May 13, 1960

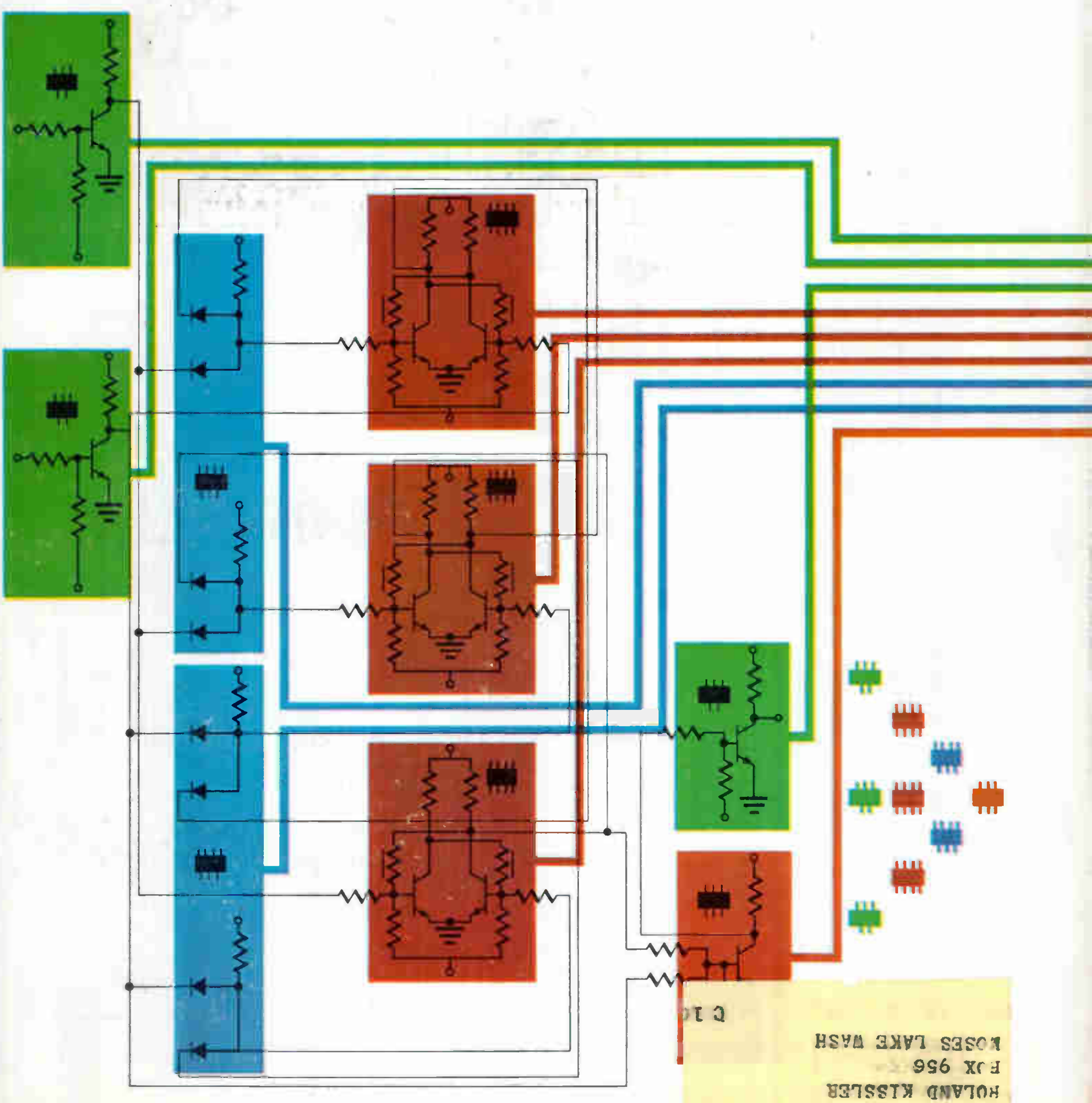
electronics

Semiconductor networks for microelectronics (below) p 69

Selecting resistance-capacitance for active filters p 82

Synchronizing flight simulators with airport radar p 86

A McGraw-Hill Publication 75 Cents



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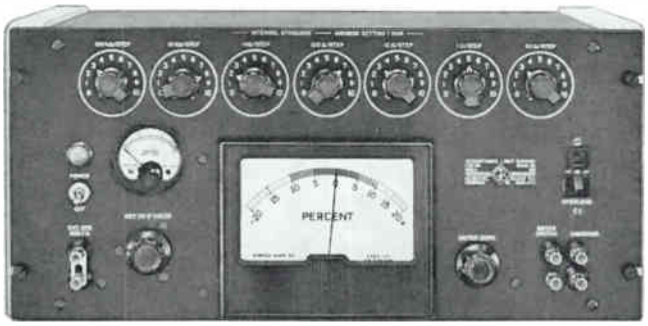

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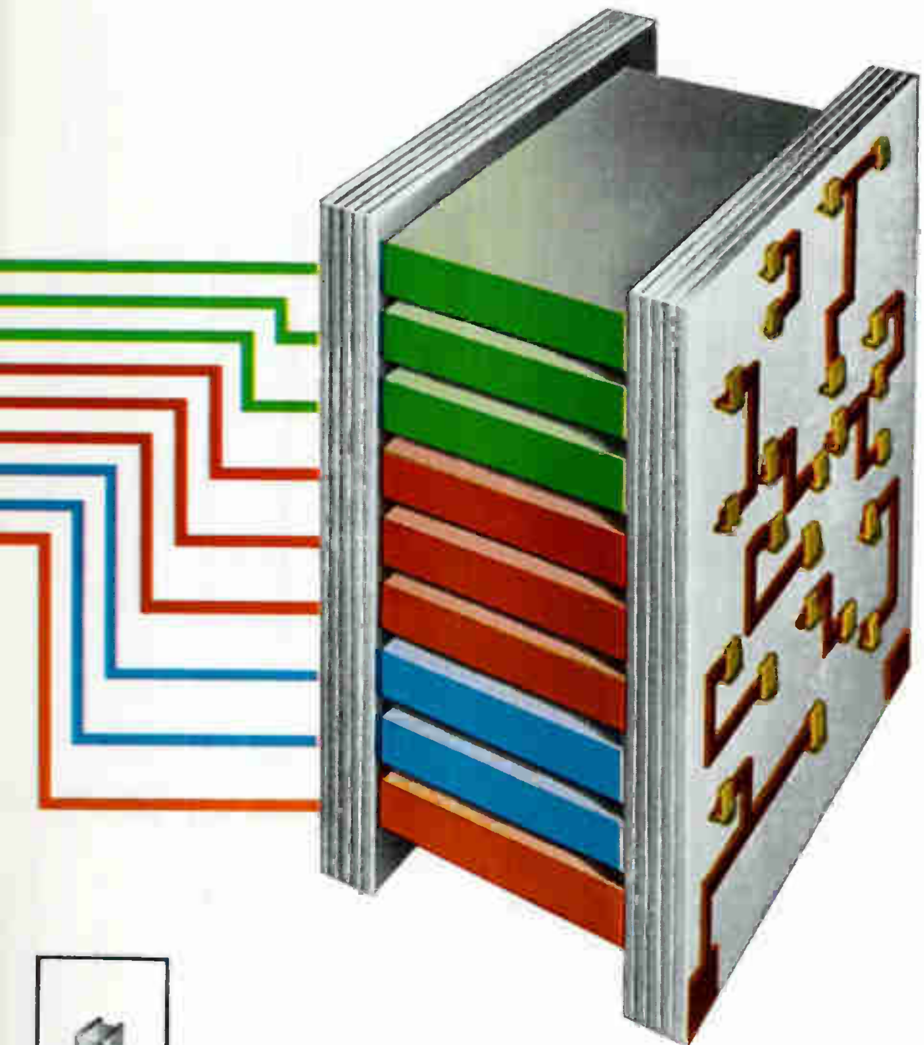

ACTUAL SIZE

THE COVER SHOWS a typical computer circuit and its realization as a microminiature package of semiconductor networks. Different circuits have been fabricated from blocks of semiconductor material by various combinations of oxide masking, diffusion, alloying, metal deposition and surface shaping techniques. The selected example includes flip-flops, pulse inverters and diode gates. When these units are interconnected as shown in the fold-out, the resultant subassembly occupies 0.013 cu in. and weighs 1.3 gm. The concept of a semiconductor network involves the relation of conductance paths in a semiconductor to classical circuit elements. This enables an orderly design approach that starts with the existing knowledge of circuit theory. Semiconductor networks are a major departure from conventional components because active and passive circuit elements are integrated into single-crystal semiconductor wafers. Protection and packaging of individual elements are eliminated. Lead wires and interconnections are reduced by as much as 80 percent. Fabrication steps have been reduced to one-tenth of those required for the same circuit function using miniature components. The result is a realistic solution to the reliability, space, weight and cost problems in microelectronic systems. Turn to page 69 for additional information on semiconductor networks.

Semiconductors and Solid State

SEMICONDUCTORS, the curiosities of 1950, are shelf products today. And combinations and configurations of semiconductors are being combined in solid state devices and packages so small that magnifying glasses are becoming necessary equipment in our editorial department as well as in many laboratories.

Our art director had some miniaturized headaches preparing the photographs and drawings which accompany the article beginning on page 69 of this issue. This article is another in a long line of ELECTRONICS firsts, being an exposition on solid state circuits revealing theory, design and fabrication in detail. There will be others in the months ahead. Also, in the months ahead, semiconductor shelf items will adjust downward from present prices as volume, improved technology and the forces of competition exert their influences.

Among subscribers to ELECTRONICS, the next-best-read business magazine is the McGraw-Hill publication Business Week. An outstanding report on semiconductors appeared in the March 26th issue of that publication. If you are one of our subscribers who also reads BW, you have seen it. If you haven't, a reprint may be obtained for 50¢ by writing to Reprint Dept., Business Week, 330 West 42nd Street, New York 36, N. Y.

PUBLISHER

May 13, 1960

electronics

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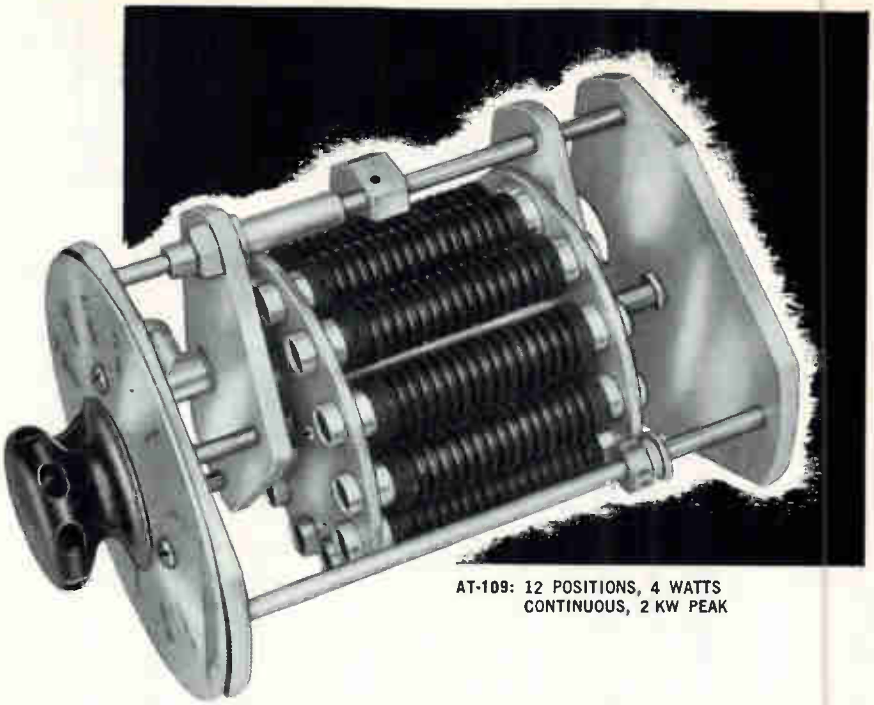

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electronics

May 13, 1960 Vol. 33, No. 20

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CROSSTALK

PROJECT DEFENDER. The technical problems that must be solved to defend the U. S. against nuclear-armed vehicles from outer space probably pose the greatest challenge to the electronics industry to date.

How is the Advanced Research Projects Agency, which is responsible for the task, attacking the problem? What approach is ARPA taking and who is doing the work?

Associate Editor Mason talked with ARPA, Army, Navy, Air Force and industry. Associate Editor Solomon helped fit into place the pieces in our story about this gigantic and vital project. It begins on p 36.

NEXT SEASON'S TV. Next season's television sets are being polished and groomed for showing at distributor conventions this month and next. Most manufacturers are keeping the details under Detroit-style wraps, but some clues are plainly evident: There will be more color sets introduced this year. The resulting competition is expected to reflect in the consumer's favor. In black-and-white lines, more attention will be given to custom furniture. There will be new models of portable sets, and many more of these will be equipped for remote tuning. One scrap shaping up centers around bonded vs unbonded picture tubes. Associate Editor Emma has been talking to manufacturers in five states. For the details of what he learned, turn to p 44.

Coming In Our May 20 Issue

SPACE COMMUNICATIONS. The problem of transmitting electromagnetic energy through ionized regions is becoming increasingly important to designers of communications and guidance equipment for nuclear vehicles, hypersonic re-entry vehicles, and equipment which must operate in a nuclear or high-temperature environment. Blackout of signals from re-entry vehicles, attenuation of electromagnetic energy through rocket motor exhausts, and transmission through a nuclear fireball are all mechanisms which must be understood by engineers who must work to specific requirements. In next week's cover story, W. A. Greenhow of Chance Vought Aeronautics discusses theoretical and experimental aspects of these ionization mechanisms.

MISSILE TRACKING. When test firings are made on the Atlantic Missile Range, missiles are followed during the power flight portion of their trajectories by a combination of an optical telescope (ROTI) and an infrared rapid scan system. Description of the ROTI system was published in our Jan. 16, 1959, issue (p 47). Now, Joseph Day, Jr., of the Perkin-Elmer Corp., who has been working on a series of ROTI missile tracking systems, brings readers a description of his firm's i-r rapid scanning system which makes spectrometric studies of missile flights, and which may eventually help in identifying missiles by their plume characteristics. The rapid-scan system consists of a monochromator, a radiation detector system and readout equipment. The spectrometer employs a double-pass Littrow optical system to feed energy to a detector whose signal is then used to produce a function-of-time plot.

FILTER DESIGN. If you're an engineer who has been designing filters, you'll want to read and clip out for your file the article by Kurt Lichtenfeld of Hughes Aircraft Co., on how to simplify your Zobel filter design problems by the use of Cauer parameters. Author Lichtenfeld describes this design method for low-pass, high-pass, bandpass and band elimination filters, and provides example problems for each type.

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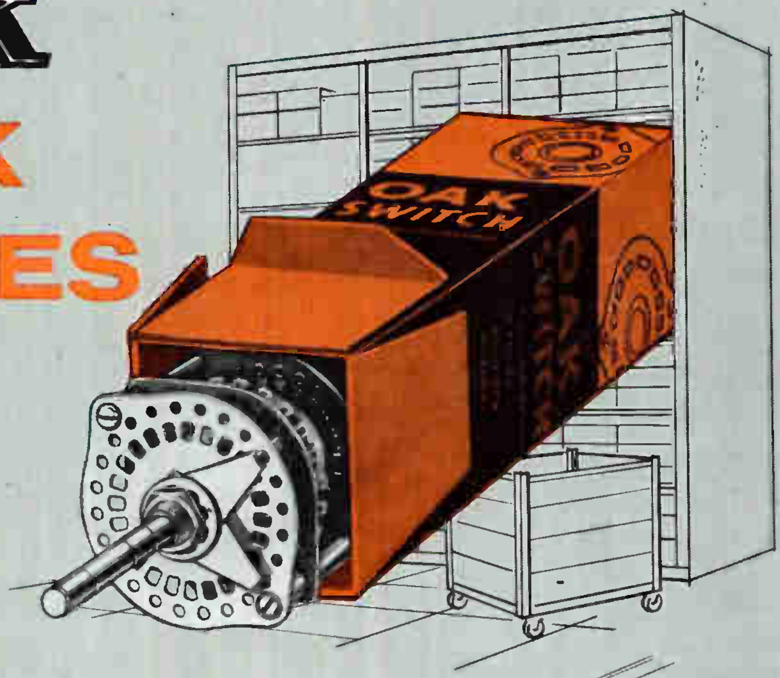

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COMMENT

Kudo In Advance

I was delighted to learn that you are planning to devote a major part of the May 27, 1960 issue of ELECTRONICS to a review of the technology of the electronic industries of Japan. We feel that this will be an invaluable service to members of the electronic industries of the United States.

In the Department of Commerce, we feel that developments in electronics in Japan are so important that I am spending several weeks here meeting with Japanese industrialists discussing these matters—just as I have done previously in the centers of electronics activities in Europe. By the way, officials of the Japanese Government (both in Washington and Tokyo) have been most cooperative in connection with my visit.

I should like to offer my commendation for your undertaking to publish this special issue of ELECTRONICS.

DONALD S. PARRIS
Director
ELECTRONICS DIV., BDSA
U. S. DEPT. OF COMMERCE

Reader Parris, also well out in front, wrote to us on stationery of The Foreign Service of the United States of America, from Tokyo. Below (also from Japan) see photo of Associate Editor Frank Leary, whose report, "Electronics in Japan," appears May 27.

Monopulse Radar

A number slipped in the radar designation in the caption in "Precision Tracking With Monopulse Radar," p 51, Apr. 15. The correct designation for the radar is AN/FPS-16, *not* AN/FPS-6.

JOHN F. DUNN
DEAN D. HOWARD
WASHINGTON, D. C.

New Format

Plaudits on your new format. I have been a reader of ELECTRONICS for more years than I care to admit, and think your latest issue represents the biggest step forward in terms of layout that I have yet seen in the magazine.

I'm glad to see color on the cover and hope that it will be a regular item in following issues. It gives your magazine the appearance of high quality that the inside material rarely fails to back up. Fine work!

R. E. COLWELL
OLD TAPPAN, N. Y.

. . . We received a copy of your special issue on vacuum tubes today (Apr. 29), and from a layout point of view it's one of the best-looking business papers we've ever seen. And the editorial material is excellent. . . .

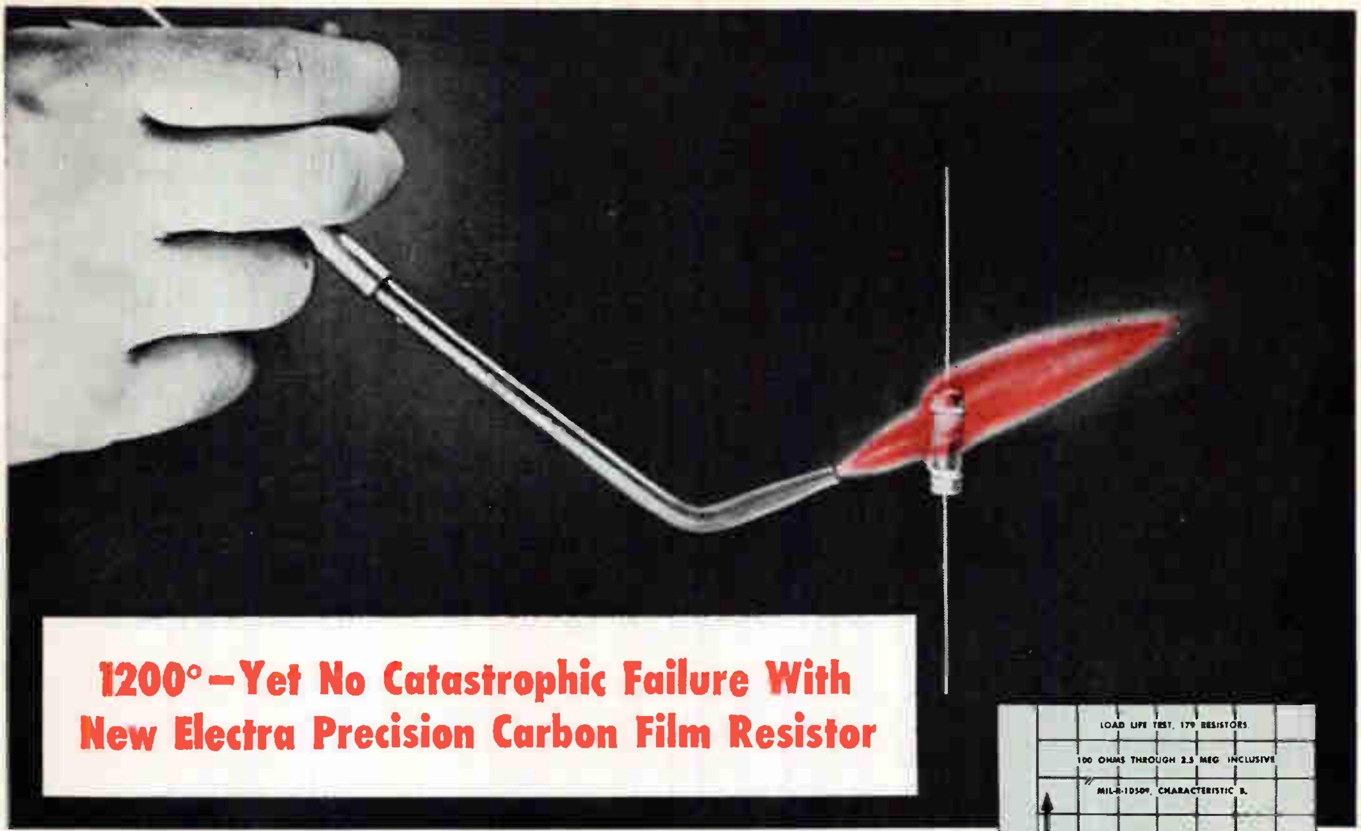
C. M. CLOUGH
TEXAS INSTRUMENTS
DALLAS

Japan's Telephone System

In "Japan Develops New Computer Logic" (p 36, Apr. 15) you describe Nippon Tel & Tel as a government communications utility. I though IT&T ran the phone service in Japan.

H. N. STOVER
HADDONFIELD, N. J.

Confusion naturally arises because IT&T has an affiliate in Japan, and because the overseas phone and cable service is handled by Kokusai Denshin Denwa, which means International Telephone & Telegraph but which is another government communications utility.

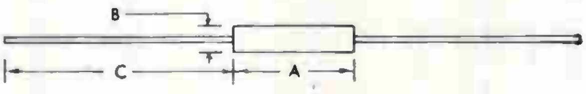


1200°—Yet No Catastrophic Failure With New Electra Precision Carbon Film Resistor

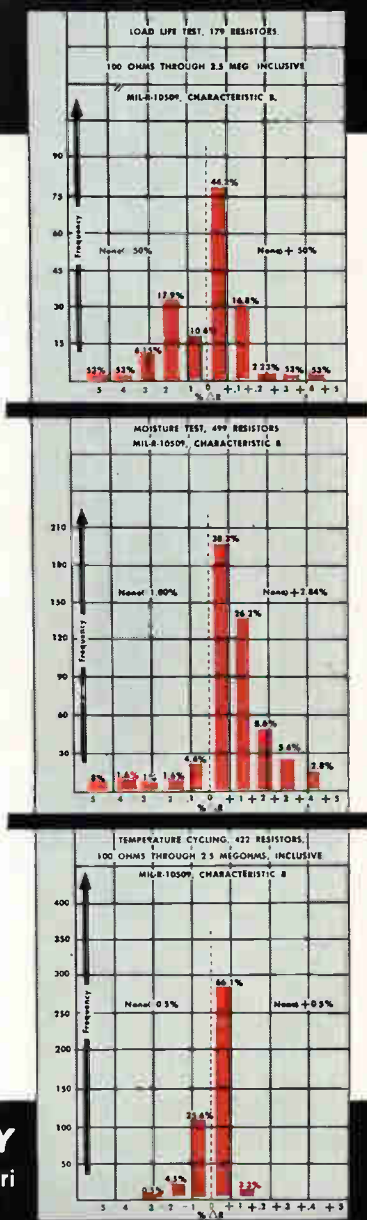
Check at right the histograms showing test results on the new Electra Precision Carbon Film Resistor. See for yourself the remarkable ability of this resistor to withstand extreme conditions of heat and humidity, also its exceptional load life. Primary credit for these outstanding characteristics goes to Electra's exclusive new Type R-5 coating, developed in our laboratory after a long period of scientific study and experimentation. But performance alone is not the whole story. Check, too, the sizes; truly, this resistor opens up a whole host of new possibilities in your design and engineering work.

Electra Part No.	Mil Style	Wattage MIL 70°C	Wattage EKC 70°C	Wattage EKC 125°C	Mil Resistance Range	Manufactured Resistance Range	Max. Rated Voltage	Length A ±1/32	Dia. B ±1/32
CF 1/8	RN60B	1/8	1/4	1/8	10 Ω 1 Meg	10 Ω 1 Meg	250	.375 +1/16 −1/32	.125 +.040 −.010
CF 1/4	RN65B	1/4	1/2	1/4	10 Ω 2 Meg	10 Ω 2 Meg	300	.625 +1/32 −1/16	.1875 +1/16 −1/32
CF 1/2	RN70B	1/2	1	1/2	10 Ω 2.5 Meg	10 Ω 5 Meg	350	.750 +3/32 −1/16	.250 +1/32 −1/32

Lead length C, 1½ for all, ±1/8. Dia. leads, #22 for CF 1/8 and CF 1/4, #20 for CF 1/2.



WRITE FOR NEW BROCHURE—Just off the press . . . new brochure describing Electra's complete line of precision carbon film resistors. Electra also manufactures a complete line of precision metal film resistors and ceramic disc and plate capacitors.



