuclear-powered Navy vessels ... TF43 Jan 22
Vibrating platform uses beads to simulate atomic motion ... PC74 Jan 29
West Berlin's Institute for Nuclear Research gets new transistorized computer ... BF31 Jun 10
Nuvistor goes into production ... BF35 Feb 19

O

OCEANGRAPHY (See also Sonar)
D-c transistor amplifier for measurement of low-amplitude long-period surface waves of ocean ... TF85 Jan 1
Equations and charts for determining range parameters of active and passive sonar systems ... TF41 Feb 19
Missile-impact locating system (MILS) developed for Navy uses oceanographic sound-ranging techniques ... EN11 Jun 17
Oceanographers position undewater photographic cameras, take samples of sea water and bottom sediments with help of sonar ... TF93 Jun 24
Oceanographic research indicates undersea fleet effectiveness could be doubled by environmental forecasts ... BF36 Jan 22
Remote Underwater Manipulator (RUM), a converted Ontos tank, uses TV guide for exploring, installing and removing fixed sonar gear ... BF31 Jun 17

Underwater camera flash and film-rewind circuits control picture taking at depths of 6 miles. .... TF62 Apr 8
Oil lines buried undersea detected by metal locator which generates electromagnetic field ..... BF57 Jan 15
Operation Skyhook balloons will study cosmic rays at 18 to 22 mi altitudes ..... EN11 Jan 1

OPTICS (See also Infrared and Photography)
Astracon, a small light amplifier tube, increases light-gathering ability of telescopes, permits viewing of high-energy particle tracks..... PC82 Jun 10
Automatic spectroscopic system for determining the spectral response of electro-optical materials..... TF66 Apr 1
Fiber optics used in closed-circuit tv dental monitor ..... RD92 Jan 1
Non-newtonian color optics being used in color-reception system using two monochrome tubes shown at regional meeting of Society of Photographic Scientists and Engineers ..... EN11 Jun 24
Optical-electronic active system for communications, navigation, and tracking and acquisition application..... TF71 Jan 15
Optical-electronic magnetometer control attitude of vehicles in space..... TF55 Apr 8
Optical maser growth expected to grow in next two years ..... TF159 Mar 11
Optical measurement for evaluating three-element semiconductor materials ..... TF103 Feb 12
Orientation of vehicles in space using optical-electronic magnetometer as control ..... TF55 Apr 8
Polyoptic sealing technique improves the reliability and life of glass envelope electron tubes PT114 May 20
Power amplifiers using electro-optical effects handle various combinations of electric, radioactive and thermal power ..... TF11 Feb 26
RCA to open research laboratory in Japan to study electrical, magnetic and optical properties of solid-state phenomena ..... EN11 Jun 24
Recording optical tracking instrument (ROTI) used with rapid scan spectrometer to detect infrared energy radiated during power flight portions of missile trajectory..... TF86 May 20
Unconventional slow-scan TV chain assists astronomers in finding sunspots with balloon-borne optical telescope ..... TF49 Jun 17

OSCILLATORS
Balanced-bridge and semiconductor diode circuits for one-tube oscillator-mixers in tv and f-m tuners..... TF76 Jan 15
Cadmium sulfide field-effect transistor used experimentally as oscillator ..... BF42 Mar 18
Cadmium sulphide field-effect phototransistors used successfully in oscillator, multivibrator, amplifier and radiation detector circuits..... EN11 Feb 26
Continuously running crystal-controlled transistor oscillator gate for pulse-height-to-digital signal converter..... TF98 Jan 8
Designing high-frequency, high-power transistor oscillator circuits..... TF52 Jan 8
Designing simultaneous dual-frequency oscillators ..... RD182 Mar 11
Determining proper bias and correct circuit impedances for operating tunnel diodes as switches, amplifiers or oscillators..... TF82 Jun 3
Dynamic tester evaluates transistors by their performance as component in oscillator circuit.. RD66 Feb 19
Eight-pulse transistor train oscillator for pulse-height-to-digital signal converter..... TF58 Jan 8
Flow rate of jet fuel containing radioactive tracer measured by simultaneously gated oscillator and radiation detector..... TF98 Feb 19
Graphical method of solving sweep oscillator multivibrator instability problems encountered in tv receivers..... TF95 Feb 19
High-voltage oscillator supply for self-powered transistor oscilloscope..... TF80 Mar 18
Plasma circuit used as an oscillator to generate microwave energy at 2,000 Mc ..... BTW11 Mar 4
Precision R-C oscillator uses controlled phase-shift network in feedback loop get high degree of frequency stability..... TF76 Apr 15
Q multiplier used as oscillator in electronic wire gage for nondestructive measurement of wire thickness ..... TF109 Feb 12
Specially developed diffused-base mesa transistor used in oscillator for tv tuner..... TF64 Apr 8
Subharmonic phase-locked oscillator give promise of microwave computer operation ..... TF95 Jan 29
Transfluxor (magnetic-electronic) oscillator retains last frequency setting many hours after control signal removal ..... TF48 Mar 4
Tunnel diode microwave oscillator and amplifier circuits reported at 1960 Solid-State Circuits Conference ..... TF39 Mar 4
Typical semiconductor phase-shift oscillator for microcircuits ..... TF69 May 13
Varactor diodes available in experimental quantities, used for high-efficiency subharmonic oscillators in microwave computers..... CM131 May 27
Variable 90-Mc oscillator for precision phase-meter used for c-w and pulsed uhf ..... TF54 Mar 4
What's new in backward-wave and magnetron oscillator tubes..... SR55 Apr 29

OSCILLOSCOPES & OSCILLOGRAPHS
Digital oscilloscope for direct readout of amplitudes and waveforms announced ..... EN11 Feb 5
Digital readout oscilloscope shown at IRE Show.. BF47 Apr 1
Oscilloscope and oscillograph market will increase 50 percent between 1962 and 1969 ..... MR24 Feb 5
Oscilloscope with direct digital readout of amplitude and duration of pulse signals reduce operator errors, cut measurement time ..... BF30 Mar 4
Sampling attachment for conventional oscilloscopes can resolve rise times of 1/3 nanosec with repetition rates up to 50 Kc ..... TF96 Jun 24
Sampling oscilloscope permits measurement of computer diode recovery times down to 500 picosec..... TF59 Apr 8
Self-powered transistor oscilloscope has response from d-c to over 5 Mc ..... TF80 Mar 18
Two-tube generator provides accurate, stable intensity marker for oscilloscope over 8 to 22 Mc frequency range for bandpass measurements.... TF108 Jun 24
Use of stroboscope principle for nano and picosecond oscilloscopes described ..... EN11 May 27
What's new in cathode ray tubes for oscillography SR55 Apr 29
Oven, electronic, uses microwave technique for assembly line production of pre-frozen meals..... BF47 Jun 10
Overload circuit, transistorized, for production and maintenance testing of transistors with low d-c voltages ..... RD125 Feb 12

P

Paging system, selective, uses coded transmission for voice intercommunications with up to 45 Stations ..... TF68 Feb 68
Paper and plastic film capacitors, characteristics of ..... TF78 Mar 25
Paper defects found by sensitive flaw detector system ..... TF64 Apr 15
Parabolic reflectors used in modern microwaves.... SR67 Jun 24
Parametric amplifier, electron-beam, operated in synchronous pumping mode improves receiver sensitivity, increases range of coho MTI radar by 50 percent ..... RD92 May 13
Parametric amplifier increases range of S-bandradar used to track reentry vehicles ..... RD116 Apr 29
Parametric amplifier, linear-beam, microwave tube for ..... SR55 Apr 29
Parametric amplifiers with variable-capacitance diodes expected to start appearing in systems soon ..... TF159 Mar 11
Parametric resonance, electronic, discussed at Instrument Society of America Meeting ..... BF47 Jun 24
Parametron logic, register, adder, counter, translator and converter circuits for digital computers . TF73 Jun 3
Patent protection in Russia obtainable only by applying for Russian patents ..... EN11 Jan 8
Patent searching using computer techniques being tested by U. S. Patent Office ..... RD124 Feb 12
Peltier effect, definition of ..... TF71 Feb 26
Peltier effect gives wide-range temperature control . TF71 Jan 15
Perceptron, Mark I, demonstrates ability to learn the alphabet ..... BF43 Jun 24
Perceptron, new development in learning systems TF159 Mar 11
Periodic focused traveling wave tubes, what's new in ..... SR55 Apr 29
Phasemeter measures two signals in 100 to 520 Mc band with 0.2 degree for c-w and 0.5 degree for pulsed uhf ..... TF54 Mar 4
Phasemeter, polarity coincidence multiplier used as TF67 Jan 29
Phenolic laminate, paper-base, provides flame retardance with excellent cold punching characteristics ..... CM103 Jun 3
Phosphors for cathode ray tubes, what's new in ... SR55 Apr 29
Photocells, silicon, used as detectors in projector optical sound track pickup ..... PC68 Jan 8
Photoconducting infrared detectors, characteristics of ..... TF72 Apr 1
Photoconductive power amplifiers using electro-optical effects handle various combinations of
Photoelectric blood pressure meter developed by Russians ..... RD75 Jun 17
electric, radioactive and thermal power ..... TF71 Feb 26
Photoelectricity, researchers demonstrate experimental photogenerator for converting solar energy by photoelectric emission ..... EN11 May 27
Photoelectromagnetic detector, uncooled, made of indium-antimonide responds to long infrared wavelengths ..... TF62 Mar 25
Photoelectromagnetic infrared detectors, characteristics of ..... TF72 Apr 1

PHOTOGRAPHY (See also Infrared and Optics)
MIT interplanetary space probe to take photographs of 40 percent of Mars' surface ..... BF49 May 20
Monoscope-camera system converts computer data into visual form on microfilm ..... BF11 Feb 26
Oceanographers position underwater photographic cameras, take samples of sea water and bottom sediments with help of sonar ..... TF93 Jun 24
Photographic system records electromagnetic radiation from lightning (sferics) propagated over long distances ..... RD64 Mar 4
Photographically-sensitized metal sheet makes custom labels for instrument and test equipment panels ..... PT100 Jan 1
Single-transistor circuit forms efficient photoflash power converter ..... TF57 Jan 22
Transistorized f-m uhf receiver for camera control system used in rocket sled tests ..... TF63 Apr 1
Underwater camera flash and film-rewind circuits control picture taking at depths of 6 miles .... TF62 Apr 8
Watchdog satellites to carry TV cameras and electrostatic tape recorders to check performance of other satellites..... BF98 Jun 10
Photorectifier based on combination of photoconductor and electret reported at 1960 Solid-State Circuits Conference ..... TF39 Mar 4
Phototubes, what's new in ..... SR55 Apr 29
Photovoltaic effect, definition of ..... TF71 Feb 26
Photovoltaic infrared detectors, characteristics of TF72 Apr 1
Pico transistors made of triple-diffused npn silicon mesa designed as low-power high-speed switches CM82 Apr 8
(See also Magndohydrodynamics)
Piezoelectricity, high degree of, discovered in zinc oxide and cadmium sulfide ..... BF52 Jun 24
Pinger, sonar, helps oceanographers position underwater photographic cameras, take samples of sea water and bottom sediments ..... TF93 Jun 24

PLASMA PHYSICS
(See also Magnetohydrodynamics)
Eliminating communication blackout resulting from plasma sheath formation during vehicle reentry using sufficently high frequency ..... TF108 May 27
Gas plasma gun sprays materials with high melting points onto materials with relatively low melting points ..... PT77 Feb 5
Magnetohydrodynamics symposium of AIEE points up electronics industry's growing interest in plasma research ..... EN11 Mar 4
Magnetohydrodynamics takes on new significance to electronics industry ..... BF52 Mar 11
NASA contracts for design of experimental cesium-stream ion engine ..... EN11 Jun 17
New development in plasma physics ..... TF159 Mar 11
Nonablative noise cone to be used to determine effects of plasma sheath on radio signals ..... RD66 Feb 5
Plasma circuit used as an oscillator to generate microwave energy at 2,000 Mc ..... BTW11 Mar 4
Properties of representative liquid polymers for cold-molding cable systems ..... TF67 May
Telemetry transmitter for ICBM operates through ionized plasma around re-entry missile ..... BTW11 Feb 12
Unique instrumentation for investigating possibilities of using plasma to propell space vehicles ..... TF66 Jun 10

PLASTICS
Dollar value of plastics parts produced by electronics companies in 1959 is $250 million, double 1958's $125 million ..... MR24 Jun 24
Flexible Mylar magnetic disk memory unit stores 50,000 to 60,000 bits ..... TF55 Jan 29
Plastic and paper film capacitors, characteristics of ..... TF78 Mar 25
Plastic holders for rack-mount printed circuit cards developed ..... PT85 Jan 29
Plastic laminates for missile use give substantially superior ablation resistance ..... CM84 Apr 15
Plastic skin packaging for electronic components, wire and circuit board assemblies and electro-mechanical parts ..... PT82 Jan 29
Plastic type transistor developed by Soviet scientist ..... EN11 Jan 1
Plotter, high-speed digital, cuts time for reducing telemetered data ..... TF41 Jan 8
Report on semiconductive plastics – in U.S.S.R. and in U.S.A. ..... CM68 Jan 22
Spincasting of plastic parabolic radio mirrors may provide antenna surface accuracies presently not practical ..... RD96 Jan 15
USSR claims to have made transistors from plastic fiber using bombardment techniques ..... BF26 Jan 22
Vacuum-formed plastic skin protects unhoused relays mounted on plug-in printed circuit boards PT195 Mar 11
Plating, brush, air-operated masking jig speeds precision soldering of transistor tabs ..... PT70 Mar 4
Plating, techniques for correcting rhodium plating defects ..... PT124 Apr 29
Polarity coincidence multiplier detects weak low-frequency signal in high-noise background ..... TF67 Jan 29
Pollution, air, step-van truck with instruments for measuring developed ..... PC48 Feb 12
Polyethylene with high tensile strength at high temperatures used for films, tapes, molded industrial parts, and wire and cable insulation ..... CM84 Apr 15
Polyoptic sealing to extend military tube life ..... EN11 May 6
Post office, self-service, installed in twin cities .. PC48 Jun 3
Potentiometer dials and knobs drilled-tapped and assembled by six-spindle turret ..... PT90 Mar 25
Potentiometers, variable, grown from pool of molten semiconductor materials ..... BTW11 Jan 29
Potting cable systems, properties of representative liquid polymers for ..... TF67 May 6
Potting base of electron tubes, material for ..... CM84 May 6
Power dissipation, reduction of in receiving-type electron tubes being researched ..... SR55 Apr 29

POWER SOURCES & SUPPLIES (See also Batteries)
Basic design considerations of silicon solar cells for use as power supplies on satellites ..... TF167 Mar 11
Cesium cell converter working at high temperatures produces significant amounts of a-c electricity CM78 Jan 29
Fuel cell power supply for Marine and Army portable field radar to be delivered ..... EN11 Apr 29
Linear circuits used to obtain precise voltage regulation of output of transistorized d-c to a-c inverter ..... TF61 Apr 15
Magnetohydrodynamics power plant generators offering high-efficiency output being studied RD92 Jan 1
Portable power pack using 30 ion-membrane fuel cells under development for Marine and Army PC53 May 6
Silicon solar cells power automobile ..... PC52 Jun 24
Single-transistor circuit forms efficient photoflash power converter ..... TF57 Jan 22
Solar-powered call system gives drivers choice of emergency highway service..... PC53 Jun 3
Sophisticated electronic gear on ships may mean use of more solid-state power supplies ..... EN11 Feb 12
Thermoelectric generator built which delivers 5 Kw by direct conversion of heat into electricity without major moving parts..... RD96 Jun 3
Power tubes, high-vacuum, what's new in ..... SR55 Apr 29

PRINTED CIRCUITS
(See also Microminiaturization and Thin Films)
Answers to printed circuit motor questions ..... CM80 Apr 22
Bins feed small parts in assembly sequence during manufacture of printed circuit boards ..... PT88 Apr 8
Interest in printed motor mounts as electric auto talk is revived ..... BTW11 Apr 22
Laminate with properties of Teflon and glass ideal for high-temperature printed circuits and microwave applications..... CM79 Jun 17
Low-pressure air mist efficient method to cool components during manual soldering of printed circuits ..... PT104 May 13
Plastic-backed paper negatives transfer etched circuit wiring patterns onto copper-clad epoxy glass laminates ..... PT70 Mar 4
Plastic holders for rack-mount printed circuit cards developed ..... PT85 Jan 29
Plug-in type single-ended tantalum foil capacitors give more capacitance in less space ..... CM98 Jan 1
Printed circuit masters drafted on film with ultraviolet light ..... PT80 Jun 17
Production of large ceramic pieces to serve as circuit boards reported..... CM87 May 6
Silk screening machine for semiautomatic production of printed circuits has traveling head ..... PT98 Mar 18
Transistors developed which are almost flush with print circuit boards ..... EN11 May 20
Vacuum-formed plastic skin protects unhoused relays mounted on plug-in printed circuit boards PT195 Mar 11
Strippable printed circuit negatives improve accuracy and design flexibility ..... PT82 Jan 29
Printer-plotter, solid state high-speed, prints and plots from computer-prepared magnetic tape ..... EN11 Jan 22
Probability analysis aided using graphical extension of transform technique ..... TF68 Apr 1
Probes make patterns of airflow around missile nose cone inside hypersonic wind tunnel in color ..... BF52 Feb 26

Process control, computer and automatic control uses in chemical, petroleum, railroad and broadcast industries discussed at winter meeting of AIEE ..... BF28 Feb 19
Process control transistorized digital computer for open-loop control in processing operations ..... BTW11 Feb 19

PRODUCTION TECHNIQUES

Adjustable punch and die kits for multiple-hole punching of short-run sheet metal parts announced ..... PT133 Feb 12
Air suspension helps regulate amplitude of vibratory finishing equipment ..... PT106 May 13
Apothecary weights used to measure brush contact force ..... PT74 Feb 19
Automated transistor assembly systems turns out npn alloy junction transistors for computers at rate of 1,800 per hour ..... BTW11 Feb 19
Automatic alloy boat loaders boost transistor production ..... PT122 Jun 24
Automatic assembly systems show little movement in Britain ..... BF52 May 13
Automatic control holds voltage across weld constant ..... PT102 Jan 1
Automatic control unit for operating dielectric strength testers ..... PT88 May 6
Bins feed small parts in assembly sequence during manufacture of printed circuit boards ..... PT88 Apr 8
Bridge circuit measures pulse response of armatures to pinpoint faults during production runs TF70 Jun 10
British approaches to producing microminiature circuits ..... TF71 Jan 1
Brush plating and air-operated masking jig speed precision soldering of transistors tabs ..... PT70 Mar 4
Characteristics and uses of electronic-production staples ..... TF68 Apr 15
Contour extruded aluminum tubing is being considered for waveguide components with integral flange ..... PT104 Jun 3
Control using voltage constraint and NOR logic improves consistency and reliability of spot welds ..... TF48 Feb 19
Current pulse generator for testing ferrite memory cores ..... TF80 Jan 1
Die makers get individual air conditioned, sound-proof booth ..... PC72 Feb 19
Digital programmer automatically adjusts and controls furnace temperature during preparation of high-purity materials ..... RD122 May 27
Drop-feeding and unloading of workpieces on centerless grinder steps up production of synchro shafts ..... PT74 Jan 22
Electron beam metalworking equipment for use in surface treating, welding, milling or drilling PT86 Feb 26
Electron sealing process using optically-ground and mated glass stem and envelopes to extend military tube life ..... EN11 May 6
Electron tube testing automatically prepares test data in digital form for computer analysis ..... PT74 Feb 5
Electronic oven uses microwave technique for assembly line production of pre-frozen meals in Holland ..... BF47 Jun 10
End-welded studs mount d-c power supply chassis to racking mounting panels ..... PT88 Apr 15
Erasers clean component leads ..... PT89 Apr 8
Fabricating semiconductor networks for microcircuits ..... TF69 May 13
Fit of mating glass parts can be accurately determined by methods known as the water drop and fringe pattern ..... PT106 Jun 3
Frame of radiation beams provides nondestructive, continuous method of testing cable insulation.. PT135 May 27
Fully automatic electromechanical machine assembles alloy-junction transistors of high uniformity and quality ..... TF57 Mar 25
Gas plasma sprays materials with high melting points onto materials with relatively low melting points ..... PT77 Feb 5
Germanium used in new alloy for brazing stainless steel ..... PT127 Apr 29
Germans cut prices of radio and TV sets through improved production techniques ..... BF49 May 13
High-purity silicon dielectric for potting transistors is nonmelting and greaselike ..... CM84 Apr 15
How built-in damping controls violent motion imposed by vibration ..... CM186 Mar 11
Improved lapping, polishing and base-plating of vhf quartz crystals developed ..... PT84 Apr 22
Ions detect pinholes in wire and cable insulation PT77 Feb 5
Low-pressure air most efficent method to cool components during manual soldering of printed circuits ..... PT104 May 13
Machine for assembling sealed contact reed relays housed in glass walled area ..... PT86 Apr 22
Magnetic spot-welding electrodes hold small parts to be welded to sheet or strip material ..... PT88 Apr 15
Making and using water virtually free of particulate matter, dissolved solids and gases ..... PT132 May 27
Mass spectrometer measures quantity of helium escaping in electron tube manufacture ..... TF74 Apr 1
Materials progress in transistor potting, high-tensile strength polyethylene and plastic laminates reported ..... CM84 Apr 15
Method of protectively coating beryllium metal described ..... PT91 May 6
Methods of metallizing ceramics for brazing into ceramic-metal assemblies ..... CM86 May 6
Micro-alloy diffused base transistor (MADT) fabrication improved using Etching by Transmitted Light (ETL) technique ..... BTW11 Apr 1
Microelectronics may cut semiconductor circuit production costs ..... BF36 Feb 12
Milliammeter sorts look-alike metals using thermoelectric effect to detect polarity ..... PT72 Jan 8
Millipore filter tape instrument monitors high-purity water ..... PT125 Jun 24
Miniature slip ring assembly starts with encapsulation, finishes with machining and metal deposition ..... PT106 Jan 15
Molding cable junctions, connectors and terminations with cast-in-place solid elastomers ..... PT90 Apr 1
Multi-aperture configuration simplifies core winding ..... CM70 Jan 8
Multipurpose fixture for fabricating bulky electronic equipment shelters and consoles ..... PT102 May 13
Novel handling techniques for producing super-power klystron over 10 feet tall ..... PT192 Mar 11
Odd-shaped cans made of easily-formed metal by filling simple die with Neoprene plug ..... PT91 Apr 15
Oscilloscope with direct digital readout of amplitude and duration of pulse signals reduce operator errors, cut measurement time ..... BF30 Mar 4
Peg board type pallet permits connections of modules to be dip soldered ..... PT192 Mar 11
Photographically-sensitized metal sheet makes custom labels for instrument and test equipment panels ..... PT100 Jan 1
Plastic-backed paper negatives transfer etched circuit wiring patterns onto copper-clad epoxy glass laminates ..... PT70 Mar 4
Plastic holders for rack-mount printed circuit cards developed ..... PT85 Jan 29
Plastic skin packaging for electronic components, wire and circuit board assemblies and electromechanical parts ..... PT82 Jan 29
Polyethylene glycol improves acid solder flux performance ..... PT132 Feb 12
Polyoptic sealing technique improves the reliability and life of glass envelope electron tubes PT114 May 20
Portable welding handgun carries own filler ..... PT77 Jan 8
Precision turning device for finishing outer-diameters of memory drums ..... PT126 Apr 29
Precision winding machine for submarine cable and capacitor manufacturing ..... PT86 Jun 10
Pre-punched tape directs numerical machine tool control equipment automatically ..... PC37 Mar 18
Printed circuit masters drafted on film with ultraviolet light ..... PT80 Jun 17
Producing germanium from flue dusts of certain kinds of coal ..... CM121 Jun 24
Production and automatic test equipment highlighted at 1960 IRE International Show and Convention ..... BF47 Apr 1
Production line tester for checking for contact chatter of electromagnetic relays uses thyratron timing circuit ..... TF94 May 20
Self-compensating fixture tests 24 capacitors at a time in an environmental test chamber ..... PT72 Jan 22
Semiautomatic silicon crystal-growing furnace triples production capacity ..... EN11 Jan 29
Servocontrolled photocell monitors diameter of wire as it is drawn ..... PT90 Feb 26
Shell-type transformer used to nondestructively test magnetic sheet material ..... PT90 Feb 26
Shrunken polyethylene tubing used as harness wrapping ..... PT86 Apr 8
Silk screening machine for semiautomatic production of printed circuits has traveling head PT98 Mar 18
Simple steps for speeding inspection of small lots of components ..... PT72 Feb 19
Single crystal rods of high-temperature compound semiconductors can be grown and purified in electron beam vertical zone refiners ..... PT104 Jun 3
Six-spindle turret drill drills, taps and assembles potentiometer dials and knobs ..... PT90 Mar 25
Soviet automatic control system checks mass-produced parts using crt scanning technique ... EN11 Jan 15
Soviets report method of drawing wires of 1 or 2 microns in diameter ..... PT100 Mar 18
Special ink for coding Teflon wire announced .... PT72 Mar 4
Special machining techniques for forming pure tungsten into intricate shapes ..... CM87 May 6
Specially-designed part trays and tote boxes speed assembly, reduce production costs ..... PT88 Mar 25
Spike power control unit overcomes misfiring of high-speed power resistance welder ..... EN11 Mar 11
Squeezer rapidly straightens bent or kinked transistor leads ..... PT72 Jan 8
Stackable small parts bins being made of molded plastic ..... PT89 Jun 10
Standardized tooling cuts cost and design time ... PT88 Jun 10
Stepping relay controls operation of lazy susan used to pace electronic assemblers ..... PT76 Feb 5
Streamlined drafting procedures to expedite R & D production ..... PT98 Mar 18
Strippable printed circuit negatives improve accuracy and design flexibility ..... PT82 Jan 29
Techniques for correcting rhodium plating defects PT124 Apr 29
Techniques for solving tin-nickel plating problems PT86 Feb 26
Three-dimensional x-rays diagnose component failures more readily ..... PT74 Jan 22
Toggle clamp makes portable hand punch press PT73 Mar 4
Umbilical tubing provides convenient method of closing a hermetically sealed container ..... PT91 Mar 25
Use of completed chassis as dipping fixtures cuts time required to fungus-proof plug-in circuit cards ..... PT93 Apr 1
Vacuum air jet and mechanical transfer methods combined in machine to weld leads to diode headers ..... PT88 Apr 15
Vacuum-formed plastic skin protects unhoused relays mounted on plug-in printed circuit boards PT195 Mar 11
Vibratory finishing equipment, our suspension helps regulate amplitude of ..... PT106 May 13
West Coast manufacturer urges government give Q awards for production ..... BE40 Jan 1
Wheel-shaped component carrier in oven makes 150 c tests of silicon diodes ..... PT130 Feb 12
Profile measuring device and lightbeam projector make up automatic surveying system for measuring airport runway roughness ..... TF54 Jun 17
Project Ace High, NATO's 4,000-mile tropospheric scatter system, to connect all major radar outposts and operational headquarters in Europe .... BF38 Apr 29
Project Defender, a study program to find tomorrow's space defense, to use pincushion radar ..... BF42 Feb 26
Project Double Jump to be operated in conjunction with NATO's 4,000-mile tropospheric scatter system Project Ace High ..... BF38 Apr 29
Project Hot Line to be incorporated into NATO's 4,000-mile tropospheric scatter system Project Ace High ..... BF38 Apr 29
Project ICEF (International Cooperative Emulsion Flight) study effect of cosmic on emulsions RD94 Jan 15
Project Jawhawk grant given by Navy to University of Kansas to study generation, detection and transmission of millimicrosec transients ..... BF60 Mar 11
Project Madre to use magnetic-drum receivers to autocorrelate echoes from over-the-horizon radar missile warning system ..... BF28 Feb 5
Project Mercury man-in-space capsule delivered .... BF31 Apr 22
Project Mercury, NASA gives $30-million contract for worldwide tracking and communications net for ..... BTW11 Feb 5
Project Mercury, NASA seeks supplemental 1960 funds of $19 million to spur development of ..... BTW11 Mar 11
Project Mercury satellite to be tracked by 50 antenna systems ..... BF33 Mar 4
Project Midas' heat-seeking missile defense satellite to work with BMEWS radar ..... BF42 Apr 1
Project Polevault provides troposcatter link for BMEWS rearward communications ..... BF42 Feb 5
Project Scout research vehicle with nonablative nose cone to be used to determine effects of plasma sheath on radio signals ..... RD66 Feb 5
Project Skyhook balloons will record cosmic rays in upper atmosphere with 800-lb block of film .... RD94 Jan 15
Project Spin for developing superconductive gyro; use seen in subs and space vehicles ..... BTW11 Jan 29
Project Tepee detects both missile launchings and nuclear explosions using over-the-horizon radar BF28 Feb 5
Project Tiros meteorological satellite, circularly-polarized, high-gain antenna for automatic tracking of ..... TF57 Apr 15
Project Trailsmoke, FAST (flight advisory service test) portion of will operationally evaluate use of SAGE computer for air traffic control use ..... EN11 May 6
Project White Alice provides troposcatter link for BMEWS rearward communications ..... BF42 Feb 5
Propagation losses in water, effect of on range parameters of active and passive sonar ..... TF41 Feb 19
Propagation, wave, R&D in Sweden ..... SR75 Feb 12
Propulsion, space vehicle, unique instrumentation for investigating possibilities of using plasma for TF66 Jun 10
Protection circuit for super-power uhf ceramic-metal tube ..... TF70 Apr 8
Pull-in drop-out gap of low-voltage relays reduced when operated from high-voltage supply ..... RD62 Jan 22