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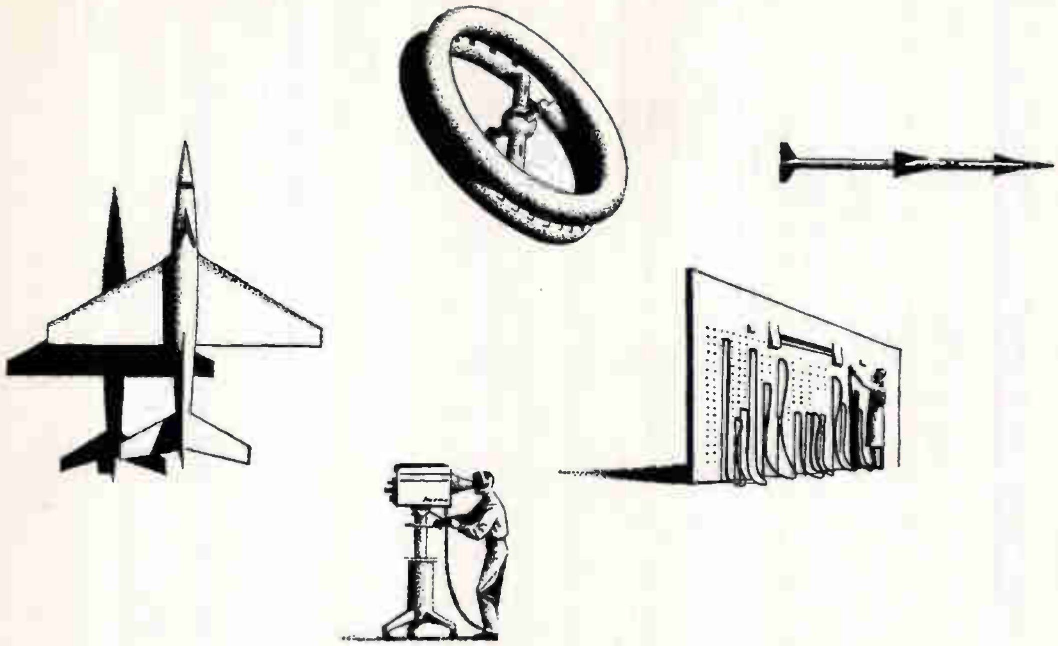

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ELECTRONICS NEWSLETTER

Navy Survey Predicts Sales Up $1.3 Billion in 1960

A Navy survey of 585 electronics companies engaged in end equipment production indicates that the 1960 projected sales output will be about $10.9-billion. This would continue the trend of rising output each year.

Sales were up in 1959 to $9.6-billion as compared with $8.3-billion in 1958. The 1959 figure was within 2½ percent of the sales predicted by industry a year ago. The figures were revealed in a report prepared by the electronics section of the Office of Naval Material.

Production for the military in 1960 is expected to be $5.9-billion as compared with $5.1-billion last year. Total military backlog as of Jan. 1 was $5.7-billion of which approximately $4.4-billion was in prime contracts and $1.3-billion in subcontracts. The backlog figures were approximately the same as a year ago.

Total number of employees climbed up to 578,000 from 514,000 a year earlier. Average sales per employee increased from $16,000 to $16,600.

The industry could produce with its present facilities (building space, machinery, etc.) $14.1-billion in one shift by merely adding people as compared to $12.6-billion a year ago, ONM estimates.

New Business Data Processor Reads Standard Terminology

Keen interest in its newly developed NCR-390 system is reported this week by National Cash Register, an active entrant in the small computer derby.

The system reads records prepared in standard business terminology from four magnetic strips imprinted on the back of a ledger sheet, invoice or other commercial document. Information on the strips duplicates data on the front of the sheet. As paperwork is processed through a reader-imprinter, a paper tape is punched to serve as a permanent storage.

NCR president S. C. Allyn believes the NCR-390 will enhance his company's position in the office equipment market. So far, ELECTRONICS learns, 50 of the new machines have been sold to buyers in 20 different kinds of business operations.

Scientists Grow Transparent Crystals of Gallium Phosphide

Transparent gallium phosphide single crystals have been grown experimentally at Bell Telephone Laboratories, it was reported last week.

Scientists say the structure produced will help in the basic understanding of high-energy gap semiconductors. Since the material is transparent, the differences that take place under varying conditions of doping and electron density may be observed visually.

Major problem with gallium phosphide, says BTL, is that it decomposes at temperatures near its melting point unless it is held under high pressures of gaseous phosphorous. C. J. Frosch and M. Gershenzon reported that their work has aimed at producing single crystals of the material by the floating zone melting technique. They built special equipment to withstand the high pressure phosphorous atmosphere. Single crystals about ¾-in. long by ¼-in. sq were obtained at temperatures of 2,640 to 2,730 F. and pressures of 10 to 50 atmospheres (overcome partly by heating the walls of the apparatus).

Small single crystals have also been grown by vapor reaction methods by Gershenzon and R. M. Milulyak of BTL, who described a reaction of gallium suboxide and phosphorous in the vapor phase. The crystals—usually n-type, although they can be doped p-type—show a whisker form and exhibit free carrier concentrations of 10^{11} to 10^{14} per cc, as calculated from resistivity measurements. The Bell scientists produced diffused and alloyed diodes which showed breakdown voltages as high as 35 volts, rectification ratios up to 3 x 10^{6} and reportedly performed well up to 500 C.

NEWS BRIEFS . . .

An international subsidiary has been formed by General Telephone & Electronics. The new group will integrate all of GT&E's international manufacturing, marketing and engineering operations. President of GT&E International is Gene K. Beare. He will also have responsibility for the operations of Automatic Electric International, Inc., and its international subsidiaries. Area headquarters will be located in Geneva, Switzerland, covering Europe and the Middle East, and in Mexico City, covering Mexico and Central America.

French President Charles DeGaulle last month visited the new Hewlett-Packard plant in the Stanford Industrial Park, Palo Alto, Calif., his only visit to an industrial facility during his U. S. tour. Exec. v-p William R. Hewlett escorted DeGaulle on the 40-minute tour, reported later that the President was impressed with the range of 400 test instruments and devices made by the company, and with the complexity of component assembly. He shook hands with many employees and asked about their hours, pay and working conditions. (Photo on p 37.)

Defense Dept. is considering establishment of an information center on ceramic materials, says John R. Townsend, special assistant to the director of Defense Research and Engineering. He told the American Ceramic Society that the government was intensifying ceramic materials research, urged industry to do the same.

Low-priced tape-controlled electronic positioning system with nominal electrical accuracy of one part in 400,000 will be shown by EMI Electronics June 25 at the Machine Tool Exhibition, Olympia, London.

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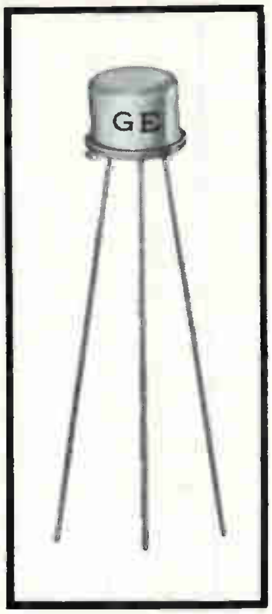

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Forward Current Transfer Ratio (I_C = 10 ma, V_{CE} = 1V)	h_{FE}	150	
Forward Current Transfer Ratio (I_C = 25 ma, V_{CE} = 1V)	h_{FE}	130	
Base to Emitter Voltage (I_C = 10 ma, I_B = .5 ma)	V_{BE}	.25	volts
Collector Saturation Voltage (I_C = 10 ma, I_B = .5 ma)	V_{CE} SAT	.2	volts
Collector Cutoff Frequency (I_E = 5 ma, V_C = 1V)	$f_{\alpha b}$	60	
Collector Capacitance (I_E = 5 ma, V_C = 1V, f = 2 mc)	C_{ob}	6	μμf
Collector Cutoff Current (V_{CB} = 15 V, I_E = 0)	I_{CO}	2	μa
Emitter Cutoff Current (V_{EB} = 5 V, I_C = 0)	I_{EO}	2	μa
Rise Time	t_r	60	mμsec
Storage Time	t_s	200	mμsec
Fall Time	t_f	60	mμsec

Absolute Maximum Ratings (25°C)		
Temperature Range		
Storage	T_{STG}	−65 to +85 °C
Operating Junction	T_J	−55 to +85 °C
Voltage		
Collector to Emitter	V_{CE}	15 volts
Emitter to Base	V_{EB}	5 volts
Collector to Base	V_{CB}	20 volts
Collector Current	I_C	50 ma
Dissipation (*Derate 1.2 mw/°C)	P_{AV}	75 mw

RELIABILITY BASED ON TWO YEARS OF MANUFACTURE

Based on the meltback technology from which have come a number of very reliable transistors, the new 2N1289 is believed to be the first germanium NPN transistor to meet the needs of high-speed computers. Thorough characterization provides all the necessary data for "worst case" designs.

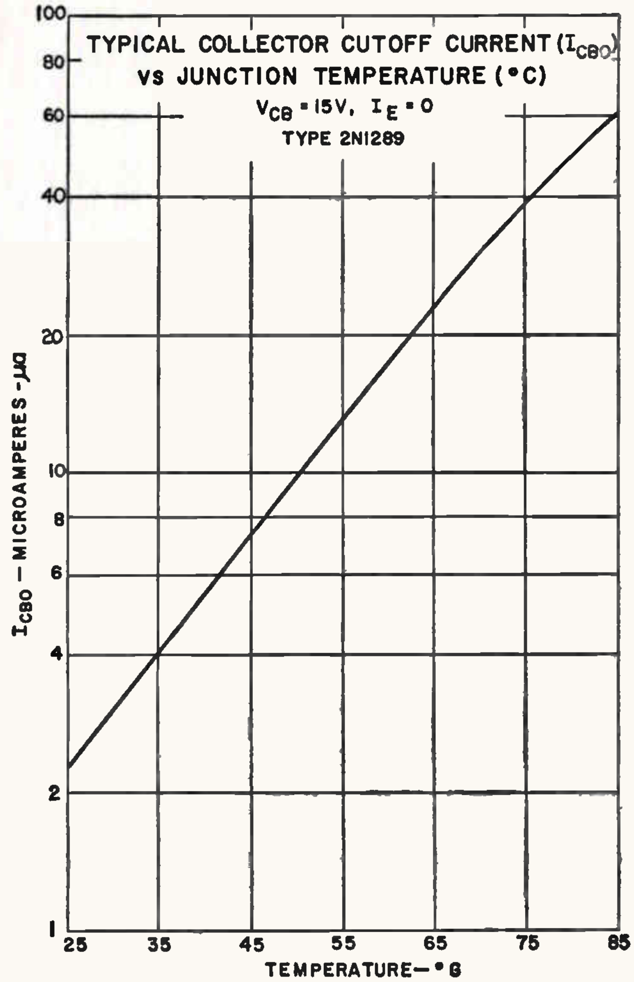
The 2N1289 features a typical alpha cutoff frequency of 60 mc, and a 10 ma beta of 150. Voltage ratings are high. Emitter cutoff current and collector cutoff current are measured at 5 and 15 volts, respectively. Also, the transistor provides a high-gain bandwidth product which is virtually independent of operating point.

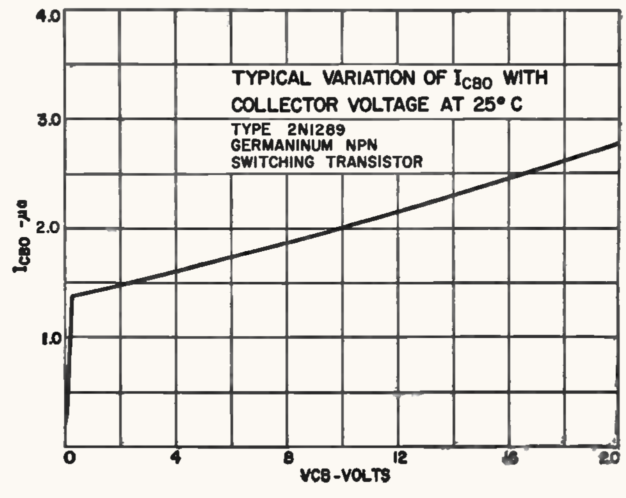
High voltages, together with a constant-gain bandwidth product, allow the 2N1289 to be used in a wide variety of complementary switching circuits with just about any PNP high-speed transistor. This device performs best out of saturation.

Backing up the 2N1289 is more than two years of manufacturing experience with meltback transistors. Over 100,000 of these transistors have been tested to severe mechanical and electrical standards. The survival rate has averaged greater than 99 percent.

Your G-E Semiconductor Sales Representative has complete details on the 2N1289. Call him to get all the facts on performance characteristics that make this device perform capably and reliably in high-speed computer circuits. Semiconductor Products Dept., Electronics Park, Syracuse, N. Y. In Canada: Canadian General Electric Company, 189 Dufferin St., Toronto, Ont. Export: International General Electric Co., 150 E. 42 St., New York 17, N. Y.

See your G-E Semiconductor Distributor for fast delivery at factory-low prices.





GENERAL ELECTRIC

CIRCLE 13 ON READER SERVICE CARD

WASHINGTON OUTLOOK

THE NEW DEFENSE BUDGET came through the first wringer—the House appropriations Committee—with $122 million extra tacked on. As was the case last year, the lawmakers severely rejuggled individual procurement and R&D projects in which electronics contractors are important suppliers.

On the plus side, the committee boosted funds for Army modernization, transport aircraft, fighter planes, the Polaris program, and antisubmarine operations well over the Administration's budget request.

On the other side of the ledger, funds for Navy's $293-million aircraft carrier were knocked out and the Air Force's Bomarc-B project was trimmed even more than the Administration recently proposed.

Of major interest to the electronics industry was the addition of $215 million for procurement of 30 to 50 Convair F-106 all-weather fighter-interceptor planes. The Pentagon's original shopping list for next year omits new orders for this aircraft. The committee called for these electronics-laden aircraft to provide air defense for the near future "in lieu" of the gutted Bomarc program.

Another key electronic provision is the addition of $321 million for antisubmarine forces. Almost one-third of this sum is earmarked for research and development.

The committee rapped the Navy for failure to provide "dramatic or dynamic leadership" to run the antisubmarine warfare show. The lawmakers want a "single manager" to take charge. In effect, this would be similar to the way the Polaris development program has been run—with a special project office headed by a naval "czar" autonomous of the traditional bureau organization.

The committee also took a serious swipe at Pentagon procurement and supply management, ordered the military services "to force more economies" in contracting. The committee's way of doing this: an over-all $400-million cut in general procurement funds. The Defense Dept. is directed to apply this saving down the line as a means of tightening up on pricing, costs, etc.

The appropriations report complains of "the seeming inability of the services to formulate reasonable and realistic plans and specifications which would allow the maximum utilization of formal competitive bidding."

The report cites cases of "profit-to-cost ratios of 24 to 41 percent" on Army Nike subcontracts, additional costs exceeding $3 million on an unspecified Air Force prime contract for fire control radar, and lower cost estimates on an unnamed Sage electronic component when bought under advertised procurement rather than negotiated contracting.

The House committee's action is just the first step in the prolonged mechanics which engulf defense budgets. Still to come: action by the House as a whole, a report from the Senate Appropriations Committee, a Senate vote, then compromise between the House and Senate versions.

Right now, the outlook is for a steep Senate increase in the military appropriation—close to $1 billion, no doubt. The final Congressional version is expected to bring this budget increase down at least 50 percent.

SHIPMENTS OF ELECTRONIC COMPONENTS in 1959 jumped more than 30 percent over 1958 totals to a new all-time record amount. A Commerce Dept. report (BD-60-64) spells out the quantities and values of shipment by major category and breaks down the total into military and non-military use.

The report on 1959 electronic component shipments, prepared by the Defense Dept. Electronics Production Resources Agency and Commerce's BDSA Electronics Div., is available upon request from the Commerce Dept. It should be extremely useful in market programming.

NOW!

Constant output level
Constant modulation level
3 volt output into 50 ohms
Low envelope distortion

50kc TO 65MC

New -*hp*- 606A HF Signal Generator

Here at last is a compact, convenient, moderately-priced signal generator providing constant output and constant modulation level plus high output from 50 kc to 65 MC. Tedious, error-producing resetting of output level and percent modulation are eliminated.

Covering the high frequency spectrum, (which includes the 30 and 60 MC radar IF bands) the new ⓗⓟ 606A is exceptionally useful in driving bridges, antennas and filters, and measuring gain, selectivity and image rejection of receivers and IF circuits.

Output is constant within ±1 db over the full frequency range, and is adjustable from +20 dbm (3 volts rms) to —110 dbm (0.1 μv rms). No level adjustments are required during operation.

SPECIFICATIONS

Frequency Range: 50 kc to 65 MC in 6 bands.

Frequency Accuracy: Within ±1%.

Frequency Calibrator: Crystal oscillator provides check points at 100 kc and 1 MC intervals accurate within 0.01% from 0° to 50° C.

RF Output Level: Continuously adjustable from 0.1 μv to 3 volts into a 50 ohm resistive load. Calibration is in volts and dbm (0 dbm is 1 milliwatt).

Output Accuracy: Within ±1 db into 50 ohm resistive load.

Frequency Response: Within ±1 db into 50 ohm resistive load over entire frequency range at any output level setting.

Output Impedance: 50 ohms, SWR less than 1.1:1 at 0.3 v and below.

Spurious Harmonic Output: Less than 3%.

Leakage: Negligible; permits sensitivity measurements to 0.1 μv.

Amplitude Modulation: Continuously adjustable from 0 to 100%.

Internal Modulation: 0 to 100% sinusoidal modulation at 400 cps ±5% or 1000 cps ±5%.

Modulation Bandwidth: Dc to 20 kc maximum.

External Modulation: 0 to 100% sinusoidal modulation dc to 20 kc.

Envelope Distortion: Less than 3% envelope distortion from 0 to 70% modulation at output levels of 1 volt or less.

Spurious FM: Less than 0.0001% or 20 cps, which greater.

Spurious AM: Hum and noise sidebands are 70 db below carrier.

Frequency Drift: Less than 0.005% or 5 cps, whichever greater.

Price: (cabinet) $1,200.00. (rack mount) $1,185.00.

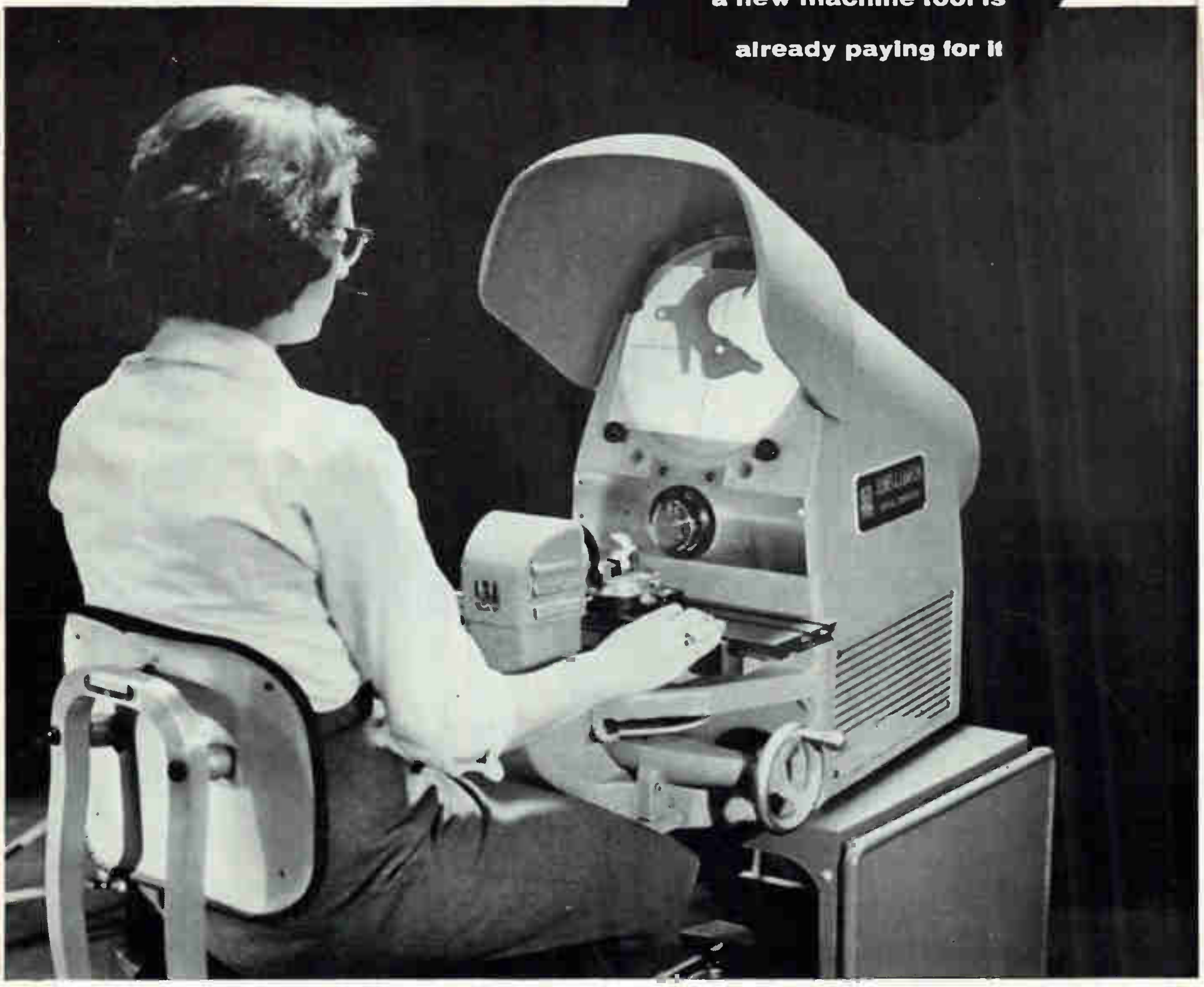
Data subject to change without notice. Prices f.o.b. factory.

HEWLETT-PACKARD COMPANY 5023A PAGE MILL ROAD • PALO ALTO, CALIFORNIA, U.S.A.
CABLE "HEWPACK" • DAVENPORT 6-7000 • *Field representatives in all principal areas*

world's most complete line of signal generators

JONES & LAMSON OPTICAL COMPARATORS

the man who needs a new machine tool is already paying for it



Now . . . an Economy-size Optical Comparator with "Big Machine" Features

Here is a fine optical inspection and measuring instrument of brand-new design. It is the first small-screen comparator to offer such BIG performance. It is equally suitable for production-line operation or job-shop work, and is extremely flexible in application.

The J & L TC-10 is of precision machine tool construction. This provides a solid base for precise inspection and measurement.

Three different table styles are available, including a fixed table for straight comparison work, a plain table, and a measuring table which gives you 6 square inches of measuring area. All measurements are read directly to .0001″, without computation.

Among other things, the TC-10 is adaptable for *reflection inspection*. Reflected images are extremely sharp—even at high magnifications.

Other "big machine" features include Angle Measuring; Quick-Change Lens Mount; Vertical Staging; Tracing Inspection. And there's a big bonus in the 5X, 2″ aperture lens, which gives inspection capacity and accuracy hitherto unattainable on a machine of this size. Write for folder. Jones & Lamson Machine Company, 539 Clinton St., Springfield, Vt.

Turret Lathes • Automatic Lathes • Tape Controlled Machines • Thread & Form Grinders • Optical Comparators • Thread Tools

N CONTROLLED RECTIFIERS

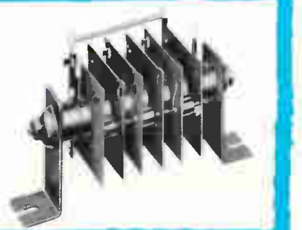
:ry devices, introduced by General :he work of thyratrons, ignitrons, :ers, power transistors, relays, :it breakers in many power con- :g applications. *Medium-current* :s blocking voltages to 400 V and 16 amperes; *high-current C60* :d 50 amperes; *low-current C10* 4 amperes. C40 Series, ratings but specially selected for fast- :eet requirements of inverter cir- has ratings lower than C35, with amperes.

GE Type No.	PIV and V_{BO}	Max. I_{DC} @ Temp. °C	Max. Temp. °C Oper.	Max. Temp. °C Stor.	Max. Req'd Gate Signal
C10U	25	Up to 4.7A @ 60°C Stud	150	150	2V, 6 ma @ 150°C T_J
C10F	50	" " " " " "	"	"	" " " " " "
C10A	100	" " " " " "	"	"	" " " " " "
C10G	150	" " " " " "	"	"	" " " " " "
C10B	200	" " " " " "	"	"	" " " " " "
C10H	250	" " " " " "	"	"	" " " " " "
C10C	300	" " " " " "	"	"	" " " " " "
C10D	400	" " " " " "	"	"	" " " " " "
C35U	25	Up to 16A @ 87°C Stud	125	150	3V, 25 ma @ 125°C T_J
C35F	50	" " " " " "	"	"	" " " " " "
C35A	100	" " " " " "	"	"	" " " " " "
C35G	150	" " " " " "	"	"	" " " " " "
C35B	200	" " " " " "	"	"	" " " " " "
C35H	250	" " " " " "	"	"	" " " " " "
C35C	300	" " " " " "	"	"	" " " " " "
C35D	400	" " " " " "	"	"	" " " " " "
C60U	25	Up to 50A @ 87°C Stud	150	150	3.5V, 50 ma @ 150°C T_J
C60F	50	" " " " " "	"	"	" " " " " "
C60A	100	" " " " " "	"	"	" " " " " "
C60G	150	" " " " " "	"	"	" " " " " "
C60B	200	" " " " " "	"	"	" " " " " "
C60H	250	" " " " " "	"	"	" " " " " "
C60C	300	" " " " " "	"	"	" " " " " "

ER STACKS

PIV (up to)	Max. I_{DC} at T°C (up to)
630V	6 Amps @ 55°C Amb.
1800V	.4 Amps @ 55°C Amb.
3360V	18 Amps @ 25°C Amb.
3000V	2.0 Amps @ 50°C Amb.
10000V	.65 Amps @ 25°C Amb.
2000V	1.50 Amps @ 25°C Amb.
630V	48 Amps @ 55°C Amb.
1800V	67.5 Amps @ 55°C Amb.
840V	573 Amps @ 35°C Amb.