PULSE TECHNIQUES

Electrical stroboscope displays pulses with rise times of 10-10 sec ..... RD81 Apr 1
Novel approach to pulse amplifier design reduces standby current, improves gain ..... TF64 May 6
Pulse-height-to-digital signal converter ..... TF58 Jan 8
Pulsed magnetrons achieve high power ..... CM96 Mar 18
Pulsed x-ray pencil beam gages thickness of hot and cold rolled metals ..... PC62 Jan 22
Remove pulse-coded fault alarm for multihop microwave systems ..... TF82 Jan 1
Sampling attachment for conventional oscilloscopes can resolve rise times of 1/3 nanosec with repetition rates up to 50 Kc ..... TF96 Jun 24
Transistorized pulse generator for synchronizing events in zero-gradient synchrontron ..... TF63 Jun 10
What's new in pulse helix traveling wave tubes .. SR55 Apr 29
Punch press, hand portable, made from toggle clamp ..... PT73 Mar 4
Punch set, adjustable, for multiple-hole punching of shortrun sheet metal parts announced ..... PT133 Feb 12

Q

Q-meter, uhf, that computes and reads out circuit Q shown at IRE Show ..... BF47 Apr 1
Quartz-to-metal seals for high-frequency vacuum tubes ..... CM102 Jun 3

R

RADAR (See also specific headings)

Air Force BMEWS antennas in Arctic near completion ..... PC33 Jan 22
Airborne early warning blimps to carry largest radar and electronic equipment complex ..... EN11 Jan 15
Applications of ignitrons in high-power long-range radars ..... SR55 Apr 29
Applications of modern microwave equipment in radar, communications, computer, remote control and cooking ..... SR67 Jun 24
Automatic gas-fume detector alarms Loran, radiotelephones, direction finders, and depth sounder fish finders make up new $10-million small boat market ..... BF30 Jan 22
BMEWS detection and communication system prime contractors get contract awards ..... EN11 Feb 26
Broadband data link designed to handle information from airborne radar mapper announced ..... EN11 Apr 1
Chart helps determine effectiveness of radar in presence of jamming ..... TF76 May 6
Compact hybrid microwave mixer for airborne radar receiver is now available ..... CM70 Feb 5
Contributions of Japanese in marine radar field... SR53 May 27
C-w Doppler radar ground velocity system for helicopter permits sonar dunking operations ..... PC35 May 27
Department of Defense pushing program to find out more about radar signatures for ICBM's .... EN11 Jun 17
Electroluminescent devices find new market in radar applications ..... BTW11 Jan 29
Electron-beam parametric amplifier operated in synchronous pumping mode improves receiver sensitivity, increases range of coho MTI radar by 50 percent ..... RD92 May 13
Electronics R&D in radar in England and France . SR75 Feb 12
Elliptically polarized X-band horn antenna has 3-db and 6-db beamwidths of 140 degrees ..... TF50 Mar 4
English radars being ordered by and going on tour to other European countries ..... BF53 Mar 11
Experimental magnetrons for 32, 12, 8 and 4 mm wavelengths give peak outputs of 1,100, 70, 80 and 40 kw, respectively ..... CM96 Mar 18
FAA 1960 program to concentrate heavily on air navigation facilities ..... BF40 Feb 12
Fifty-pound Doppler radar detects and accurately locates moving vehicles and men to trace battlefield deployment ..... TF67 Mar 18
Frequency scanning antennas for ground mapping or scanning radar systems ..... TF70 May 6
Fuel cell power supply for Marine and Army portable field radar to be delivered ..... EN11 Apr 29

Generation, detection and transmission of millimicrosec transients being studied at University of Kansas under Navy grant for Project Jayhawk BF60 Mar 11
Georgia Institute of Technology creates division to study radar and communications BF53 Feb 12
Ground-velocity indicator using c-w Doppler radar developed for helicopters EN11 Jan 8
High-power pulsed S-band klystron for long-range radar or troposcatter communications CM82 Feb 26
How to determine whether to use visual, ir or radar detection in fog or rain T64 Jan 29
Insuring stability in precision time delay multivibrators used in radar and industrial electronics TF73 Apr 8
International Ordinary Administrative Radio Conference reallocates frequency spectrum and reports new regulations BF33 Feb 19
Invisible electronic shield for baffling radar and radar-guided missiles is reported EN11 May 6
Lab model thermoplastic recording system has radar, ir, information retrieval and data processor applications EN11 Jan 22
Long-range 3-D target finding radar installed PC42 Jun 10
Long-range radar, computer with high reliability key units in ground-controlled satellite guidance system BF43 May 27
Magnetron with 25-kw peak power at 35-kmc developed for surface detection radar set EN11 Jan 15
Maneuverable dish radar to scan and track ballistic missiles for BMEWS BF47 Mar 18
Military to get mobile, high-power folding radar assembly PC34 Jun 10
Missile tracking ship to get more radar measuring equipment EN11 Jan 1
Monopulse tracking radars compared with sequential lobing and conical scan techniques TF51 Apr 22
NATO's 4,000-mile tropospheric scatter system Project Ace High to connect all major radar outposts and operational headquarters in Europe BF38 Apr 29
Navy's Corvus carrier aircraft missile, with passive radar guidance, gets contract push BTW11 Mar 11
New Radar and communications system guard Korea against surprise invasion BF40 May 20
Parametric amplifier increases range of S-band radar used to track reentry vehicles RD116 Apr 29
Plasma circuit used as an oscillator to generate microwave energy at 2,000 Mc BTW11 Mar 4
Project Defender, a study program to find tomorrow's space defense, to use pincushion radar BF42 Feb 26
Project Madre to use magnetic-drum receivers to autocorrelate echoes from over-the-horizon radar missile warning system BF28 Feb 5
Project Midas heat-seeking missile defense satellite to work with BMEWS radar BF42 Apr 1
Project Tepee detects both missile launchings and nuclear explosions using over-the-horizon radar BF28 Feb 5
Radar field causes continuous discharge in bulb with gas of reduced pressure PC83 Apr 15
Radar signal bounced off sun's outer corona found to take 17 minute to echo BTW11 Feb 12
Radar target simulator to train operators for DEW line PC64 Jan 8
Radar telescope detects micrometeorites, determines meteor showers are more frequent than previously suspected RD106 May 20
Radar test tower determines effect of radomes on antenna radiation BF49 Mar 25
Radar transmitter for antimissile Zeus being tested BF34 May 27
Radar view of atlas ICBM BF45 Feb 26
Radar warning system that gives 3-dimensional information can be airlifted to site EN11 Jan 1
Reflex klystrons used as microwave receiver amplifiers for X-band radars TF56 Jan 8
Search radar facility built by Air Force to provide defense against airborne vehicles PC45 Jan 1
Side-looking radar makes all-weather air maps of ground terrain BF49 Apr 15
Subsection of antenna for 3-D Air Height Surveillance Radar portion of air traffic control system to be delivered BF29 Apr 8
Super-power uhf ceramic-metal tube developed for possible long-range radar missile detection and intercontinental tv TF70 Apr 8
System for typing flight simulator into remote standard ground-controlled intercept radar TF86 May 13
Transistorized precision multiple-range sweep generator for airborne radar system TF92 Jan 15
Uhf transponder beacon in Tiros I improves radar data quality, provides horizon-to-horizon coverage RD96 May 13
Ultra-clean electron gun promises greater power rating, longer life for radar klystrons EN11 Mar 25
Using graphical extension of transform techniques to find spectrum of radar return in presence of antenna scan modulation TF68 Apr 1

RADAR AND RADIO ASTRONOMY (See also Space Electronics)

Army announces development of 25-lb ruby maser EN11 Apr 22
Broadband log-periodic antennas for monitoring and signal interception, direction finding, satellite tracking, radio astronomy and h-f communications uses TF58 Jun 17
Cost of world's largest radio telescopes has soared to over $100 million BF33 May 6
Electronic R&D in radio astronomy in Australia SR75 Feb 12
International Ordinary Administrative Radio Conference reallocates frequency spectrum and reports new regulations BF33 Feb 19
Large fixed hemisphere and small movable barrel-shaped reflector cut antenna sag for radio telescope use RD81 Apr 1
NASA reports satellite tracking performance is tied to size of antenna new BF33 29
Radar telescope detects micrometeorites, determines meteor showers are more frequent than previously suspected RD106 May 20
Spider-web 142-ft radio telescope built in Scotland to study aurora PC52 May 13

RADIATION (See also Antennas, Communications, Microwaves, Nucleonics and Radar)

Battery-powered transistorized scale-of-64-counter for measuring radioactive tracers improves reliability, reduces cost and weight TF74 May 6
Cadmium sulfide field-effect transistor used experimentally as radiation detector BF42 Mar 18
Data gathering and logging system monitors nuclear radiation levels and weather conditions RD64 Jan 22
Design criteria for electrically short antennas with high radiation efficiency TF84 Jun 3
Flow rate of jet fuel containing radioactive tracer measured by simultaneously gated oscillator and radiation detector TF58 Feb 19
Frame of radiation beams provides nondestructive, continuous method of testing cable insulation PT135 May 27
How radiation affects tunnel diode operation BF32 May 6
Low-energy short-lived radioisotope samarium-153 produce high quality diagnostic radiograms BF42 Mar 18
Microminiature tube circuits featuring nuclear radiation resistance offered at IRE International Show and Convention BTW11 Apr 1
Model test range will permit all-weather, interference-free testing of antenna radiation patterns RD64 Jun 8
Multiplex circuits control robot which performs jobs in dangerously radioactive areas TF46 Jan 22
Photomultiplier and electrometer measure fluorescence of glass dosimetry needle to determine radiation exposure in human body TF74 Mar 18
Radiation damage to semiconductors seen as major research task EN11 May 20
Radiation-operated fuel gage for missiles and aircraft RD117 Apr 29
Response of electronic system components and materials to irradiation from nuclear-powered aircraft TF69 Apr 22
Semiconducting industrial diamonds may find application as counters of radioactivity RD76 Apr 22
Signal transmission through natural ionized and ion shields formed by nuclear vehicles, hypersonic reentry vehicles, rocket motor exhausts and nuclear explosions TF81 May 20
Silicon pn junctions used as particle detectors RD74 Apr 22
Solid-state radiation detector made of doped silicon gives new speed and accuracy to particle analysis BTW11 Feb 5
Telemetry transmitter for investigating Van Allen radiation belt uses novel transistorized phase modulator circuit TF68 May 6
Transistorized radiation monitor sounds alarm when alpha and beta radiation reaches preset level in nuclear-powered Navy vessels TF43 Jan 22
Ultraviolet radiometry standard developed by NBS RD64 Feb 19
University of California probes new ways to use radiation in brain study BF53 Feb 12
What's new in radiation detecting tubes SR55 Apr 29

RADIO (See also Broadcasting, Communications, Consumer Products, Receivers and Transmitters)

American-made all-transistor a-m/f-m portable radio being test-marketed EN11 Jun 10
Atmospheric duct which traps and propagates radio waves at low loss discovered BTW11 Feb 5
Balanced-bridge and semiconductor diode circuits for one-tube oscillator-mixers in tv and f-m tuners TF76 Jan 15
British tv and radio manufacturers break all sales records EN11 Jan 15
Crackdown on Class D Citizens Radio looms if users don't toe the line BF28 Jan 8
Double-sideband suppressed carrier modulation technique save power, permits exalted-carrier detection TF47 Feb 5
FCC yearend report shows more than 1½ million transmitters now on air in more than 50 services BF33 Jan 22
F-m radio set sales to show gain of 50 percent over last year MR26 Feb 12
Future of stereophonic radio broadcasting to be determined by Washington this week BF37 Jan 1
India has decide to mass-produce cheap radio receivers (under $25) BF52 Jun 24
Missile telemeter-radio interference: Cause and cure BF24 Jan 8
Multi-junction drift-field transistor simplifiers design of portable and auto radios CM82 Apr 22
NBS studies automatic computation methods for determining best possible frequencies for radio transmitters used as road markers on air lanes RD72 Jun 17
Nonablative noise cone to be used to determine effects of plasma sheath on radio signals RD66 Feb 5
Precipitation static eliminated from airborne radio and navigation equipment by sharp tungsten pins RD96 Jun 3
Radio and tv production rise in Austria EN11 Jun 10
Self-policing by industries of class D Citizens' Radio being studied BF29 Feb 5
Thailand, Laos and Vietnam to have telecommunication network for radio and tv BF29 Jan 1
Transistorized radio beacon designed to function as air craft crash position indicator TF54 Jan 22
Transistorized receiver in model ship helps Navy trainees to study ship-handling problems PC43 Apr 29
Use of sun as huge reflector to relay radio signals between distan points described RD115 Jun 24
What's new in radio frequency power tubes SR55 Apr 29

RADIO ASTRONOMY (See Radar & Radio Astronomy)

Radioisotope density altimeter is designed for missiles and fast new aircraft 37 Jan 8
Radiometer, d-c controlled attenuator called Gyraline varies L-Band maser pump power in TF71 Jan 15
Radiometer measures noise radiated from plasma at low power levels TF159 Mar 11
Radiometric sextant, miniaturized all-weather, developed for submarine use EN11 Jan 15
Radiophonograph weighing 2.8 lb developed by Japanese EN11 Jan 15
Radiotelephones together with automatic gas-fume detector alarms Loran, direction finders, and depth sounder fish finders make up new $10-million small boat market BF30 Jan 22
Radomes, radar test tower determines effect of on antenna radiation BF49 Mar 25
Radomes, transmission analogy for propagation in sandwiches of dielectric sheets and conducting films or grids used for ERS100 May 20
Rain, how to determine whether to use visual, ir or radar detection in TF64 Jun 29
RCC (Remote Communications Complex) for SAC's Automatic Combat Control System (SACCS) BF36 Mar 25
Reactor R&D, electronic, in France SR75 Feb 12
Reader, optical-electronic, for translation machine recognizes 1,000 Russian characters per second EN11 Jun 10

READOUT DEVICES (See also Dispays, Electroluminescent Devices, Indicators and Registers)

Indicator triode has fluorescent anode whose illumination is controlled by grid potential for direct data readout TF52 Feb 5
Monoscope tube generates characters for direct readout on a cro or on paper of digital computer output TF117 Feb 12
Readout circuits for magnetic noncontact shaft-position disk encoders RD114 Apr 29
Reversible decade counter used eight-digit transistor-Nixie readout circuit TF86 Jan 1
Small BEAM-X switch tube may claim extended market CM126 Feb 12
Solid-state character generator for VIDIAC (Visual Information Display and Control) System TF55 Jun 10
Solid-state high-speed printer-plotter prints and plots from computer-prepared magnetic tape EN11 Jan 22

RECEIVERS (See Broadcasting, Communications, Consumer Products, Radar, Radio and Television)

Advanced crystal-controlled carrier-operated antinoise circuits for receivers feature simple design, low power drain, high dependability TF113 May 27
Ceramic filters improve selectivity of multiband communications-type receiver CM84 Feb 26
Circuit reduces interference from other stations during ionospheric sounding by separating desired pulses from unwanted tone signals TF118 May 27
Compact hybrid microwave mixer for airborne radar receiver is now available CM70 Feb 5
Electron-beam parametric amplifier operated in synchronous pumping mode improves receiver sensitivity, increases range of coho MTI radar by 50 percent RD92 May 13
French compatible color tv system features sequential transmission of chrominance, uses one-line memory in receiver TF57 May 6
Frequency synthesizer uses solid-state tuner to provide stable, high-accuracy receivers and transmitters RD122 Feb 12
India has decided to mass-produce cheap radio receivers (under $25) BF52 Jun 24
Microalloy diffused-base transistors used in tuner design for portable tv sets TF76 Mar 18
Production of 100 receivers for use in $2 million uhf TV rejuvenation planned BF32 Jun 3
Project Madre to use magnetic-drum receivers to autocorrelate echoes from over-the-horizon radar missile warning system BF28 Feb 5
Receiver used in vhf telemetry system for eliminating communication blackout from plasma sheath formation during vehicle reentry TF105 May 27
Reflex klystrons used as microwave receiver amplifiers for X-band radars TF56 Jan 8
Remote transmitter generates control pulses during vertical blanking interval to control TV receiver TF79 May 13
Selective paging system uses coded transmission for voice intercommunications with up to 45 stations TF68 Feb 26
Self-powered portables, more color sets and additional remote control models focal points of 1960 TV Market BF44 May 13
Specially developed diffused-base mesa transistors permit design of low-noise tuners TF64 Apr 8
Transistorized f-m uhf receiver for camera control system used in rocket sled tests TF63 Apr 1
Transistorized receiver in model ship helps navy trainees to study ship-handling problems PC43 Apr 29
Transistorized TV receiver with 19-in. screen and rechargeable battery announced EN11 Jun 3
Tunnel diode circuit designs open new markets for computer, communications and receiver amplifier applications BF36 Feb 26
Vhf receiver may be grown from pool of molten semiconductor materials BTW11 Jan 29
Receiving-type electron tubes, what's new in SR55 Apr 29
Reciprocal circuit gives output which is inversely proportional to input for use with analog computers and systems TF92 May 20
Reconnaissance systems, acknowledgement by U.S. of recon operation drops cloak from a big and growing area of electronics industry BF34 May 27

RECORDERS (See also Audio, Consumer Products, Magnetics and Photography)

Cosmic rays in upper atmosphere to be recorded by 800-lb block of film carried in Project Skyhook balloon RD94 Jan 15
Four-track stereo tape recorder and miniature 7-transistor 45-rpm radio-phonograph shown at Japanese Industrial Trade Fair EN11 Apr 29
High-speed digital plotter cuts time for reducing telemetered data TF41 Jan 8
Hungarian automatic telephone-answering tape recorder shown at Leipzig Fair BF47 May 27
Japanese to emphasis development of video tape recorders EN11 Feb 12
Japanese to market stereo 4-channel tape recorder in U.S. EN11 Jan 22
Lab model thermoplastic recording system gives kinescope-quality b-w picture, green and red predominating color picture EN11 Jan 22
Magnetic recording of color television using time-correction circuits to reproduce hues faithfully TF76 Jan 1
Magnetic tape instrumentation recorder has extended bandwidth to accommodate new heads TF44 Jan 8
Mobile tv recorder can be modified for American, UK or European standards PC94 Jan 15
New magnetic tape system TRACTOR capable of storing 60 million characters is announced EN11 May 6
New tube produces velocity modulation gratings on thermoplastic recording tape EN11 Jan 15
Photographic system records electromagnetic radiation from lightning (sferics) propagated over long distances RD64 Mar 4
Portable recorder designed to operate unattended in remote areas announced at Western Joint Computer Conference BF35 May 27
Recording and measuring system for automatic survey system used to measure airport runway roughness TF54 Jun 17
Tape target classifier trains land-based sonar student operators TF65 Mar 25

Television tracking system records eye focus points and movements ... TF57 Apr 22
Thermoplastic recording of television signals provoking interest ... BF46 Jan 15
Transistor audio volume compressor for interview tape recorders ... TF62 Jan 8
Video band recorder-reproducer for analog and pulse signals to be produced ... EN11 Mar 25
Watchdog satellites to carry TV cameras and electrostatic tape recorders to check performance of other satellites ... BF35 Jun 10
Wow-flutter indicator for precise measurement of tape recorder performance ... TF100 Jun 24
Rectification characteristic, determination of In evaluating three-element semiconductor materials. TF103 Feb 12

RECTIFIERS (See also Diode Circuits, Diodes, and Power Sources and Supplies)
Color code standards for designating semiconducting diode and rectifier types adopted ... CM83 Apr 22
Controlled-rectifier switch called Transwitch for computers turned off by small negative pulse ... TF71 Jan 15
Silicon-carbide rectifier that withstand 500 C and is useable in nuclear environments ... CM94 Mar 18
Silicon controlled rectifier dollar sales to double in 1960 ... MR22 Jan 1
Solid-state static power relays and circuit breakers using silicon-controlled rectifiers have contact rating from milliwatts to kilowatts ... TF114 May 27
Refiners, electron beam zone, can be used for growing and purifying single crystal rods of high-temperature compound semiconductors ... PT104 Jun 3
Reflector, sixty-ft, for 3 axis antenna provides hemispheric coverage of missile and satellite telemetered data ... PC40 Jan 1
Reflectors, spincasting of plastic parabolic radio mirrors may provide antenna surface accuracies presently not practical ... RD96 Jan 15
Reflex klystrons, what's new in ... SR55 Apr 29

REGISTERS
Film cryotron shift register reported at 1960 Solid-State Circuits Conference ... TF39 Mar 4
Indicator triode-transistor flip-flops are coupled to form shift register ... TF52 Feb 5
Parametron register circuits for digital computers. TF73 Jun 3
Shift register made from crossed film cryotrons deposited on insulating superconductors ... TF55 Jan 29
Six ways to use magnetic core shift register elements ... TF80 Jan 15
Tunnel diodes used in shift registers ... TF55 Jan 29

REGIONAL DEVELOPMENTS
Control systems, solid-state electronics and electromagnetics featured at Seattle's 7th Regional IRE Conference ... BF39 Jun 10
Detroit area fast becoming important to electronics industry, particularly in R&D ... BF42 Mar 18
Florida's new industrial lure: plant-and-house package ... BF30 Jun 10
Hawaii's Department of Economic Development reports rapid expansion of electronics work ... EN11 Jun 17
Latest survey indicates New England 1970 sales will be $2 billion ... BF45 Apr 22
Minnesota Governor indicates expanding universities, skilled manpower and favorable financial climate stimulates area's growth ... BF30 Jun 17
New Mexico's electronics industry now in multi-million dollar bracket through missile development, R&D ... BF41 Apr 15
Regional distribution of electronics industry personnel ... SR49 Jan 1
Self-help plan involving team bidding and establishment of trade association speeds Industrial growth on Long Island ... BF38 May 6
Six-month shakedown of instantaneous audiometer used to rate viewing habits in New York City completed ... BF44 Apr 8
Sixteen colleges in six midwestern states designated as communications network for Midwest Program on Airborne Television Instruction BF59 May 20
Transistormen give financial aid to support Stanford solid-state research ... BF45 Jan 1
Twin cities get self-service post office ... PC48 Jun 3
Washington, D.C., is where firms go to seek an inside track for R & D ... BF34 Apr 22
West Coast manufacturer urges government give Q awards for production ... BF40 Jan 1

REGULATORS (See also Power Sources and Supplies)
Five-transistor line voltage regulator uses Zener diodes ... TF64 Feb 5
Generator-regulator for autos uses only semiconductors and resistors ... TF52 Feb 19
Linear circuits used to obtain precise voltage regulation of output of transistorized d-c to a-c inverter ... TF61 Apr 15
Regulator circuit for self-powered transistor oscilloscope ... TF80 Mar 18

RELAYS
Close differential operation of stock relays using low-voltage relays operated from a high-voltage supply ... RD62 Jan 22
Machine for assembling sealed contact reed relays housed in glass walled area ... PT86 Apr 22
Production line tester for checking for contact chatter of electromagnetic relays uses thyratron timing circuit ... TF94 May 20
Solid-state static power relays and circuit breakers using silicon-controlled rectifiers have contact rating from milliwatts to kilowatts ... TF114 May 27
Stepping relay controls operation of lazy susan used to pace electronic assemblers ... PT76 Feb 5
Two transistor voltage amplifiers and latchtype relay provide overload protection for voltmeter ... RD92 Mar 18
Vacuum-formed plastic skin protects unhoused relays mounted on plug-in printed circuit boards PT195 Mar 11

RELIABILITY
Electronic equivalent of neuron discussed at winter meeting of AIEE ... BF28 Feb 19
Military weapon system development stresses too much breakthrough research, too many unit cost compromises ... BF39 Jan 29
Minuteman's guidance and control systems need reliable components for underground storage lasting years ... BF39 Jun 17
Over 1,000 British design engineers crowd one-day special symposium on Electronic Equipment Reliability ... BF34 Jun 10
Reliability of receiving-type-electron tubes ... SR55 Apr 29
Test equipment for reliability checkout of Subroc antisubmarine telemetering system ... PC78 Jan 29
Remote pulse-coded fault alarm for multihop microwave systems ... TF82 Jan 1
Remote transmitter generates control pulses during vertical blanking interval to control TV receiver ... TF79 May 13
Replacement parts market for 1960 ... SR49 Jan 1
Representatives, manufacturers, place in 1960 electronics sales picture ... SR49 Jan 1
Rescue beacons become part of airliner liferaft equipment ... PC52 May 20

RESEARCH (See also specific headings)
Academic research laboratories map new project to open new research areas, expand others ... BF60 Mar 11
Academic research probes new ways to expand man's knowledge ... BF53 Feb 12
Advanced research project discussed at Northeast Electronics Research and Engineering Meeting. TF71 Jan 15
Alloyed-emitter, pnp mesa transistor operates in low microwave region and is mounted in coaxial shell ... RD82 Apr 15
Atmospheric duct which traps and propagates radio waves at low loss discovered ... BTW11 Feb 5
Batelle Memorial Institute to research cooling techniques ... CM78 Jun 17
Britain reports 10 percent of annual sales are absorbed in research ... BF37 Mar 18
Cadmium sulfide field-effect transistor announced by GM Research ... BF42 Mar 18
Cesium cell converter working at high temperatures produces significant amounts of a-c electricity CM78 Jan 29
Closed-circuit tv for monitoring dental surgery and for assisting in diagnosis being studied ... TD92 Jan 1
College and universities deeply involved in research and scientific projects at half-year mark ... BF59 May 20
Completely passive, balance modulator circuits using thin permalloy film described at 1960 Winter Convention on Military Electronics ... RD78 Feb 26
Controlled environment for infared studies made possible with 86-ft tunnel ... BF61 Mar 18
Cosmic rays in upper atmosphere to be recorded by 800-lb block of film carried in Project Skyhook balloons ... RD94 Jan 15
Cryogenic gyro under development; broad capabilities inherent in low-temperature devices spur further studies ... BF32 Feb 5
Defense Department considers establishment of information center on ceramic materials to aid research ... EN11 May 13
Dielectric absorption in capacitors ... RD78 Jun 10
Double-focusing mass spectrometer measures relative amounts and weights of atoms ... RD74 Jan 29
Emphasis on basic scientific progress and discoveries in Conference on Electronic Conductivity in Organic Solids ... RD127 May 27
Experimental magnetohydrodynamic generator produces 2½ kw, runs for four minutes ... EN11 Mar 25
FAA has raft of big and little plans for 1960 ... BF40 Feb 12
Federal spending on R&D to surpass $15 billion in 1960 ... BF40 Jan 29
Fluid amplifier uses gas and liquid pressures instead of voltages ... BF41 Mar 25
Forthcoming Solid-State Circuits Conference indicates R & D labs are in tunnel diode race ... BF32 Jan 1
Four basic research programs underway to develop ductile ceramic and ionic crystals ... CM100 Jan 15
Galactic noise measured by 4-stage sounding rocket ... EN11 Jan 8
How radiation affects tunnel diode operation ... BF32 May 6
Industrial diamonds with semiconducting properties made in South Africa ... RD76 Apr 22
Low-temperature research program to provide higher-precision thermometry being expanded ... RD98 Jun 3
Magnetic element of ferrite composition for storage, switching and logic applications in digital computers has advantage of open flux path, excellent squareness characteristics ... RD104 May 20
Magnetohydrodynamics power plant generators offering high-efficiency output being studied ... RD92 Jan 1
Magnetohydrodynamics symposium of AIEE points electronics industry's growing interest in plasma research ... EN11 Mar 4
Magnetohydrodynamics takes on new significance electronics industry ... BF52 Mar 11
Mark I perceptron demostrates ability to learn the alphabet ... BF43 Jun 24
Materials hold key to development of electron tubes capable of reliable performance at high ambient temperatures ... CM118 Apr 29
Military weapon system development stresses too much breakthrough research, too many unit cost compromises ... BF39 Jan 29
Missiles and space continue to account for much government money spent in guidance and componentry research area ... EN11 Jun 3
MIT interplanetary space probe to take photographs of 40 percent of Mar's surface ... BF49 May 20
Model test range will permit all-weather, interference-free testing of antenna radiation patterns RD64 Jan 8
National Research Council urges government to give high priority to development of material ... CM85 Apr 8
NBS studies automatic computation methods for determining best possible frequencies for radio transmitters used as road markers on air lanes ... RD72 Jun 17
New applications of moder microwaves in medical research and spectroscopy ... SR67 Jun 24
New Mexico's electronics industry now in multi-million dollar bracket through missile development, R & D ... BF41 Apr 15
New mode of transistor operation (combination tunneling and avalanche effect) being explored by several companies ... BTW11 Apr 22
Nonablative noise cone to be used to determine effects of plasma sheath on radio signals ... RD66 Feb 5
Oceanographic research indicates undersea fleet effectiveness could be doubled by environmental forecasts ... BD36 Jan 22
Plasma circuit used as an oscillator to generate microwave energy at 2,000 Mc ... BTW11 Mar 4
Plastic type transistor developed by Soviet Scientist ... EN11 Jan 1
Predicting possible three-element semiconductor materials ... TF103 Feb 12
Probes make patterns of airflow around missile nose cone inside hypersonic wind tunnel in color BF52 Feb 26
Project Defender, a study program to find tomorrow's space defense, to use pin-cushion radar ... BF42 Feb 26
Propagation of electromagnetic waves through subsurface of earth being studied for AF ... BTW11 Mar 4
Proton synchrotron of European Organization for Nuclear Research in Operation ... EN11 Jan 1
Public facsimile research spreads, faster transmission and privacy are goals ... BF51 Apr 8
Radar field causes continuous discharge in bulb with gas of reduced pressure ... PC83 Apr 15
Radar signal bounced off sun's outer corona found to take 17 minutes to echo ... BTW11 Feb 12
Radar telescope detects micrometeorites, determines meteor showers are more frequent than previously suspected ... RD106 May 20
Radiation damage to semiconductors seen as major research task ... EN11 May 20
RCA to open research laboratory in Japan, will study solid-state phnomena ... EN11 Jun 24
Research activities in electron tubes ... SR55 Apr 29
Research activities in Japan ... SR53 May 27
Researchers demonstrate experimental photogenerator for converting solar energy by photoelectric emission ... EN11 May 27
Scientists grow single crystals of transparent gallium phosphide experimentally ... EN11 May 13
Series of papers on thin films presented in IBM Journal ... CM78 Jun 17
Silicon pn junctions used as particle detectors ... RD74 Apr 22
Simulator for selecting best possible target among all in-range attackers ... RD76 Jan 29
Soviet Academy of Sciences changing some of its research approaches ... BF43 Apr 1
Spincasting of plastic parabolic radio mirrors may provide antenna surface accuracies presently not practical ... RD96 Jan 15
Stanford Research Institute reports $22 million research contracts were handled in 1959 ... BF59 May 20
Streamlined drafting procedures to expedite R&D production ... PT98 Mar 18
Study of atmospheric noise needed to develop long-range vlf navigation systems ... RD78 Apr 8
Subsurface propagation of electromagnetic waves being studied ... PC30 Apr 22
Sun-position sensor for establishing coordinate reference system on space vehicle reported at 1960 Winter Convention on Military Electronics ... RD62 Mar 4
Superconducting electromagnets being explored for use with masers and in solid-state research requiring cryogenic temperatures and a magnetic field ... EN11 May 20
Superconductivity symposium disclosed basic work is still concentrating on cryotron, major problem is fabrication ... EN11 May 27
Survey of future developments now emerging from electronics' laboratories ... TF159 Mar 11
Thermoelectric cooling modules for electronic components in R&D stage ... RD68 Feb 5
Transistormen give financial aid to support Stanford solid-state research ... BF45 Jan 1
Tunnel diode circuit designs open new markets for computer, communications and receiver amplifier applications ... BF36 Feb 26
Tunnel diodes being pushed to higher oscillation frequencies ... EN11 Jan 8
Tunnel triode being investigated as potentially useful computer element ... EN11 Mar 4
Two American electronic men who toured Russia impressed with Soviet scientific education and research ... BTW11 Apr 8
Two Operation Skyhook balloons will study cosmic rays at 18 to 22 mi altitudes ... EN11 Jan 1
Ultrafast spectrometer for analyzing chemical reactions occurring on 0.1 millisec developed ... BF42 Mar 18
Use of carbon monoxide for frequency standards being studied ... BTW11 Apr 8
Vibrating platform uses beads to simulate atomic motion ... PC74 Jan 29
Washington, D.C., is where firms go to seek an inside trackfor R & D ... BF34 Apr 22
Resin, solventless silicone, for high-temperature insulation now commercially aviable ... CM118 Jun 24
Resistors, British approaches to producing film resistors for microminiaturization ... TF71 Jan 1
Resources--their role in future of Japanese electronics industry ... SR53 May 27
R-f precision fixed capacitors, characteristics of ... TFB26 Feb 26
Righi-Leduc effect, definition of ... TF71 Feb 26
Robot performs jobs in dangerously radioactive areas by multiplexed commands ... TF46 Jan 22

ROCKETS (See also Missiles)
Eliminating communication blackout resulting from plasma sheath formation during vehicle reentry using sufficiently high frequency ... TF105 May 27
Instrumented low-cost Arcas and Loki weather, rockets slated for daily firing ... BF43 Apr 29
NASA plans to launch 25 to 30 major vehicles and 100 sounding rockets each year for three years ... EN11 May 20
Rocket sleds use transistorized camera control to photograph ejection seat performance ... TF63 Apr 1
Signal transmission through natural ionized layers and ion shields formed by nuclear vehicles, hypersonic reentry vehicles, rocket motor exhausts and nuclear explosions ... TF81 May 20
ROTI (recording optical tracking instrument) used with rapid scan spectrometer to detect infrared energy radiated during power flight portions of missile trajectory ... TF86 May 20
RUM (Remote Underwater Manipulator), a converted Ontos tank, uses TV guide for exploring, installing and removing fixed sonar gear ... BF31 Jun 17
Runway, airport, roughness of measured by automatic surveying system using lightbeam projector and profile measuring device ... TF54 Jun 17

S

SACCS (SAC Control System) prototype being set up BF36 Mar 25
SAGE transmitter provides 20-kw output level ... PC34 Apr 22

SALES (See also Business, Government, Marketing, Market Research and Military Electronics)
British and U.S. computermakers step up sales, promotional and service activities in Europe ... BF34 Jan 8
British tv and radio manufacturers break all sales records ... EN11 Jan 15
Color tv sales to rise $10 million in 1960 ... MR24 Apr 22
Components manufacturers say total sales were up 23 percent for the year ... BF35 Jun 24
East Germans expect $175 million sales from western customers, publicize a-c voltmeter and Robtron computer ... BF37 Mar 18
Electronics firms urged at EAI Industrial Electronics Conference to sell systems instead of hardware to industrial customers ... MR22 Jan 22
Federal spending for coming fiscal year to hold close to last year's figures ... BF32 Jan 29
Federal spending on R&D to surpass $15 billion in 1960 ... BF40 Jan 29
Fivefold increase in data processing sales for 1965 ... BTW11 Feb 19
F-m radio set sales to show gain of 50 percent over last year ... MR26 Feb 12
Hearing aid sales rise 11% ... MR28 Mar 18
Industrial products to reach $8-10 billion sales ... MR26 Apr 15
Japanese tv set sales increase rapidly ... EN11 Jan 15
Latest survey indicates New England 1970 sales will be $2 billion ... BF45 Apr 22
Magnetic tape sales to increase by 30 to 35 percent on 1959 in 1960 ... MR22 Jan 8
Manufacturers expect continued increase in tv and audio market ... BF39 Feb 5
Manufacturers look for quadrupled digital computer sales over next five years ... MR24 Jun 3
Navy survey predicts and equipment sales up $1.3 billion in 1960 ... EN11 May 13
Nuclear instrument shipments for 1958 rise 33 percent over those of 1957 ... MR22 Feb 19
Prediction of industry-wide increase in semiconductor sales boosted by announcements of production expansion ... EN11 Feb 12
Retail sales of tv sets will rise 60 to 70 percent higher in 1970 ... MR26 May 27
Sales in electronic industry for 1960 ... SR49 Jan 1
Silicon controlled rectifier dollar sales to double in 1960 ... MR22 Jan 1
Tantalum capacitor manufacturers look for 20 percent sales increase over 1959 level ... MR24 Jun 10
Test instrument sales to both industry and military rise fast ... MR26 Jan 15
What exhibitors are saying about sales at forthcoming IRE International Show and Convention ... BF30 Mar 11
Year 1960 to see increased semiconductor sales, maintenance of high level 1959 electron tube sales ... MR24 Jan 29
Sampler, axis-crossing interval, for design of weak signal detectors ... TF88 Jun 3
Sampler circuit for noise suppression factor display unit ... TF55 Feb 5
Sampling problems solved using graphical extension of transfer technique ... TF68 Apr 1
Sandwich propagation, transmission line analogy for ... ERS100 May 20
SATCO (supranational automatic air traffic control system) being pushed in Europe ... BF40 Apr 22

SATELLITES
(See also Military Electronics, Missiles & Space Electronics)
Advent active communications satellite should have space relay station in operation by 1962, be totally operational by 1964 ... EN11 Jun 24
Basic design considerations of silicon solar cells for use as power supplies on satellites ... TF167 Mar 11
Broadband log-periodic antenna for monitoring and signal interception, direction finding, satellite tracking, radio astronomy and h-f communicates uses ... TF98 Jun 17
Circularly-polarized, high-gain antenna for automatic tracking of Tiros meteorological satellites ... TF57 Apr 15
Command guidance system developed for Titan ICBM guides Tiros into preselected circular orbit ... PC40 Jun 3
Electronics R&D in satellites in England and Australia ... SR75 Feb 12
Experimental progress towards transoceanic communication by means of passive earth satellites reported ... BTW11 Apr 8
First Project Mercury man-in-space capsule delivered ... BF31 Apr 22
High-thrust propulsion systems to shift critical emphasis in satellite development to component and instruments ... BF48 Apr 29
Long-range radar, computer with high reliability in ground-controlled satellite guidance system ... BF43 May 27
Match-head size tunnel diode holds great promise for missile satellite and ultra-high-speed data processing applications ... PC69 Mar 4
NASA gives $30-million contract for worldwide tracking and communications net for Project Mercury ... BTW11 Feb 5
NASA plans to launch 25 to 30 major vehicles and 100 sounding rockets each year for three years ... EN11 May 20
NASA reports satellite tracking performance is tied to size of antenna ... BF33 Apr 29
New AF-operated facility uses computers and complex communications system to coordinate space surveillance, catalog everything in orbit ... BF34 Mar 4
Participants in Sixth National Flight Test instrumentation Symposium hear that U.S. is far ahead of Soviets in ballistic missile and satellite fields ... BF53 Jun 3
Pioneer V will be transmitting information over distance of 50 million miles in August, 1960 ... BF49 Mar 25
Project Mercury satellite to be tracked by 50 antenna systems ... BF33 Mar 4
Project Midas heat-seeking missile defense satellite to work with BMEWS radar ... BF42 Apr 1
Satellite astronomical observatory with 50-inch telescope and data communicating systems planned by NSF and NASA ... BTW11 Mar 18
Sixty-ft reflector for 3-axis antenna provides hemispheric coverage of missile and satellite telemetered data ... PC40 Jan 1
Soviets plan whole new series of artificial satellites ... BF57 May 19
Spray-on insulator dissipates heat and controls temperature on outside of space capsules ... CM105 Jan 15
Telemetry transmitter for investigating Van Allen radiation belt uses novel transistorized phase modulator circuit ... TF68 May 6
Tiros transmits data with two 33-ounce off-the-shelf f-m telemetry transmitters ... BTW11 Apr 15
Transistorized pulse height-to-time converter for earth satellite telemetry system ... TF82 Jan 15
Uhf transponder beacon in Tiros I improves radar data quality, provides horizon-to horizon coverage ... RD96 May 13
U.S. to help Canada launch first satellite for studying ionosphere and galactic noise ... BF61 Mar 18
Watchdog satellites to carry TV cameras and electrostatic tape recorders to check performance of other satellites ... BF35 Jun 10
Saturable reactor used in adjustable counting and timing circuits operating primarily as frequency dividers ... TF61 May 6
Saturable reactor used in high-speed, low cost simple latch circuit ... RD66 Jan 8
Scaler, battery-powered transistorized, for measuring radioactive tracers improves reliability, reduces cost and weight ... TF74 May 6
Schmitt trigger for transistorized slicer used to measure amplitude probability density functions ... TF70 Jan 29
Screens for cathode ray tubes, what's new in ... SR55 Apr 29
Sea life, noise spectrum for ... TF41 Feb 19
Seal tightness in manufacture of electron tubes measured with mass spectrometer ... TF74 Apr 1
Seals, quartz-to-metal, for high-frequency vacuum tubes ... CM102 Jun 3
Secam (sequential a memoire) French compatible color tv system, features sequential transmission of chrominance, uses one-line memory in receiver ... TF57 May 6
Seebeck effect, definition of ... TF71 Feb 16

SEMICONDUCTORS
(See also Diodes, Microminiaturization, Solid-State Physics and Transistors)
American and Japanese firms agree to share techniques of design and manufacture of diodes ... BF32 Apr 8
Circuits grown from pool of molten semiconductor materials ... BTW11 Jan 29
Color code standards for designating semiconductor diode and rectifier types adopted ... CM83 Apr 22
Company combates shortage of semiconductor engineers by giving series of in-depth, 13-week courses ... BF44 Jun 17
Controlled-rectifier switch called Transwitch for computers turned off by small negative pulse ... TF71 Jan 15
Electronics R&D in semiconductors and transistors in England, Sweden, Israel and Japan ... SR75 Feb 12
Germanium diffused base transistor with open circuit base connection serves as inductive negative resistance diode in microcircuits ... TF60 Apr 22
Germans concentrate on semiconductor and vacuum tube development ... BF49 May 13
Gold-antimony alloy fives more even control of semiconductor doping ... CM71 Jan 22
Industrial diamonds with semiconducting properties made in South Africa ... RD76 Apr 22
Multi-junction drift-field transistor simplifies design of portable and auto radios ... CM82 Apr 22
New developments in semiconductor research ... TF159 Mar 11
Predicting possible three-element semiconductor materials ... TF103 Feb 12
Prediction of industry-wide increase in semiconductor sales boosted by announcements of production expansion ... EN11 Feb 12
Radiation damage to semiconductors seen as major research task ... EN11 May 20
Report on semiconductive plastics -- in U.S.S.R. and in U.S.A. ... CM68 Jan 22
Review of uranium compounds suggests some may possess semiconductive properties of interest in high-temperature applications ... CM130 May 27
Scientists grow single crystals of transparent gallium phosphide experimentally ... EN11 May 13
Selective diffusion and shaping of semiconductors to form complete circuits cuts size and weight, improves reliability ... TF69 May 13
Semiautomatic silicon crystal-growing furnace triples production capacity ... EN11 Jan 29
Semiconductor resistors and capacitors for microcircuits ... TF69 May 13
Semiconductor r-f switches for modern microwave applications ... SR67 Jun 24
Semiconductor wafer Hall probe in magnetic field plotting system speeds cyclotron desegn ... RD80 Apr 8
Silicon carbide rectifier that withstand 500 c in useable in nuclear environments ... CM94 Mar 18
Silicon pn junctions used as particle detectors ... RD74 Apr 22
Single crystal rods of high-temperature compound semiconductors can be grown and purified in electron beam vertical zone refiners ... PT104 Jun 3
Solid-State Circuits Conference indicates microelectronics is moving rapidly out of research phase ... BF36 Feb 12
Soviet semiconductor and computer production rates increase ... EN11 Jan 29
Strain sensing element of whisker size and high strength give 50 times greater sensitivity than present metallic devices ... BF11 Feb 26
Technique of vapor-growing hig resistivity collector films on a low-resistivity substrate (revealed at IRE-AIEE conference) may have far reaching implications ... EN11 Jan 24
Thermoelectirc cooling now possible using new semiconductor materials ... CM85 Feb 26
Transistorized automobile ignition system uses surfacegap spark plugs ... RD82 Mar 25
Tunnel diode circuit designs open new markets for computer, communications and receiver amplifier applications ... BF36 Feb 26
Uncooled indium-antimonide photoelectromagnetic detector responds to long infrared wavelengths ... TF62 Mar 25
U.S. electron tubes and semiconductors of specialized types and advanced designs in demand abroad ... BF48 Feb 26
Year 1960 to see increased semiconductor sales, maintenance of high level 1959 electron tube sales ... MR24 Jan 29
Sensor, light, in automatic bomb alarm system now being installed in strategic U.S. cities ... PC45 Apr 8
Sensor, sun-position, for establishing coordinate reference system on space vehicle reported at 1960 Winter Convention on Military Electronics ... RD62 Mar 4

SERVOMECHANISMS
(See also Control Circuits and Systems)
Control transformer tester aligns course-fine servo systems without precision synchros ... TF84 Mar 18
Electronics R&D in servomechanisms in Italy ... SR75 Feb 12
Multiplex circuits control robot which performs jobs in dangerously radioactive areas ... TF46 Jan 22
Servo detector for automatic survey system used to measure roughness of airport runways ... TF54 Jun 17
Steering transistor circuits control reversible decade counter generating error signals ... TF86 Jan 1
Setun computer developed by Russia uses magnetic amplifiers and operates on ternary rather than binary code ... BF11 Feb 26
Sextant, miniaturized all-weather radiometaric, developed for submarine use ... EN11 Jan 15
Sferic data may improve navigation ... RD78 Apr 8
Sferics (lightning photographed by intermittent recorder ... RD64 Mar 4
Shaper, ramp and step, for noise suppression factor display unit ... TF55 Feb 5
Shaping network for attitude-control system in Able series space exploration probes ... TF60 Jan 29
Shields, r-f, transmission line analogy for propagation in sandwiches of dielectric sheets and conducting films or grids used for ... ERS100 May 20
Shipbuilding automation shows good start in Britain ... BF52 May 13
Shock, knitted metal mesh protects electronic equipment from ... CM94 Mar 18
Silver antimony telluride, evaluation of as semiconductor material ... TF103 Feb 12
Simulated transformer tests magnetic sheet ... PT90 Feb 26
Simulator for selecting best possible target among all in-range attackers ... RD76 Jan 29
Simulator, radar target, to train operators for DEW line ... PC64 Jan 8
Simulators, system for typing flights simulator into remote standard ground-controlled intercept radar ... TF86 May 13
Similitude theory and relation to microelectronics discussed at 1960 Solid-State Circuits Conference ... TF39 Mar 4
Slicer, transistorized, measures amplitude probability density functions ... TF70 Jan 29
Slip ring assemblies become major electronics components market, sales risa 25 percent yearly ... MR30 May 13
Slip rings, miniature, assembly starts with encapsulation, finishes with machine and metal disposition ... PT106 Jan 15
Test circuit shows how to accurately measure gain and phase angle characteristics of closed-loop synchro, resolver and computer amplifiers ... ERS88 May 13
Transistorized subaudio swept signal generator for testing servos and related equipment and components ... TF67 Apr 22
Sockets, floating tube, for uhf triodes ... CM68 Jan 8
Solar cells, silicon, power automobile ... PC52 Jun 24