GERMANIUM LOW CURRENT



4JA211 Stacks: The industry's most widely-used semiconductor rectifier series. Hundreds of thousands in use. May be arranged in stacks up to 12 fins to produce more than 160 various circuit configurations. Small, lightweight, excellent regulation.

RENT

Combine high temperature operation :ith increased ratings (up to 18 amps :f stack combinations to meet a variety :ons. High efficiency plus excellent

GERMANIUM MEDIUM CURRENT

SINGLE-FIN MOUNTING

4JA3011 Series: For general-purpose power supplies, control devices, blocking circuits, and many other applications. Extremely low power dissipation and forward voltage drop provide excellent regulation and efficiency. Available in stacks up to 12 fins, providing ratings in thousands of watts, depending upon the circuit design, with operation to 85° C. Also available in single-fin mounting. Transient PIV's up to 600 volts per cell.

Provide a wide-range of power appli- outputs up to 65 amps.

SILICON HIGH CURRENT

4JA6011, 4JA6211 Stacks: Hundreds of combinations available in various circuit configurations. D-c outputs up to 573 amps. The 4JA6211 series is for lower-current, lower-cost operation.

R S

4JA220, 4JA420-421-422 Series: Mounted in standard eight-pin tube base (4JA220-420 Series) or in rectangular design with solder lug connections (4JA221-421-422 Series). Available in a large number of circuit configurations. One to 20 cells may be potted in a single circuit. Individual cell specifications determine ratings. 4JA220 Series utilize germanium 1N91-93 cells. 4JA420-421-422 Series utilize silicon 1N536-540, 1N1095 cells. (See BASIC-RECTIFIER-CELL LISTING.)

GENERAL ELECTRIC

General Electric believes that maintenance of product quality must take place throughout the whole industrial cycle, beginning with the refining of raw materials even before the crystal-growing process (shown left).

GENERAL ELECTRIC SEMICONDUCTORS

Close control of temperature and humidity is an essential part of General Electric's quality assurance procedures. For this reason, you will find "dry boxes" at many points in the production process. Rooms are also slightly pressurized to keep out dust. (Near right photo)

Operatar inspects transistors manufactured under General Electric's exclusive Fixed Bed Mounting process. Critical elements are welded flat on a disk of ceramic so that the device reacts as a solid block in resisting shock and vibration. These units exceed the requirements of all standard shock, centrifuge and temperature-cycling tests. (Far right photo)

As part of General Electric's leak-testing procedures, transistors or rectifiers are locked in a Radiflo* unit and exposed to radioactive krypton gas under pressure. They are then monitored through the Scintiscaler*, a super-sensitive Geiger counter which can detect leaks at the rate of 10^{-13} cc/sec.

*TM of Reed-Curtis Div. of American Electronics, Inc.

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TRANSISTORS

General Electric transistors and rectifiers have earned a reputation for reliability without equal in the industry. Superior quality is *built into* all G-E semiconductors—by careful control of every step, from refining the raw materials to packaging the finished product.

Up through 1959, General Electric has manufactured well over 21,000,000 transistors, of which over 191,000 were diverted for life-testing. Life test readings total 2,293,000.

Among the more than 30,000 transistors on G.E.'s cycled life-test racks at any time are Series 2N43 PNP germanium devices dating back to 1954. Each has clocked at least 40,000 hours—or five years of "power-on" operation without failure.

But life testing is only one of the product quality assurance procedures through which all General Electric semiconductors must pass. The average is sixteen separate tests—electrical, mechanical and environmental, as well as life.

General Electric has also introduced a series of design improvements which have raised reliability expectations to a new peak. G.E.'s Fixed Bed Mounting, for example, almost overnight changed delicate grown-junction devices into rugged units with extreme stability and inherently higher power dissipation. One Fixed Bed Mounted Series, types 2N332A through 2N336A, can dissipate up to 500 mw without a heat sink at 25°C, providing an unusually wide safety factor.

THE TUNNEL DIODE

Tightly-controlled parameters, low capacitance and a high peak-to-valley current ratio are three outstanding features of General Electric's tunnel diode, now available for the first time in production quantities at sharply reduced prices.

Pioneered by General Electric, this newest arrival in the fast-growing family of electronic devices is smaller, simpler, and many times faster than a transistor. It takes advantage of quantum mechanical tunneling to attain unique negative conductance and very high frequency performance.

G-E germanium tunnel diodes provide switching times of 2 millimicroseconds and resistive cutoff frequencies of 2 kmc. These devices offer good temperature stability, extreme resistance to nuclear radiation, a closely controlled peak-point current with a peak-to-valley ratio of 3 for the lower-priced 1N2940. See your G-E Semiconductor Sales Representative for complete specifications and application data.

ELECTRICAL CHARACTERISTICS (25°C) (Typical)

	Symbol	1N2939	1N2940	1N2941	Units
Peak Point Current	I_P	1.0	1.0	4.7	ma
Valley Point Current	I_V	0.10	0.15	0.6	ma
Peak Point Voltage	V_P	55	55	55	mv
Valley Point Voltage	V_V	350	350	350	mv
Peak Point Current to Valley Point Current Ratio	$\frac{I_P}{I_V}$	10	3	8	
Negative Conductance	$-g$	10×10^{-3}	6.5×10^{-3}	30×10^{-3}	mho
Total Capacity	C	7.0	7.0	30	μμfd
Series Inductance*	L_s	6×10^{-9}	6×10^{-9}	6×10^{-9}	henry
Series Resistance	R_s	1.0	1.0	0.5	ohm

*Inductance will vary 2-12 x 10^{-9} henry depending on lead length

Resistive Cutoff Frequency 2.3 kmc (1N2939 typical)
1.8 kmc (1N2940 typical)
1.3 kmc (1N2941 typical)

Fast switching capabilities due to low junction capacitance.

				RATINGS							TYPICAL SPECIFICATIONS										
	USE	TYPE NO.	CASE	MAXIMUM DISSIPATION @ 25°C (mw) P_{AV}	MAXIMUM RATED VOLTAGE (VOLTS) V_{EBO}	V_{CBO}	V_{CE}	MAXIMUM COLLECTOR CURRENT (ma) I_C	MAXIMUM OPERATING TEMPERATURE T_J	MAXIMUM STORAGE TEMP. (°C) T_{STG}	CURRENT GAIN h_{FE} MIN.	h_{FE} MAX.	h_{fe} MIN.	h_{fe} MAX.	ALPHA CUTOFF FREQ. (mc) f_{ab}	POWER GAIN (db) G_e (1000 Cyc.) (5 Mc)*	SATURATION VOLTAGE (VOLTS) V_{CE} (SAT) R_{SC} (ohms)*	COLLECTOR CAPACITY (μμf) C_{ob}	COLLECTOR TO BASE CURRENT (μa) MAX I_{CO}	@	V_{CB}
SILICON	AMPLIFIER AND COMPUTER NPN (Ceramic Fixed Bed Construction)	2N332	TO-5	150	1	45		25	175	200	14 typ		9	22	10	14*	90*	7	2	25°C	30
		Certified to meet MIL-T-19500/37A (NAVY)																			
		2N333*	TO-5	150	1	45		25	175	200	31 "		18	44	12	14*	80*	7	2	"	30
		2N334*	TO-5	150	1	45		25	175	200	38 "		18	90	13	13*	75*	7	2	"	30
		2N335*	TO-5	150	1	45		25	175	200	56 "		37	90	14	13*	70*	7	2	"	30
		*Per MIL-T-19500/37A (NAVY)																			
		2N336	TO-5	150		45		25	175	200	100 "		76	333	15	12*	70*	7	2	"	30
		2N337†	TO-5	125	1	45		20	150	200	20	55	19		30		75*	1.4	1	"	20
		2N338†	TO-5	125	1	45		20	150	200	45	150	39		45		75*	1.4	1	"	20
		†Certified to meet MIL-T-19500/69A (NAVY)																			
		2N332A	TO-5	500	4	45	45	25	175	200	16 typ		9	22	10	11*	0.5	7	20	150°C	30
		2N333A	TO-5	500	4	45	45	25	175	200	27 "		18	44	11	11*	0.45	7	20	"	30
		2N334A	TO-5	500	4	45	45	25	175	200	36 "		18	90	12	12*	0.42	7	20	"	30
		2N335A	TO-5	500	4	45	45	25	175	200	45 "		37	90	13	12*	0.4	7	20	"	30
		2N336A	TO-5	500	4	45	45	25	175	200	75 "		76	333	15	12*	0.4	7	20	"	30
		2N1276	TO-5	150	1	40	30	25	150	200			9	22	30	37	0.49	2	50	"	30
		2N1277	TO-5	150	1	40	30	25	150	200			18	44	30	39	0.53	2	50	"	30
		2N1278	TO-5	150	1	40	30	25	150	200			37	90	30	44	0.56	2	50	"	30
		2N1279	TO-5	150	1	40	30	25	150	200			76	333	34	45	0.47	2	50	"	30
						V_{BB} (MAX)		I_E			η				f_{MAX} (Mc)	R_{BBO} (K ohms)	V_E (SAT)	I_{B2} (ma)	I_{EO}	150°C	V_{B2E}
	UNIJUNCTION PN (Ceramic Fixed Bed Construction)	2N489*	TO-5	450		55		70	175	175	.51	.62			0.9	5.6	3.1	12	20	"	10
		2N490*	TO-5	450		65		70	175	175	.51	.62			0.7	7.5	3.3	12	20	"	10
		2N491*	TO-5	450		55		70	175	175	.56	.68			0.8	5.6	3.4	12	20	"	10
		2N492*	TO-5	450		65		70	175	175	.56	.68			0.7	7.5	3.6	12	20	"	10
		2N493*	TO-5	450		55		70	175	175	.62	.75			0.7	5.6	3.8	12	20	"	10
		2N494*	TO-5	450		65		70	175	175	.62	.75			0.65	7.5	3.9	12	20	"	10
		*A PN Device, per MIL-T-19500/75 (USAF)																			
						V_{CBO}		I_C			h_{FE}				f_{ab}	G_e	V_{CE} (SAT)	C_{OB}	I_{CO}	@	V_{CB}
GERMANIUM	AUDIO PNP	2N43		240	5	45	30	300	85	100	34	65	30		1.3		0.09	40	16	25°C	45
		(USAF) 2N43A Per MIL-T-19500/18																			
		2N44		240	5	45	30	300	85	100	18	43			1		0.09	40	16	"	45
		(USAF) 2N44A Per MIL-T-19500/6																			
		2N524	TO-5	225	15	45	30	500	85	100	19	42	16	41	2		0.07	25	10	"	30
		2N525	TO-5	225	15	45	30	500	85	100	34	65	30	64	2.5		0.075	25	10	"	30
		2N526*	TO-5	225	15	45	30	500	85	100	53	90	44	88	3		0.08	25	10	"	30
		2N527	TO-5	225	15	45	30	500	85	100	72	121	60	120	3.3		0.09	25	10	"	30
		*Also supplied as certified to meet MIL-T-19500/60B (NAVY)																			
	COMPUTER PNP	2N123		150	10	20	15	125	85	85	30	150			8		0.15	12	6	25°C	20
		Per MIL-T-19500/30 (USAF)																			
		2N123A		150	10	20	15	125	85	85					8		0.15	12	6	"	20
		2N395	TO-5	200	20	30	15	200	100	100	20	150			4.5		0.1	12	6	"	15
		2N396	TO-5	200	20	30	20	200	100	100	30	150			8.0		0.08	12	6	"	20
		2N396A	TO-5	150	20	30	20	200	100	100	30	150			8		0.2	12	6	"	15
		Certified to meet MIL-T-19500/64 (NAVY)																			
		2N397	TO-5	200	20	30	15	200	85	100	40	150			12		0.07	12	6	"	12
		2N404	TO-5	120	12	25	24	100	85	85					4 min.		0.14	12	5	"	12
		Certified to meet MIL-T-19500/20 (USAF)																			
		2N450		150	10	20	12	125	85	85	30				5 min.		0.04 max.	12	6	"	12
		2N518		150	30	45	12	125	85	85	60				10 min.		0.15 max.	12	6	"	70
		2N1057		240	5	45	30	300	85	100	34	90			1.3		0.08	40	16	"	45
	MEDIUM FREQ. AMPLIFIER NPN	2N78		65	5	15	15	20	85	85	45	135	30	200	9	31 (455Kc)		3	3	25°C	15
		2N169A		65	5	25	25	25	85	85	34	200			9	28 "	0.23	2.4	5	"	15
	COMPUTER NPN	2N167		75	5	30	30	75	85	85	17	90	20	200	9		0.35	2.5	3	25°C	15
		(USAF) 2N167		"	"	"	"	"	"	"	"	"	"	"	"		"	"	"	"	
		2N167A		"	"	"	"	"	"	"	"	"	"	"	"		"	"	29	71°C	
		Per MIL-T-19500/11 (USAF)																			
		2N377	TO-5	150	15	25	20	200	100	100	20	60			6			12	20	25°C	25
		2N388	TO-5	150	15	25	20	200	100	100	60	180			5 min.			12	10	"	25
		Certified to meet MIL-T-19500/65 (NAVY)																			
		2N634A	TO-5	150	25	25	20	300	85	100	40	120			8		0.10	12	80	71°C	25
		2N635A	TO-5	150	25	25	20	300	85	100	80	240			12.5		0.085	12	80	"	25
		2N636A	TO-5	150	25	25	15	300	85	100	100	300			17		0.075	12	80	"	25
		2N1198		65	5	25	25	75	85	85	17	90	20	200	9		0.35	2.5	1.5	25°C	15
		2N1288	TO-5	75	5	15	10	50	85	85	50	300			60		0.2	6	5	"	10
		2N1289	TO-5	75	5	20	15	50	85	85	50	300			60		0.2	6	5	"	15
		2N1304	TO-5	150	25	25	20	300	85	100	40	200			8		0.10	12	6	"	25
		2N1306	TO-5	150	25	25	15	300	85	100	60	300			12.5		0.085	12	6	"	25
		2N1308	TO-5	150	25	25	15	300	85	100	80				17		0.075	12	6	"	25

RECTIFIERS

General Electric's record in rectifiers is outstanding—over 20,000,000 units produced, over 70,000 units life-tested (not including government types). Survival rates of 98.5%, in operating tests at maximum ratings for many thousands of hours, are not unusual.

In the medium and high-current areas, General Electric has completely eliminated soft solder joints and with them has greatly reduced the problem of thermal fatigue. This means that G-E medium and high-current silicon rectifiers can be worked right up to maximum current and temperature ratings, even on highly cyclical loads.

In addition, all General Electric medium and high-current rectifiers now carry *transient* PIV ratings which give the user additional protection against voltage transients.

The rectifier cells shown are listed in ascending order based on forward current ratings. Maximum full load voltage drop is taken at full cycle average. Complete specifications are available through your Semiconductor Products District Sales Office or your authorized G-E Semiconductor Distributor.

Low Current Germanium Rectifier Cells

General Electric germanium junction rectifiers have become the industry standard for high reliability units. They have demonstrated life for over 25,000 hours with no significant change in characteristics, and a survival rate of 98.5 percent. They feature extremely low forward resistance, high back resistance.

JEDEC or GE Type Number	PIV	Max. I_{DC} at T°C	Max. Peak 1 cycle Surge	Max. Rev. Current (full cycle Av.)	Max. Full Load Voltage Drop	Max. Oper. °C
		@ 55°C Amb.				
1N93	300	75 ma	25A	.6 ma	.18	95°
USN1N93	300	75 ma	25A	.6 ma	.18	95°
1N315	300	75 ma	25A	Min. Fwd./Rev. Ratio-700 @ 55°C		85°
USAF1N315	300	75 ma	25A	Min. Fwd./Rev. Ratio-700 @ 55°C		85°
1N368	200	100 ma	25A	.3 ma @ 150 V.D.C.	.48	55°
1N92	200	100 ma	25A	.95 ma	.19	95°
1N91	100	150 ma	25A	1.35 ma	.22	95°
1N153	300	750 ma	25A			95°
1N158	400	1000 ma	25A			95°
1N152	200	1000 ma	25A			95°
1N151	100	1200 ma	25A			95°

Low Current Silicon Rectifier Cells (Lead

General Electric low current rectifie
well known top hat design. Operating
tests up to 10,000 hours yield surviva
percent. A wide variety of cells are
follows. Military approved units are
each listing.

Series: 1N536-540, 1N547, 1N1095-
maximum forward conductance at hi
temperatures (165°C.). 1N440-445, 1
—Similar to 1N536-540 series, but wi
low reverse current. Ideal for mag
applications. 1N1100-1103 — Similar
445B series. 1N1487-1492—Essentially
1N536-540 series, except provides lo
for lower-temperature requiremen
1N599-606, 1N599A-606A — Similar
and 1N440B-445B series, respectivel
somewhat lower forward-current rati
1695 — Provides lower current and
operation (115°C.) than any of above
economical.

JEDEC or GE Type Number	PIV	Max. I_{DC} @ T°C Amb.	Max. Peak 1 cycle Surge	Max. Rev. Cur. (Full cycle Av.)
		@ 50°C		@ 25°C
1N440	100	300 ma	15 A	.3 μa
1N441	200	300 ma	15 A	.75 μa
1N442	300	300 ma	15 A	1.0 μa
1N443	400	300 ma	15 A	1.5 μa
1N444	500	300 ma	15 A	1.75 μa
1N445	600	300 ma	15 A	2.0 μa
		@ 25°C		
1N599	50	600 ma	10 A	1.0 μa
1N599A	50	600 ma	10 A	1.0 μa
1N600	100	600 ma	10 A	1.0 μa
1N600A	100	600 ma	10 A	1.0 μa
1N601	150	600 ma	10 A	1.0 μa
1N601A	150	600 ma	10 A	1.0 μa
1N602	200	600 ma	10 A	1.0 μa
1N602A	200	600 ma	10 A	1.0 μa
1N603	300	600 ma	10 A	1.0 μa
1N603A	300	600 ma	10 A	1.0 μa
1N604	400	600 ma	10 A	1.5 μa
1N604A	400	600 ma	10 A	1.5 μa
1N605	500	600 ma	10 A	2.0 μa
1N605A	500	600 ma	10 A	2.0 μa
1N606	600	600 ma	10 A	2.5 μa
1N606A	600	600 ma	10 A	2.5 μa
		@ 30°C		@ 150°C
1N560	800	600 ma	15 A	.3 ma
1N561	1000	600 ma	15 A	.3 ma
		@ 50°C		@ 100°C
1N1692	100	600 ma	20 A	.5 ma
1N1693	200	600 ma	20 A	.5 ma
1N1694	300	600 ma	20 A	.5 ma
1N1695	400	600 ma	20 A	.5 ma
1N1696	500	600 ma	20 A	.5 ma
1N1697	600	600 ma	20 A	.5 ma
				@ 25°C
1N444B	500	650 ma	15 A	1.75 ma
1N445B	600	650 ma	15 A	2.0 ma
1N440B	100	750 ma	15 A	0.3 ma
1N441B	200	750 ma	15 A	0.75 ma
1N442B	300	750 ma	15 A	1.0 ma
1N443B	400	750 ma	15 A	1.5 ma
		@ 50°C		@ 150°C
1N1100	100	750 ma	15 A	.3 ma
1N1101	200	750 ma	15 A	.3 ma
1N1102	300	750 ma	15 A	.3 ma
1N1103	400	750 ma	15 A	.3 ma
		@ 25°C		@ 125°C
1N1487	100	750 ma	15 A	.4 ma
1N1488	200	750 ma	15 A	.3 ma
1N1489	300	750 ma	15 A	.3 ma
1N1490	400	750 ma	15 A	.3 ma
1N1491	500	750 ma	15 A	.3 ma
1N1492	600	750 ma	15 A	.3 ma
		@ 50°C		@ 150°C
1N536	50	750 ma	15 A	.4 ma
1N537	100	750 ma	15 A	.4 ma
1N538 (1)	200	750 ma	15 A	.3 ma
1N539	300	750 ma	15 A	.3 ma
1N540 (1)	400	750 ma	15 A	.3 ma
1N1095	500	750 ma	15 A	.3 ma
1N1096	600	750 ma	15 A	.3 ma
1N547 (1)	600	750 ma	15 A	.3 ma

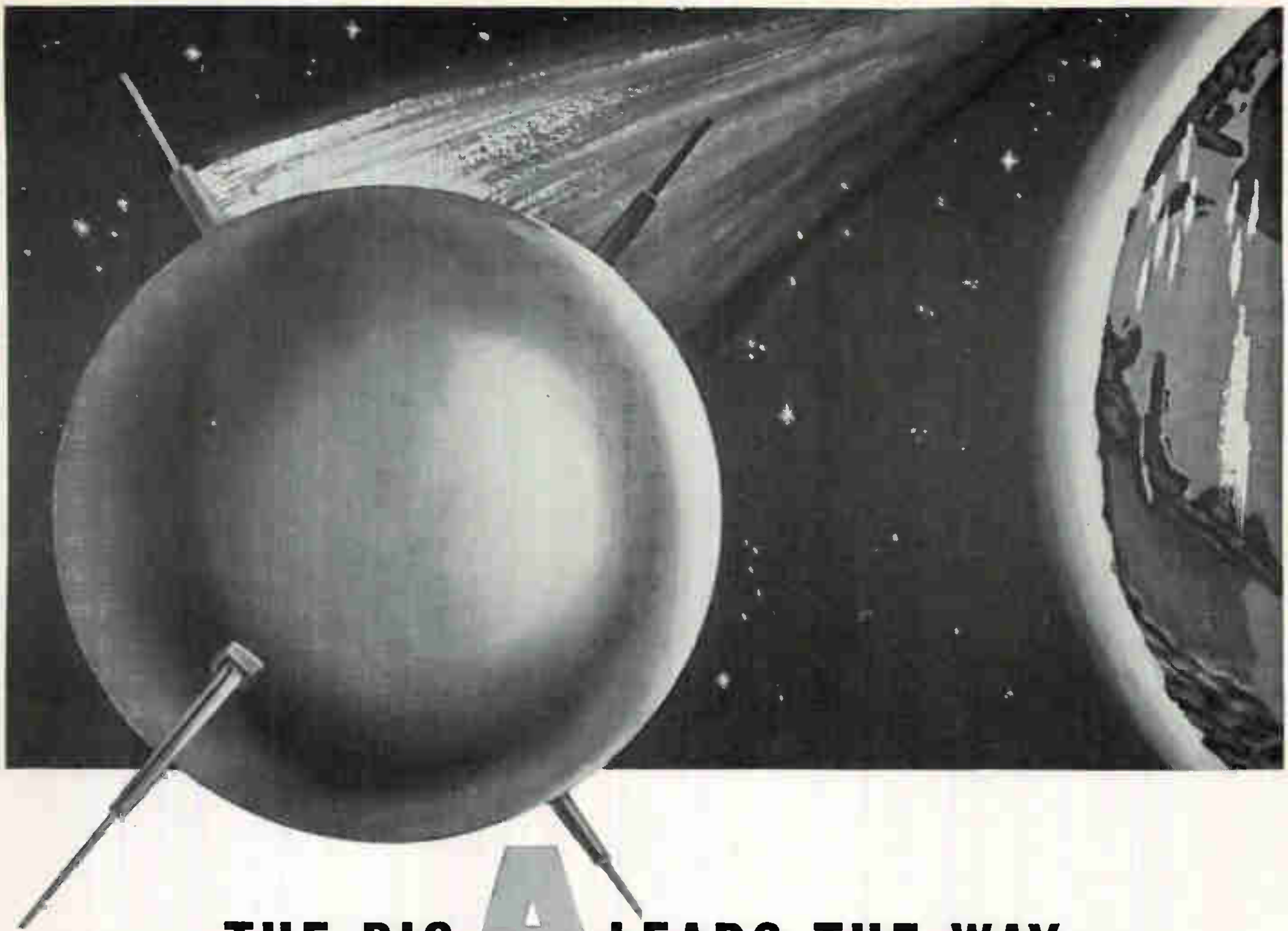
(1) Available in JAN approved units.

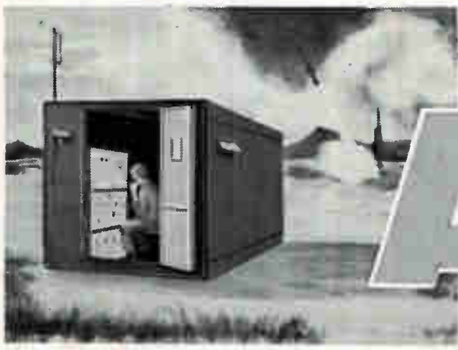
Subminiature Silicon Glass Rectifier Cells (Lead Mounted)

Designed for maximum thermal con
Rugged design to meet military requi

JEDEC or GE Type Number	Repetitive PIV	Transient PIV	Max. I_{DC} at T°C	Max. Rev. Cur. (Full Cycle Av.)	M
			@ 25°C	@ 100°C	
1N645	225	275	400 ma	15 μa	
1N646	300	360	400 ma	15 μa	
1N647	400	480	400 ma	20 μa	
1N648	500	600	400 ma	20 μa	
1N649	600	720	400 ma	25 μa	
1N677	100	120	400 ma	.2 ma	
				@ 150°C	

1N676-1N679, 1N681-1N687 and 1N689 are also available in th





Reports Earnings 44% Higher

General Precision Equipment Corp., New York, announces earnings of $1,322,000 for the first quarter of this year, or 86 cents a share. This is a rise of 44 percent over the $920,000 earned in the first quarter of 1959. Sales for the first three months of this year were $55,656,921, compared with $47,035,711 a year ago. Company officials expect total 1960 sales to be in the $225-$240-million range. J. W. Murray, GPE chairman, also announced the formation of a new company, **Kearfott Semiconductor**, which will manufacture transistors in W. Newton, Mass.