SOLDERING TECHNIQUES (See also Production Techniques)
Brush plating and air-operated masking jig speed precision soldering of transistor tabs ... PT70 Mar 4
Low-pressure air most efficient method to cool components during manual soldering of printed circuits ... PT104 May 13
Peg board type pallet permits connections of modules to be dip soldered ... PT192 Mar 11
Polyethylene glycol improves acid solder flux perfomance ... PT132 Feb 12
Solenoids, rotary, designing for space and weight saving with ... CM66 Mar 4

SOLID - STATE PHYSICS
(See also Diodes, Microminiaturization and Transistors)
Cadmium sulfide field-effect transistor announced by GM Research ... BF42 Mar 18
Control systems, solid-state electronics and electromagnetics featured at Seattle's 7th Regional IRE Conference ... BF39 Jun 10
Dielectric diodes and triodes to control large amounts of current using thin insulating crystals of cadmium sulphide being developed ... BTW11 Jan 22
Electronics R&D in solid state physics in France ... SR75 Feb 12
Experimental solid-state generator for converting pulsed d-c magnetic fields into microwave radiation has been built ... EN11 Feb 19
Frequency synthesizer uses solid-state tuner to provide stable, high-accuracy receivers and transmitters ... RD122 Feb 12
Microelectronics to get special attention at 1960 Solid-State Circuit Conference ... EN11 Jan 29
Predicting possible three-element semiconductor materials ... TF103 Feb 12
RCA to open research laboratory in Japan, will study solid-state phenomena ... EN11 Jun 24
Recent progress in solid state technology reported at 1960 Solid-State Circuits Conference ... TF39 Mar 4
Solid state high-speed printer-plotter prints and plots from computer-prepared magnetic tape ... EN11 Jan 22
Superconducting electromagnets being explored for use with masers and in solid-state research requiring cryogenic temperatures and a magnetic field ... EN11 May 20
Temperature-insensitive solid-state dielectric diodes and triodes ... TF59 Feb 26
Transistormen give financial aid to support Stanford solid-state research ... BF45 Jan 1

SONAR (See also Military Electronics, Oceanography & Transducers)
C-w Doppler radar ground velocity system for helicopter permits sonar dunking operations ... PC35 May 27
Equations and charts for determining range parameters of active and passive sonar systems ... TF41 Feb 19
Material and backing-plate selection for sonar transducer design ... TF62 Feb 26
Oceanographers position underwater photographic cameras, take samples of sea water and bottom sediments with help of sonar ... TF93 Jun 24
Remote Underwater Manipulator (RUM), a converted Ontos tank, uses TV guide for exploring, installing and removing fixed sonar gear ... BF31 Jun 17
Sonobuoys and repair kits bought by Navy for antisubmarine wargare ... EN11 Jan 15
Tape target classifier trains land-based sonar student operators ... TF65 Mar 25
Space-charge focused klystrons, what's new in ... SR55 Apr 29

Space-charge-limited dielectric diodes and triodes.. TF59 Feb 29

SPACE ELECTRONICS
(See also Military Electronics, Missiles, & Radar & Radio Telescopes)
Advent active communications satellite should space relay station in operation by 1962, be totally operational by 1964 ..... EN11 Jun 24
AF is investigating X-rays as possible means of space communication ..... BF45 Feb 12
Approaches to design and fabrication of micro-miniaturized digital computer for space applications ..... TF95 Apr 29
ARPA contracts awarded to study ways of nullifying attack by nuclear-armed vehicles entering earth's atmosphere from outer space... BF36 May 13
Basic design considerations of silicon solar cells for use as power supplies on satellites..... TF67 Mar 11
Biomedical space flight instrumentation system tested on racing car crews..... RD185 Mar 11
Ceramic gas bearings in new gyro reduces drift for space guidance applications ..... CM76 Jun 17
Computers, instruments and electrostatic propulsion for space discussed at winter meeting of AIEE..... BF28 Feb 19
Cost of world's largest radio telescopes has soared to over $100 million..... BF33 May 6
Double focusing mass spectrometer going into satellite to measure elements in the exosphere. RD81 Feb 26
Electronics probes the universe is theme of 12th Annual National Aeronautical Electronics Conference ..... BF45 May 20
Electronics R&D in satellites in England and Australia..... SR75 Feb 12
Federal spending on space research for coming fiscal year to increase over last year ..... BF32 Jan 29
Hawaii's Department of Economic Development reports rapid expansion of electronics work ... EN11 Jun 17
High-thrust propulsion sytems to shift critical emphasis in satellite development to components and instruments..... BF48 Apr 29
Instrument fault in orientation system causes Soviet spaceship backfire ..... EN11 Jun 10
Instrumented low-cost Arcas and Loki weather rockets slated for daily firing..... BF43 Apr 29
International Ordinary Administrative Radio Conference reallocates frequency spectrum and reports new regulations ..... BF33 Feb 19
Ions affect health and behavior in space, submarines and department stores ..... BF45 Feb 26
Missiles and space continue to account for much government money spent in guidance and componentry research area ..... EN11 Jun 3
MIT interplanetary space probe to take photographs of 40 percent of Mar's surface ..... BF49 May 20
NASA contracts for desegn of experimental ceslum-stream ion engine ..... EN11 Jun 17
NASA gives $30-million contract for worldwide tracking and communications net for Project Mercury..... BTW11 Feb 5
NASA plans to spend 12-15 billion dollars on space exploration over next 10 years..... EN11 Feb 26
NASA reports satellite tracking perfomance is tied to size of antenna..... BF33 Apr 29
NASA seeks supplemental 1960 funds of $19 million to spur man-in-space program..... BTW11 Mar 11
Navigation for hypersonic or space craft aided by computer-directed map projection system under development ..... EN11 Jun 3
Navy experimental moon-relay communications system demonstrated..... EN11 Feb 5
Negotiation for instrumented package for moon shot started ..... EN11 May 6
New AF-operated facility uses computers and complex communications system to coordinate space surveilance, catalog everything in orbit..... BF34 Mar 4
Optical-electronic magnetometer control attitude of vehicles in space ..... TF55 Apr 8
Parametric amplifier increases range of S-band radar used to track reentry vehicles..... RD116 Apr 29
Participants in Sixth National Flight Test Instrumentation Symposium hear that U.S. is far ahead of Soviets in ballistic missile and satellite fields ..... BF53 Jun 3
Pioner V wil be transmitting information over distance of 50 million miles in August, 1960..... BF49 Mar 25
Preview of space electronics sessions for forthcoming IRE International Show and Convention. BF32 Mar 11
Project Defender, a study program to find tomorrow's space defense, to use pincushion radar.. BF42 Feb 26
Project Mercury satellite to be tracked by 50 antenna..... BF33 Mar 4
Radar signal bounced of sun's outer corona found to take 17 minutes to echo..... BTW11 Feb 12
Radar telescope detects micrometeorites, determines meteor showers are more frequent than previously suspected ..... RD106 May 20
Satellite astronomical observatory with 50-inch telescope and data communicating system planned by NSF and NASA ..... EN11 Mar 18
Signal transmission through natural ionized layers and ion shields formed by nuclear vehicles, hypersonic reentry vehicles, rocket motor exhausts and nuclear explosions ..... TF81 May 20
Small revolving globe for use by astronaut indicates posltlon of orbiting capsule over earth... RD85 Apr 1
Solid-state radiation detector made of doped silicon gives precise measurement of cosmic rays and Van Allen radiation belt..... BTW11 Feb 5
Soviet exhibit at 1960 Leipzig trade fair focused on new electronic instruments, automation and space..... EN11 Mar 11
Space communications plans outlined at Armed Forces Communications and Electronics Association's 14th Convention ..... BF42 Jun 10
Spider-web 142-ft telescope built in Scotland to study aurora..... PC52 May 13
Sun-position sensor for establishing coordinate reference system on space vehicles reported at 1960 Winter Convention on Military Electronics. RD62 Mar 4
Technical details of Soviet spaceship launched May 16 beginning to leak out ..... EN11 Jun 3
Telemetry transmitter for investigating Van Allen radiation belt uses novel transistorized phase modulator circuit..... TF68 May 6
Timepiece calibrated to two references will be needed by astronauts reports University of Michigan..... BF59 May 20
Transistorized circuits for guiding Able series space exploration probes..... TF60 29
Transportable probe tracking facility (antenna and data collector) being tested for ARPA..... BF33 Apr 29
Unconventional slow-scan TV chain assists astronomers in finding sunspots with balloon-borne optical telescope ..... TF49 Jun 17
Unique instrumentation for investigating possibilities of using plasma to propell space vehicles ..... TF66 Jun 10
University of California Lick obsrvatory to construct nebular spectrograph for collecting information on motions of gaseous nebulae..... BF60 Mar 11
University of Michigan reports astronauts will need to keep track of two kinds of time..... BF59 May 20
U. S. headstart over Russia in microminiaturization seen as future space asset ..... BTW11 Apr 8
U. S. to help Canada launch first satellite for studying ionosphere and galactic noise..... BF61 Mar 18
Use of sun as huge reflector to relay radio signals between distant points described ..... RD115 Jun 24
Watchdog satellites to carry TV cameras and electrostatic tape recorders to check perfomance of other satellites ..... BF35 Jun 10
Spectrometer, double-focusing mass, measures relative amounts and weights of atoms..... RD74 Jan 29
Spectrometer, mass, measures quantity of helium escaping in electron tube manufacture..... TF74 Apr 1
Spectroscopic system, automatic, for determining the spectral response of electro-optical materials. TF66 Apr 1
Spectroscopy, new applications of modern microwaves in ..... SR67 Jun 24
Spectrum analysis aided using graphical extension of transform techique ..... TF68 Apr 1
Speech research in Swede ..... SR75 Feb 12
Spincasting of plastic parabolic radio mirrors may provide antenna surface accuracies presently not practical..... RD96 Jan 15
Squeezer rapidly straightens bent or kinked transistor leads..... PT72 Jan 8
Stabilotron, what's new in..... SR55 Apr 29
Standard, frequency, use of carbon monoxide for for being studied..... BTW11 Apr 8
Standard of ultraviolet radiation developed by NBS . RD64 Feb 19
Standard time code added experimentally to WWV's regular broadcasts for simultaneous observations at widely separated locations ..... RD114 Jun 24
Staples, characteristics and use of types used in electronic production ..... TF68 Apr 15
Static power relays and circuit breakers using silicon-controlled rectifiers have contact rating from milliwatts to kilowatts..... TF114 May 27
Static, precipitation, eliminated from airborne radio and navigation equipment by sharp tungsten pins . RD96 Jun 3
Steering, automatic, using wire loops, guidance cable and transistorized detector demonstrated .. BF40 Jun 17

STEREOPHONICS
(See also Audio, Broadcasting and Radio)
A-m/a-m method of stereo broadcasting announced EN11 Feb 5
British multiplex system for bilingual broadcasts or conventional stereophonic transmissions.... TF87 Jun 3
Confusion hinders stereo growth — fierce competition centers on remote speaker business ..... BF39 Feb 5
Dental anasthetic device using stereo sound placed in production..... EN11 May 27
FCC to evalute industry groups stereophonic f-m broadcast tests ..... BF48 Jun 3
Four-track stereo tape recorder and miniature 7-transistor 45-rpm radio-phonograph shown at Japanese Industrial Trade Fair ..... EN11 Apr 29
Future of stereophonic radio broadcasting to be determined by Washington this week ..... BF37 Jan 1
German's market binaural tape for stereo equipment..... BF49 May 13
Japanese to market stereo 4-channel tape recorder in U.S..... EN11 Jan 22
NAB convention to discuss stereophonic and station automation equipment ..... BF48 Apr 1
National Stereophnic Radio Committee suspends activities ..... BF63 Mar 11
Regular stereophonic broadcasting to be initiated in Canada ..... BF45 Jan 15
Stereo stimulates f-m broadcasters; FCC says standards may be established by fall 1960..... BF30 Apr 22
Stereophonic broadcasting will no make big breakthrough for some time ..... TF159 Mar 11
Stereoscopic x-rays diagnose component failures more readily..... PT74 Jan 22

STORAGE DEVICES
(See also Memories and Thin Films)
Electronics R&D in thin film storage in England.. SR75 Feb 12
Ferroresonant storage and switching circuits combined with alphanumeric indicator form electroluminescent typewriter..... TF49 Jan 22
Information stored in form of acoustic energy in quartz delay line..... TF159 Mar 11
Magnetic element of ferrite composition for storage, switching and logic applications in digital computers has advantage of open flux path, excellent squareness characteristics..... RD104 May 20
Switching and storage circuits are made from crossed film crytrons deposited on insulating superconductors ..... TF55 Jan 29
What's new in storage tubes ..... SR55 Apr 29
Store automation in Britain behind U. S. but big move expected ..... BF52 May 13
Stratoscope 1, unconventional slow-scan TV chain for assists astronomers in finding sunspots with balloon-borne optical telescope ..... TF49 Jun 17
Stretcher circuit pulse, for transistorized pulse height-to-time analyzer..... TF82 Jan 15
Strip techniques used in modern microwave equipment SR67 Jun 24
Strobe circuit using pnpn 4-layer diode for portable battlefield radar..... TF67 Mar 18
Stroboscope, electrical, displays pulses with rise time of 10-10 sec..... RD81 Apr 1
Stroboscope principle used of for nano and picosecond oscilloscopes described..... EN11 May 27
SUBIC (Submarine Integrated Control) program for automatic submarine..... BF28 Jan 29
Subroc antisubmarine telemetering system is given Reliability Checkout..... PC78 Jan 29
Subtracter, electronic, for reducing system disturbances when measuring switching speed of thin magnetic film using strip transmission line ..... TF79 Jun 3
Suhl effect, definition of..... TF71 Feb 26
Sun-position sensor for establishing coordinate reference system on space vehicle reported at 1960 Winter Convention on Military Electronics. RD62 Mar 4

SUPERCONDUCTORS (See also Cryogenics)
Cryogenic gyro under development; broad capabilities inherent in low-temperature devices spur further studies..... BF32 Feb 5
Superconductive gyro called feasible; use seen in subs and space vehicles ..... BTW11 Jan 29
Switching and storage circuits are made from crossed film cryotrons deposited on insulating superconductors..... TF55 Jan 29
Transistorized test set for measuring critical current in superconducting contacts of cryogenic circuits..... TF52 Jan 22
Super-power electron tubes, what's new in..... SR55 Apr 29
Surface-gap spark plug used in transistorized ignition system for automobiles..... RD82 Mar 25
Surface treating, electron beam metalworking equipment for..... PT86 Feb 26
Surveillance systems frequency scanning antennas for groundmapping or scanning radar systems..... TF70 May 6
Survey system, automatic, uses lightbeam projector and profile measuring device to measure airport runway roughness ..... TF54 Jun 17
Sweden — research and development currently underway in..... SR75 Feb 12

SWITCHES (See also Relays)
Biasing techiques permit small-area junction germanium diodes to switch microwave in waveguides or transmission lines..... TF85
Bilateral word switch for expandable random-access solid-state memory..... TF164 Mar 11
Controlled-rectifier switch called Transwitch for computers turned off by small negative pulse... TF71 Jan 15
Determining proper bias and correct circuit impedances for operating tunnel diodes as switches, amplifiers or oscillators ..... TF82 Jun 3
Gallium phosphide diodes and switching devices withstand 1,500 C..... CM71 Jan 8
Half-amp silicon diodes with 0.3 usec recovery time in volume production for computers..... CM105 Jan 15
High-speed transistor switch for computer logic circuit perfoms at micro-energy levels..... CM98 May 13
Magnetic element of ferrite composition for storage, switching and logic applications in digital computers has advantage of open flux path, excellent squareness characteristics..... RD104 May 20
Measuring switching speed of thin magnetic films using strip transmission line ..... TF79 Jun 3
Small BEAM-X switch tube may claim extended market..... CM126 Feb 12
Solid-state static power relays and circuit breakers using silicon-controlled rectifiers have contact rating from milliwatts to kilowatts..... TF114 May 27
Switching speeds of 100 to 10 nanoseconds or less possible with cryotron Superconductivity Symposium hears..... EN11 May 27
Temperature-insensitive solid-state dielectric circuit devices for switching applications ..... TF59 Feb 26

SWITCHING CIRCUITS
Electronics R&D in semiconductor switching in Japan ..... SR57 Feb 12
Equalizer switching network for wideband magnetic tape instrumentation recorder..... TF44 Jan 8
Ferroresonant storage and switching circuits combined with alphanumeric indicator form electroluminescent typewriter ..... TF49 Jan 22
Five nanosec switching of high currents required to electrically explode wires ..... CM97 Mar 18
Flip-flop uses indicator triode with fluorescent-anode whose illumination is controlled by grid potential ..... TF52 Feb 5
Frequency modulating a resonant circuit using reactance switching technique ..... TF74 Feb 26
Remote switching circuits for controlling robot which performs jobs in dangerously radioactive areas ..... TF46 Jan 22
Sampling oscilloscope permits measurement of computer diode recovery times down to 500 picosec ..... TF59 Apr 8
Selecting power transistors to give required switching speed, gain and current-carrying capacity in computer switching applications ... TF44 Mar 4
Superconductors to find use as components for high-speed switches and memory systems ..... BF32 Feb 5
Switching and storage circuits are made from crossed film cryotrons deposited on insulating superconductors ..... TF55 Jan 29
Transistor reverse-biasing technique raises breakdown point for switching indicator tubes ..... TF48 Jan 8
Unique switching device (not specified) makes side-looking radar used for all-weather air mapping of ground terrain ..... BF49 Apr 15
Switzerland — research and development currently underway in ..... SR75 Feb 12
Synchro shafts, drop-feeding and unloading of workpieces on centerless grinder steps up production of..... PT74 Jan 22
Synchronized sweep devices, graphical method of solving multivibrator instability problems encountered in..... TF55 Feb 19
Synthesizer, frequency, uses solid-state tuner to provide stable, high-accuracy receivers and transmitters..... RD122 Feb 12
Systems, electronics firms urged at EAI Industrial Electronics Conference to sell systems instead of hardware to industrial customers ..... MR22 Jan 22

T

Tachometer, cardio-, using transistors is in use in Czechoslovakia ..... BF28 Jan 1
Tape, magnetic, sales to increase by 30 to 35 percent on 1959 in 1960 ..... MR22 Jan 8
Tape target classifier trains land-based sonar student operators ..... TF65 Mar 25
TCC (Traffic Control Center) for SAC's Automatic Combat Control System (SACCS) ..... BF36 Mar 25

Teaching machine (Tutor) automatically simulates complex electronic gear, speeds development of technical personnel ... BF39 Apr 22

TELEMETRY
(See also Communications, Military Electronics, Missiles and Space Electronics)
Accurate pulse-code modulation system for missile telemetering being built ... EN11 Jan 1
Berryllium oxide heat sink solves problem of heat removal from tube anode in r-f telemetry power amplifier ... CM110 May 20
Circularly-polarized, high-gain antenna for handling large quantities of telemetry data from Tiros Meteorological satellite ... TF57 Apr 15
Elliptically polarized X-band horn antenna has 3-db and 6-db beamwidths of 140 degrees ... TF50 Mar 4
High-speed digital plotter cuts time for reducing telemetered data ... TF41 Jan 8
Interlacing of two helical antennas improves overall radiation pattern of single helix ... TF99 Apr 29
Missile telemeter-radio interference: Cause and cure ... BF24 Jan 8
Pioneer V will be transmitting information over distance of 50 million miles in August, 1960 .. BF49 Mar 25
Telemetry system, vhf, for eliminating communication blackout from plasma sheath formation during vehicle reentry ... TF105 May 27
Telemetry technique for studying car behavior developed ... BF42 Mar 18
Telemetry transmitter for ICBM operates through ionized plasma around re-entry missile ... BTW11 Feb 12
Telemetry transmitter for investigating Van Allen radiation belt uses novel transistorized phase modulator circuit ... TF68 May 6
Telephone and teleprinter R&D in Switzerland ... SR75 Feb 12
Test equipment for reliability checkout of Subroc antisubmarine telemetering system ... PC78 Jan 29
Tiros transmits data with two 33-ounce off-the-shelf f-m telemetry transmitters ... BTW11 Apr 15
Titan flight test program will use pulse-code-modulation telemetry system ... BTW11 Mar 4
Transistorized low-pass filters-amplifier for subaudio frequencies used in missile telemetry ... TF88 Jan 15
Transistorized pulse height-to-time converter for earth satellite telemetry system ... TF82 Jan 15
Telephone submarine cable being run between Britain and Sweden ... EN11 Jun 17

TELEVISION
(See also Broadcasting, Communications, Consumer Products, Receivers and Transmitters)
Balanced-bridge and semiconductor diode circuits for one-tube oscillator-mixers in tv and f-m tuners ... TF76 Jan 15
British tv and radio manufacturers break all sales records ... EN11 Jan 15
Closed-circuit tv for monitoring dental surgery and for assisting in diagnosis being studied ... RD92 Jan 1
Closed-circuit tv monitors quality during production of mesa transistors ... PT86 Apr 8
Color tv sales to rise $10 million in 1960. ... MR24 Apr 22
Computers and closed-circuit television are bringing office automation to Mideast banks and oil firms ... EN11 Jul 1
Electronics R&D in tv in France and Switzerland. SR75 Feb 12
FCC plans to spend $2 million to find out whether or not uhf TV can be rejuvenated ... BF32 Jun 3
FCC yearend report shows more than 1½ million transmitters now on air in more than 50 services ... BF33 Jan 22
French compatible color tv system features sequential transmission of chrominance, uses one-line memory in receiver ... TF57 May 6
Graphical method of solving sweep oscillator multivibrator instability problems encountered in tv receivers ... TF55 Feb 19
International Ordinary Administrative Radio Conference re-allocates frequency spectrum and reports new regulations ... BF33 Feb 19
Israel to make a decision for or against establishing nation-wide tv net in 1960 ... BF31 Jan 22
Japan adopts American NTSC standards to pave way for marketing transistorized color, and black and white tv set in U.S. ... BF27 Jan 22
Japan boosts tv set output for export ... BF48 Feb 26
Japanese– black-and white- and color tv sets arriving in quantity in U.S. ports ... BF32 Apr 29
Japanese to emphasis development of crt tubes for color tv and video tape recorders ... EN11 Feb 12
Japanese tv set sales increase rapidly ... EN11 Jan 15
Japan's electronics industry concentrating on production of color tv sets ... EN11 Jun 24
Lab model thermoplastic recording system gives kinescope-quality b-w picture, green and red predominating color picture ... EN11 Jan 22
Lighter, smaller silver-cadmium portable tv battery capable of more than 2,000 operating hours available ... CM87 Apr 15
Magnetic recording of color television using time-correction circuits to reproduce hues faithfully ... TF76 Jan 1
Manufacturers expect continued increase in tv and audio market ... BF39 Feb 5
Microalloy diffused-base transistors used in tuner design for portable tv sets ... TF76 Mar 18
Miniature tv camera system transmitted high-resolution pictures from Redstone missile ... BTW11 Mar 25
Mobile tv recorder can be modified for American, UK or European standards ... PC94 Jan 15
New image orthicon tv camera tube improves resolution ... CM84 Apr 8
Non-newtonian color optics being used in color-reception system using two monochrome tubes shown at regional meeting of Society of Photographic Scientists and Engineers ... EN11 Jun 24
Pay tv in Canada uses direct wire to give choice of three channels to viewers ... BF52 Mar 18
Pay tv to get three-year, $10 million test if FCC approves ... BTW11 Apr 15
Plane and vehicle movements monitored by tv system ... BF44 Mar 25
Radio and TV production rise in Austria ... EN11 Jun 10
Remote transmitter generates control pulses during vertical blanking interval to control TV receiver ... TF79 May 13
Remote Underwater Manipulator (RUM), a converted Ontos tank, uses TV guide for exploring, installing and removing fixed sonar gear ... BF31 Jun 17
Retail sales of tv sets will rise 60 to 70 percent higher in 1970 ... MR26 May 27
Satellite astronomical observatory with 50-inch telescope and television communication system planned by NSF and NASA ... BTW11 Mar 18
Self-powered portables, more color sets and additional remote control models focal points of 1960 TV market ... BF44 May 13
Six-month shakedown of instantaneous audiometer used to rate viewing habits in New York City completed ... BF44 Apr 8
Sixteen colleges in six midwestern states designated as communications network for Midwest Program on Airborne Television Instruction ... BF59 May 20
Slow-scan tv now considered as supplement to regular civilian amateur activities ... BF48 Feb 12
Soviets plan to triple tv set production by 1965 ... BF51 Jan 15
Specially developed diffused-base mesa transistors permit design of low-noise tuners. ... TF64 Apr 8
Super-power uhf ceramic-metal tube developed for possible long-range radar missile detection and intercontinental tv ... TF70 Apr 8
Technique for checking calibration of f-m and tv transmitter percentage-of-modulation monitors ... TF67 Apr 15
Television sparks growth of electronics industry in Japan ... SR53 May 27
Television tracking system records eye focus points and movements ... TF57 Apr 22
Thailand, Laos and Vietnam to have telecommunication network for radio and tv ... BF29 Jan 1
Thermoplastic recording of television signals provoking interest ... BF46 Jan 15
Transistorized TV receiver with 19-in. screen and rechargeable battery announced ... EN11 Jun 3
Transistorized tv set to be marketed by Japanese firm during 1960 ... EN11 Jan 8
Transistorized video amplifier uses shunt feedback circuits to get 100 MC bandwidth ... TF73 Apr 15
Tunnel diodes will be used in preliminary circuit design of tv sets in two years ... TF159 Mar 11
Unconventional slow-scan TV chain assists astronomers in finding sunspots with balloon-borne optical telescope ... TF49 Jun 17
U.S. National television Standards formally okayed by Japan's Electrowave Control Council ... EN11 Jun 17
Use of commercial uhf tv sets for reception of tv signals from aircraft for educational purposes discussed at winter meeting of AIEE ... BF28 Feb 19
Video band recorder-reproducer for analog and pulse signals to be produced ... EN11 Mar 25
Watchdog satellites to carry TV cameras and electrostatic tape recorders to check performance of other satellites ... BF35 Jun 10
What's new in cathode ray tubes ... SR55 Apr 29
Temperature of commercial tube cathodes measured using magnetic field parallel to retarding potential ... RD80 Apr 15
Terminations, coaxial cable and waveguide, characteristics and relative cost of ... TF50 Jan 8
Ternary compounds, predicting possible use as semiconductor materials ... TF103 Feb 12
Terrain mapping, frequency scanning antennas for ground mapping or scanning radar systems ... TF70 May 6