Laboratory for Electronics, Boston, is filing with Securities and Exchange Commission to register a maximum of 100,000 shares of common stock to be offered initially to shareholders. Paine, Weber, Jackson & Curtis will head the underwriting. Company officials say they need another $2 million in new working capital to finance expansion and conduct company business at its present rate.

Ling-Altec Electronics and **Temco Aircraft Corp.**, both of Dallas, are studying a merger proposal. If plans go through, the new entity will be called **Ling-Temco. Each** present Temco stockholder would receive 6/10 of a share in the new company, and each present Ling-Altec share would be exchanged on a one-for-one basis. The companies' combined sales last year topped $148 million.

Dynamics Corporation of America reports plans to begin issuing regular quarterly sales-earnings reports to shareholders for the first time in its history. The new policy, according to R. F. Kelley, is made feasible by the achievement of a better balance between R&D work and actual production and shipments. For the first quarter of this year, DCA recorded sales and other income of $10,072,708, compared with $6,385,418 in the first quarter of last year. Per-share earnings after taxes were 14 cents, double the 7-cent figure recorded in the same period last year.

Collins Radio, Cedar Rapids, Ia., announces formation of an Australian subsidiary. The new arm, **Collins Radio Co. (Australasia) PTY**, will locate in Melbourne. It will act as the sales and service unit for Australia, New Zealand and Southeast Asia. A spare parts service center and complete test facilities will be maintained.

25 MOST ACTIVE STOCKS

WEEK ENOING APRIL 29

	SHARES (IN 100's)	HIGH	LOW	CLOSE
Temco Aircraft	2185	16⅜	11⅞	13¾
RCA	1110	74⅛	70	70⅝
Gen Inst	1020	32⅝	28¼	31
Ampex	1013	33¼	30½	30⅝
Int'l Tel & Tel	803	41⅜	39¼	39⅜
Sperry Rand	656	21⅛	20¼	20¼
Electronics Capital	633	19⅜	15⅞	19⅜
Westinghouse	621	55⅝	52¾	53⅜
Siegler Corp	611	40⅝	38¼	39¾
Gen Elec	586	91	88⅛	88⅝
Amer Bosch Arma	529	22⅛	19	19
Raytheon	527	39⅞	37½	37⅞
Beckman Inst	480	80	74	76⅛
Philco Corp	477	32⅝	29½	30⅜
Dynamics Corp Amer	447	12	10¾	10⅞
Gen Tel & Elec	418	85	81⅞	82
Lockheed	380	23⅛	21⅝	22⅛
DuMont Labs	370	9⅞	9⅛	9¼
ITE Circuit Breaker	369	30⅜	24⅛	24¼
Avco Corp	366	12⅞	12⅜	12½
Zenith	357	100¾	93¾	94
Collins Radio	344	56	51¼	51½
Litton Ind	338	76¾	72⅛	73⅛
Gen Dynamics	325	41⅛	39⅞	40
Reeves Sndcrft	300	8⅛	7⅛	7¾

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.

DIVIDEND ANNOUNCEMENTS

	Amount per Share	Date Payable
Allied Radio	$.08	May 20
AMP & Pamcor	.20	Jun. 1
Friden Inc.	.25	Jun. 10
Daystrom	.30	May 16
Tv Shares Mgt.	.20	May 31
United Industrial	.05	Jun. 30

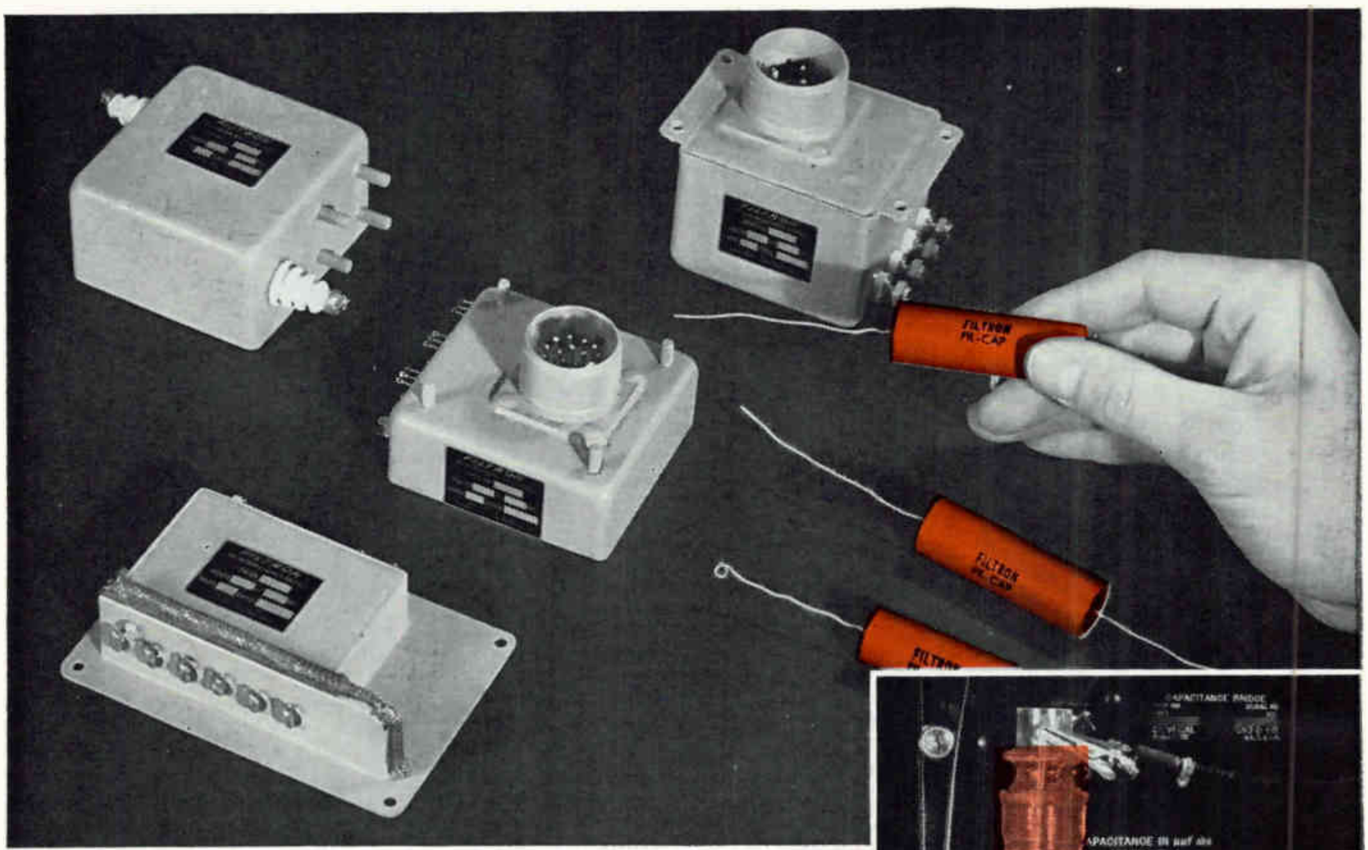
NEW ISSUES PLANNED

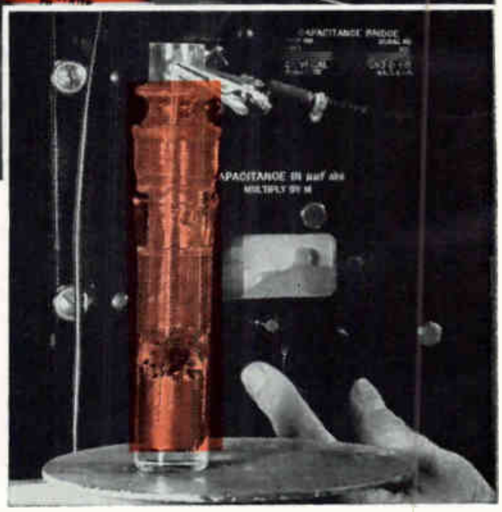
	No. of Shares	Price per Share
C.W.S. Waveguide	300,000	$1.00
Electrnc. Asstnce. Corp.	152,698	*
Electrnc. Test Equip't.	75,000	4.00
Newark Electronics — A	200,000	*

* to be announced

SILICONE NEWS from Dow Corning

Plan For Uniform Performance





Low Power Factor and Constant Capacity Assured by Dow Corning Silicone Fluids

Here's an example of value engineering with silicone fluids:

The Filtron Co., Inc., of Flushing, N. Y., manufactures RF interference filters and capacitors for both military and commercial use. To assure an almost constant capacitance vs temperature relationship for their specialty capacitors . . . and the lowest possible power factor for their RF interference filters . . . Filtron engineers impregnate them with Dow Corning silicone fluids.

Silicone fluids are, in themselves, excellent dielectrics. In capacitors and RF filters such as these, silicone fluids boost the performance of the paper dielectric . . . substantially increase permissible operating temperatures, decrease electrical losses. Highly stable to changing environments, silicones show little drift in electrical or physical properties over a broad range of temperature and frequency conditions. They add greatly to reliability . . . often eliminate costly compensating circuits.

Dielectric-Coolants . . . Silicone fluids also make highly effective heat transfer media. Because of their relatively constant viscosity, their pumping rate does not vary appreciably at differing temperatures. They're nonoxidizing, nongumming . . . can be sealed in for the life of the equipment. Electric grade fluids may be cycled directly over operating assemblies.

Typical Dielectric Properties of 200 Fluid, 100 CSTK.

Property	Temperature −55 C	23 C	200 C
Dielectric Constant,			
1.0 kcs.	3.1	2.7	2.3
0.1 mcs.	3.1	2.7	2.3
Dissipation Factor,			
1.0 kcs.	0.0005	0.00004	0.001
0.1 mcs.	0.0002	0.00001	0.0003
Resistivity, ohm-cm	10×10^{14}	2.0×10^{14}	1.0×10^{13}
Electric Strength, dc, 20 mil gap v/mil	700	650	550

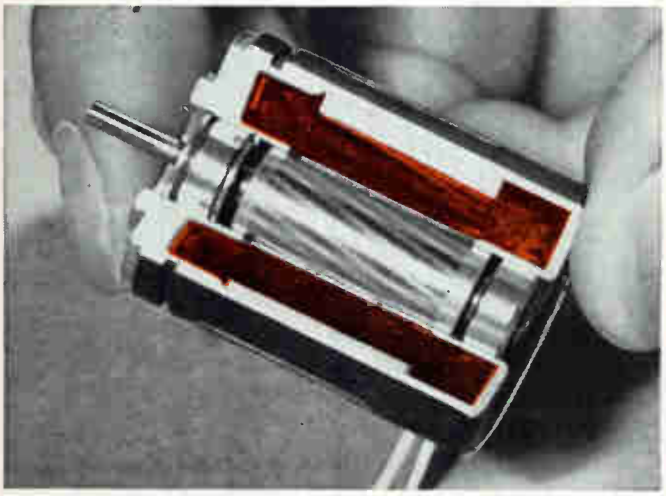
CIRCLE 289 ON READER SERVICE CARD

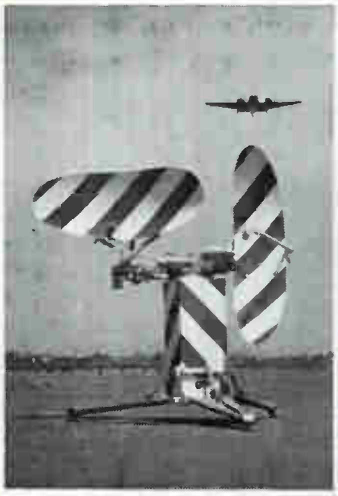
Your nearest Dow Corning office is the number one source for information and technical service on silicones.

first in silicones

Dow Corning

. . . engineer for value with silicones





Solventless Resin Fills A Void

This servo motor, made by G-M Laboratories, Inc., Chicago, must withstand high humidity and high temperatures in operation. On analyzing the requirements of size, weight and reliability, engineers at G-M Laboratories concluded that a silicone insulation system would permit the best design, so they impregnated the stator under vacuum with Dow Corning solventless silicone resin. This moisture-proof, heat-resistant material fills the coil interstices and sets up to a solid, bubble-free mass. It protects against vibration, oxidation, corona and moisture . . . provides good heat transfer.

Investigate Dow Corning solventless silicone resins for use as rigid potting, filling, impregnating or encapsulating materials. They're radiation resistant . . . can be used with inorganic fillers.

CIRCLE 290 ON READER SERVICE CARD

Soften Shock With Silastic RTV

This transistorized oscillator, produced by Delta-f, Inc., Geneva, Illinois, is designed for use in airborne and transportable communications equipment. To protect against shock, Delta-f engineers use a flowed-on blanket of Silastic® RTV. It supplies needed cushioning, and is unaffected by the built-in heating element. Silastic RTV can withstand temperatures up to 260 C, down to —70 on the cold side. In addition, it resists moisture, oxidation, and other adverse conditions.

Silastic RTV is the Dow Corning fluid silicone rubber that vulcanizes at room temperature. Easy to use, it can be applied by dipping, pouring or with a caulking gun. When used as a potting material, it flows into place, filling all voids . . . sets up to form silicone rubber with excellent dielectric properties.

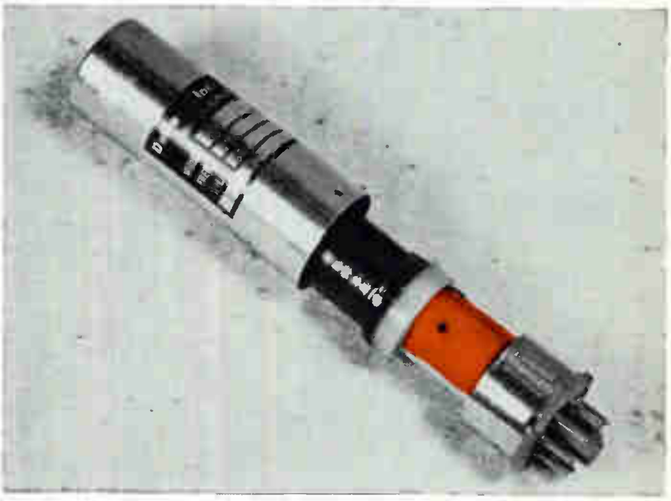
CIRCLE 292 ON READER SERVICE CARD

For Maximum Security: Silicone-Glass

Ground approach radar must provide the ultimate in reliability. That's why Gilfillan Brothers, Inc., of Los Angeles, use silicone-glass laminates in their Quadradar sets which are designed to provide vital flight information that facilitates ground controlled approach and landing of high speed aircraft.

Silicone laminates are specified because they have uniform dielectric properties under climatic and atmospheric conditions. Little affected by moisture, silicone-glass terminal boards prevent recurrent arcing even at high voltage and high humidity . . . provide low loss factor and low attenuation at RF frequencies. In addition, silicone laminates are strong and resist creep under pressure of fasteners; and, when needed, their heat resistance is exceptional . . . up to 250 C continuous for years on end.

CIRCLE 291 ON READER SERVICE CARD



CORPORATION MIDLAND, MICHIGAN

branches: ATLANTA BOSTON CHICAGO CLEVELAND DALLAS LOS ANGELES NEW YORK WASHINGTON, D.C.

CIRCLE 29 ON READER SERVICE CARD

Slip Ring Sales Rise 25% Yearly

SLIP RING ASSEMBLIES are becoming a major electronics industry components market, says George Pandapas, president of Electro-Tec Corp., a major producer of precision slip rings.

Essentially electrical joints, slip rings are used wherever electrical signals must be transmitted from a rotary object to a stationary one. Major equipment applications are in gyros for missiles, aircraft and spacecraft and in radar antennas.

Pandapas estimates 1960 sales of precision, high-performance slip rings will total $10 million. Estimate excludes slip rings manufactured for captive markets (currently worth about $10 million annually), and those made for use with synchros and resolvers.

Sales have been gaining at a 25-percent annual rate for several years, he says. But the annual rate of gain will probably jump to 50 percent over the next five years, Pandapas adds.

Extent of the movement of aircraft firms into electronics was recently highlighted by George M. Bunker, chairman of The Martin Co., in a talk before the New York Society of Security Analysts.

Of 7,500 engineers employed by Martin, 3,500 are in electronics. Traditionally an old-line airplane manufacturer, Martin has become a manufacturer of diversified weapon systems, many of which are electronic and none of which includes a new airplane design. Change came about because of the capabilities needed to build missile systems and their guidance, control, ground and support equipment—all largely electronic.

Military suppliers must plan on increasing sales in future years and learn how to perform research and development contracts profitably in order to maintain current profits, Bunker said. It now appears that more and more of the available defense industry business will be in low-profit-margin research and development work. Eighty percent of Martin's present business is in cost-plus-fixed-fee contracts.

Bunker stressed the value of reports on hearings of the House Subcommittee on Appropriations as one of the best sources of information on military markets and developments.

There was no reasonable basis for thinking the Titan program would be cancelled, he said, "and if commentators had paid more attention to committee testimony than to flight tests this situation would have been obvious."

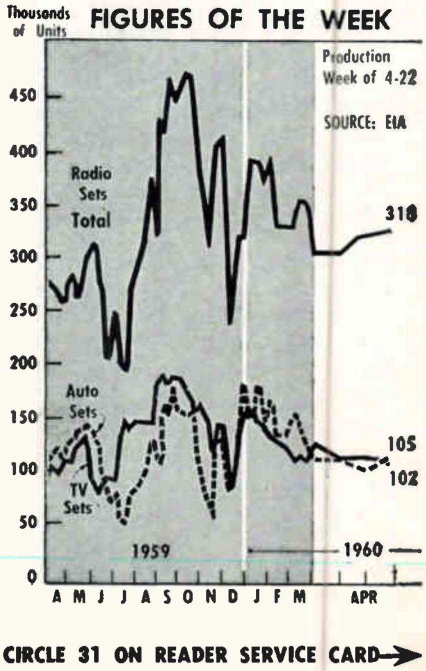
Lt. Gen. Bernard A. Schriever, head of Air Research and Development Command, recently testified:

"When people talk about cancelling out the Titan, they simply are not familiar with all the facts and problems that go into bringing missiles into the operational inventory. To cancel out today would mean that we would have approximately one-third less missiles in our inventory in this critical time period than we now have programmed."

LATEST MONTHLY SALES TOTALS
(Source: EIA)
(Add 000)

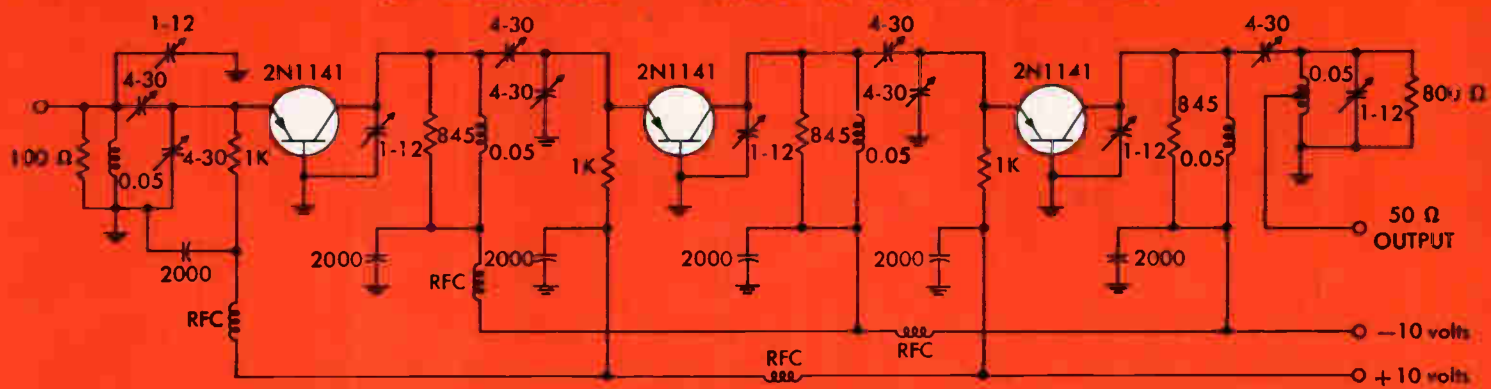
	Feb. 1960	Jan. 1960	Change From One Year Ago
Rec. Tubes, Value	$27,881	$26,872	− 2.6%
Rec. Tubes, Units	32,734	31,367	− 1.3%
Pic. Tubes, Value	$14,495	$15,831	+ 2.9%
Pic. Tubes, Units	741	795	+ .4%
Transistors, Value	$24,832	$24,715	+70.7%
Transistors, Units	9,528	9,607	+76.7%

FIGURES OF THE WEEK



30 db gain in 200 mc RF amplifier

30 DB GAIN 16 MC BANDWIDTH IN 200 MC RF AMPLIFIER



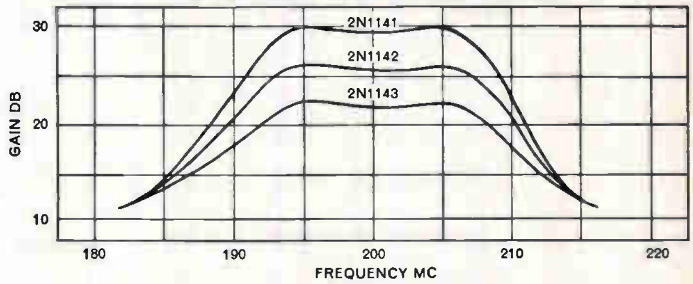
.05 µh coils: 1 turn #14 Tinned Buss Wire; Air Core Diameter ⅜"; All Capacitors in mmfd;
All Resistors are TI MIL-Line Precision Carbon Film; All RFC's encapsulated and self resonant @ 200 mcs.

...with TI 2N1141 series germanium mesa transistors

Exceptionally high ac beta TI 2N1141 germanium mesa transistors provide 30 db gain — *with 16 mc bandwidth* — in a 200 mc RF amplifier. Ideal for your high frequency amplifiers and power oscillators, 2N1141 series diffused base transistors give you . . . maximum dissipation to 750 mw . . . voltage ratings to 35v at 100 µa I_C . . . 750 mc alpha cutoff.

These devices are backed by *more than 3,500,000 unit hours* of life test reliability data . . . see curves below.