TEST EQUIPMENT (See also Instruments)
Auto Company tests energy absorption of materials by measuring impact of steel ball of surface ... PC30 Jun 17
Automatic fault-finding system for testing battery control center of Hawk Weapons System ... TF60 Jun 17
Bridge circuit measures pulse response of armatures to pinpoint faults during production runs . TF70 Jun 10
Control transformer tester aligns coarse-fine servo systems without precision synchros ... TF84 Mar 18
Current pulse generator for testing ferrite memory cores ... TF80 Jan 1
Dynamic tester evaluates transistors by their performance as component in oscillator circuit . RD66 Feb 19
Electron tube tester automatically prepares test data in digital form for computer analysis ... PT74 Feb 5
FAA orders test monitoring control equipment to check out VORTAC air navigation system ... EN11 Feb 26
Mobile antenna radiating facility for aircraft flight-line testing (RADFAC) ... PC96 Jan 15
Mobile controller-recorder programs temperatures to test missile components ... PC34 Jun 17
Model test range will permit all-weather, interference-free testing of antenna radiation patterns ... RD64 Jan 8
Modern microwave test equipment. ... SR67 Jun 24
Photographically-sensitized metal sheet makes custom labels for instrument and test equipment panels ... PT100 Jan 1
Production line tester for checking for contact chatter of electromagnetic relays uses thyratron timing circuit ... TF94 May 20
Self-compensating fixture tests 24 capacitors at a time in an environmental test chamber ... PT72 Jan 22
Servocontrolled photocell monitors diameter of wire as it is drawn ... PT90 Feb 26
Shell-type transformer used to nondestructively test magnetic sheet material ... PT90 Feb 26
Test circuit for super-power uhf ceramic-metal tube ... TF70 Apr 8
Test circuit shows how to accurately measure gain and phase angle characteristics of closed-loop synchro, resolver and computer amplifiers. ERS88 May 13
Test equipment for reliability checkout of Subroc antisubmarine telemetering system ... PC78 Jan 29
Three-dimensional x-rays diagnose component failures more readily ... PT74 Jan 22
Transistorized monitor developed to test electrical contacts under shock and vibration conditions ... RD78 Apr 8
Transistorized overload circuit for production and maintenance testing of transistors with low d-c voltages ... RD125 Feb 12
Transistorized test set for measuring critical current in superconducting contacts of cryogenic circuits ... TF52 Jan 22
Wheel-shaped component carrier in oven makes 150 C tests of silicon diodes ... PT130 Feb 12
Wow-flutter indicator for precise measurement of tape recorder performance ... TF100 Jun 24
Thermal conductivity, determination of in evaluating three-element semiconductors ... TF103 Feb 12
Thermal design of receiving-type electron tubes .... SR55 Apr 29
Thermal infrared detectors, characteristics of ..... TF72 Apr 1
Thermionic driver for boosting speed of conventional electromechanical counters ... TF112 Feb 12
Thermionics, new developments in direct conversion of heat to electric power without using moving parts ... TF159 Mar 11

THERMOELECTRICITY
(See also Converters, Generators, and Power Sources and Supplies)
Americans study Soviet-built heat-to-electricity converter ... BF48 Apr 1
Cesium cell converter working at high temperatures produces significant amounts of a-c electricity ... CM78 Jan 29
Measurement of thermoelectric power to evaluate three-element semiconductor materials ... TF103 Feb 12
New developments in direct conversion of heat to electric power without using moving parts ... TF159 Mar 11
Power amplifiers using electro-optical effects handle various combinations of electric radioactive and thermal power ... TF71 Feb 26
Researchers demonstrate experimental photogenerator for converting solar energy by photoelectric emission ... EN11 May 27
Thermoelectric cooling modules for electronic components in R&D stage ... RD68 Feb 5
Thermoelectric cooling now possible using new semiconductor materials ... CM85 Feb 26
Thermoelectric developments shown at IRE International Show and Convention ... EN11 Apr 1
Thermoelectric generator built which delivers 5 kw by direct conversion of heat into electricity without major moving parts ... RD96 Jun 3
Thermoelectric transistor cooler using Peltier effect gives wide-range temperature control ... TF71 Jan 15
Thermometry program for getting higher precision at low temperatures being expanded ... RD98 Jun 3

THERMOPLASTICS
Lab model thermoplastic recording system gives kinescope-quality b-w picture, green and red predominating color picture ... EN11 Jan 22
New tube produces velocity modulation gratings on thermoplastic recording tape ... EN11 Jan 15
Thermoplastic recording of television signals provoking interest ... BF46 Jan 15
Thickness measurement of wire, electronic gage for nondestructive measurement of ... TF109 Feb 12

THIN FILMS
(See also Magnetics and Microminiaturization)
Completely passive, balance modulator circuits using thin permalloy film described at 1960 Winter Convention on Military Electronic ... RD78 Feb 26
Electron beam device accurately drills small holes in evaporating masks used in microminiaturization ... TF71 Jan 15
Electronics R&D in thin film storage in England.. SR75 Feb 12
Magnetic thin film dots for computer memories ... PC184 Mar 11
Measuring switching speed of thin magnetic films using strip transmission line ... TF79 Jun 3
New developments in thin film techniques for microminiaturization ... TF159 Mar 11
Recent advances in preparing thin film ceramic dielectrics for microminiature capacitors ... CM96 Jan 1
Recent progress in solid state technology reported at 1960 Solid-State Circuits Conference ... TF39 Mar 4
Series of papers on thin films presented in IBM Journal ... CM78 Jun 17
Switching and storage circuits are made from crossed film cryotrons deposited on insulating superconductors ... TF55 Jan 29
Value of thin magnetic films in computer memory systems being explored by Case Institute of Technology ... BF53 Feb 12
Thyratron timing circuit used in production line tester for checking for contact chatter of electromagnetic relays ... TF94 May 20
Thyratrons control a milling machine by driving step motors in response to signals from a programmed tape ... TF174 Mar 11
Thyratrons, what's new in development of ... SR55 Apr 29
Time and frequency signal broadcasts being coordinated by Britain and U.S. ... RD81 Jun 10
Time-correction circuits to reproduce hues faithfully in magnetic recording of color television ... TF76 Jan 1
Timing circuit for noise suppression factor display unit ... TF55 Feb 5
Timing circuit, thyratron, used in production line tester for checking for contact of electromagnetic relays ... TF94 May 20
Timing circuits, adjustible, operate primarily as frequency dividers using a controlled rectifier and saturable reactor ... TF61 May 6
Timing light, circuit, transistorized, for camera control system used in rocket sled tests ... TF63 Apr 1
TIMMS (Thermionic Integrated Micromodulator) circuits demonstrated at IRE International Show and Convention ... BTW11 Apr 1
TIMMS (Thermionic Integrated Micromodular Circuits), practicality of using small ceramic receiving tube in ... CM82 Jun 10
Tiros guided into preselected circular orbit by command guidance system developed for Titan ICBM ... PC40 Jun 3
Tonometer, electronic, detects glaucoma by measuring pressure within eyeball. ... TF115 Feb 12
Tooling standardization cuts most and design time .. PT88 Jun 10
Tote boxes and trays of special design speed assembly, reduce production costs ... PT88 Mar 25

TRACKING & ACQUISITION SYSTEMS
(See also Missiles, Radar, Rockets and Satellites)
Broadband log-periodic antennas for monitoring and signal interception, direction finding, satellite tracking, radio astronomy and h-f communications uses ... TF58 Jun 17
Circularly-polarized, high-gain antenna for automatic tracking of Tiros meteorological satellites ... TF57 Apr 15
Ground based missile roll control system used photosensitive or infrared detectors ... RD80 Mar 25
Interlacing of two helical antennas improves overall radiation pattern of single helix ... TF99 Apr 29

NASA gives $30-million contract for worldwide tracking and communications net for Project Mercury ... BTW11 Feb 5
NASA reports satellite tracking performance is tied to size of antenna new ... BF33 Apr 29
Optical-electronic active system for communications, navigation, and tracking, and acquisition applications ... TF71 Jan 15
Maneuverable dish radar to scan and track ballistic missiles for BMEWS ... BF47 Mar 18
Monopulse tracking radars compared with sequential lobing and conical scan techniques ... TF51 Apr 22
Navy begins test on UDOFT (Universal Digital Operation Flight Trainer) used to simulate complicated jet flight conditions ... BF44 Apr 15
Project Mercury satellite to be tracked by 50 antenna system ... BF33 Mar 4
Television tracking system records eye focus points and movements ... TF57 Apr 22
Tracking ship for measuring missile capabilities gets more radar equipment ... EN11 Jan 1
Transportable probe tracking facility (antenna and data collector) being tested for ARPA ... BF33 Apr 29
WWV adds experimental standard time code to regular broadcasts for simultaneous observations at widely separated locations ... RD114 Jun 24
TRACTOR, a new magnetic tape system capable of storing 60 million characters is announced ... EN11 May 6
Transceiver, binary data, permits computers to talk to each other at 2,400 bits per sec over phone lines ... EN11 Jun 3

TRANSDUCERS
Inductor with ferrite core used in tonometer probe for detecting glaucoma by measuring pressure within eyeball ... TF115 Feb 5
Material and backing-plate selection for sonar transducer design ... TF62 Feb 26
Passive, reversible, distributed-coupling transducer introduced at 3rd International Congress on Acoustics ... CM73 Feb 5
Rugged ultrasonic transducer with novel vibrating system for indoor and outdoor remote control applications ... CM128 May 27
Single-disk barium titanate transducer for portable transistorized depth indicator ... TF50 Feb 5
Strain sensing element of whisker size and high strength gives 50 times greater sensitivity than present metallic devices ... BF11 Feb 26
Ultrasonic flowmeter uses two crystal transducers for common-path beam direction to eliminate temperature errors ... RD78 Apr 22
Transfluxor (magnetic-electronic) oscillator retains last frequency setting many hours after control signal removal ... TF48 Mar 4
Transformer, shell-type, used to nondestructively test magnetic sheet material ... PT90 Feb 26
Transformers, linear differential, demodulators for ... ERS92 Jun 3
Transforms—review of Fourier and convolution integrals and graphical extension of convolution technique ... TF68 Apr 1

TRANSISTOR CIRCUITS
Accurate and stable pulse height discriminator uses forward-biased shunt diode in input circuit ... TF89 May 20
Analytical design of transistor push-pull amplifiers ... TF60 Jun 10
Battery-powered transistorized scale-of-64 counter for measuring radioactive tracers, improves reliability, reduced cost and weight ... TF74 May 6
Choosing transistors for monostable multivibrators used as variable delay generators ... ERS58 Jan 22
Combination flip-flop and bootstrap sweep generator gives same type waveforms as phantastrons ... TF177 Mar 11
Data reduction speeded using transistorized pulse-height-to-digital signal converter ... TF58 Jan 8
D-c transistor amplifier for measurement of low-amplitude long-period surface waves of ocean ... TF85 Jan 1
Designing high-frequency, high-power transistor oscillator circuits ... TF52 Jan 8
Direct record and reproduce transistor amplifiers for wideband magnetic tape instrumentation recorder ... TF44 Jan 8
Expandable random-access solid-state memories operate over 15 to 55 C temperature range, require only 3 percent supplies ... TF164 Mar 11
Extensive transistorization of portable radar permits silent surveillance of enemy movement ... TF67 Mar 18
Five-transistor line voltage regulator uses Zener diodes ... TF64 Feb 5
Flow rate of jet fuel containing radioactive tracer measured by simultaneously gated oscillator and radiation detector ... TF58 Feb 19
Generator-regulator for autos uses only semiconductors and resistors ... TF52 Feb 19
Indicator triode-transistor flip-flops are coupled to form shift register ... TF52 Feb 5
Insuring stability in precision time delay multivibrators used in radar and industrial electronics ... TF73 Apr 8
Linear circuits used to obtain precise voltage regulation of output of transistorized d-c- to a-c inverter ... TF61 Apr 15
Magnetic shift register core-transistor pulse amplifier and blocking oscillator ... TF80 Jan 15
Microalloy diffused-base transistors used in tuner design for portable tv sets ... TF76 Mar 18
Parallel-to-serial converter for solid-state character generator used in VIDIAC (Visual Information Display and Control) system ... TF55 Jun 10
Peak voltmeter uses transistorized flip-flop comparison and adjustment circuit to charge storage capacitor during substanital part of interpulse interval ... TF57 Jun 17
Portable transistorized depth indicator for locating fish doesn't need crt ... TF50 Feb 5
Portable transistorized sound lever meter for measuring noise ... TF64 Jun 17
Reciprocal circuit gives output which is inversely proportional to input for use with analog computers and control systems ... TF92 May 20
Selecting power transistors to give required switching speed, gain and current-carrying capacity in computer switching applications ... TF44 Mar 4
Selective calling system for aircraft data links removes necessity of continuously monitoring a communication channel ... TF108 Apr 29
Selective paging system uses coded transmission for voice intercommunications with up to 45 stations ... TF68 Feb 26
Self-powered transistor oscilloscope has response from d-c to over 5 Mc ... TF80 Mar 18
Single-transistor circuit forms efficient photoflash power converter ... TF57 Jan 22
Specially developed diffused-base mesa transistors permit design of low-noise tuners ... TF64 Apr 8
Steering transistor circuits control reversible decade counter generating error signals ... TF86 Jan 1
Telemetry transmitter for investigating Van Allen radiation belt uses novel transistorized phase modulator circuit ... TF68 May 6
Three-stage silicon transistor amplifier with high-value circuit resistances operates with less than one milliwatt battery drain ... TF106 Apr 29
Transistor audio volume compressor for interview tape recorders ... TF62 Jan 8
Transistor reverse-biasing technique raises breakdown point for switching indicator tubes ... TF48 Jan 8
Transistorized automobile ignition system uses surface-gap spark plugs ... RD82 Mar 25
Transistorized circuits for guiding Able series space exploration probes ... TF60 Jan 29
Transistorized f-m modulator and demodulator, peak amplitude detector and audio selection gate for sonar student operator trainer ... TF65 Mar 25
Transistorized function generator eliminates need for d-c amplifier ... TF75 Mar 25
Transistorized gear stars at National Motor Boat Show ... BF30 Jan 22
Transistorized high-power sound generating system used to replace mechanical sirent alarms ... TF70 Apr 15
Transistorized inverters working at 1,250 cps power 40-watt fluorescent lamp off 24-v battery in British railway coaches ... TF58 Feb 5
Transistorized monitor developed to test electrical contacts under shock and vibration conditions ... RD78 Apr 8
Transistorized multiplex single-sideband suppressed carrier system capable of handling 600 voice channels announced ... EN11 Feb 19
Transistorized overload circuit for production and maintenance testing of transistors with low d-c voltages ... RD125 Feb 12
Transistorized precision multiple-range sweep generator for airborne radar system ... TF92 Jan 15
Transistorized pulse height-to-time converter for earth satellite telemetry system ... TF82 Jan 15
Transistorized radiation monitor sounds alarm when alpha and beta radiation reaches preset level in nuclear-powered Navy vessels ... TF43 Jan 22
Transistorized radio beacon designed to function as aircraft crash position indicator ... TF54 Jan 22
Transistorized sense amplifier, gate and inverter for Mobile Digital Computer (MOBIDIC) ... TF72 Mar 25
Transistorized slicer measures amplitude probability density functions ... TF70 Jan 29
Transistorized slow-scan TV chain for Stratoscope I ... TF49 Jun 17
Transistorized subaudio swept signal generator for testing servos and related equipment and components ... TF67 Apr 22
Transistorized test set for measuring critical current in superconducting contacts of cryogenic circuits ... TF52 Jan 22
Transistorized video amplifier uses shunt feedback circuits to get 100 MC bandwidth ... TF73 Apr 15
Two transistor voltage amplifiers and latchtype relay provide overload protection for voltmeter ... RD92 Mar 18
Underwater camera flash and film-rewind circuits control picture taking at depths of 6 miles ... TF62 Apr 8
Wide- and narrow band- feedback amplifiers made from new alloyed-emitter, pnp mesa transistor for low microwave region operation ... RD82 Apr 15

TRANSISTORS
(See also Semiconductors and Solid-State Physics)
Alloyed-emitter, pnp mesa transistor operates in low microwave region and is mounted in coaxial shell ... RD82 Apr 15
Automated transistor assembly systems turns out npn alloy junction transistors for computers at transistors for microminiaturization ... TF71 Jan 1
Automatic alloy boat loaders boost transistor production ... PT122 Jun 24
British approaches to producting flat-plate rate of 1,800 per hour ... BTW11 Feb 19
Brush plating and air-operated masking jig speed precision soldering of transistor tabs ... PT70 Mar 4
Cadmium sulphide field-effect phototransistors used successfully in oscillator, multivibrator, amplifier and radiation detector circuits ... EN11 Feb 26
Caseless mesa microtransistor 15 mils thick by 25 mils square to be marketed at mid-year ... BTW11 Mar 25
Closed-circuit tv monitors quality during production of mesa transistors ... PT86 Apr 8
Counterattacks to petition for import curbs on Japanese transistors are registered in Washington ... BF42 Jan 15
Dutch market their first electronic computer which uses transistors and ferrite cores ... BTW11 Feb 12
Dynamic tester evaluates transistors by their performance as component in oscillator circuit ... RD66 Feb 19
Electronics R&D in semiconductors and transistors in England, Sweden, Israel and Japan ... SR75 Feb 12
Fully automatic electromechanical machine assemblies alloy-junction transistors of high uniformity and quality ... TF57 Mar 25
Germanium diffused base transistor with open circuit base connection serves as inductive negative resistance diode in microcircuits ... TF60 Apr 22
Germans concentrate on semiconductor and vacuum tube development ... BF49 May 13
Gold-antimony alloy gives more even control of semiconductor doping ... CM71 Jan 22
High-purity silicon dielectric for potting transistors is nonmelting and greaselike ... CM84 Apr 15
High-speed transistor switch for computer logic circuit performs at micro-energy levels ... CM98 May 13
Micro-alloy diffused base transistor (MADT) fabrication improved using Etching by Transmitted Light (ETL) technique ... BTW11 Apr 1
Multi-junction drift-field transistor simplifies design of portable and auto radios ... CM82 Apr 22
New mode of transistor operation (combination tunneling and avalanche effect) being explored excitedly by several companies ... BTW11 Apr 22
New triple-diffused npn silicon mesa devices designed for low-power high-speed switches shrunk to pico size ... CM82 Apr 8
Plastic type transistor developed by Soviet scientist ... EN11 Jan 1
Respective merits of tubes and transistors discussed at winter meeting of AIEE ... BF28 Feb 19
Semiconducting industrial diamonds may find application as transistors ... RD76 Apr 22
Services need inventions in component, transistor, antenna and instrument areas ... BF39 Jan 22
Silicon transistors of mesa construction capable of handling 10, 20, 50 and 100 amp being investigated ... CM86 Apr 1
Squeezer rapidly straightens bent or kinked transistor leads ... PT72 Jan 8
Technique of vapor-growing high resistivity collector films on a low-resistivity substrate (revealed at IRE-AIEE conference) may have far reaching implications ... EN11 Jun 24
Thermoelectric transistor cooler using Peltier effect gives wide-range temperature control ... TF71 Jan 15
Transistors developed which are almost flush with print circuit boards ... EN11 May 20
USSR claims to have made transistors from plastic fiber using bombardment techniques ... BF26 Jan 22
Vhf silicon transistor for high-power oscillators ... TF52 Jan 8
Translation machine using optical—electronic reader to recognize 1,000 Russian characters per second ... EN11 Jun 10
Translator circuit, parametron, for digital computers ... TF73 Jun 3
Transmission line, strip, used to measure switching speed of thin magnetic film ... TF79 Jun 3
Transmission lines, biasing techniques permit small-area junction germanium diodes to switch microwaves in ... TF85 Jan 15
Transmission lines used in modern microwave systems ... SR67 Jun 24

TRANSMITTERS
(See also Broadcasting, Communications, Consumer Products, Radar, Radio and Television)
Circle diagram for impedance matching transmitter to antenna ... ERS73 Jun 10
Double-sideband suppressed carrier transmitter for medium power operations ... TF47 Feb 5
Frequency sythesizer uses solid-state tuner to provide stable, high-accuracy receivers and transmitters ... RD122 Feb 12
Million-watt transmitter to be completed by year's end for Navy ... BF41 Jan 29
NBS studies automatic computation methods for determining best possible frequencies for radio transmitters used as road markers on air lanes ... RD72 Jun 17
Portable Doppler radar for battlefield surveillance of enemy uses X-band transmitter ... TF67 Mar 18
Radar transmitter for antimissile Zeus being tested ... BF34 May 27
Remote transmitter generates control pulses during vertical blanking interval to control TV receiver ... TF79 May 13
Selective paging system uses coded transmission for voice intercommunications with up to 45 stations ... TF68 Feb 26
Technique for checking calibration of f-m and t-v transmitter percentage-of-modulation monitors ... TF67 Apr 15
Telemetry transmitter for ICBM operates through ionized plasma around re-entry missile ... BTW11 Feb 12
Telemetry transmitter for investigating Van Allen ... TF68 May 6
Tiros transmits data with two 33-ounce off-the-shelf f-m telemetry transmitters ... BTW11 Apr 15
Transistorized radio beacon transmitter designed to function as aircraft crash position indicator ... TF54 Jan 22
Transmitter for SAGE warning system provides 20-kw output level ... PC34 Apr 22
Transponders, special, for aircraft identification system ... PC37 Jan 8
Transponders, uhf beacon, in Tiros I improves radar data quality, provides horizon-to-horizon coverage ... RD96 May 13

TRANSPORTATION
(See also Automobile Electronics and Aviation)
New IBM solid-state business data processor order by Southern Railway ... EN11 Feb 12
Solar-powered call system gives drivers choice of emergency highway service ... PC53 Jun 3
Sophisticated electronic gear on ships may mean use of more solid-state power supplies ... EN11 Feb 12
Transistorized inverters working at 1,250 cps power 40-watt fluorescent lamp off 24-v battery in British railway coaches ... TF58 Feb 5
Traveling-wave cathode ray tubes, what's new in ... SR55 Apr 29
Traveling-wave tubes, what's new in ... SR55 Apr 29
Trays and tote boxes of special design speed assembly, reduce production costs ... PT88 Mar 25
Trend of manufacturers to step up efforts to make own components ... BTW11 Mar 18
Trigger circuit, ferroresonant, for electroluminescent typewriter ... TF49 Jan 22
Trlodes, temperature-insensitive solid-state dielectric ... TF59 Feb 26
Trixies switch Nixie tubes by means of transistor reverse-biasing technique which raises breakdown point ... TF48 Jan 8

TUBES (See also specific tube types)
Astracon, a small light amplifier tube, increases light-gathering ability of telescopes, permits viewing of high-energy particle tracks ... PC82 Jun 10
Berryllium oxide heat sink solves problem of heat removal from tube anode in r-f telemetry power amplifier ... CM110 May 20
Cold-cathode ring-counter drives numerical indicator ... TF80 APR 1
Controversy shaping up as to merits of bonded or unbonded picture tubes ... BF44 May 13
Electron sealing process using optically-ground and mated glass stem and envelopes to extend military tube life ... EN11 May 6