TYPICAL RF RESPONSE

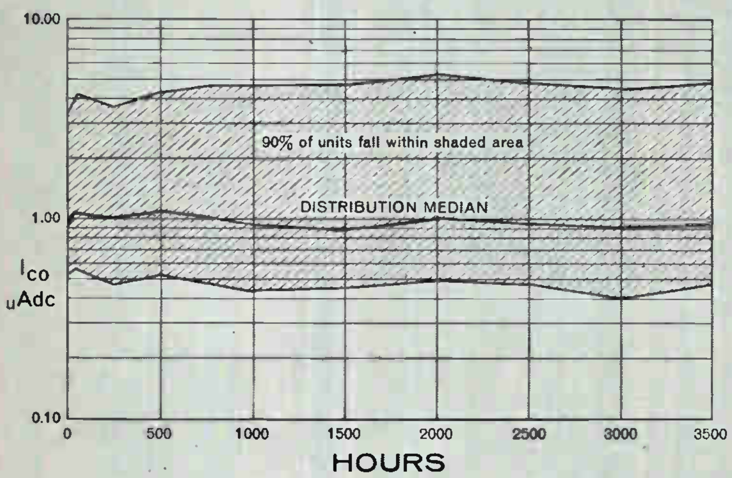


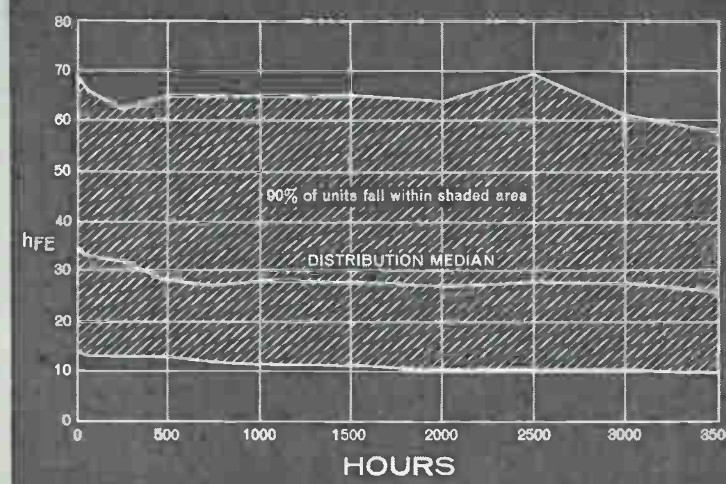
TYPICAL CHARACTERISTICS AT 25°C

	2N1141	2N1142	2N1143	unit
f_{ab}	750	600	480	mc
C_{Tc}	1.2	1.4	1.5	µµf
r_b'	65	80	110	ohms

UNIT TYPE 2N1142: I_{CBO} AND h_{FE} VS HOURS OF STORAGE AT +100°C

TEST LEGEND: Sample Size: 1000 units ▪ Test Condition: Storage at +100°C ▪ I_{co} Measured at: V_{CB} = −20v, I_E = 0 ▪ h_{FE} Measured at: V_{CE} = −6v, I_C = −10ma





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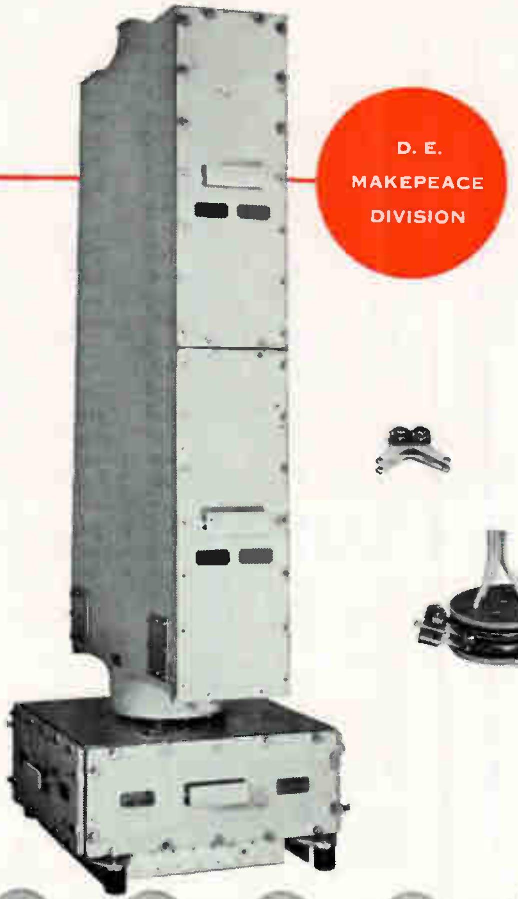

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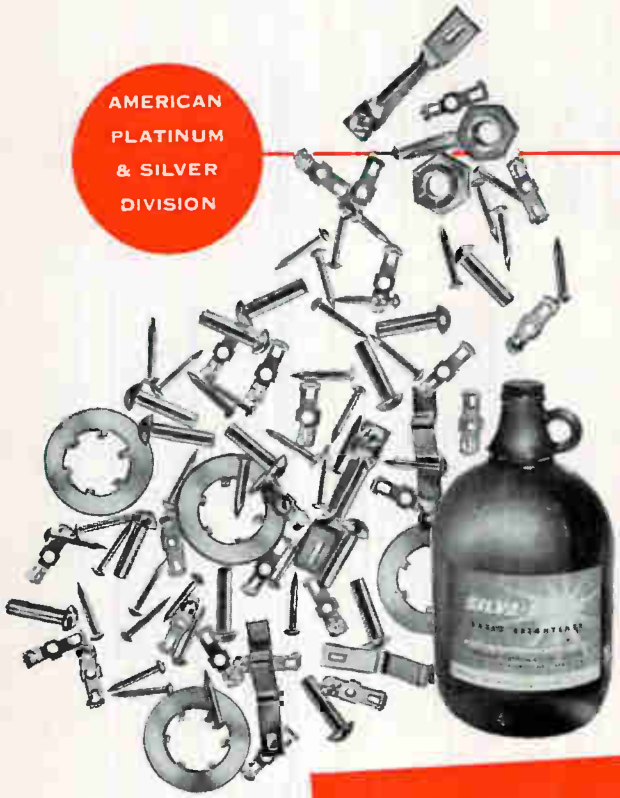

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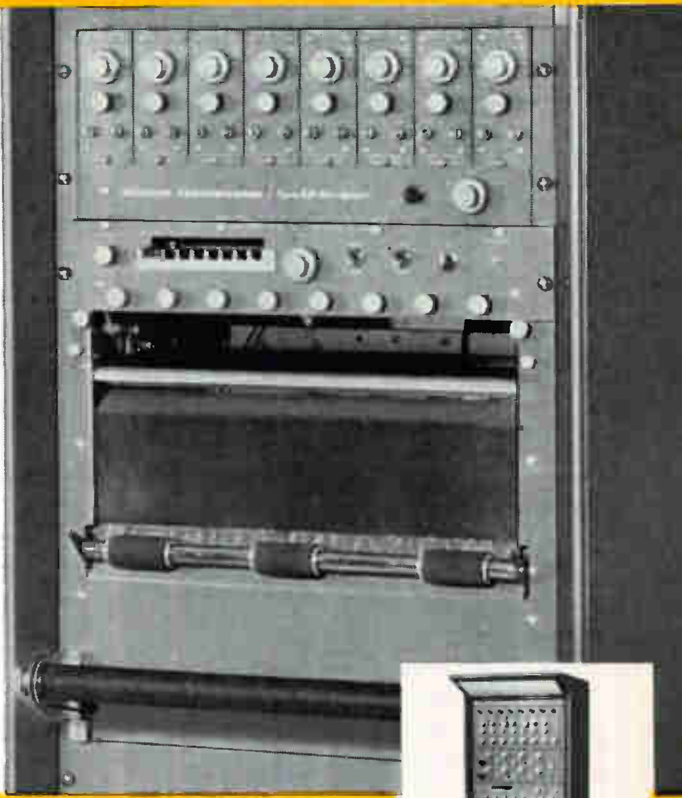

The Type RD is available in a variety of mountings, including the BMR rack. The Type R (illustrated above in the BMR rack) should be specified where microvolt sensitivity and greatest versatility are required.

The Offner Type RD Dynograph provides the same performance, the same convenience as the Type RC, (the Type R without pre-amplifiers). Economies in design were made possible by eliminating circuit components necessary only when preamplifiers are employed.

In the Type RD each amplifier is *completely* replaceable; only the power supply is common.

The Type 473 Amplifiers are all-transistor in construction, and provide advantages of high reliability and instant operation with no stabilizing warm-up. Sensitivity is 10 MV per cm. to 100 volts per cm., with a zero drift of less than 0.2 MV per hour at highest sensitivity.

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SPECIFICATIONS

Sensitivity: 10 MV per cm. to 100 volts per cm.

Drift: 0.2 MV per hour at max. sensitivity[1].

Frequency Response: To beyond 200 cps, ± 10%[2].

Zero Suppression: 40 cm., plus and minus.

Recording Media: Ink or electric curvilinear; heat or electric rectilinear. Recording media interchangeable.

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1. From low resistance source at normal ambients.
2. Ink or electric recording. Heat sensitive limited by capability of medium.

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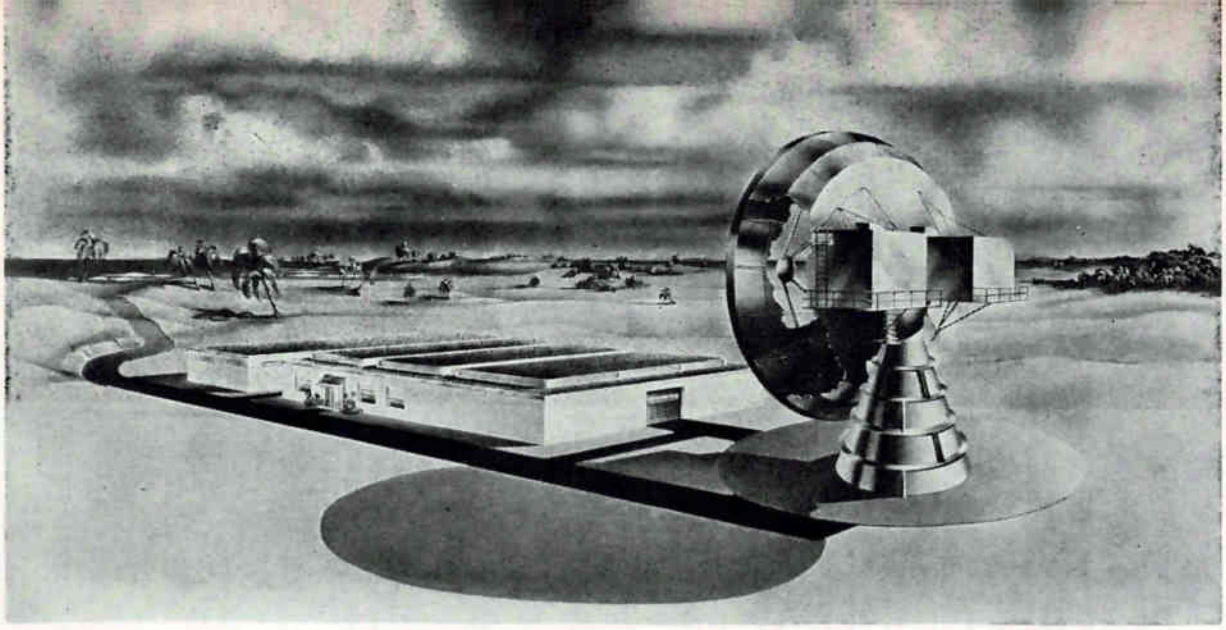

Five-story Pincushion radar by Raytheon may distinguish ICBM warheads and decoys

Our Defense Against Attack From Space

By JOHN F. MASON,
Associate Editor

DEFENSE against destruction by nuclear bombs carried by ballistic missiles, reentry satellites, or other vehicles from outer space, is considered by many to be the most urgent need facing the U. S. today.

Solution to this problem is probably the greatest challenge, to date, to the imagination and ingenuity of the electronics industry.

Administering these creative efforts is the task of a portion of the Defense Department's Advanced Projects Agency (ARPA) known as Project Defender.

Participants in the effort are all three military services, other government agencies, universities and industry.

The work consists of a mountain of contracts—study, R&D, and hardware. At first glance, few of the contracts appear to have much relation to the others. This seeming discrepancy is due to the vast number of areas in which solutions, or partial solutions, might be found. (For a listing of major contracts see ELECTRONICS, p 42, Feb. 26.)

Funds appropriated for fiscal year 1960 amount to $106 million; requested for 1961, $110 million more. Funding for succeeding years will be bigger since study contracts will turn into systems contracts requiring more engineering and hardware.

Common denominator of Defender contracts, present and future, is the attempt to come up with a way to nullify an attack by nuclear-armed vehicles entering the earth's atmosphere from outer space.

There are several theoretical ways to do this:

(1) Detonate the bomb prematurely before it's close enough to do any damage.

(2) Convert the nuclear mixture, somewhere along the vehicle's route, to a harmless "bucket of sand" so that the impact damage will be no greater than a clean cut hole in the ground.

(3) Send the missile back into outer space intact by use of an antigravity device.

(4) Get rid of the whole thing—vehicle, payload and all—by using an antimatter projector which would turn it into its opposite: Nothing.

Though application of concepts (3) and (4) belong at present to blue sky thinking, basic research is being performed in these fields. The outcome may one day be as significant as the basic research that resulted in the atomic bomb.

ARPA's Approach

ARPA is actively concerned with detection and interception techniques beyond present conventional concepts. To keep ahead of the game, new concepts must be evaluated. "Far-out" ideas are not dignified into projects but they are given a hearing by ARPA physicists.

One of the first problems is: In which of the missile's three trajectory phases can it best be attacked—boost phase, mid-course, or terminal? Secondly, how can it be attacked in each stage—by vehicle or by other means?

Boost Phase

Convair has just completed a Defender contract to study the problems involved in detecting and killing a missile during its boost phase.

This is a vulnerable period for a missile. All its subsystems are in operation: guidance—which might be jammed; propulsion—the fuel supply might be punctured; controls—damaged or misdirected; payload—predetonated.

Requirements for killing a missile during its powered phase include immediate detection and interception while the missile is over enemy territory. One method might involve a detection satellite that also carries kill capabilities—either electromagnetic jamming or the actual launching of an intercept missile. Detection might be achieved by a long range ionospheric scatter system like Navy's Teepee, based a safe distance away, but kill would probably have to originate over the enemy country.

ARPA plans to spend $2 million in 1961 for studies on guidance and control features for intercept missiles launched from the ground, aircraft or space vehicles.

Of all the phases of the trajectory, the boost phase is probably the one with which missile engineers have had the most experience. Even failures at the U. S. missile ranges have at least gone through a part, or all, of this phase. Good data during powered flight are available from telemetry, radar, infrared and optical measurements and from first-hand examination of recovered vehicles.

Part of a $57-million request for missile range measurement equipment will be used to study boost-phase missile characteristics. In the Atlantic Missile Range, Defender operates two converted mariner ships, laden with electronic gear, and a number of aircraft carrying infrared equipment.

Mid-Course

In some ways the mid-course phase offers advantages to a defender. The enemy no longer has control over the missile; guidance and power are both off. The missile is following a predictable trajectory and is not yet affected by reentry into the earth's atmosphere.

The problems, however, are numerous. Distance to point of intercept is formidable. Speed of the intercept missile would have to be far greater than that of the target. In case of a salvo of 100 enemy missiles, how many intercept missiles and what kind of omniscient guidance would be used to keep all the intercept missiles from attacking the same target, letting the other 99 get by? The problem suggests the nightmarishly complicated solution of sending 100 intercept missiles up, with no preset guidance, to wait, choose a target, and attack.

A far more comprehensive, and therefore comfortable, solution would be erecting a screen to detonate or nullify all warheads passing through it. Such a screen could possibly take the shape of a ground-based particle accelerator.

De Gaulle Inspects Electronic Instruments

France's President De Gaulle tours new Hewlett-Packard plant in Palo Alto, Calif., during only industrial stop in recent U. S. tour. H-P executive vice president William R. Hewlett (on De Gaulle's left) describes instruments

ARPA is studying the Argus effect, the release of chemicals at high altitude and the creation of artificial electron clouds and luminescence. ARPA is asking for $10 million for this kind of work under "Physics."

ARPA plans to spend $9 million more in 1961 to study new ways to kill missiles and satellites.

Precise knowledge of missile characteristics during the midcourse, coasting phase is more difficult to come by than during the powered phase. Far fewer missiles at the test range have gone this far. Distance makes precise monitoring more difficult. And the physical conditions in outer space are still relatively unknown quantities.

ARPA has an active radar program to develop long-range, high-capacity, high-resolution radars that are significantly beyond the capability of existing radars. This is particularly necessary, ARPA stresses, for midcourse studies.

To date, the program has accomplished, ARPA says: initiation of development of h-f multiple-beam radar, called Pincushion, by Raytheon; continuation of development of a multielement, electronically-scanned radar (ESAR) by Bendix; continuation of multi-static radar development (ORDIR), by Columbia University; initiation of development of a super-power microwave tube; continuation of research in high-power components, radar receiving techniques, signal processing techniques and various others.

Two new radars, Raytheon's Pincushion and an RCA tracking radar, will be installed on Kwajalein to study midcourse missile characteristics of test flights launched in the Pacific.

Terminal Phase

Major effort to date has gone into defense against missiles during their terminal phase. Nike-Zeus, antimissile missile still in the R&D stage, is the product of this endeavor.

Defender's objective, however, is to come up with concepts beyond the capabilities of a Nike-Zeus-type system.

Problems in the terminal phase are lack of time and target discrimination.

ARPA is requesting $4 million for research on target discrimination (decoy sorting) and countermeasures (the enemy will want to jam ground radars and guidance of intercept vehicles).

OZALID NEWSLETTER

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This is just one illustration to start your mental salivary glands working. We are sure that you can find uses we haven't even dreamed of, once you get going. And if you discover any new applications for this best of all possible color worlds, tell us about them so we can spread the good news to others.

When it comes to cost estimating . . .

. . . there's nothing like a handy whiteprinter to cut preparation time of cost estimates, according to the Stackpole Carbon Company, St. Mary's, Pa. The company's Supervisor of Cost Estimating has just written us a letter on the subject which we pass on to you verbatim. "Our estimates are made in pencil on printed translucent vellum in pad form. These are reproduced on specially cut and punched Ozalid copy paper. Originals carry only basic information that has to remain constant. And from the originals we produce duplicate originals on Ozalid sepia line intermediate paper (#402 IT) as required, and these are used until the basic information is obsolete. To revise a cost, it is only necessary to add current rates and extend. With this simple Ozalid method we have eliminated typing, proofreading, and copying errors."

The Supervisor goes on to say that Stackpole uses Ozalid copying in many other areas of its business because of convenience and economy. Perhaps we'll be able to tell you about these uses in a future *Newsletter*.

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Price: $525.00 (cabinet model), $510.00 (rack mount).

ⓗⓟ 650A TEST OSCILLATOR—Flat within 1 db, 10 cps to 10 MC!

Uses: Testing TV amplifiers or wide-band systems, measuring filter transmission characteristics and tuned circuit response, determining receiver alignment, making telephone carrier and bridge measurements.

Advantages: No zero set, no adjustments during operation, output voltage range 30 μv to 3 v, less than 1% distortion, 20 cps to 100 KC; less than 2%, 100 KC to 1 MC; approx. 5% at 10 MC. Hum less than 0.5%, output voltage attenuator, self-contained voltmeter, 2% to 3% stability.

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ⓗⓟ 205AG AUDIO SIGNAL GENERATOR—Six instruments in one; 20 cps to 20 KC!

Uses: Measure amplifier gain and network frequency response, measure broadcast transmitter audio and loudspeaker response, drive bridges, use in production testing or as precision source for voltages. Monitors oscillator output, measures output of device under test.

Advantages: Self-contained instrument, no auxiliary equipment needed. 5 watts output, ± 1 db response, less than 1% distortion, hum more than 60 db down, no zero setting, output and input meters read v and dbm; four output impedances.

Price: $500.00 (cabinet model), $485.00 (rack mount).

ⓗⓟ 206A AUDIO SIGNAL GENERATOR—Less than 0.1% distortion; 20 cps to 20 KC!

Uses: Convenient, precision audio voltage source; checks FM transmitter response, makes high quality, high fidelity amplifier tests, transmission measurements.

Advantages: Continuously variable audio frequency voltage, (output 15 dbm) 0.2 db response, hum 75 db down, 2% frequency accuracy, less than 0.1% distortion. 111 db attenuator with 0.1 db steps.

Price: $750.00 (cabinet model), $735.00 (rack mount).

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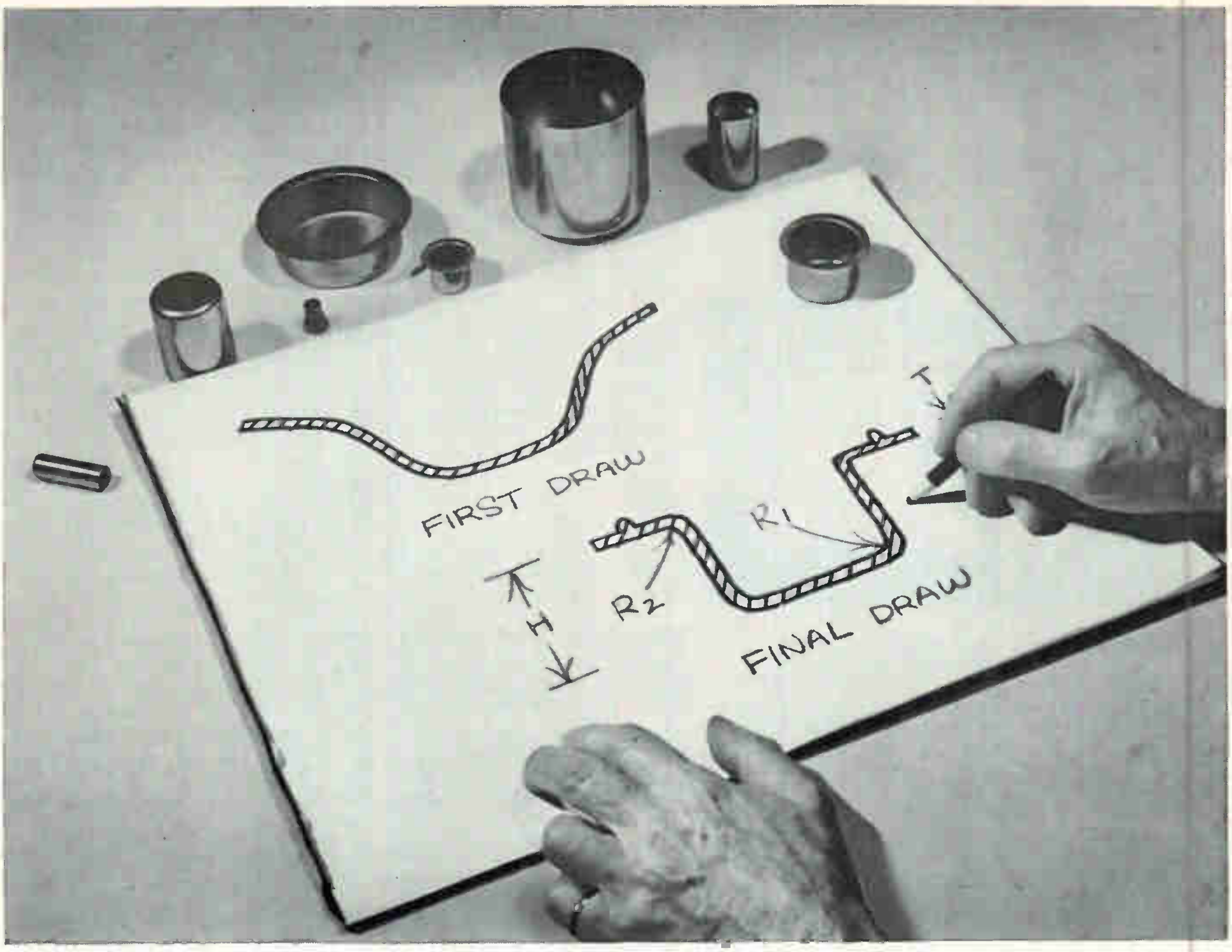

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KOVAR is an iron-nickel-cobalt alloy with thermal expansion characteristics essentially matching those of several hard glasses. It is the ideal material for making high-quality drawn shapes required for vacuum- or pressure-tight glass-to-metal seals in equipment such as electron tubes and semi-conductors.

KOVAR has deep drawing qualities similar to cold-rolled steel. Satisfactory results are assured by observing a few simple precautions:

1. On the initial draw, punch radius should be a minimum of four times the material thickness. Reduce successively on re-draws.
2. Inside radii at the corners on the final draw should be not less than the thickness of the metal.
3. Sharper radii, if absolutely essential, should be produced by a subsequent coining operation.
4. Hold-down pressures in drawing should be kept to a minimum to insure metal flow from the outside rather than stretching.

Obviously, to prolong tool life and simplify production, maximum permissible tolerances should be allowed. More detailed information on deep drawing of KOVAR alloy is supplied in Technical Data Bulletin 100 EB11.

Carborundum maintains large stocks of KOVAR alloy in a wide variety of sizes and forms. This alloy can be welded, brazed, soldered and plated with other metals. It can be either oxide bonded to hard glass or brazed to metallized-ceramic insulators. Technical service is available to help you solve processing and application problems. Contact The Carborundum Company, Refractories Division, Dept. E-50, Latrobe Plant, Latrobe, Pa.

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Bulletin 5134 gives data on composition, fabrication techniques and applications. Send for your free copy today.

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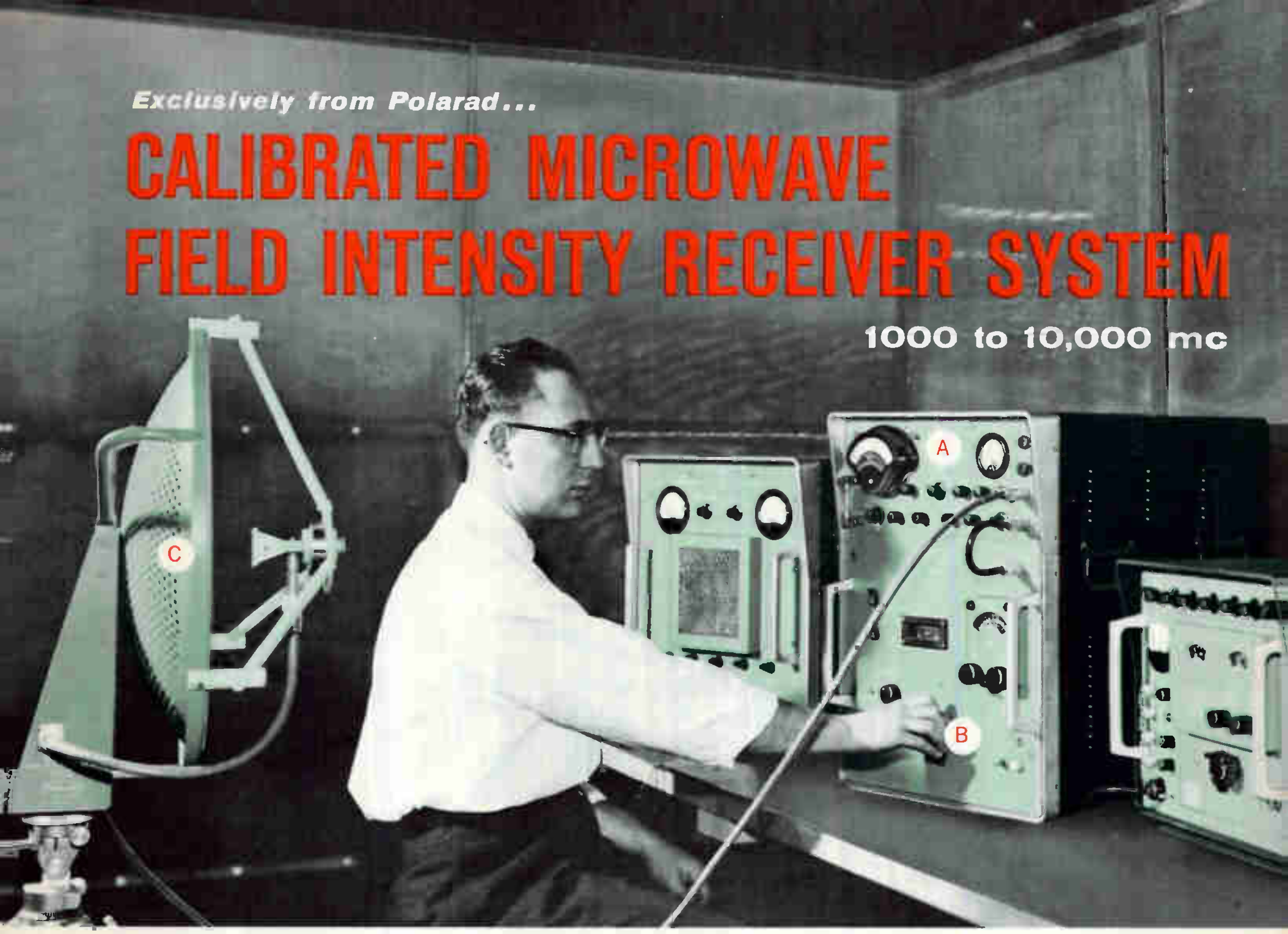

Model FIM being used to check radiated interference against MIL-I-26600

The complete integrated Model FIM includes:

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New Tv Lines Ready to Go

Self-powered portables, more color sets and an increase in remote tuning will highlight next season's receiver production

RCA steps up color tube production in anticipation of rising sales

SELF-POWERED PORTABLES, more color sets and additional remote control models are the major focal points of this season's television receiver market.

Most manufacturers say they have no present plans to introduce a battery-operated portable this year. ELECTRONICS learns, however, that at least one major company plans to introduce a self-powered portable three days from today.

Color

Expectations of increased sales of color receivers are sparked by RCA's recent reports that their sales in this line are up 40 percent for the first quarter of 1960 as compared with the same period a year ago. The company adds that inventories at almost all distribution points are low.

Packard-Bell and Admiral are also reporting increased sales of color sets. P-B president, Robert Bell, estimates last year's industry-wide sale of color receivers to be more than $50 million. He anticipates sales closer to $60 million by the end of this year. (See p 24, ELECTRONICS, Apr. 22)

If other firms are planning to come out with color sets, they are not speaking until later this month or early June when most new-line presentations are scheduled.

RCA plans to increase its color set output this year by setting up a second production facility at its Bloomington, Ind. plant. Also in the works are plans to double color picture tube output. In addition, the corporation's broadcasting facilities will be making more color programming available with increases ranging from two to five hours a week on most stations.

From all indications, there will be no appreciable alterations in present prices of color sets. Consumers will see tags ranging from about $495 to $1,100. There may, however, be some drop in service contract prices according to RCA. These now run at about $70 for the first year, $120 for the second. Set sizes will continue at the 21 and 23-in. picture tubes.

Black-and-White

The 19-in. set is expected to attract a good portion of the consumer market for monochrome according to most manufacturers. Virtually all brand names will soon be available in this size. Philco's new line will include three 19-in. models as well as the 17, 21 and 24-in. sizes. New engineering features in the Philadelphia company's receivers will show emphasis on top-mounted components aimed at keeping set operating temperatures down.

Magnavox is planning to introduce 19 and 23-in. sets in its new line.

The Admiral line includes two 19-in. console models and five portables. These units are wide-angle 19-in. receivers.

Bonded Tubes

Some controversy appears to be shaping up as to the merits of bonded or unbonded picture tubes. The bonded tubes have a glass safety panel bonded directly to the tube faceplate. Sylvania, which worked out much of the manufacturing process of bonded tubes along with Corning Glass, plans to stress the glare reduction, elimination of dead space and maintenance features of the tubes. In addition, the company points to the increased safety against implosion damage.

Other manufacturers appear to be taking sides on the issue. Some have rejected the bonded tubes as being too expensive as far as replacement goes; one setmaker commented on static charge buildup attracting dust.

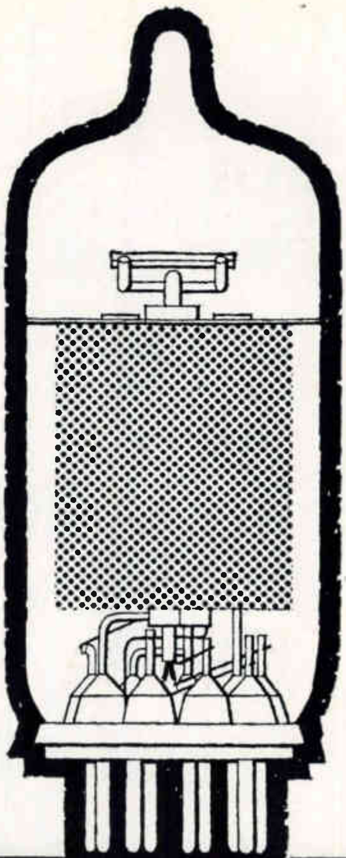
More prudent than flat rejection perhaps, is the attitude of a third body of tv men who will introduce models next month having both bonded and unbonded picture tubes.

Remote Tuning

Once in the luxury or gadget class, the remote tuner this year will be available in a wide variety of sets ranging from the low-priced portables to the expensive "home entertainment centers." Most manufacturers told ELECTRONICS the percentage of their set sales with remote tuning ranged in the high teens, although 30 percent of some lines are so equipped.

General Electric, planning more new models in the higher style category, says a greater percentage of GE sets than last year will be equipped for remote. Westinghouse, going along with predictions that the next season will see more emphasis on furniture styling, anticipates remote tuning will even extend to hi-fi and other audio equipment.

Along with technical upgrading, Motorola's new line will stress styling, although the amount of remote-tuned production will remain about the same number as 1959.



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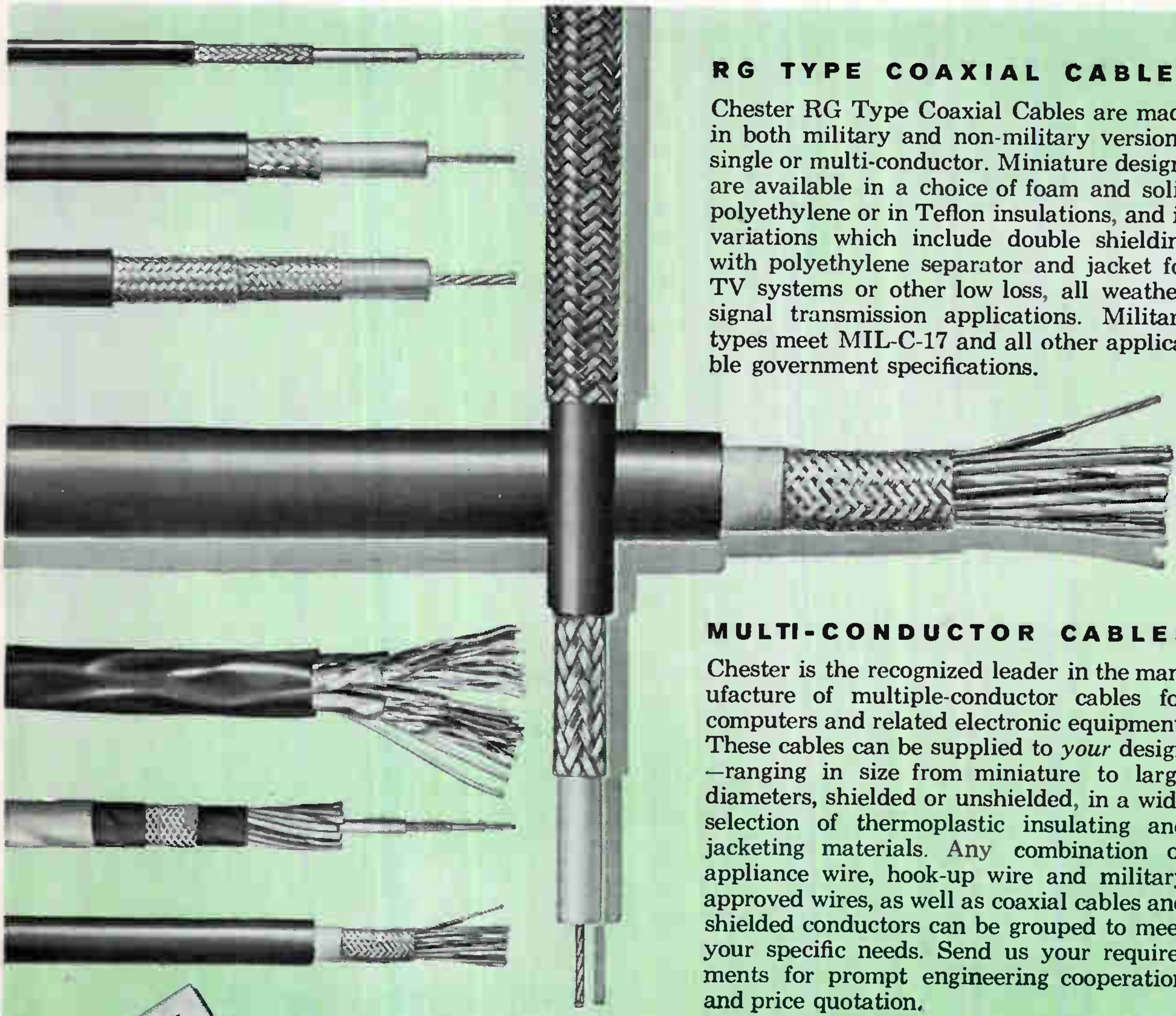

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Chester RG Type Coaxial Cables are made in both military and non-military versions, single or multi-conductor. Miniature designs are available in a choice of foam and solid polyethylene or in Teflon insulations, and in variations which include double shielding with polyethylene separator and jacket for TV systems or other low loss, all weather, signal transmission applications. Military types meet MIL-C-17 and all other applicable government specifications.

MULTI-CONDUCTOR CABLES

Chester is the recognized leader in the manufacture of multiple-conductor cables for computers and related electronic equipment. These cables can be supplied to *your* design —ranging in size from miniature to large diameters, shielded or unshielded, in a wide selection of thermoplastic insulating and jacketing materials. Any combination of appliance wire, hook-up wire and military approved wires, as well as coaxial cables and shielded conductors can be grouped to meet your specific needs. Send us your requirements for prompt engineering cooperation and price quotation.

Complete data on Chester's full line of wires and cables for military and commercial electronic service available on request. Ask for Bulletin No. ELT-1.

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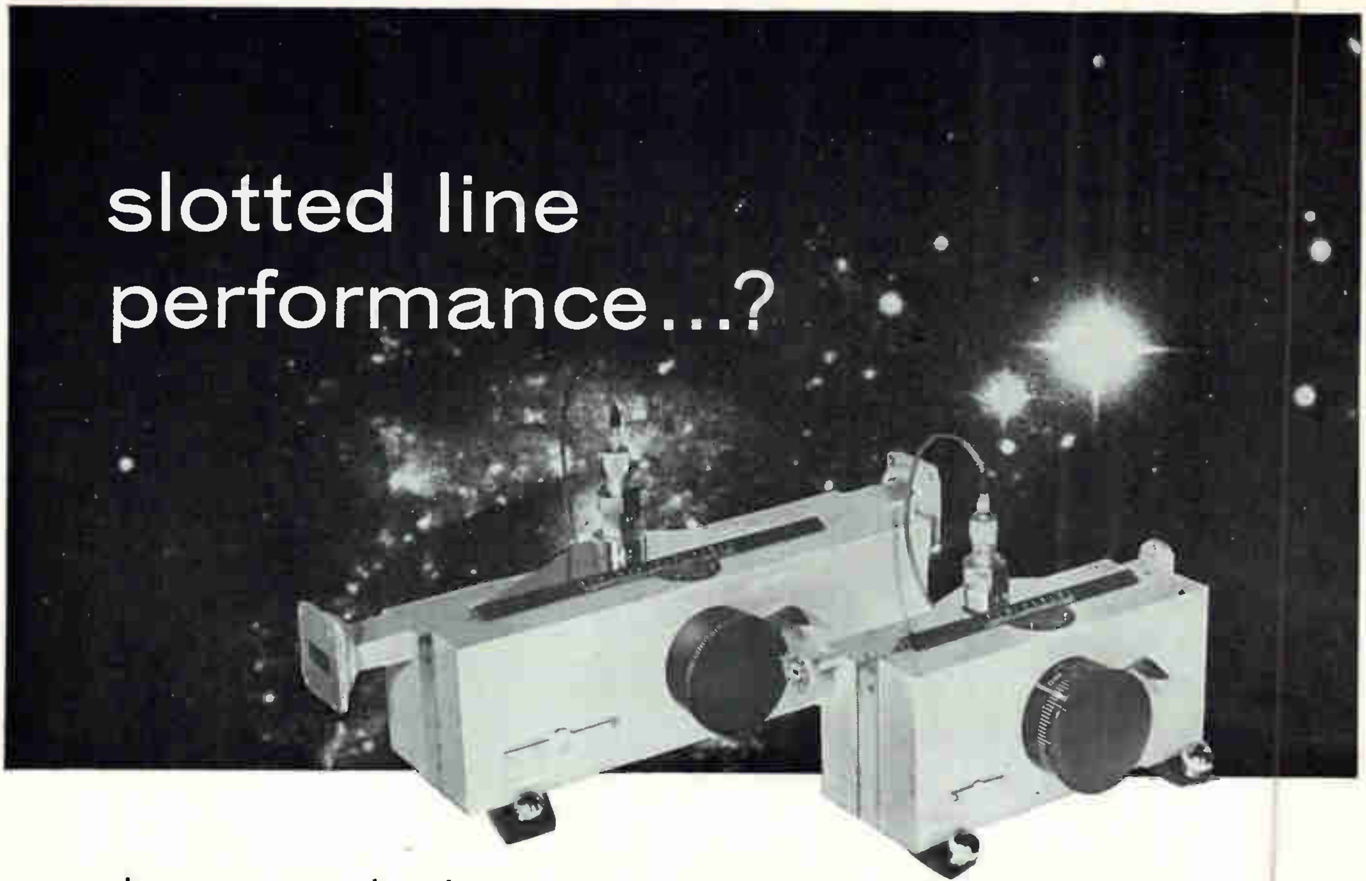


—here are design parameters uniquely defined

Note how comprehensively D-B parameters cover all requirements of a standing wave detector.

D-B units are designed for unprecedented accuracy, repeatability, and operator convenience. They're built with high-precision parts, under close quality control. Attractively styled and fully guaranteed, they have achieved a tremendous acceptance by the industry.

Interchangeability with precision. Any D-B unit will handle adjacent frequency bands by using a different size waveguide block and probe. You can make the change in 30 seconds, with no loss whatever in alignment accuracy.

Complete range of sizes—10 models cover from 5.85 KMC to 140 KMC—or you can purchase interchangeable blocks and probes to extend the range of any model, at a saving.

Uniformity of waveguide surfaces. D-B provides a high internal surface uniformity by precision machining its millimeter waveguides, and using carefully selected precision waveguide for lower-frequency units. This construction insures a uniform path for measured waves, thus minimizing residual VSWR.

Slot excitation is negligible, resulting in minimum RF leakage—another reason why residual VSWR is very low.

Probe impedance is properly matched to the waveguide. Uniform probe penetration is provided by a fast, convenient slope adjustment, made in a few minutes.

Adequate probe travel ($\geqq 1\frac{1}{2}\ \lambda_g$) available at all frequencies. Operator can read at least 3 maxima and 3 minima of VSWR.

Efficient mechanical translation. D-B mechanism functions with exceptional smoothness, giving the unit a definite instrument "feel." Five point kinematic carriage suspension insures excellent linearity of probe motion.

Vernier readout on knob periphery permits reading of probe travel to .01mm without mounting of costly accessories.

Continuously variable drive ratio changes carriage travel from "vernier" to "fast"—a time saver during rapid measurements.

Direct phase readout. Phase shift may be measured accurately on the calibrated knob, which reads percentage of 180° directly.

For complete data, see your D-B Catalogue, or request folder DB-825.

Interchangeable waveguide blocks. Each realigns perfectly to probe travel in a few seconds.

DE MORNAY BONARDI® 780 SOUTH ARROYO PARKWAY • PASADENA, CALIFORNIA

German Electronics Comes of Age

Ninety-one American exhibitors (six more than last year) showed wares recently at opening of German Industries Fair in Hanover

HANOVER, GERMANY (McGraw-Hill World News)—The 1960 German Industries Fair at Hanover, Germany, showed that in western Europe as a whole and Germany in particular electronics is rapidly assuming the status of a major industry and, to meet the high technological requirements of the age, is becoming one of the most vital industries.

Prohibited until 1952 from participating in electronics in any form, Germany has marked its reentry with two major developments either of which could revolutionize the industry. Siemens together with U. S. Westinghouse has devised a method to produce what is claimed to be the world's purest silicon; and Wacker Chemie of Munich late last year introduced a continuous process for pure crystallized silicon which can be used directly for transistor production.

Paralleling U. S. trends, small-size transistors are today being constructed to give added strength, better reliability, and lower cost. Applications at higher frequencies are being successfully tried out.

Over the next few years, production and use of electronic equipment will advance rapidly, and both vacuum tubes and semiconductors will occupy important roles in the expansion. German tube manufacturers (who mostly also manufacture semiconductor devices) are concentrating their development work on design ruggedness plus compact construction. Though a certain amount of research work has gone into ceramics as a basis for tube design, German manufacturers are presently playing the wait and see game before following the U. S. lead.

Though accurate figures are not presently available, opinion is that upwards of 10 million transistors were produced in Western Germany in 1959. Forecast for 1962 is 70 million. About 12 million semiconductor diodes were manufactured through 1959. Through this period, sales of electron tubes (including tv tubes), transistors and semiconductor diodes reached about $100 million compared to sales of $83 million in 1958.

Hit sorely by the acute labor shortage, the West German electronics industry has invested heavily in equipment and plant to step up production. Investment has been so effective that consumer goods predominantly utilizing electronic devices of one kind or another have recently been heavily reduced in price. As an example, at the beginning of the year radio and tv tube prices were cut 20 percent.

New technically improved tv sets are about eight to ten percent cheaper than last year's models and radio prices have gone down by six to eight percent. At the same time, prices for last year's models were reduced by up to 15-20 percent.

New tv sets feature uhf tuners for the second tv program scheduled to start next year. Other innovations are automatic controls adjusting voltage fluctuations as standard equipment for medium-priced sets and better serviceability: Chassis can be flipped out easily and the printed circuits are marked with position numbers of resistors and capacitors.

In radios, general trend is towards more wavelengths and smaller size. All new radios are equipped with transistors. They range from a tiny pocket model at $24 to a four-wave super with big loudspeaker. Tape recorder prices are generally stable.

Prominent among the 210 foreign exhibitors of electrical and electronic equipment at Hanover were Texas Instruments Incorporated and Minneapolis-Honeywell. Texas Instruments was represented by subsidiaries Texas Instruments Limited of Bedford, Eng., and Metappa N.V. of Almelo, Holland.

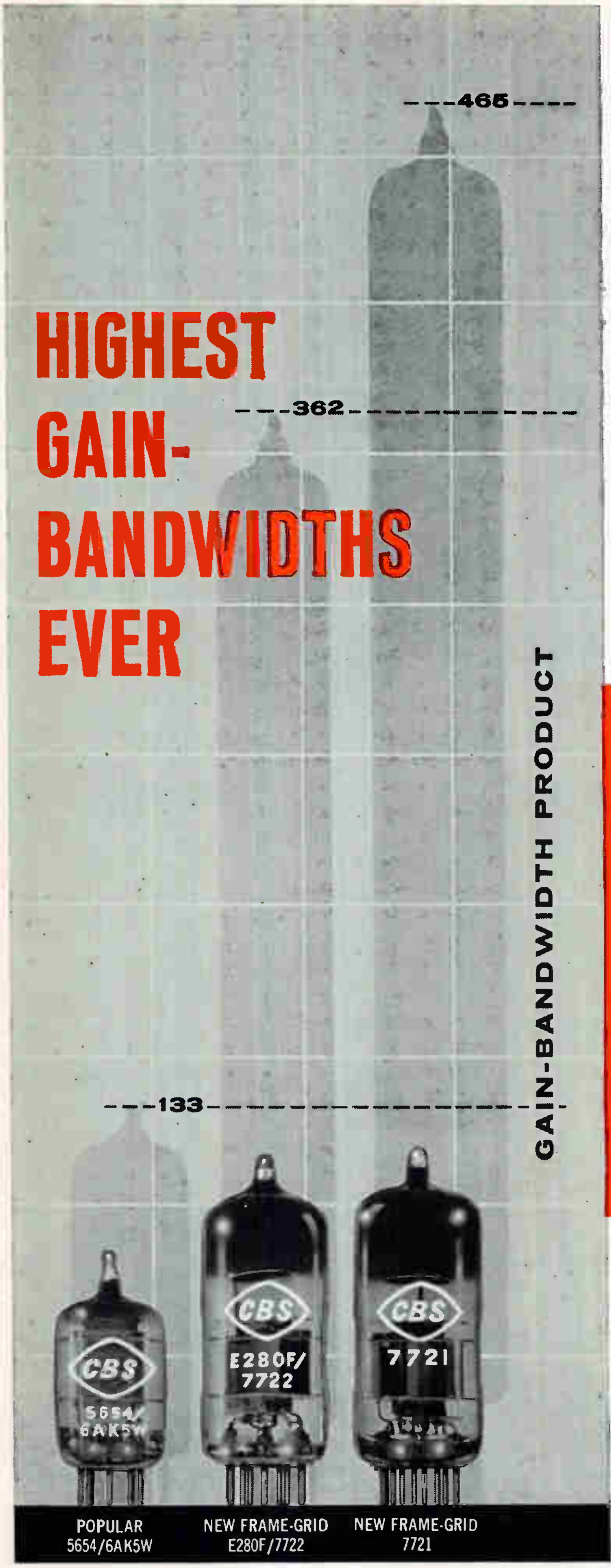
A check made by ELECTRONICS shows the following trends:

(1) Altogether some 2¼ million tv sets will be produced in Germany through 1960 as against 1.85 million in 1959. Color tv is in an advanced stage of development but will be commercially unfeasible until prices can be lowered.

(2) Radio sales in 1959 reached the record 4¼ million mark. Manufacturers see a flattening out of the curve through 1960 with major sales emphasis on fully-transistorized portables. All-transistor auto radios should revitalize this section of the industry.

(3) The recent slashes in sales prices should boost production of stereophonic high-fidelity units to the detriment of monaural phonographs.

(4) Binaural tape for stereo equipment is on the market but manufacturers believe that it is too early and too expensive to create customer interest.



POPULAR 5654/6AK5W — NEW FRAME-GRID E280F/7722 — NEW FRAME-GRID 7721

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Exclusive new CBS E280F/7722 and 7721 sharp-cutoff, 9-pin miniature pentodes offer you the highest ratings ever for gain-bandwidth product. The premium quality tubes make possible new high levels of performance in i-f and video stages of industrial and instrumentation equipment. You benefit from fewer stages, fewer tubes, fewer passive components, and fewer interconnections . . . due to the many advantages of true frame-grid construction.

Order from your local sales office or Manufacturers Warehousing Distributor. Get technical bulletins T-1006 and T-1007. Ask about other CBS frame-grid types. Watch for many new announcements on the rapidly expanding CBS industrial tube line.

ELECTRICAL CHARACTERISTICS

	E280F/ 7722	7721
Plate supply voltage	190	190 volts
Grid supply voltage	+8	+10 volts
Cathode bias resistor	370	400 ohms
Plate current	20	22 ma
Screen-grid current	6	6 ma
Transconductance	26,000	35,000 μmhos
$C_{g\text{-}p}$	.035	.035 μμf
C_{in}	9.3	10 μμf
C_{out}	2.1	2 μμf
Gain-bandwidth product	362	465
Input resistance, 100 mc	1400	1000 ohms

OTHER NEW CBS INDUSTRIAL TUBES . . . NOW AVAILABLE!

ECC88/6DJ8	High-gain, low-noise, frame-grid twin triode
E88CC/6922	Reliable version of ECC88/6DJ8
PCC88/7DJ8	7-volt version of ECC88/6DJ8
EF86/6267	Low-noise audio preamplifier pentode
E182CC/7119	Reliable high-perveance computer twin triode
E83F/6689	Reliable, 10,000-hour wide-band pentode
E81L/6686	Reliable, 10,000-hour wide-band output pentode
E235L	Reliable, 10,000-hour switching power pentode
E84L	Reliable version of EL84 (6BQ5) audio power pentode
E80L/6227	Reliable, 10,000-hour industrial power pentode

Write for Chart E-378 on CBS Industrial Tubes.

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CIRCLE 51 ON READER SERVICE CARD

Industrial Controls in Britain

Here's a survey of U.K.'s progress. National Automation Center may be set up

LONDON—British progress in the industrial controls field over the last five years has been slow, but there are some bright spots. Of special importance now is the fact that the suggestion is being widely circulated in industry that the government, through its Dept. of Scientific and Industrial Research, set up a National Automation Center.

At the center a staff of specialists would deal with industrial queries while a permanent exhibition of typical applications would point up economic advantages and sell executives on control systems.

'Strong In Ideas'

Another sign of British activity in the industrial controls field was the recent move by Production Engineering Ltd., a large consulting firm, to set up a special section for automatic inspection systems. David Nicolson, firm's managing director, told McGraw-Hill World News:

"We want to generate in the industry the same enthusiasm for automatic inspection as British industry now has for the currently fashionable diversification rage. Money spent on modernizing the existing methods can often eliminate the need to diversify."

Automation consultant David Foster surveyed 100 British companies, concluded: "Britain is strong in ideas but user industry lags in their adoption. It is two to five years behind the States."

Here are his ratings of British firms in 10 fields of control:

Batch process sequencing and dispensing control—Good progress.

This sector is forging ahead, especially in automatic dispensing of solids and liquid mixes from punched card and tape recipes. Wide acceptance is largely due to adoption of simple telephone techniques involving stepping switches in standard functional units. Solid-state actuator monitoring systems are being introduced.

Computer controlled processes—Still exploratory.

With most chemical and oil companies still engaged in exploratory simulator studies, Britain is probably a couple of years behind the U. S. in this work. A recent symposium showed steady work on the theoretical foundations but no applications.

Machine tool control—Little commercial penetration.

Apart from point-to-point positioning in the jig-boring and spotting table fields, most projects are still restricted to aircraft special parts manufacture. To date there is no great penetration into commercial applications, these being still firmly wedded to older copying techniques. Development engineers are searching for cheap systems at $6,000 per dimension with an 0.0002 in. accuracy.

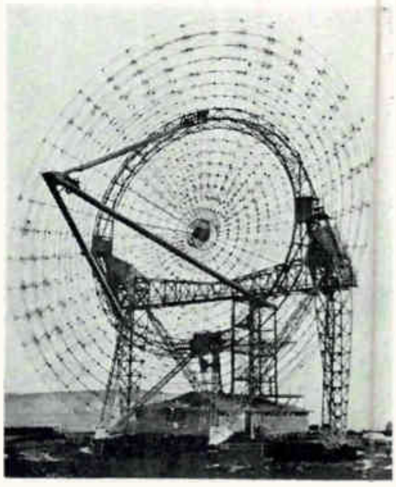
Automated shipbuilding—A good starter.