Experimental magnetrons for 32, 12, 8 and 4mm wavelengths give peak outputs of 1,100, 70, 80 and 40 kw, respectively ... CM96 Mar 18
Gas-filled stepping tubes ... TF46 Feb 19
Germans concentrate on semiconductor and vacuum tube development ... BF49 May 13
High-power pulse S-band klystron for long-range radar or troposcatter communications ... CM82 Feb 26
Hybrid tube development for modern microwave applications ... SR67 Jun 24
Indicator triode has fluorescent anode whose is controlled by grid potential for direct data readout ... TF52 Feb 5
Japanese to emphasis development of microwave tubes ... EN11 Feb 12
Mass spectrometer measures quantity of helium escaping in electron tube manufacture ... TF74 Apr 1
Materials for potting base of electron tubes ... CM84 May 6
Materials hold key to development of electron tubes capable of reliable performance at high ambient temperatures ... CM118 Apr 29
Measuring cathode temperature of commercial tubes by using magnetic field parallel to retarding potential ... RD60 Apr 15
Microminiature tube circuits featuring nuclear radiation resistance offered at IRE International Show and Convention ... BTW11 Apr 1
Micro-sized vacuum tubes encapulated in a solid block reported at 1960 Western Joint Computer Conference ... CM100 Jun 3
Microwave tube called X-band Amplitron has large anode-dissipation densities ... TF71 Jan 15
Monoscope tube generates characters for direct readout on a cro or on paper of digital computer output ... TF117 Feb 12
New cathode base metal for tubes greatly improves microphonics and resistance to cathode bowing under severe shock ... CM79 Jun 17
New crt with higher-than-usual phosphor sensitivity developed for digital readout oscilloscope ... BF30 Mar 4
New image orthicon tv camera tube improves resolution ... CM84 Apr 8
New tube produces velocity modulation gratings on thermoplastic recording tape ... EN11 Jan 15
Non-newtonian color optics being used in color-reception system using two monochrome tubes shown at regional meeting of Society of Photographic Scientists and Engineers ... EN11 Jun 24
Novel handling techniques for producing super-poer klystron over 10 feet tall ... PT192 Mar 11
Nuvistor goes into production ... BF35 Feb 19
One-watt electrostatically focused twt announced ... PC182 Mar 11
Polyoptic sealing technique improves the reliability and life of glass envelope electron tubes ... PT114 May 20
Practicality of using small ceramic receiving tubes in thermionic integrated micromodular circuits (TIMMS) ... CM82 Jun 10
Preliminary statistics indicate tube shipments increased 145 percent between 1954 and 1958 ... MR22 Mar 4
Printing and storage tubes receive much attention at 1960 IRE International Show and Convention ... BF47 Apr 1
Quartz-to-metal seals for high-frequency vacuum tubes ... CM102 Jun 3
Reflex klystrons used as millimeter wave amplifiers millimeter wave amplifiers made from reflex klystrons ... TF71 Mar 18
Respective merits of tubes and transistors discussed at winter meeting of AIEE ... BF28 Feb 19
Rice Institute develops 8,·192-word grid tube memory, expect expansion to 32,000 words ... BF59 May 20
Small BEAM-X switch tube may claim extended market ... CM126 Feb 12
Specifications for carcinotron and reflex klystrons used in millimeter band ... CM68 Feb 19
Super-power uhf ceramic-metal tube developed for possible long-range radar missile detection and intercontinental ... TF70 Apr 8
Ultra-clean electron gun promises greater power rating, longer life for radar klystrons ... EN11 Mar 25
U.S. electron tubes and semiconductors of specialized types and advanced designs in demand abroad ... BF48 Feb 26
What's new in electron tubes ... SR55 Apr 29
X-ray detector being built to find troubles in high-voltage mercury-arc tubes ... RD87 Mar 25
Year 1960 to see increased semiconductor sales, maintenance of high level 1959 electron tube sales ... MR24 Jan 29

TUNERS (See also Receivers)
Balanced-bridge and semiconductor diode circuits for one-tube oscillator-mixers in tv and f-m tuners ... TF76 Jan 15
Microalloy diffused-base transistors used in tuner design for portable tv sets ... TF76 Mar 18
Specially developed diffused-base mesa transistors permit design of low-noise tuners ... TF64 Apr 8
Tungsten, high-purity, now easily plated on metal surface using vapor deposition process ... CM85 Jun 10
Tuning, incremental, possible with precision R-C oscillator with high degree of stability ... TF76 Apr 15

TUNNEL DIODES
Big push in tunnel diodes noted at 1960 IRE International Show and Convention ... BF47 Apr 1
Broadband microwave amplifier uses negative resistance of tunnel diode in combination with nonreciprocal ferrite attenuation ... CM84 Mar 25
Design criteria for negative-resistance amplifiers giving low noise and high gain at very high frequencies ... TF110 May 27
Determining proper bias and correct circuit impedances for operating tunnel diodes as switches, amplifiers or oscillators ... TF82 Jun 3
Development of tunnel diode circuits in Japan ... SR53 May 27
Forthcoming Solid-State Circuits Conference indicates R & D labs are in tunnel diode race ... BF32 Jan 1
GE sponsors investigation into computer uses of tunnel diodes at University of Arizona ... BF60 Mar 11
How radiation effects tunnel diode operation ... BF32 May 6
Major use of tunnel diodes seen in industrial and military electronics ... TF159 Mar 11
Match-head size tunnel diode holds great promise for missile satellite and ultra-high-speed data processing applications ... PC69 Mar 4
Packaged miniaturized tunnel diodes announced capable of 4,000 Mc oscillations, 10KMc units a distinct possibility ... BF33 Jun 3
Recent progress in solid state technology reported at 1960 Solid-State Circuits Conference ... TF39 Mar 4
Tunnel and variable capacitance diodes give promise of 1,000-Mc computers ... TF55 Jan 29
Tunnel diode amplifier, broadband traveling-wave, for microwave applications ... SR67 Jun 24
Tunnel diode circuit designs open new markets for computer, communications and receiver amplifier applications ... BF36 Feb 26
Tunnel diode factory production announced by U.S. and Japanese firms ... BTW11 Feb 12
Tunnel diode logic circuits – modes of operation and effect of circuit component tolerances ... TF103 Jun 24
Tunnel diodes being pushed to higher oscillation frequencies ... EN11 Jan 8
Tunnel effect, definition of ... TF71 Feb 26
Tunnel triode being investigated as potentially useful computer element ... EN11 Mar 4
Tunnel triodes featured in new computer developments ... TF159 Mar 11
Turbidimetric assays calculated by computer in automatic microbiological testing ... RD67 Jan 8
Tutor (automatic teaching machine) simulates complex electronic gear, speeds development of technical personnel ... BF39 Apr 22
TVOR (terminal-type vhf omnirange) equipment to be installed in 18 locations by FAA during 1960 ... BF40 Feb 12
Twistor, a permanent magnetic unit, ready for mass production ... BTW11 Jan 29
Twistor technique of spiral magnetic paths used in digital computer memory ... CM84 Mar 25
Typewriter, electroluminescent, formed by ferro-resonant storage and switching circuits combined with alphanumeric indicator ... TF49 Jan 22
Typhon, new dual-purpose guided missile system being developed for Navy's surface warships ... BF49 Apr 29

U

UDOFT (Universal Digital Operation Flight Trainer) to begin evaluation tests by Navy ... BF44 Apr 15

ULTRASONICS
Immersion goniometer for measuring ultrasonic velocity in different media ... RD112 Jun 24
New developments in ultrasonics ... TF159 Mar 11
Rugged ultrasonic transducer with novel vibrating system for indoor and outdoor remote control applications ... CM128 May 27
Status of ultrasonics industry in Japan ... SR53 May 27
Ultrasonic cleaning equipment sales to be up 30 percent over next five years ... MR28 May 20
Ultrasonic flowmeter uses two crystal transducers for common-pathbeam direction to eliminate temperature errors ... RD78 Apr 22
Ultrasonic resonance thickness gage measures missile radomes and nose cones ... PC86 Feb 26
Ultraviolet radiometry standard developed by NBS ... RD64 Feb 19

V

Varactor diodes available in experimental quantities, used for high-efficiency subharmonic oscillators in microwave computers ... CM131 May 27
Varactor tuning devices for frequency synthesizer gives stable, high-accuracy receiver and transmitters ... RD122 Feb 12
Variable capacitance diodes give promise of 1,000-Mc computers ... TF55 Jan 29
Vibration, built-in damping controls violent motion imposed by ... CM186 Mar 11
Vibration, knitted metal mesh protects electronic equipment from ... CM94 Mar 18
Vibrator uses beads to simulate atomic motion ... PC74 Jan 29
Video band recorder-reproducer for analog and pulse signals to be produced ... EN11 Mar 25
VIDIAC (visual information display and control) solid state character generator developed ... EN11 Apr 29
VIDIAC (Visual Information Display and Control) system, solid-state character generator for ... TF55 Jun 10
Visual compared with ir and radar detection in fog and rain ... TF64 Jan 29
Voltmeter, peak, uses transistorized flip-flop comparsion and adjustment circuit to charge stocapacitor during substantial part of interpulse interval ... TF57 Jun 17
Voltmeter two transistor voltage amplifiers and latchtype relay provide overload protection for ... RD92 Mar 18
VORTAC air navigation system, FAA orders test monitoring control equipment to check out ... EN11 Feb 26

W

Water, high-purity, making and using ... PT132 May 27

WAVEGUIDES
(See also Microwave Systems and Devices, and Radar)
Biasing techniques permit small-area junction germanium diodes to switch microwaves in waveguides or transmission lines ... TF85 Jan 15
Characteristics and relative cost of coaxial cable and waveguide terminations ... TF50 Jan 8
Contour extruded aluminum tubing is being considered for waveguide components with integral flange ... PT104 Jun 3
Elliptically polarized X-band horn antenna has 3-db and 6-db beamwidths of 140 degrees ... TF50 Mar 4
Loaded waveguides for modern microwave applications ... SR67 Jun 24
Status of waveguide development in Japan ... SR53 May 27
Triangular waveguide antenna is more rigid and easier to construct than large slotted waveguide cross sections ... RD64 Feb 19
Waveguide 2, 200 ft long delivered to AF missile center ... EN11 Jan 1

WELDING
Control using voltage constraint and NOR logic improves consistency and reliability of spot welds ... TF48 Feb 19
End-welded studs mount d-c power supply chassis to racking mounting panels ... PT88 Apr 15
Magnetic spot-welding electrodes hold small parts to be welded to sheet or strip material ... PT88 Apr 15
Portable welding handgun carries own filler ... PT77 Jan 8
Spike power control unit overcomes misfiring of high-speed power resistance welders ... EN11 Mar 11
Vacuum, air jet and mechanical transfer methods combined in machine to weld leads to diode headers ... PT88 Apr 15
Welding control automatic hold voltage across weld constant ... PT102 Jan 1
Welding, electron beam metalworking equipment for ... PT86 Feb 26
What's new in welding control ignitrons ... SR55 Apr 29
Winding machine, precision, for submarine cable and capacitor manufacturing ... PT86 Jun 10

WIRE (See also Cables)
Electrically exploded wires aid hypervelocity work ... CM97 Mar 18
Electronic wire gage for nondestructive measurement of wire thickness ... TF109 Feb 12
Ions detect pinholes in wire and cable insulation ... PT77 Feb 5
Servocontrolled photocell monitors diameter of wire as it is drawn ... PT90 Feb 26
Soviets report method of drawing wires of 1 or 2 microns in diameter ... PT100 Mar 18
Special ink for coding Teflon wire announced ... PT72 Mar 4
Teflon coated wire eliminates failure under corona stress ... CM80 Jan 29
Tiny platinum wire is heart of Japanese bolometer mount for measuring microwave power ... CM88 Apr 1
Wire stitching, characteristics and use of types used in electronic production ... TF68 Apr 15
Wires in aircraft individually identified by portable current-path verifier ... PC51 Jan 15
Wire-guided missiles developed in Europe being appraised by Army ... BF38 Jan 15
Wow-flutter indicator for precise measurement of tape recorder performance ... TF100 Jun 24

X-Y-Z

X-RAYS (See also Medical Electronics)
AF is investigating X-rays as possible means of space communication ... BF45 Feb 12
Pulsed x-ray pencil beam gages thickness of hot and cold rolled metals ... PC62 Jan 22
Three-dimensional x-rays diagnose component failures more readily ... PT74 Jan 22
X-ray analytical instrumentation to find expanding market ... BF53 May 6
X-ray detector being built to find troubles in high-voltage mercury-arc tubes ... RD87 Mar 25
Zener diodes used in five-transistor line voltage regulator ... TF64 Feb 5
Zobel filters design procedure straightforward by use of Cauer parameters for specified stop-band attenuation ... TF96 May 20

AUTHORS' INDEX

(All entries are technical features unless otherwise indicated by prefix)

A

Acker, R. M. Lipkis, Miller and Robison, Solar-Cell Power Supplies For Satellites ..... 167 Mar 11
Affleck, J. H., Measuring Cathode Temperatures .. RD80 Apr 15
Agdur, B., Research & Development Around the World — Sweden ..... SR84 Feb 12
Alexander, G. E., and Keys, Radioactive Tracers Find Jet Fuel Flow Rates ..... 58 Feb 19
Allen, H. G., Types of Staples for Electronic Production ..... 68 Apr 15
Allen, J., Precision R-F Capacitors ..... 79 Mar 18
Amato, C., Spreckeis, Roswit, Reid & Malsky, Measuring Radiation Within Human Body..... 74 Mar 18
Amodei, J. J., Converting Oscilloscopes for Fast Rise Time Sampling ..... 96 Jun 24
Apel, K., and Berweger, Miniature Gas-Filled Tubes For High-Speed Counting..... 46 Feb 19
Archer, G. R., Feedback and NOR Logic Yield Sound Spot Welds ..... 48 Feb 19
Armstrong, F. E., Battery Powered Portable Scaler ..... 75 May 6
Armstrong, H. L., Dielectric Absorption in Capacitors ..... RD78 Jun 10
Aronow, M. & Lipshutz, J., Demodulators for Linear Differential Transformers ..... ERS92 Jun 3
Ashley, A. H. and Cohler, Solving Noise Problems in Digital Computer Memories..... 72 Mar 25

B

Bach, R. E., Jr., Selecting R-C Values for Active Filters..... 82 May 13
Bailey, G. W., How to See the Show ..... BF47 Mar 11
Baldwin, K. M., Bassett, Hawthorne, & Langberg, Missile Communication During Reentry Blackout.. 105 May 27
Barlow, D., Europe to Integrate Air Control..... BF40 Apr 22
Barlow, D., More U. S. Gear Going into New British Missiles..... BF32 Mar 25
Barsony, C. L., Graphical Checkout of Multivibrator Design..... 55 Feb 19
Bassett, O. E., Hawthorne, Langberg, & Baldwin, Missile Communication During Reentry Blackout.. 105 May 27
Bauer, J., Research & Development Around the World — Switzerland ..... SR89 Feb 12
Bell, R. L., Broadband Log-Periodic Antennas.... 58 Jun 17
Berweger, P., and Apel, Miniature Gas-Filled Tubes For High-Speed Counting..... 46 Feb 19
Bickart, T. A., Transistorized Slicer Analyzes Signal Amplitude..... 70 Jan 29
Blake, R. F., Designing Solid-State Static Power Relays..... 114 May 27
Bloom, M., Microwave Switching With Computer Diodes ..... 85 Jan 15
Bocast, D. R., Graphicla Solution for Twin-T Networks..... ERS67 Jun 17
Bockemuehl, R. R., and Wood, Industrial Hysteresigraph Uses D-C Integration..... 70 Mar 25
Bostick, G., Microwave Terminations..... 50 Jun 8
Bowen, E. G., Research & Development Around the World — Australia..... SR96 Feb 12
Brady, M. M., Frequency Modulation By Reactance Switching ..... 74 Feb 26
Brady, R. F., and Davidson, Unity-Gain Amplifier Offers High Stability..... 66 Feb 26
Breslow, D. H., Built-in Test System for Automatic Fault Detection..... 60 Jun 17
Brockman, H. P., Sweep Generator Design: How to Keep It Simple..... 92 Jan 15
Brown, R. S., Automatic Surveying System Measures Runway Roughness ..... 54 Jun 17
Brown, W. C., What's New in Electron Tubes - Crossed-Field Microwave Tubes..... SR75 Apr 29
Bruns, R., Making and Using High-Purity Water.... PT132 May 27
Bullock, J. B., Pulse-Coded Fault Alarm in Microwave Systems..... 82 Jan 1
Bushor, W. E., Model Perception Makes Debut .... BF43 Jun 24
Bushor, W. E., Motor City Enters Electronics Derby..... BF42 Mar 18
Butler, T. W., Jr. and Roberts, Solid-State Electronic Tuning..... RD122 Feb 12
Bystrom. A., Hill, & Metter, Ground-Mapping Antennas with Frequency Scanning ..... 70 May 6

C

Campbell, D. A., Multiplex Circuits for Control of a Robot..... 46 Jan 22
Carlson, R. D., Steering Circuits Control Reversible Counters..... 86 Jan 1
Carroll, J. M., What's New in Electron Tubes..... SR55 Apr 29
Carson, D. N. & Dhawan, Data Conversion Circuits For Earth Satellite Telemetry ..... 82 Jan 15
Carter, S. P. & Solomon, Modern Microwaves..... SR67 Jun 24
Cassagne, P., Colas, & Chaste, Sequential Receivers For French Color Tv System..... 57 May 6
Chamberlain, L. J., How to See the Show ..... BF47 Mar 11
Charest, R. J., Guiding Satellites Into Orbit..... BF43 May 27
Chaste, R., Cassagne, & Colas, Sequential Receivers For French Color Tv System..... 57 May 6
Chick, D. R., Boosting Function Generator Output With Transistors ..... 75 Mar 25
Chittenden, W. R., Fisher, & Talbert, Telemetry Transmitter for Radiation Satellite..... 69 May 6
Chow, W. F., Tunnel Diode Logic Circuits ..... 103 Jun 24
Clements, L. D., Solid-State Generator Regulator for Autos ..... 52 Feb 19
Clounie, F. J., Degroat, & Szymanski, Control Makes Test Safe, Accurate..... PT88 May 6
Cohler, E. U. and Ashley, Solving Noise Problems in Digital Computer Memories..... 72 Mar 25
Colas, M., Chaste, & Cassagne, Sequential Receivers For French Color Tv System..... 57 May 6
Conine, E., Automatic Controls Conference Open in Moscow Next Week ..... BF34 Jun 24
Conner, C. L., Frequency-Independent Current Dividers ..... ERS74 Apr 8
Cooke, H. F., Designing Tv Tuners With Mesa Transistors ..... 64 Apr 8
Corbell, P. L., Microwave Mixer for Airborne Radar CM70 Feb 5

D

Damon, M. H., Jr., Tape Target Classifier Trains Sonar Operators..... 65 Mar 25
Daniels, R. E. & Swoboda, C., Pulse Generator for Synchronizing Events..... 63 Jun 10
Davidson, G. M., and Brady, Unity-Gain Amplifier Offers High Stability..... 66 Feb 26
Day, J. N., Jr., Spectrometric Analysis Of Missile Flights ..... 86 May 20
DeBolt, H. E., How Radiation Monitor Guards Nuclear Navy..... 43 Jan 22
DeBolt, H. E., Magnetometer System for Orientation in Space..... 55 Apr 8
de Broekert, J. C. & Scarlett, Transistor Amplifier Has 100 Megacycle Bandwidth ..... 73 Apr 15
deGraaf, J. G., Selective Paging System Uses Coded Transmission..... 68 Feb 26
Degroat, P. M. Szymanski, & Clounie, Control Makes Test Safe, Accurate..... PT88 May 6
De Jongh, E., Emma & Janis, The Electronics Market Looking Into the 60's ..... SR49 Jan 1
de Miranda, H. R. & Rudich, Indicator Triode For Direct Data Readout..... 52 Feb 5
Deutsch, A. R., Don't Promise the Moon ..... BF40 Mar 11
Dhawan, S. K. & Carson, Data Conversion Circuits For Earth Satellite Telemetry ..... 82 Jan 15
Dickinson, W. A., Loughlin, & Gessford, What's New in Electron Tubes - Cathode-Ray Tubes..... SR80 Apr 29
Diemer, G., Power Amplifiers Using Electro-Optical Effects ..... 71 Feb 26
Dietrich, W. & Proebster, W. E., Measuring Switching Speed of Magnetic Films ..... 79 Jun 3
Drake, R. & Pankove, Measuring Critical Current In Cryogenic Circuits..... 52 Jun 22
Ducker, P. G., & Eckess, Measurement Of Diode Switching Characteristics ..... 59 Apr 8
Dummer, G. W. A., British Approaches to Microminiaturization ..... 71 Jan 1
Dunn, J. H. & Howard, Precision Tracking With Monopulse Radar..... 51 Apr 22
Dysinger, J., Whyland & Wood, New Suppressed-Carrier Modulation Technique ..... 47 Feb 5

E

Eastwood, E., Research & Development Around the World — England ..... SR76 Feb 12
Eckess, W. S. & Ducker, Measurement of Diode Switching Characteristics ..... 59 Apr 8
Edgerton, H. E., Uses of Sonar in Oceanography .. 93 Jun 24
Edgerton, H. E. & Raymond, Instrumentation for Exploring the Oceans..... 62 Apr 8
Ekem, W. F., & Levine, Radiation Effects On Electronic Systems..... 69 Apr 22
Emma, T., See Growth in Minnesota..... BF30 Jun 17
Emma, T., Janis & De Jongh, The Electronics Market Looking Into the 60's ..... SR49 Jan 1
Emma, T., and Wolff, Future Developments in Engineering ..... 159 Mar 11
Endsley, D., Summers, Lommasson, Pope, Smith, Grannemann, Longerot & Jones, Pulse-Height-to-Digital Signal Converter ..... 58 Jan 8

F

Faulis, D. R., and Lund, Expandable Random Access Memories ..... 144 Mar 11
Ferguson, W. F., High-Powered Audio Alarm Systems ..... 70 Apr 15
Fisher, A. J., Talbert, & Chittenden, Telemetry Transmitter for Radiation Satellite ..... 69 May 6
Fisher, G. F., Monitor Crystal Base-Plating ..... PT84 Apr 22
Flory, L. E., Gray, Morgan, & Pike, Television System for Stratoscope I..... 49 Jun 17
Flynn, G., Super-Power Electron Tube for UHF Band ..... 70 Apr 8
Flynn, G. J., Frequency Conference: Atomic Clocks and Quartz Crystals ..... BF38 Jun 24

G

Gamero, R., Withrow, & Le Fave, Mold Cable Covering at Junctions ..... PT90 Apr 1
Gamero, R., Withrow, & LeFave, Plastics For Potted Cables ..... 67 May 6
Gamzon, R., Research & Development Around the World — Israel ..... SR92 Feb 12
Gannett, E. K., How to See the Show ..... BF47 Mar 11
Gardner, F. M., & Hawn, Camera Control System For Rocket Sled Tests ..... 63 Apr 1
Gardner, L. J., Transistorized Inverters For Fluorescent Lights ..... 58 Feb 5
Gartner, W. W., & Schuller, Inductive Elements for Solid-State Circuits ..... 60 Apr 22
Gessford, R. K., Sr., Dickinson & Loughlin, What's New in Electron Tubes - Cathode-Ray Tubes ..... SR80 Apr 29
Gill, A., Procedure for Designing Reciprocal Computer Circuits ..... 92 May 20
Golding, J. F., Novel Approach to Pulse Amplifier Design ..... 64 May 6
Goss, H. W., Current Pulse Generator Tests Magnetic Cores ..... 80 Jan 1
Goudet, G. and Grivet, Research & Development Around the World — France ..... SR79 Feb 12
Goulding, F. S., & Robinson, Achieving Discriminator Levels With a Biased Input Diode ..... 89 May 20
Grannemann, W. W., Longerot, Jones, Endsley, Summers, Lommasson, Pope & Smith, Pulse-Height-to Digital Signal Converter ..... 58 Jan 8
Gray, G. W., Flory, Morgan, & Pike, Television System for Stratoscope I ..... 49 Jun 17
Greene, K., Measuring Dielectric Absorption ..... RD90 Mar 18
Greenhow, W. A., Signal Transmission Through Ionized Media ..... 81 May 20
Greiner, R. A., Line Voltage Control Uses Zener Diodes ..... 64 Feb 5
Griffin, D. P., Disk Encoder Design Avoids Ambiguities ..... 62 Apr 22
Grivet, P. and Goudet, Research & Development Around the World — France ..... SR79 Feb 12

H

Hamburger, T., Electroluminescent Alphanumeric Display ..... 49 Jan 22
Harris, P. E., Insuring Stability in Time Delay Multivibrators ..... 73 Apr 8
Hasse-Dubosc, A., Sealed-Off Power Source for S-Band ..... CM82 Feb 26
Hawn, L. R., & Gardner, Camera Control System For Rocket Sled Tests ..... 63 Apr 1
Hawthrone, E. I., Langberg, Baldwin, & Bassett, Missile Communication During Reentry Blackout . 105 May 27
Henry, D. S., Calibrating Broadcast Modulation Meters ..... 67 Apr 15
Hill, R. V., Metter, & Bystrom, Ground-Mapping Antennas With Frequency Scanning ..... 70 May 6
Hodgson, P. G., Cold-Cathode Ring-Counter Drives Numerical Indicator ..... 80 Apr 1
Holt, W. J., Tuning Fork for High-Q Resonance ... CM108 May 20
Holtum, A. G., Jr., Improving the Helical Beam Antenna ..... 99 Apr 29
Horvath, A., Circle Diagrams for Impedance Matching ..... ERS73 Jun 10
Howard, D. D., & Dunn, Precision Tracking With Monopulse Radar ..... 51 Apr 22
Howat, R., Mackworth & Thomas, Tv Tracker Records Eye Focus Points ..... 57 Apr 22
Hugenholtz, E. H., One-Tube Oscillator Mixers For Tv and F-M Tuners ..... 76 Jan 15