Computer calculation of ship plate profiles coupled to automatic flame cutting systems are planned to eliminate the moulding loft. This is one of Britain's great hopes as a shipbuilding nation.

Automatic inspection machines—Lagging.

In production line automatic inspection machines, Britain lags be-

Aurora Telescope



Stanford Research will study the aurora for ARDC with this spider-web, 142-ft radiotelescope in Scotland cause even her longest production run does not yet approach the four-million-piece-part annual output required for an economic breakeven point on these techniques. The British market is for a machine that is adaptable for batch production runs of the odd 1,000 or so. How to achieve this economically is the designers' current problem. One approach, which if successful would leapfrog Britain ahead of the international position, is using optical techniques for dimensional inspection without jigging the product.

Automatic assembly systems—Little movement.

Low labor rates for semiskilled workers still fail to make automatic assembly systems an attractive economic proposition in the U.K. There is little activity in the field and what there is in the radio set production follows U. S. practice.

Automatic identification systems—Bubbling.

Just about to break in Britain is the identification of shapes and code marks on mixed products flowing down conveyor lines. In other fields a coded photoelectric recognition system on London buses is giving centralized information on bus positions along their routes. Experimental installations are under consideration for railroad marshalling yards.

Automated stores—A dark horse.

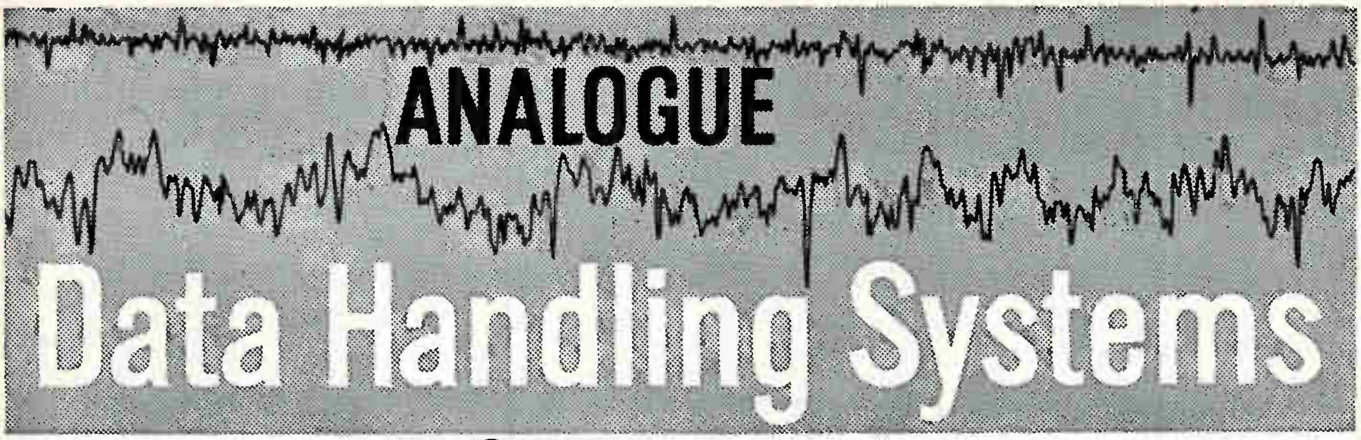
Although way behind the U. S., the current high user interest and the set-up of a new British combine with a license from an American firm is expected to move this category way up the list of practical automation hardware in the next few years.

Road traffic control—A new entry.

The threatened strangulation of the country's road system will call for more highly automated traffic signal control. A concentrated attack here might give Britain a lead in this field.

Monitoring production flow items—Good start.

Steel industries in particular have applied automatic monitoring systems to keep tabs on billets flowing through the mills. With such systems basically pioneered by the government-sponsored Department of Scientific and Industrial Research, this is likely to spread fast to other industries.



DIGITAL

The DIDAS transmitter

891362	108572
243895	925841
239810	189463
654958	194857
193847	237583
901205	867493
294736	910485
271057	839120
984752	856321
379824	658493
105447	539582
459233	937562
811278	423038
532485	902475
114857	521054
984735	284731
927411	883746
210473	937561
567482	109235
665820	991375
857395	274837
948573	198573
195847	958473
248571	984421
125434	103425
354321	978679
748275	213486
859483	210084
942106	330198
772689	921006

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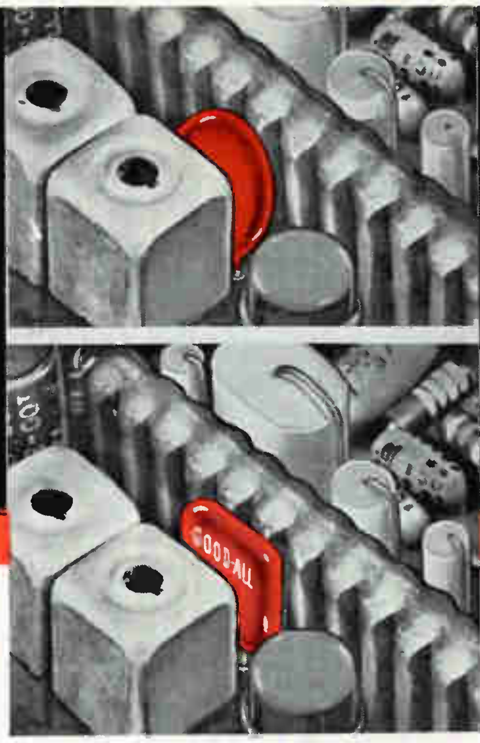
- **Fully Transistorized**
- **Extremely High Speed**
- **Compact**
- **Reliable**
- **Modern Construction**
- **Rugged but light**

Speedy measurement and analysis of data has become a necessity in modern industry.
Armstrong Whitworth Aircraft have developed data handling systems for measurement and remote control.
The data can be transmitted at the speed of light by radio, or by cable link, with extreme accuracy.
In one system (the DIDAS vehicle system), over 250,000 different readings can be obtained in one minute. Analogue/digital and digital analogue converters, working at over 50,000 conversions a second, eliminate processing bottlenecks. Systems can be engineered to customers' requirements.

ARMSTRONG WHITWORTH AIRCRAFT LIMITED, Baginton, Coventry, England
(A member of Hawker Siddeley Aviation)

GOOD-ALL 601PE
CAPACITORS

"fit" like a disc
PLUS...



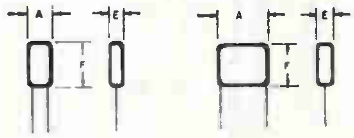
...Temperature STABILITY

Identical to high quality tubular capacitors and far superior to that attainable with high capacity discs.

MILITARY APPLICATIONS—Widely used in military equipment; also well suited to high quality civilian instrumentation where space is critical.

Tailored for TRANSISTORS

Wafer-thin shape..permits great flexibility in tight chassis layouts. The 601PE is competitive in price with ceramic discs in the range of .1 MFD and above.



DIMENSIONS 50 VDC Rating

CAP. (MFD)	A	E	F
.01	.310	.187	.562
.022	.359	.187	.562
.033	.531	.191	.406
.047	.531	.203	.453
.068	.531	.218	.500
.1	.650	.235	.525
.15	.671	.260	.650
.22	.728	.306	.687
.33	.812	.312	.750

SPECIFICATIONS

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

Capacity Tolerance—Standard tolerance is 20%.

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

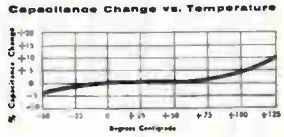
Lead Variations—Formed or straight leads.

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

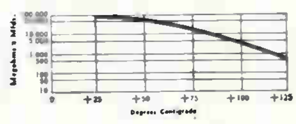
Dielectric Strength—100 volts D.C. for 1 to 5 seconds through a minimum current limiting resistance of 100 ohms per volt.

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

Capacitance Change vs. Temperature



Insulation Resistance vs. Temperature



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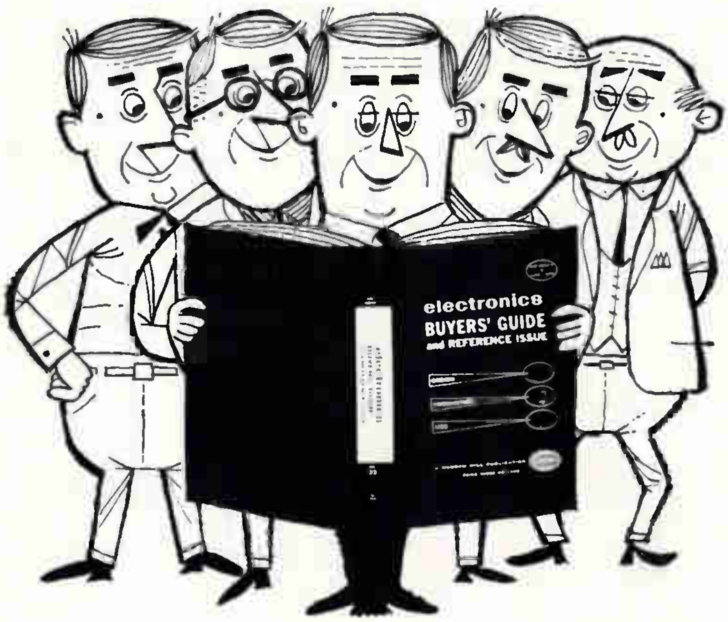

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Russia Plans New Satellites

"Whole series" will be part of a vast undertaking, reports Soviet academician

MOSCOW—Soviet Union is planning "a whole new series of new artificial satellites," Academician Anatoly Blagonravov is quoted in Soviet Weekly.

Blagonravov said the vast undertaking "will cover study of ultraviolet radiation and X-rays in the spectra of the sun and other celestial bodies, mapping the starry sky in various spectral lines, photographing solar corona and nebulae."

He said the program also "provides for further investigations of cosmic rays, the structure of the earth's magnetic field and its relation to solar activity, the degrees of ionization and composition of the ionosphere, as well as its condition for radio wave propagation."

High-Precision Measuring

The academician said there are plans to study the earth's gravitational field and to take high-precision time measurements for astronomical purposes.

"The second major line of research," he reported, "will be continued investigation of the moon and the area around it. At a later stage, relying on the experience we have gained, we hope to carry through a whole series of experiments with rockets to be sent to planets of the solar system, and above all, Mars and Venus."

Blagonravov disclosed "extensive biological investigations are planned in preparation for human travel in space." He said the experiments would involve a comprehensive study of the effects of cosmic radiation on living organisms and methods of protection.

The Soviet scientist said special containers with plants and animals would be sent into space near the earth. He noted that the delivery of scientific instruments to the surfaces of other planets would permit scientists to determine their habitability.

Blagonravov said space problems could be conquered best if scientists of all nations work together.

Sun Powers Japanese Lighthouse Beacon

SOLAR BATTERY containing 648 silicon cells powers the warning light atop Japanese lighthouse (left) which has operated successfully since November.

Japan's Maritime Safety Agency said recently it would build six more solar installations to reduce ship accidents along the Seto Inland Sea coast.

Sunlight converter, which is made by Nippon Electric Co., charges a 12-volt nickel-cadmium battery during the day.

At night the power lights a 10-watt bulb for two flashes of 1½ seconds in a 7-second cycle. Flash reaches 9 miles. Photo at right shows a closeup of the warning beacon behind solar battery.

MEETINGS AHEAD

May 17-18: Superconductive Techniques for Computing Systems, Office of Naval Research, Dept. of Interior Auditorium, Washington, D. C.

May 19: Medical Electronics, Panel X-ray Amplifier, PGME of IRE, Physical Sciences Bldg., Univ. of Penn., Philadelphia.

May 23-25: Telemetering Conf., Annual, West Coast, ISA with ARS, AIEE, Miramar Hotel, Santa Barbara, Calif.

May 23-26: Design Engineering Conf., Coliseum, N. Y. C.

May 23-28: I.E.A. Exhibition, Instruments, Equipments & Components, Olympia, London.

May 24-26: Technical Conf. and Trade Show, Seventh Regional, IRE. ISA, Olympic Hotel, Seattle, Wash.

May 31-June 2: Frequency Control Symposium, USA Signal Research & Devel. Lab., Shelbourne Hotel, Atlantic City, N. J.

June 1-3: Analysis Instrumentation, Latest Advances, ISA, Queen Elizabeth Hotel, Montreal, Canada.

June 1-3: Radar Symposium, Willow Run Laboratories, Univ. of Michigan, Ann Arbor, Mich.

June 9-12: Society of Women Engineers, Annual Convention, Ben Franklin Hotel, Seattle, Wash.

June 10-26: British Exhibition, Electrical and Electronic Equipment, Coliseum, N. Y. C.

June 12-15: American Nuclear Society, Annual, Palmer House, Chicago.

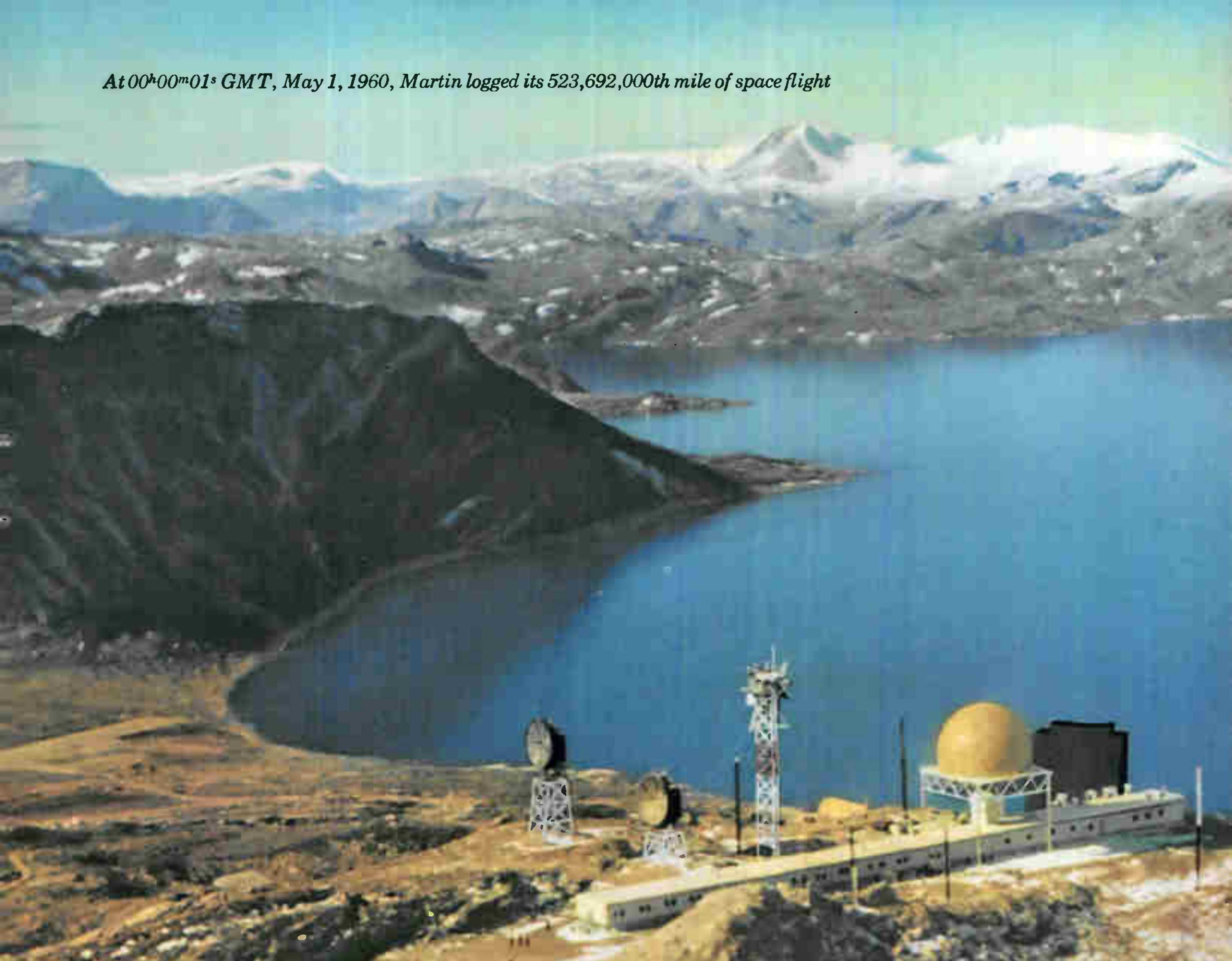
June 14-16: Railroad Communications, Assoc. of Amer. Railroads, Communications Section, Sheraton-Cadillac Hotel, Detroit.

June 20-21: Broadcast and Tv Receivers, Chicago Spring Conf., IRE, Graemere Hotel, Chicago.

June 20-24: American Institute of Electrical Engineers, Summer General, Chalfont-Haddon Hotel, Atlantic City, N. J.

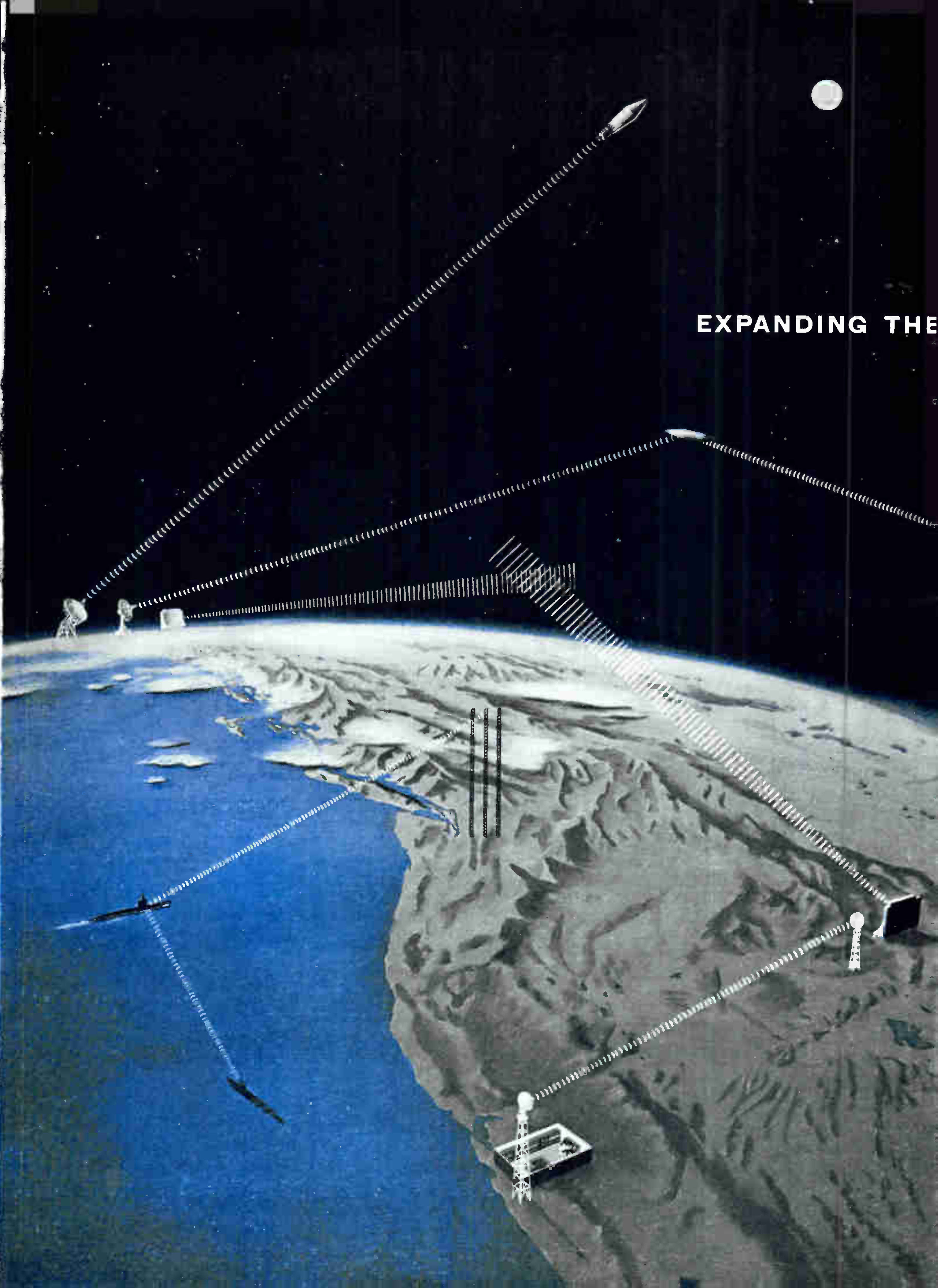
Aug. 23-26: Western Electronic Show and Convention, WESCON, Memorial Sports Arena, Los Angeles.

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

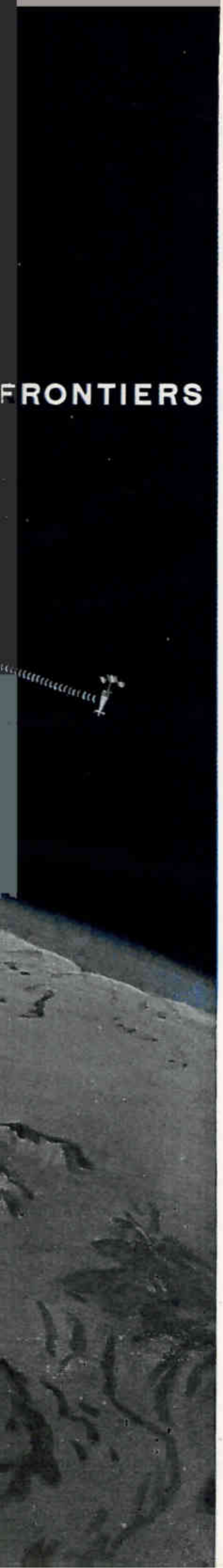


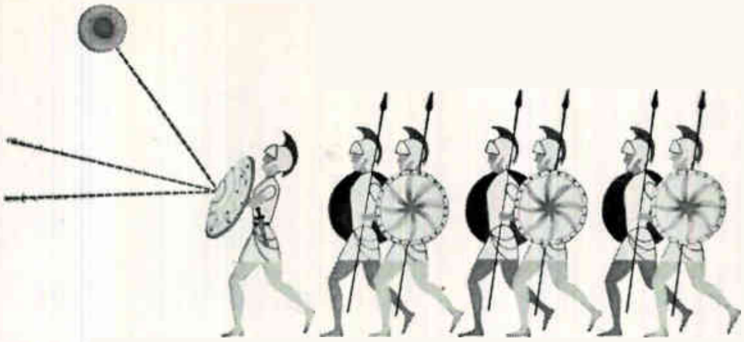
To keep the lonely vigil . . . *Martin PM-1 air-portable nuclear reactor, to supply electricity and heat at remote Air Force stations, is now being developed and produced for the AEC.*

MARTIN



EXPANDING THE





Herodotus, the historian, records (490 B.C.) the use of burnished shields for military signaling. This was the forerunner of the heliograph, invented by Sir Henry C. Mance, which came into wide use centuries later.

FRONTIERS OF SPACE TECHNOLOGY IN COMMUNICATIONS

Lockheed's interest in developing the science of communications extends from the depths of the oceans to deep space. Its Missiles and Space Division research programs deal with the development and application of statistical communication and decision theory in such areas as countermeasures; telemetry multiplexing and modulation; scatter communications; multiple vehicle tracking; millimeter wave generation and utilization; sonic signal detection and processing; avoidance of multipath degradation; and interference avoidance.

Associated research and development efforts are directed toward propagation studies and advanced antenna design; low noise amplifiers; vehicle borne signal transmission and reception, data storage and processing; solid state materials and devices.

The scope of such activities extends from advanced studies of naval communication problems on and under the oceans; the many applications to satellite vehicles; on to the specialized communication problems of deep space explorations. Latter needs are exemplified by high frequencies, low weight and power, high stability, low effective bandwidth, extreme reliability and basic simplicity requirements.

Engineers and Scientists: Investigating the entire spectrum of communications is typical of Lockheed Missiles and Space Division's broad diversification. The Division possesses complete capability in more than 40 areas of science and technology – from concept to operation. Its programs provide a fascinating challenge to creative engineers and scientists. They include: celestial mechanics; communications; computer research and development; electromagnetic wave propagation and radiation; electronics; the flight sciences; human engineering; magnetohydrodynamics; man in space; materials and processes; applied mathematics; oceanography; operations research and analysis; ionic, nuclear and plasma propulsion and exotic fuels; sonics; space medicine; space navigation; and space physics.

If you are experienced in work related to any of the above areas, you are invited to inquire into the interesting programs being conducted and planned at Lockheed. Write: Research and Development Staff, Dept. E-22, 962 W. El Camino Real, Sunnyvale, California. U.S. citizenship or existing Department of Defense clearance required.

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. . . *why it pays to specify and use dependable* BUSS FUSES

IT'S A FACT! By specifying BUSS fuses, you obtain the finest electrical protection possible — and you help safeguard the reputation of your product for quality and reliability.

IT'S A FACT! BUSS fuses have provided dependable electrical protection under all service conditions for over 45 years—in the home, in industry and on the farm.

IT'S A FACT! To make sure BUSS fuses will give your equipment maximum protection, every one made is tested in a sensitive electronic device. Any fuse not correctly calibrated, properly constructed and right in all physical dimensions is automatically rejected.

IT'S A FACT! Whatever your fuse requirements, there's a dependable BUSS or FUSETRON fuse to satisfy them. Sizes from 1/500 ampere up and there's a companion line of fuse clips, blocks and fuseholders.

IT'S A FACT! The BUSS fuse engineering staff will work with you to help you find or develop the best-suited to your needs. This places the world's largest fuse research laboratory and its personnel at your command to save you engineering time.

For more information on BUSS and FUSETRON Small Dimension fuses and fuseholders, write today for Bulletin SFB.