I

Ishii, K., Reflex Klystron Amplifier with Hybrid T Coupling ..... 64 Jun 10
Ishii, K., Reflex Klystons as Receiver Amplifiers . 56 Jan 8
Ishii, K., Using Reflex Klystrons as Millimeter-Wave Amplifiers ..... 71 Mar 18
Ishino, T., & Kazama, Remote Tv Control by Blanking-Interval Pulses ..... 79 May 13
Ives, R. L., Circuit Modifications For Boosting Counter Speed ..... 112 Feb 12
Ives, R. L., Crystal Codans Give Accurate Receiver Tuning ..... 113 May 27
Ives, R. L., Reducing Relay Pull-In Drop-Out Gap RD62 Jan 22

J

Jacobs, F., Automatic Weather Station Travels by Helicopter ..... BF43 May 6
Jacobs, S. F., Characteristics of Infrared Detectors ..... 72 Apr 1
Jaensch, K. H., Wire Gage Provides Continuous Measurement ..... 109 Feb 12
Janis, H. K., Air Traffic Data Center Tests Begin BF28 Apr 8
Janis, H. K., De Jongh & Emma, The Electronics Market Looking Into 60's ..... SR49 Jan 1
Johnson, H. R., Lt. Col., Tropo Scatter Spans a Continent ..... BF38 Apr 29
Jones, E. D., Character Generator For Digital Computers ..... 117 Feb 12
Jones, R. D., Endsley, Summers, Lommasson, Pope, Smith, Grannemann & Longerot, Pulse-Height to-Digital Signal Converter ..... 58 Jan 8

K

Kashiwabara, N., Triangular Waveguide Antenna .. RD64 Feb 19
Kaufman, D. E., Finding Ultrasonic Velocity ..... RD112 Jun 24
Kazama, K., & Ishino, Remote Tv Control by Blanking-Interval Pulses ..... 79 May 13
Kear, F. W., Contact Monitoring For Vibration Tests..... RD78 Apr 8
Kear, F. W., Fast-Response Overload Protection . RD125 Feb 12
Kear, F. W., Overload Protection Circuit for Voltmeters ..... RD92 Mar 18
Keonjian, E., Microminiaturizing a Space Vehicle Computer ..... 95 Apr 29
Keys, J. D. and Alexander, Radioactive Tracers Find Jet Fuel Flow Rates ..... 58 Feb 19
King, R. E. & Low, Solid-State Guidance For Able-Series Rockets ..... 60 Jan 29
Kingsborough, D. G., and Swindell, Aligning Servo Loops Without Precision Synchros ..... 84 Mar 18
Klienberg, L., Dual-Frequency Oscillator Design . RD182 Mar 11
Knight, M. B., What's New in Electron Tubes- Receiving-Type Tubes ..... SR56 Apr 29
Kobbe, J. R., & Svehaug, Battery-Operated Transistor Oscilloscope ..... 80 Mar 18
Kohler, G. M., Photography Makes Custom Labels. PT100 Jan 1
Kopp, E. H., Production Line Checker For Relay Contact Chatter ..... 94 May 20
Kotlarski, J. R., Choosing Transistors for Monostable Multivibrators ..... ERS58 Jan 22
Kramer, A. S., What's New in Electron Tubes-Storage, Counting and Phototubes ..... SR86 Apr 29
Kronenber, M. &, K. Moore, Generating High-Quality Characters and Symbols ..... 55 Jun 10
Kruse, P. W., Uncooled IR Detectors For Long Wavelengths ..... 62 Mar 25

L

Lafferty, R. E., How to See the Show ..... BF47 Mar 11
Lafferty, R. E., Low-Q Coil Measurements ..... 112 Apr 29
Landon, N., Bilingual Multiplex..... 87 Jun 3
Langberg, E., Baldwin, Bassett, & Hawthrone, Missile Communication During Reentry Blackout . 105 May 27
Lathrop, J. W., Lee, & Phipps, Semiconductor Net works for Microelectronis ..... 69 May 13

Lawrence, H. C., What Designers Should Know About Missile Components ..... 102 Apr 29
Leach, T. J., Automated Assembly of Alloy-Junction Transistors ..... 57 Mar 25
Learned, V. R., What's New In Electron Tubes-Linear-Beam Microwave Tubes ..... SR70 Apr 29
Leary, F., American, Japan Firms Reach Accord . BF32 Apr 8
Leary, F., Electronics in Japan ..... SR53 May 27
Leary, F., Japan Develops New Computer Logic .. BF36 Apr 15
Leary, F., Japanese Production Workers: A Close-up ..... BF36 Apr 1
Leary, F., Korea: On Guard 10 Years After Invasion ..... BF40 May 20
Lee, R. E., Phipps, & Lathrop, Semiconductor Networks for Microelectronics ..... 69 May 13
Le Fave, G. M., Gamero & Withrow, Mold Cable Covering at Junctions ..... PT90 Apr 1
LeFave, G. M., Gamero, & Withrow, Plastics For Potted Cables ..... 67 May 6
Levine, J. H., & Ekem, Radiation Effects On Electronic Systems ..... 69 Apr 22
Lichtenfeld, K., Method for Simplifying Filter Design ..... 96 May 20
Lindgren, N. and Perugini, Recent Progress in Solid State Technology ..... 39 Mar 4
Lipkis, R. P., Miller, Robison, & Acker, Solar-Cell Power Supplies For Satellites ..... 167 Mar 11
Lipshutz, J. & Aronow, M., Demodulators for Linear Differential Transformes ..... ERS92 Jun 3
Lommasson, T., Pope, Smith, Grannemann, Longerot, Jones, Endsley & Summers, Pulse-Height-to-Digital Signal Converter ..... 58 Jan 8
Longerot, C. D., Jones, Endsley, Summers, Lommasson, Pope, Smith & Grannemann, Pulse-Height-to-Digital Signal Converter ..... 58 Jan 8
Loughlin, J. H., Gessford, & Dickinson, What's New In Electron Tubes-Cathode Ray Tubes ..... SR80 Apr 29
Low, H. & King, Solid-State Guidance For Able-Series Rockets ..... 60 Jan 29
Lowrie, R., Ground-Based Missile Roll Control ... RD80 Mar 25
Lukacovic, R. P., Scott, and Randise, Portable Radar Traces Battlefield Deployment ..... 67 Mar 18
Lunchick, A., Non-Precision Capacitors ..... 173 Mar 11
Lunchick, A., Paper and Plastic Film Capacitors . 78 Mar 25
Lund, G. E., and Faulis, Expandable Random Access Memories ..... 164 Mar 11

M

MacDonald, W. W., Electronics Research & Development Around the World ..... SR75 Feb 12
Mackay, R. S. and Marg, Electronic Tonometer For Glaucoma Diagnosis ..... 115 Feb 12
MacKenzie, R. P., Novel Design Peak Voltmeter . 57 Jun 17
Mackworth, N. H., Thomas, & Howat, Tv Tracker Records Eye Focus Points ..... 57 Apr 22
MacMartin, M. P., Sensitive Flaw Detector Solves Noise Problems ..... 64 Apr 15
Macpherson, A. C., Noise Source Has Constant Impedance ..... RD66 Feb 5
Maguire, T., Computers Head for 1,000-Mc Operation ..... 55 Jan 29
Maguire, T. & Vogel, What's Going On In Advanced Research ..... 71 Jan 15
Makow, D. M., Radio Beacon Helps Locate Aircraft Crashes ..... 54 Jan 22
Malsky, S. J., Amato, Spreckles, Roswit and Reid Measuring Radiation Within Human Body ..... 74 Mar 18
Marg, E. and Mackey, Electronic Tonometer for Glaucoma Diagnosis ..... 115 Feb 12
Marsili, P. and Quazza, Research & Development Around the World – Italy ..... SR82 Feb 12
Mason, J. F., First Details on SAC Control System ..... BF36 Mar 25
Mason, J. F., Our Defense Against Attack From Space ..... BF36 May 13
Mason, J. F., Where Polares Stands Today ..... BF32 Apr 15
Massa, F., Low-Cost Transducer Opens Up New Uses ..... CM128 May 27
Mathis, H. F., Transmission Line Analogy for Sandwich Propagation ..... ERS100 May 20
Meacham, D. D., What's New In Electron Tubes - High-Vacuum Power Tubes ..... SR60 Apr 29
Metter, R. E., X-Band Horn Antenna Has Broad Beamwidth ..... 50 Mar 4
Metter, R. E., Bystrom, & Hill, Ground-Mapping Antennas With Frequency Scanning ..... 70 Jan 8
Miller, E. C., Audio Volume Compressor ..... 62 Jan 8
Miller, R. S., Robison, Acker, & Lipkis, Solar-Cell Power Supplies For Satellites ..... 167 Mar 11
Monser, G. J., Design Charts for Low-Frequency Antennas ..... ERS86 Mar 18
Monser, G. J. & Sabin, W. D., Antenna Design for Maximum L–F Radiation ..... 84 Jun 3
Moore, J. K. & Kronenberg, M., Generating High-Quality Characters and Symbols ..... 55 Jun 10
Moore, J. L. & Morrow, High-Dielectric Rod Antenna Arrays For UHF ..... 60 Feb 5
Moore, P. H., and Scharla-Nielsen, Helical Antenna Chart ..... ERS180 Mar 11
Morgan, J. M., Flory, Gray, & Pike, Television System for Stratoscope I ..... 49 Jun 17
Morrow, C. W. & Moore, High-Dielectric Rod Antenna Arrays For UHF ..... 60 Feb 5
Mukai, V. and Simpson, Transistorized Tuners for Portable Television ..... 76 Mar 18
Mullin, J. T., Precise Meaaurement of Wow and Flutter ..... 100 Jun 24
Murray, R. P., Biasing Methods for Tunnel Diodes 82 Jun 3

N

Nagamori, K., Parametron Computer Circuits..... 73 Jun 3

O

Odorizzi, D. J., Z-Axis Marker Generator for Bandpass Circuit Alignment ..... 108 Jun 24
O'Kelley, H. E., Tracking Telemetry for Tiros Weather Satellite ..... 57 Apr 15
Onstad, R. C., Low-Pass Filter for Subaudio Frequencies ..... 88 Jan 15
Orlando, L., Designing With Rotary Solenoids ..... CM66 Mar 4

P

Pankove, J. I. & Drake, Measuring Critical Current In Cryogenic Circuits ..... 52 Jan 22
Payne, J. B., III, Voltage-Controlled Bootstrap Generator ..... 177 Mar 11
Pearson, J. J., Instrumentation for Plasma Propulsion ..... 66 Jun 10
Perham, J. N., Correcting Rhodium Plating Defects ..... PT124 Apr 29
Perlin, A. I., Selective Calling for Data Link Systems ..... 108 Apr 29
Perry, K., Reducing Interference in Ionospheric Sounding ..... 118 May 27
Sounding ..... 118 May 27
Perugini, M. M. and Lindgren, Recent Progress in Solid State Technology ..... 39 Mar 4
Peters, J. L., Mass Spectrometer Tests Tightness of Seals ..... 74 Apr 1
Phipps, C. H., Lathrop, & Lee, Semiconductor Networks for Microelectronics ..... 69 May 13
Pike, W. S., Flory, Gray, Morgan, Television System for Stratoscope I ..... 49 Jun 17
Pomerantz, M., R-F Cable Hardware ..... 90 Jan 1
Pope, A., Smith, Grannemann, Longerot, Jones, Endsley, Summers & Lommasson, Pulse-Height-to-Digital Signal Converter ..... 58 Jan 8
Porter, J., Six Ways to Use Magnetic Shift Register Elements ..... 80 Jan 15
Proebster, W. E. & Dietrich, W., Measuring Switching Speed of Magnetic Films ..... 79 Jun 3

Q

Quazza, G. and Marsili, Research & Development Around the World—Italy ..... SR82 Feb 12

R

Rainal, A. J., Digital Measurement of Axis-Crossing Intervals ..... 88 Jun 3
Rand, G., Designing Transducers For Sonar Systems ..... 62 Feb 26
Rand, G., Determining Sonar Systems Capability .. 41 Feb 19
Randise, D., Lukacovic, and Scott, Portable Radar Traces Battlefield Deployment ..... 67 Mar 18
Rappaport, P. J., Performance Ratings Of Secondary Batteries ..... 60 Feb 19
Raymond, S. O., & Edgerton, Instrumentation for Exploring the Oceans ..... 62 Apr 8
Reap, W. J., Simple Latch Circuit Uses Saturable Reactor ..... RD66 Jan 8
Reid, C., Malsky, Amato, Spreckels and Roswit, Measuring Radiation Within Human Body ..... 74 Mar 18
Reyner, J. H., Precision Oscillator With Incremental Tuning ..... 76 Apr 15
Richings, W. V., & White, Transistorized Sound Level Meter ..... 64 Jun 17
Riggs, R. H., Analystical Design of Transistor Push-Pull Amplifiers ..... 60 Jun 10
Ritterman, S., Measuring Total Circuit Inductance ERS58 Mar 4
Roach, W. E., Designing High-Power Transistor Oscillators ..... 52 Jan 8
Roberts, G. A. and Butler, Solid-State Electronic Tuning ..... RD122 Feb 12
Robinson, L. B., & Goulding, Achieving Discriminator Levels with a Biased Input Diode ..... 89 May 20
Robison P. C., Acker, Lipkis, Miller, Solar-Cell Power Supplies For Satellites ..... 167 Mar 11
Rohrer, K. L., Electronic Tube Base Potting ..... CM84 May 6
Roizen, J., Magnetic Recording Of Color Television ..... 76 Jan 1
Ronne, J. S., Computer Switching With High-Power Transistors ..... 44 Mar 4
Rosen, M., Subaudio Swept Signal Generator ..... 67 Apr 22
Rosenheck, B. M., Detecting Signals By Polarity Coincidence ..... 67 Jan 29
Roswit, B., Reid, Malsky, Amato and Spreckels, Measuring Radiation Within Human Body ..... 74 Mar 18
Roth, S. J., Finding Spectral Response of Electro-Optical Materials ..... 66 Apr 1
Rudich, I. & de Miranda, Indicator Triode For Direct Data Readout ..... 52 Feb 5

S

Sabin, W. D. & Monser, G. J., Antenna Design for Maximum L–F Radiation ..... 84 Jun 3
Sands, L. G., Dymamic Testers For Transistors .. RD66 Feb 19
Sapirstein, R. L., High-Speed Plotting Of Telemetering Data ..... 41 Jan 8
Scarlett, R. M. & deBroekert, Transistor Amplifier Has 100 Megacycle Bandwidth ..... 73 Apr 15
Scharla-Nielsen, H., and Moore, Helical Antenna Chart ..... ERS180 Mar 11
Schreibman, M., Gain-Phase Measurements In Feedback Amplifiers ..... ERS88 May 13
Schuller, M. & Gartner, Inductive Elements for Solid-State Circuits ..... 60 Apr 22
Schultz, J. B., & Yin, Negative-Resistance Amplifier Design ..... 110 May 27
Scott, J., Randise and Lukacovic, Portable Radar Traces Battlefield Deployment ..... 67 Mar 18
Seymour, M. E., In Fog And Rain–Sight, IR or Radar? ..... 64 Jan 29
Sherin, R. J., Efficient Photoflash Power Converter ..... 57 Jan 22
Sherin, R. J., Transfluxor Oscillator Gives Drift-Free Output ..... 48 Mar 4
Shinn, W. T., Boat Loader Boosts Transistor Production ..... PT122 Jun 24
Sicko, J. S., Counting and Timing Curcuits use Saturable Reactor ..... 61 May 6
Simpson, P. V. and Mukai, Transistorized Tuners For Portable Television ..... 76 Mar 18
Singer, J. R., Measuring Fluid Velocity By Nuclear Resonance ..... 77 Apr 1
Single, H. C., Portable Depth Finder For Small Boats ..... 50 Feb 5
Slawsby, N., Determining Radar Visibility ..... 76 May 6
Smith, D., Grannemann, Longerot, Jones, Endsley Summers, Lommasson & Pope, Pulse-Height-to Digital Signal Converter ..... 58 Jan 8
Smith, R. S., Graphical Extension of Transform Techniques ..... 68 Apr 1
Soderquist, G. W., Missile Interference: Cause and Cure ..... 24 Jan 8
Solomon, L. & Carter, Mordern Microwaves ..... SR67 Jan 24
Somlyody, A., Transistor Bias Method Raises Breakdown Point ..... 48 Jan 8
Spreckels, C., Roswit, Reid, Malsky, and Amato, Measuring Radiation Within Human Body ..... 74 Mar 18
Staiger, P. W., Using Ground-Control Radar to Improve Flight Simulation ..... 86 May 13
Steele, D. R., More Bandwidth for Magnetic Recorders ..... 44 Jan 8
Steiner, H. C., What's New in Electron Tubes - Gas-Filled Tubes ..... SR65 Apr 29
Stevens, R. T., Precision Phasemeter for CW or Pulsed UHF ..... 54 Mar 4
Summers, T., Lommasson, Pope, Smith, Grannemann., Longerot, Jones & Endsley, Pulse-Height to-Digital Signal Converter ..... 58 Jan 8
Svehaug, O., & Kobbe, Battery-Operated Transistor Oscilloscope ..... 80 Mar 18
Swindell, D. H. and Kingsborough, Aligning Servo Loops Without Precision Synchros ..... 84 Mar 18
Szymanski, E. M., Clounie, & Degroat, Control Makes Test Safe, Accurate ..... PT88 May 6

T

Talbert, W. R., Chittenden, & Fisher, Telemetry Transmitter for Radiation Satellite ..... 69 May 6
Tamiya, J., Automatic Display of Noise Suppression Factor ..... 55 Feb 5
Thomas, A. G., Digital Control of Machine Tools 174 Mar 11
Thomas, E. L., Howat & Mackworth, Tv Tracker Records Eye Focus Points ..... 57 Apr 22
Todd, C. D., Preamplifier Designed For Minimum Power Consumption ..... 106 Apr 29
Tomaino, M. F., How Built-In Damping Stills Vibration ..... CM186 Mar 11
Tomaino, M. F., Report on Semiconductive Plastics ..... CM68 Jan 22

V

Van Dorn, W. G., Transistor D-C Amplifier For Rugged Use in Field ..... 85 Jan 1
Vogel, S. & Maguire, What's Going On In Advanced Research ..... 71 Jan 15

W

Wada, H., Research & Development Around the World—Japan ..... SR93 Feb 12
Weed, H. R., & Weed, S. K., Pulse Reeponse Pinpoints Armature Faults ..... 70 Jun 10
Weed, S. K. & Weed, H. R., Pulse Response Pinpoints Armature Faults ..... 70 Jun 10
Weinig, S., Bending Ceramic and Ionic Crystals .. CM100 Jan 15
Wernick, J. H. and Wolfe, Three-Element Semiconductor Materials ..... 103 Feb 12
White, B. J., & Richings, Transistorized Sound Level Meter ..... 64 Jun 17
Whyland, W., Wood & Dysinger, New Suppressed-Carrier Modulation Technique ..... 47 Feb 5
Wileman, R., Linear Circuits Regulate Solid-State Inverter ..... 61 Apr 15
Withrow, D., Le Fave & Gamero, Mold Cable Covering at Junctions ..... PT90 Apr 1
Withrow, D., LeFave & Gamero, Plastics for Potted Cables ..... 67 May 6
Wolfe, R. and Wernick, Three-Element Semiconductor Materials ..... 103 Feb 12
Wolff, M. F., and Emma, Future Developments In Engineering ..... 159 Mar 11
Wood, P. W., and Bockemuehl, Industrial Hysteresigraph Uses D-C Integration ..... 70 Mar 25
Wood, R., Dysinger & Whyland, New Suppressed-Carrier Modultation Technique ..... 47 Feb 5
Wright, G. T., Solid-State Dielectric Circuit Devices ..... 59 Feb 26

Y

Yin, H. B., & Schultz, Negative-Resistance Amplifier Design ..... 110 May 27

To order Reprints of this Index address requests to Reader Service Dept. Electronics, 330 W. 42nd St., N.Y. 36, N. Y.
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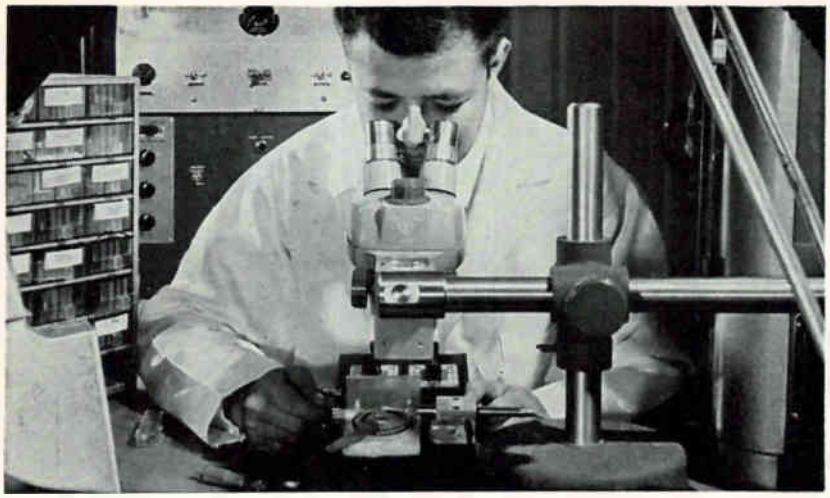

Micromodule Kit

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.

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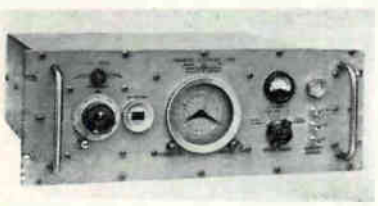


Frequency Divider

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.

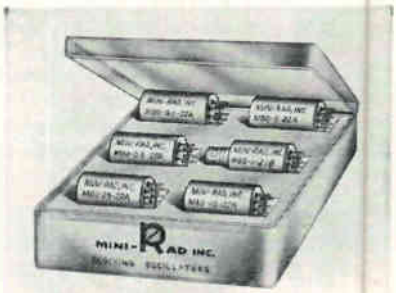
CIRCLE 302 ON READER SERVICE CARD

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-

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Model A15—Noise level less than 1 microvolt!

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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.

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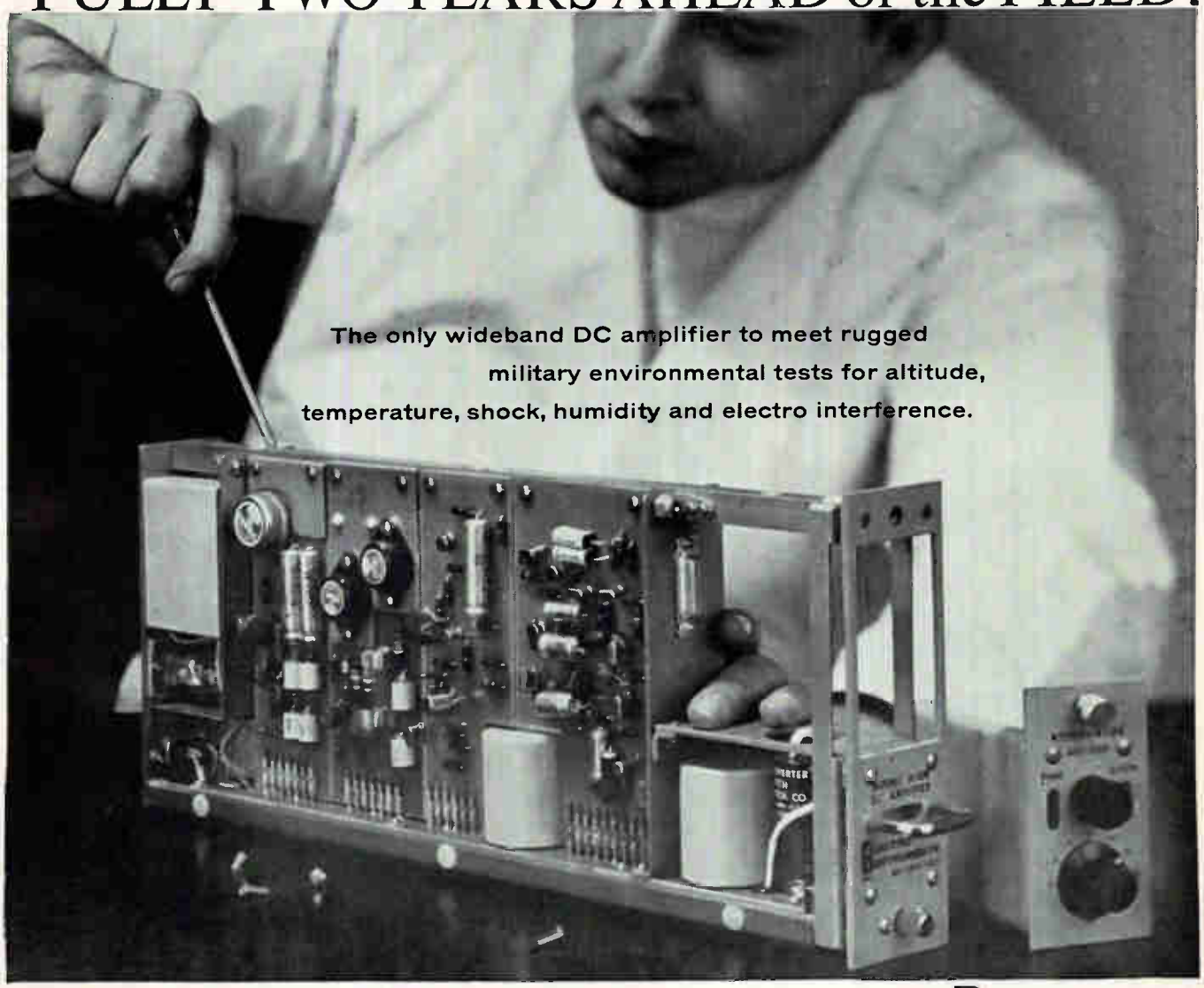

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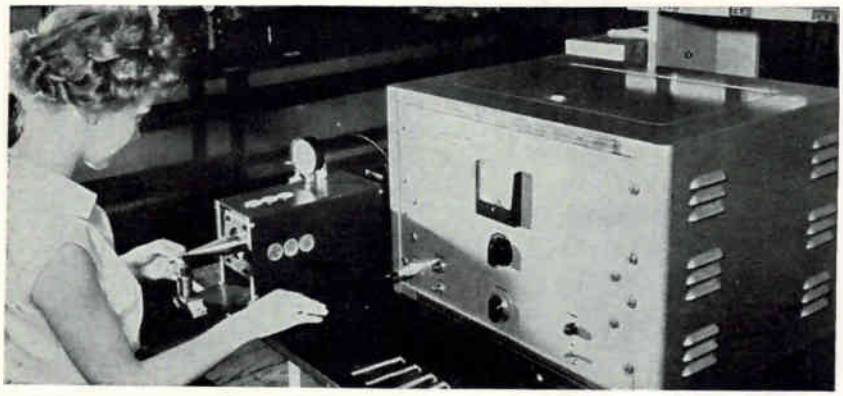
tionally high losses of 9.05 db per cm at 25 C and minimum attenuation over an extremely wide range of frequencies. In addition, CFI-1003 is stable at temperatures in excess of 1,000 C in both low and high power systems.

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

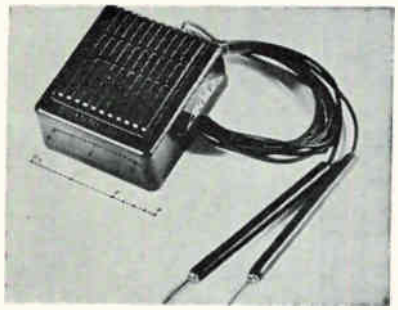
SELF-TUNING CIRCUIT

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?

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We select the materials, make the tubes and test the tubes with this  in mind. All General Electric hi-fi amplifier tubes are controlled for low Contact Potential. Use them. They're the BEST.

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411-201

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.

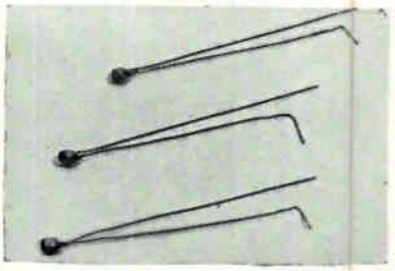
CIRCLE 308 ON READER SERVICE CARD

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

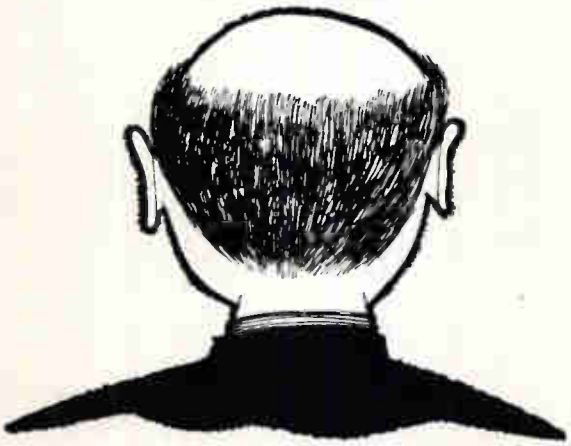


Selenium Diodes

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



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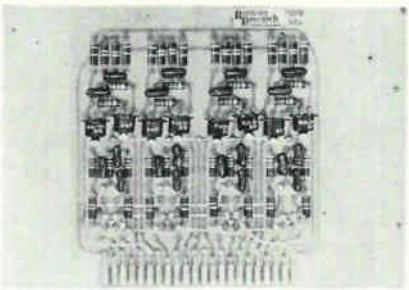
in eight types, with peak voltage ranges up to 400 v at 3.75 ma. Maximum case length is 0.188 in. for all types, with widths ranging from 0.188 in. for the 50 and 100 piv units to 0.350 in. for the 350 and 400 piv units. They are capable of operating in ambient temperatures from — 50 C to + 100 C without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

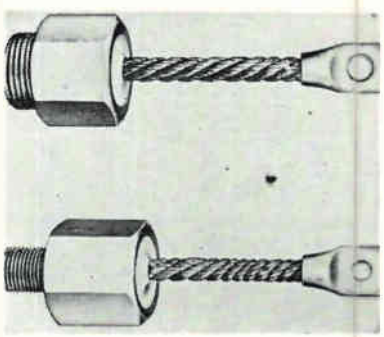
CIRCLE 311 ON READER SERVICE CARD

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.

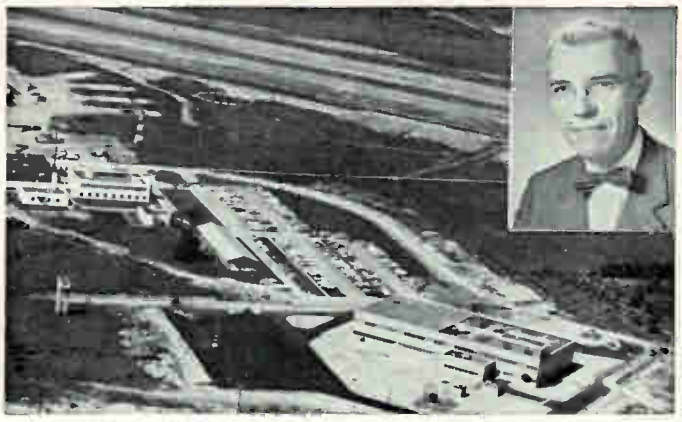
CIRCLE 328 ON READER SERVICE CARD

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



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.

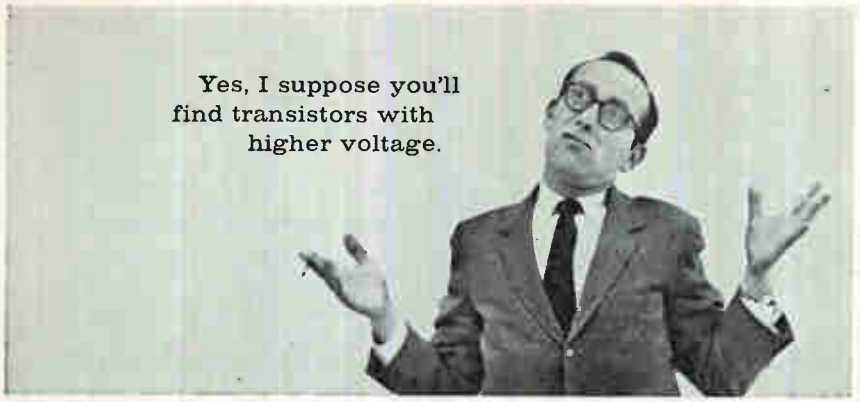
Amperex Electronic Corp. is engaged in the research and development, manufacture and sale of electron tubes and semiconductors for communications, defense and industry.

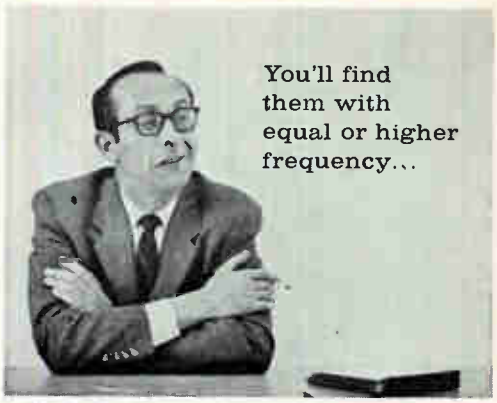
Both promotions are part of Amperex's current expansion program, which also includes the acquisition of a new plant in Slatersville, R. I., for the manufacture of transistors and diodes.

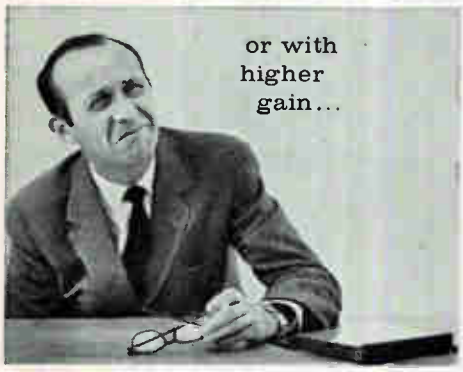
Petruschke Joins Assembly Products

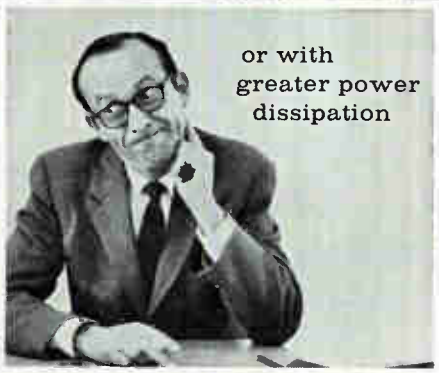
APPOINTMENT of Reinhold Petruschke to the newly-created position of chief industrial engineer at Assembly Products, Inc., Chesterland, O., has been announced. He will be in charge of production of all parts and sub-assemblies for the company's meter-relays, panel meters and complete controls. He will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

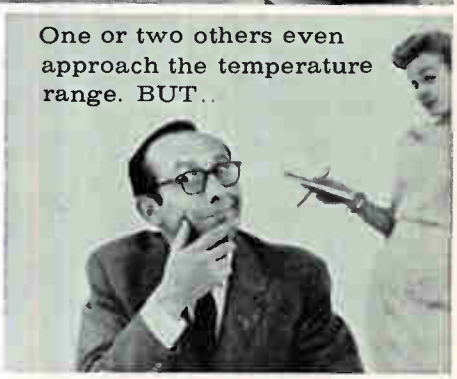
Before joining Assembly Products, Petruschke was production manager of the phonograph plant at the V-M Corp., Benton Harbor, Mich.





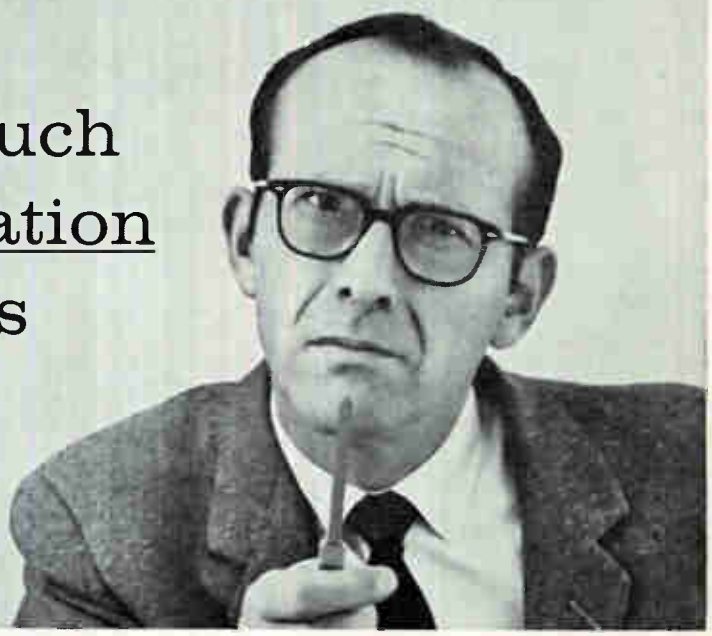






no other transistor has such an ideal combination of parameters

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_{eb} @ 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

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- 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
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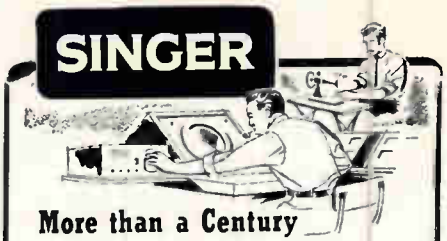

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Send inquiries and resumes to Mr. John Starbuck, Dept. 5

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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.

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EQUIPMENT - USED or RESALE

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$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**

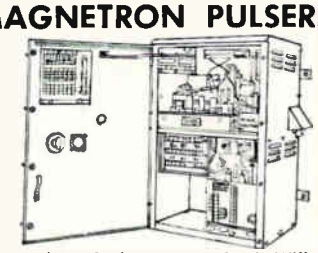
FOR OPERATION ON 230 OR 460 VOLTS: Max. input at nominal 115 volts when 5 KVA is used, is 71 amps (8165 VA). For use on 460/230 V lines, an 8½ KVA isolating step-down transformer is required. We can get it wound to order in Los Angeles, 1 ph., fully cased, boxed for shipment: 60 cy, $155.00, shpg wt 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

AMP Incorporated 42
Aeronautical Communications Equipment, Inc. 20
Air Express 26
Automatic Metal Products Corp..... 6
Avco Corporation
Crosley Division 108

Bausch & Lomb Optical Co..... 39
Bendix Corporation
Scintilla Division 61

Cinch Mfg. Company..... 59
Clevite Corp.
Clevite Transistor 17, 18
Coto-Coil Co., Inc..... 106
Cubic Corp. 41

Dade County Development Dept..... 107
Du Pont de Nemours & Co., Inc.
"Freon" Products Division..... 71

Eitel-McCullough, Inc. 24
Electro Instruments Inc..... 103
Elgin National Watch Co..... 72

Fairchild Semiconductor Corp.....64, 65
Freed Transformer Co., Inc..... 115

General Aniline & Film Corp.
Ozalid Division 16
General Electric Co.
Semiconductor Products Dept...21, 23
25, 27
Power Tubes 105
General Products Corp..... 106
Granger Associates 2

Hallicrafters Company, The..... 10
Hughes Aircraft Co..... 111

Imtra Corporation 101
Industrial Electronic Engineers, Inc... 101
International Nickel Company, Inc... 30
International Resistance Co.....3rd Cover
International Telephone and Telegraph Corp. 101

Lambda Electronics Corp..... 3
Lapp Insulator Co., Inc..... 40
Lepel High Frequency Laboratories, Inc. 107

MacDonald Inc., Samuel K..... 114
Magnetics, Inc. 12
Mallory and Co., Inc., P. R..... 67
Marconi Instruments, Ltd..... 33

Precision Scientific Co..... 69

Radiation Inc. 86
Radio Corporation of America...4th Cover
Raytheon Company .....2nd Cover

Sangamo Electric Co.....68, 69
Sarkes Tarzian Inc..... 73
Sigma Instruments, Inc..... 109
Southern Electronic Corp..... 19
Speer Carbon Co.....8 & 9
Sprague Electric Co..... 5

Texas Instruments, Incorporated
Semiconductor-Components Division.. 13
Thompson-Ramo-Woolridge, Tapco Group 15
Tung-Sol Electric, Inc..... 63

Ucinite Company, Division of United Carr 72

Vector Electronics Co..... 7

Weinschel Engineering 14
Weston Instrument Division of Daystrom, Incorporated 81
White, S. S., Industrial Division..... 74

■

CLASSIFIED ADVERTISING
F. J. Eberle, Business Mgr.

EMPLOYMENT OPPORTUNITIES.112-114

EQUIPMENT
(Used or Surplus New)
For Rent 114

ADVERTISERS INDEX

Aeronutronic, a Div. of Ford Motor Corp.. 114
Fidelity Personnel 114
Goodheart Co., R. E..... 114
Liberty Electronics 114
Minnesota Mining & Mfg. Co..... 114
Motorola Inc. 112
Schlumberger, Ridgefield Instrument Group 112
Singer-Bridgeport, Div. of Singer Mfg. Co. 112
Stromberg-Carlson, Div. of General Dynamics 113

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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.*

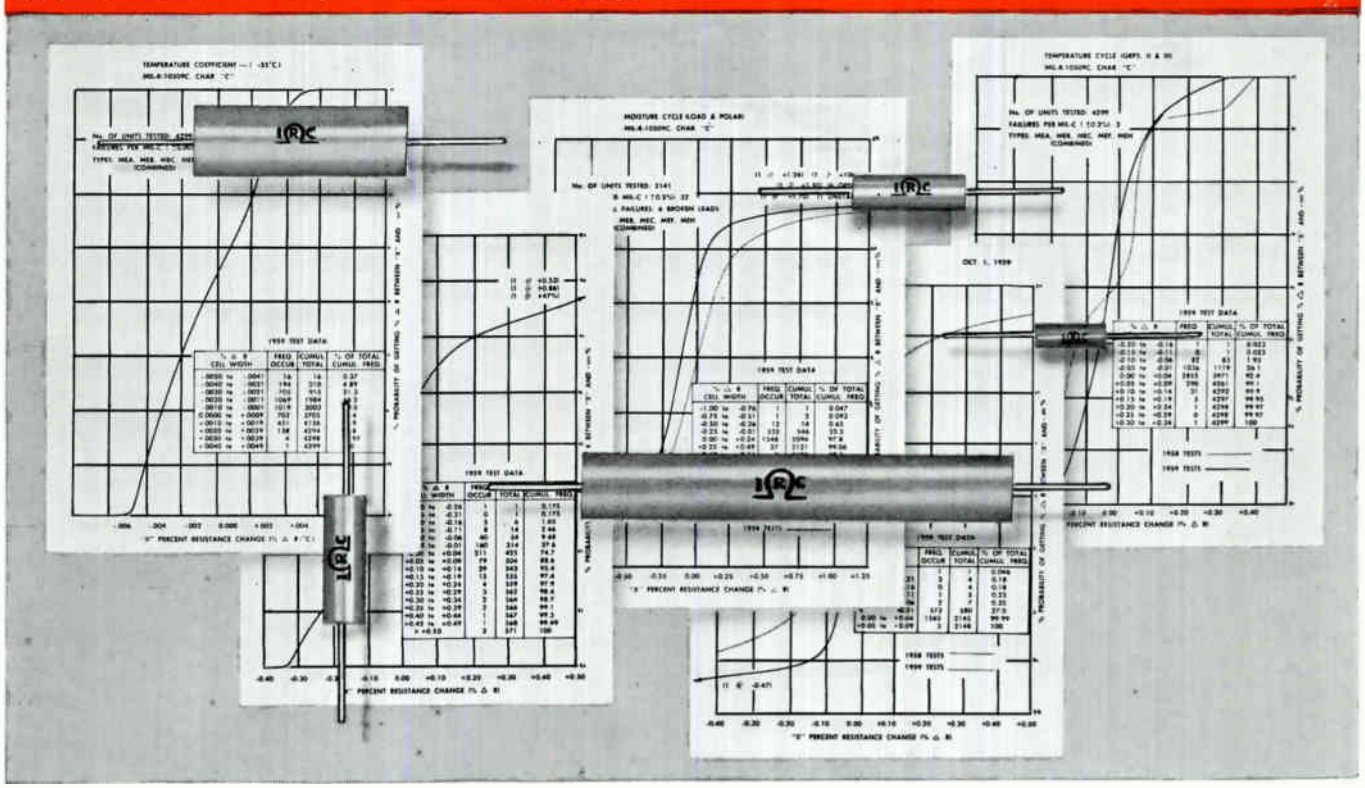
For the most part, manufacturers in the electronics industry have cooperated, with a remarkable degree of self-censorship, to preserve truth in their advertising pages. There have been astonishingly few exceptions through the years. For this we thank them. And we charge them at the same time with the 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 Gledwood

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

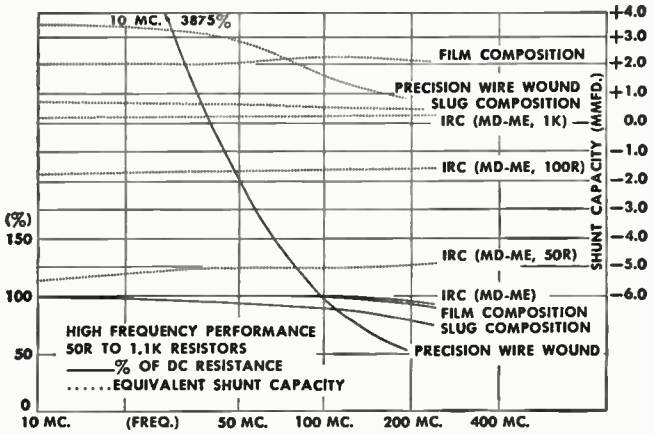
IRC has completed a new series of tests upon 7500 molded metal film resistors. The charted results are presented in a booklet just released: "Performance and Reliability of IRC Molded Metal Film Resistors."

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.

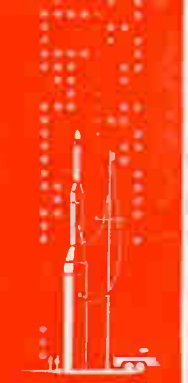
TYPICAL HIGH FREQUENCY PERFORMANCE OF IRC MOLDED METAL FILM RESISTORS



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.

IRC

Leading supplier to manufacturers of electronic equipment



MISSILE GUIDANCE

EARLY WARNING SYSTEMS

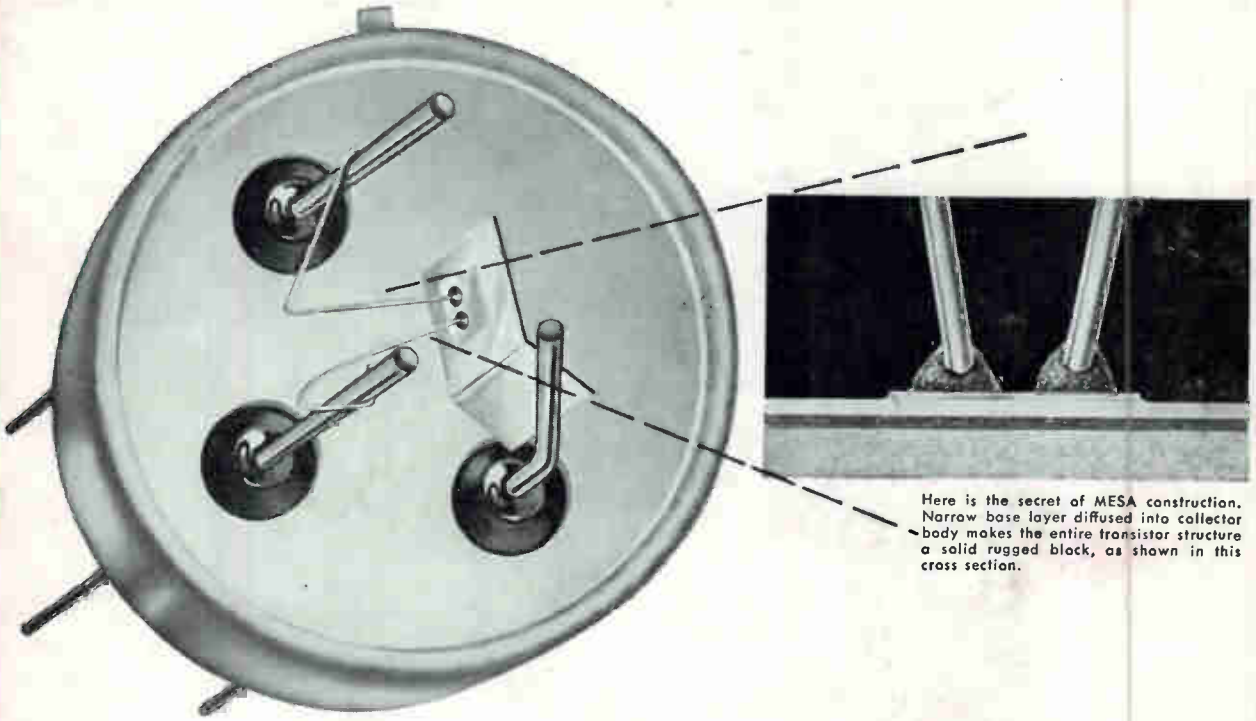
COMMERCIAL DATA SYSTEMS

FIRE CONTROL

MULTIPLEX SYSTEMS

SPACE EXPLORATION

Rugged all the way...inside and out



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

Now you can see why RCA-2N1300 and 2N1301 germanium P-N-P diffused-junction Mesa computer transistors achieve and maintain top performance at high frequencies. From base to case, reliability is built in for today's high-speed switching applications.

Ruggedness and reliability are inherent in the RCA-2N1300 and 2N1301 Mesa Computer Transistors. They are specifically designed, constructed, and tested to assure extra dependability.

Through rugged Mesa construction RCA achieves the extremely narrow base-width necessary for switching speeds up to 10 Mc without sacrificing mechanical strength. Mesa construction provides high dissipation capabilities and assures long and dependable performance under the most severe *field* conditions.

RCA's diffused-junction process provides a flat, precise junction assuring exceptional uniformity of electrical characteristics from unit to unit. This diffused-junction process in combination with RCA's mesa-construction technique makes possible the high collector-breakdown-voltage and punch-through-voltage rating of these devices.

As a result of these features plus built-in ruggedness, the RCA-2N1300 and 2N1301 can meet the stringent mechanical and environmental requirements of the basic military specification MIL-T-19500A.

Call your RCA representative today and get the complete story on these low-cost extra reliable types. For further technical information, write RCA Commercial Engineering, G-19-NN-1, Somerville, New Jersey.

RADIO CORPORATION OF AMERICA
SEMICONDUCTOR AND MATERIALS DIVISION — SOMERVILLE, N. J.

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