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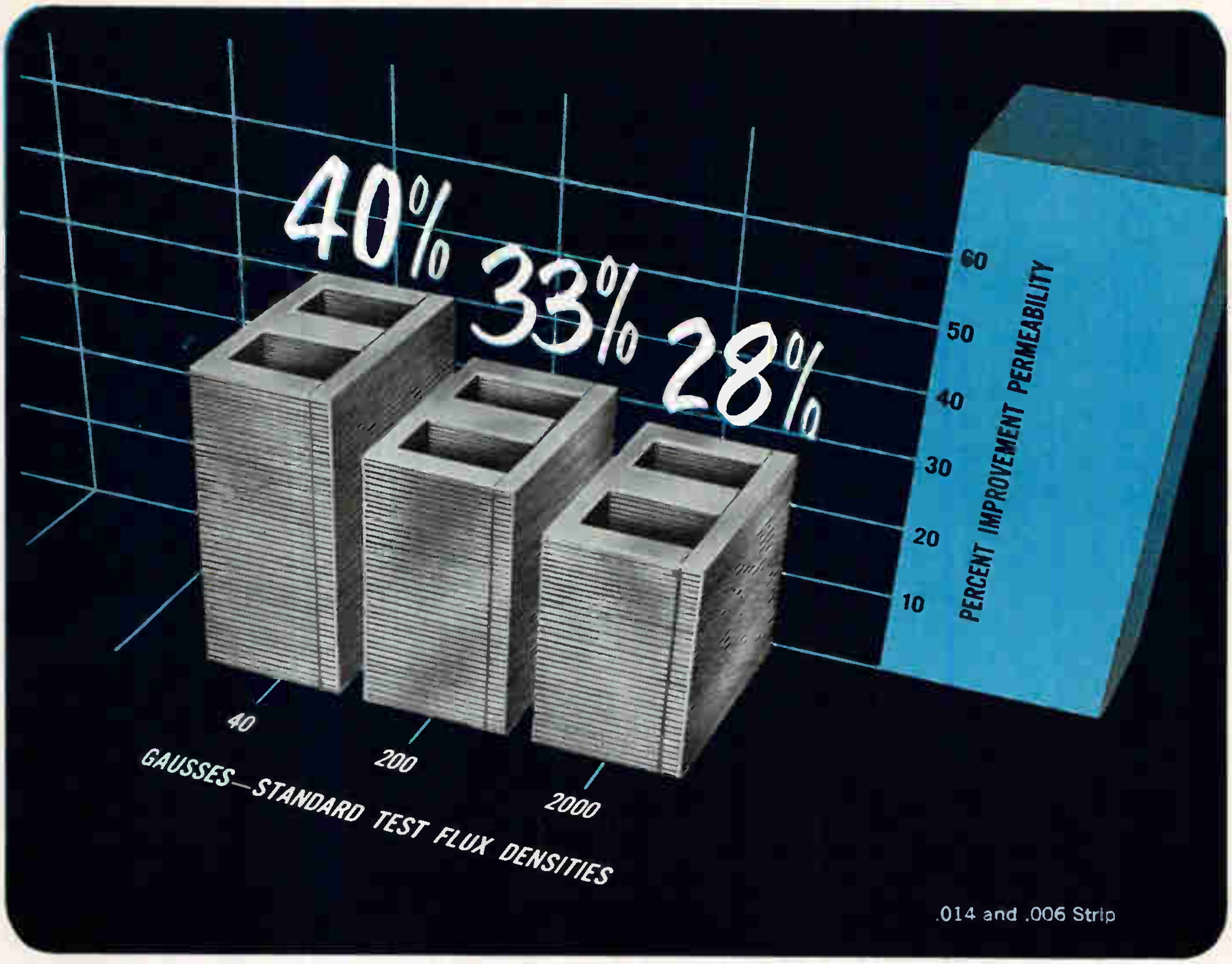

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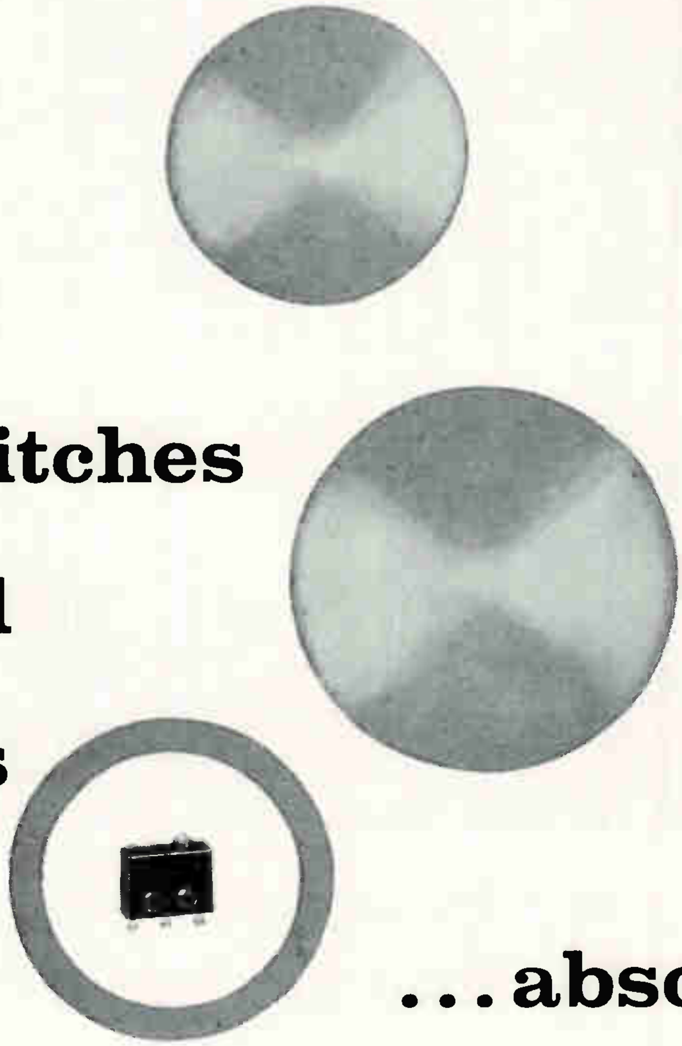
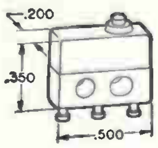
Basic Switches with Gold Contacts ...absolute





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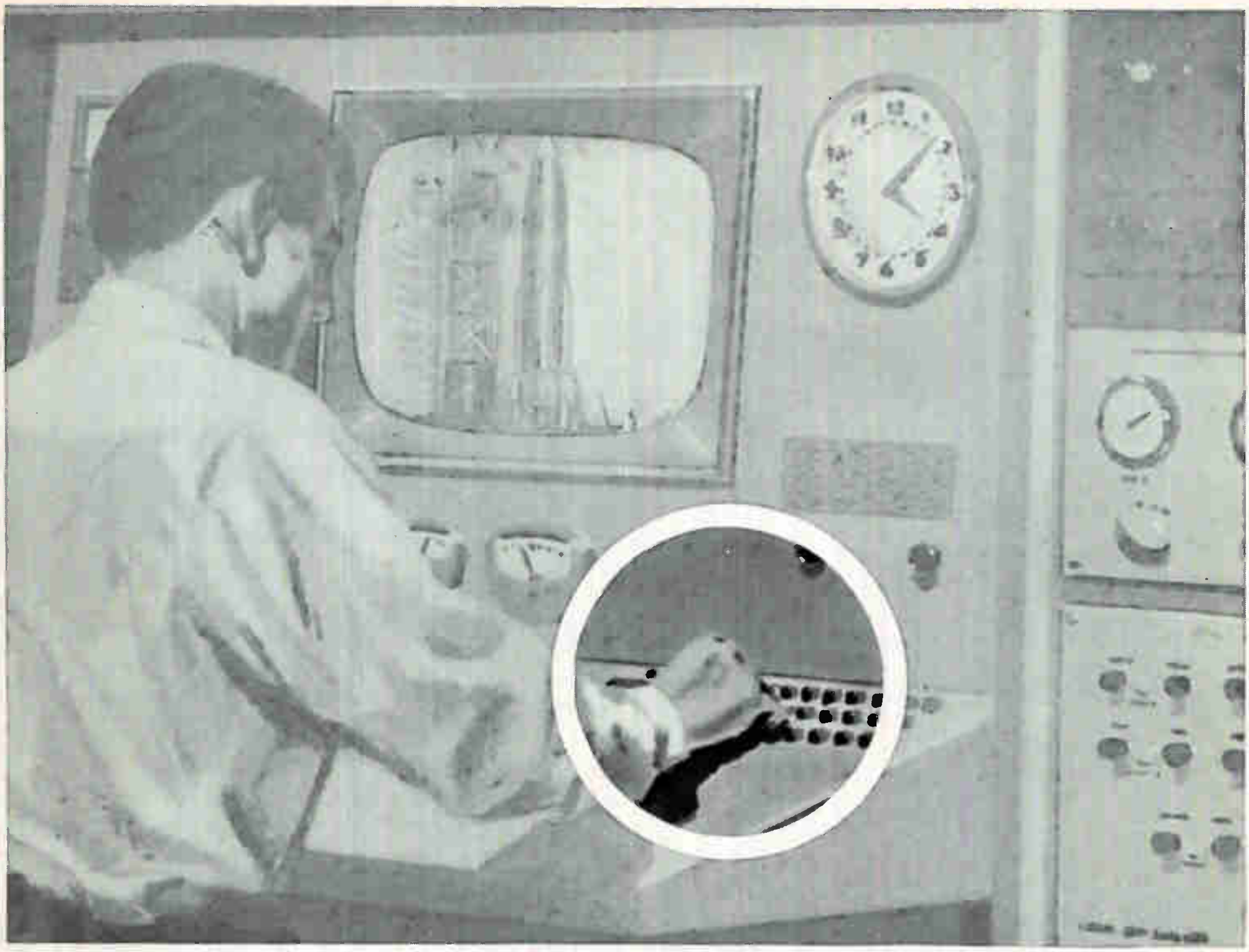

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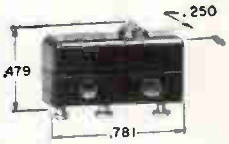
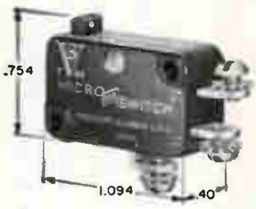


"SM" Series



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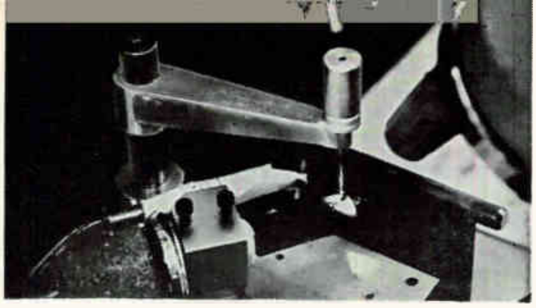
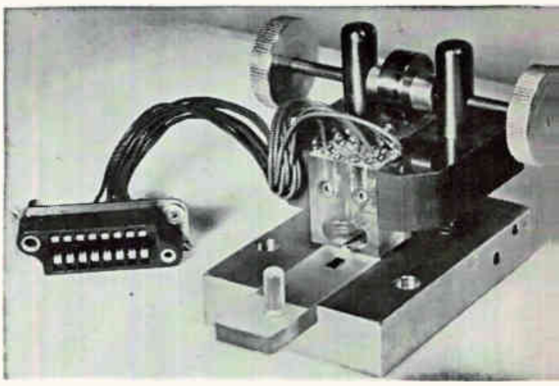
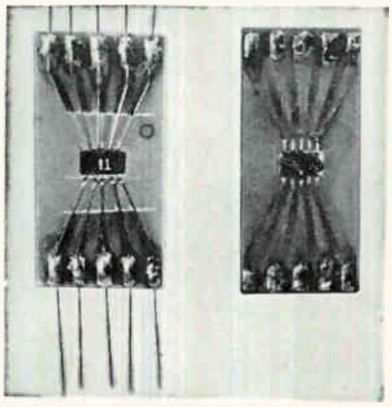


THERMAL COMPRESSION BONDING connects gold wires to diffused semiconductor layers



SEMICONDUCTOR NETWORKS mounted for experimental work



TEST FIXTURE for holding unmounted semiconductor networks

Semiconductor Networks

FOR MICROELECTRONICS

Selective diffusion and shaping of a semiconductor to form complete circuits reduces size and weight and improves reliability. This article includes description of how a circuit is developed from a diagram to a network on and within a single-crystal semiconductor wafer

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RAPID INCREASES in complexity of electronic equipment have created a serious need for reliable microminiature packaged circuits. In fact, on many proposed electronic systems the random failure rates for present-day components may cause the average time between failures to be so short that acceptable performance will be unobtainable. Some believe that a major improvement in reliability should be the prime objective of microelectronics work; others think that a significant reduction in size and weight is paramount; and still others feel that a cost reduction should be the main objective. This article reviews the concept of Solid Circuit semiconductor networks and discusses why they can provide better reliability, smaller size and weight, and ultimate savings in total equipment cost when compared with subminiature components or with other approaches.

There are many different types of microminiature packaged circuits or functional devices such as ceramic-base printed circuits, microcircuits, micrologic elements, micromodules, molecular electronics, semiconductor networks and thin films. A description and comparison of all these types is outside the scope of this article; however, it may be helpful to consider one method of categorizing this work.

The first major category includes the redesign of conventional components to change their form factor and the development of assembly or packaging techniques for these new components. This category may be subdivided into assemblies that require a stack of substrates, each of which contains only a few components, and assemblies that have all the required circuit elements fabricated on one substrate. In either assembly, there is a one-to-one cor-

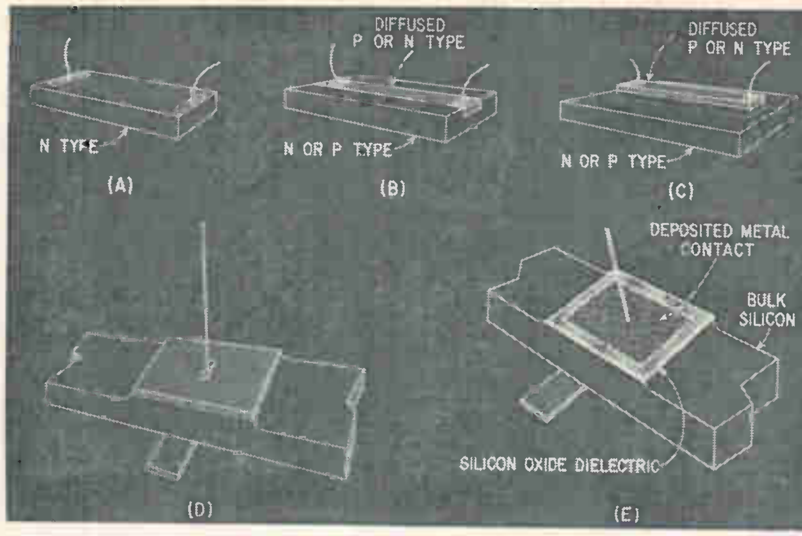

FIG. 1—Semiconductor resistors and capacitors: (A) bulk resistor, (B) oxidemasked diffused resistor, (C) mesa-etched diffused resistor, (D) p-n *junction capacitor and (E) silicon-oxide capacitor*

respondence between each component in the microminiature package and the same component in an operating breadboard of the circuit. Thus there are the same number of lead wires, conducting paths and interconnections. Unfortunately, there is no way to fabricate a transistor as an integral part of the package. Each active element must be separately fabricated, inserted or mounted in the package, and then electrically connected to the other components. Some miniaturization approaches in this category are using uncased or bare transistor wafers.

The production and shipment of reliable transistors without a hermetically sealed package presents several new problems. Adequate surface passivation is one of these problems. Although the can and header are quite large compared with the size of the active element, to eliminate completely these items and work with unprotected wafers may deteriorate transistor performance and reliability because of unknown surface contamination.

The second major category of microelectronics work includes those devices that have a complete circuit fabricated on or within one or more blocks of semiconductor material. Solid Circuit semiconductor networks are in this category. By combining oxide masking, diffusion, metal deposition, alloying, and surface shaping, complex networks are fabricated using single-crystal semiconductor wafers for both active and passive components. Individual circuit elements are difficult to distinguish because there are few internal junction points. The resultant devices frequently have performance characteristics that can be best explained by using distributed-constant networks. We have a three-dimensional circuit; however, there are no discrete components soldered from one point to another. Thus a direct comparison between a semiconductor network and a conventional circuit is best made on a functional basis. The problem of individually protecting and packaging components has been eliminated. Also, by using one homogeneous high-purity material for all circuit elements, the number of contacts between dissimilar materials is reduced so that the majority of electrical connections or junction points are for input, output and power supply leads.

Recent talks and technical articles have generated some confusion regarding the state of the art. Part of this confusion is the result of combining discussions on microminiaturization with the concept of a semiconductor functional device. Before the latter can be of value in complete microelectronic systems, there must be an orderly approach to the design of each new function. Also, a useful semiconductor functional device must be reproducible. Most of the functional devices proposed in the past four years have contributed little to the advancement of microelectronics because they pose insuperable problems.

Solid Circuit semiconductor networks were first announced in March 1959. Today, they are in pilot production. This progress was possible because semiconductor networks are fabricated with much of the same technology and equipment that have been perfected in the production of mesa-type transistors.

Typically, only 15 or 20 process steps are needed to convert a semiconductor wafer into a network. With so few process steps, it becomes economical to apply a high degree of process control. This is one more reason why reliability is built-in. The fabrication details to be discussed are intended to show how conventional transistor processing steps are related to those required to produce semiconductor networks.

Although semiconductor devices may be analyzed from basic principles governing current flow in solids, their three - dimensional nature complicates the problem. The fact that accurate mathematical treatments are not available

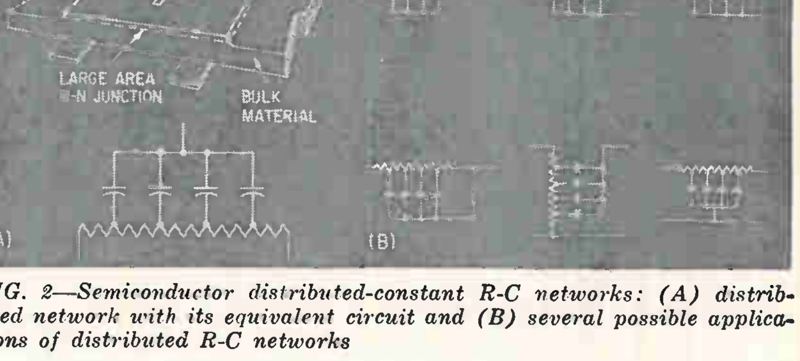

FIG. 2—Semiconductor distributed-constant R-C networks: (A) distributed network with its equivalent circuit and (B) several possible applications of distributed R-C networks

for many common transistor structures is an indication of the complexity of three-dimensional device mathematics. Consequently, there are no simple theoretical procedures that can be used to translate a desired circuit into a functional device.

Thus, semiconductor networks are designed by relating sections within a semiconductor to conventional circuit elements. Certain regions are considered as resistors, others as capacitors, diodes, transistors or as any other device that can be formed from a semiconductor. Any number of such regions may be arranged to form a desired circuit. Since these regions may lie entirely within a single semiconductor wafer, the resulting structure is fully integrated.

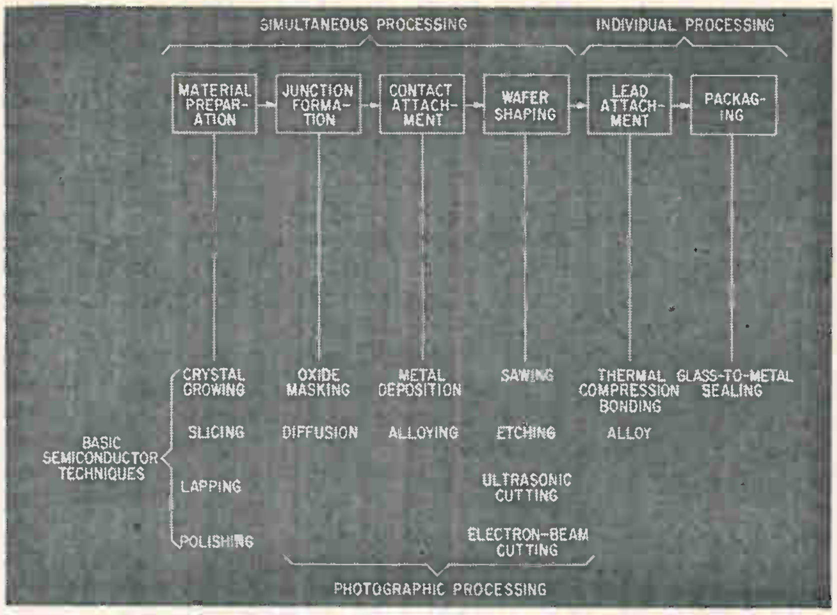

FIG. 3—Fabrication flow chart for semiconductor networks

It often is impossible to identify the individual regions in a functional device; however an existing circuit may be translated into an equivalent semiconductor network by relating known circuit elements to conductance paths in the semiconductor. If electrical properties of the various regions are known, performance of the finished device can be calculated. As an alternative, the regions may be simulated with conventional components and the circuit breadboarded for evaluation.

The region between any pair of ohmic contacts on a homogeneous semiconductor will act like a resistor, where the equivalent value of resistance is a function of material resistivity, length and cross-sectional area of the region. Such resistors are linear and closely follow Ohm's law for the voltages encountered in transistor circuits. Since current conduction takes place within the bulk of the material, these resistors are not subject to many of the changes with time and load that occur in deposited thin films. With the proper selection of material, the resistance temperature coefficient may be accurately controlled. For example, if high-resistivity silicon is used, the resistance may increase as much as 7,000 parts per million per deg C, or it may decrease for heavily doped low-resistivity material.

Resistance regions may be formed from a uniformly doped wafer as shown in Fig. 1A, or diffusion techniques may be used to produce a thin surface layer of opposite conductivity type, shown in Fig. 1B and 1C. In the latter, the resultant *p-n* junction is a barrier that confines current flow to a region near the surface. Since diffused-layer resistors have a resistivity that varies as a function of distance from the surface, their equivalent value of resistance is not as easy to calculate as for the bulk resistor. High-resistivity material is usually used for bulk resistors, while diffused-layer resistors may use low-resistivity material. Resistors produced by either process are formed from single-crystal material. This means they have extremely good noise properties because current conduction is entirely within one crystal; conduction does not take place between individual particles of resistance material. There is no absolute limit on the resistance value which may be produced by diffusion techniques; however, size restrictions and typical material resistivities make it desirable to limit maximum values to about 40,000 ohms for bulk resistors.

A reverse-biased *p-n* junction may be used as a capacitor (Fig. 1D), where the depletion region at the junction serves as the dielectric. For a given material, the capacitance is a function of the width of the depletion region and the junction area. For silicon, capacitance values up to 200,000 pf per sq cm are possible. Breakdown voltages of several hundred volts can be obtained with a low temperature coefficient of capacitance. Since the width of the depletion region changes with applied voltage, a nonlinear response results. Although this effect has been used to advantage in many applications, capacitors of this type are not suitable for high-level linear circuits. Another disadvantage is that the capacitors are polarized, and must be connected so that the junction is not forward-biased.

For applications where linearity is important, or where reverse bias cannot always be maintained, another type of capacitor can be formed on silicon wafers. The dielectric in these capacitors consists of a silicon-oxide layer formed on the surface of the silicon, as shown in Fig. 1E. The semiconductor serves as one plate of the capacitor and a layer of metal is deposited on the oxide for the second plate. Since the oxide is formed on a single-crystal wafer the oxide is unusually free of defects. Oxide-type capacitors have temperature coefficients well below 100 parts per million per deg C, low voltage coefficients and excellent stability with time. For 50-volt breakdown ratings, capacitances of 50,000 pf per sq cm can be obtained.

Although large values of junction or oxide-type capacitors may be fabricated, for extreme miniaturization it is necessary to limit the maximum capacitance. The limit for junction-type capacitors is between 2,000 and 5,000 pf depending on the number of other components required. A similar limit for oxide capacitors would be from 500 to 1,000 pf.

Distributed-constant resistor-capacitor networks are readily formed in semiconductor networks. One type of distributed R-C network is shown in Fig. 2A. Several ways to connect its three terminals are shown in Fig. 2B. Such networks have many useful properties, particularly for low-pass filters or phase-shift networks. A distributed R-C network used as a low-pass filter will have much sharper cutoff characteristics than a three-stage lumped-constant network and will provide more attenuation for a given R-C product. Phase-shift networks constructed in this manner have more phase shift for a given attenuation than a lumped-constant equivalent. Because of the layerized nature of the structures, distributed-constant networks are particularly easy to fabricate and thus are frequently used.

The remaining passive circuit element to be discussed is the inductor. Inductance is a measure of flux-linkages per unit current. Since a finite volume is required to link lines of flux, it is difficult to imagine a one-henry inductor comparable in size to a match head. At present, there is no microminiature semiconductor device that will produce the equivalent characteristics of a very large inductor. A recent conference paper described a semiconductor diode with an equivalent circuit that had, under certain conditions, a high-Q large inductance in series with a negative resistance. Also, it is possible to realize an inductive reactance between two terminals by using active network techniques.

One possible solution is to simulate the required function. For example, semiconductor delay lines may be used to replace an inductor in a time-delay circuit; R-C networks may be used in place of L-C tuned circuits; field-effect devices may replace chokes; or impedance matching by circuit design may replace transformers. Also, a small spiral of semiconductor material may be built to actually realize an inductor. However, when henries of inductance are necessary or if the skirt selectivity of an L-C network cannot be sacrificed, the best solution is to build a hybrid unit which combines a semiconductor network with a separate inductor. So far, this problem has not been serious because we have concentrated our design efforts on computer and switching-type circuits.

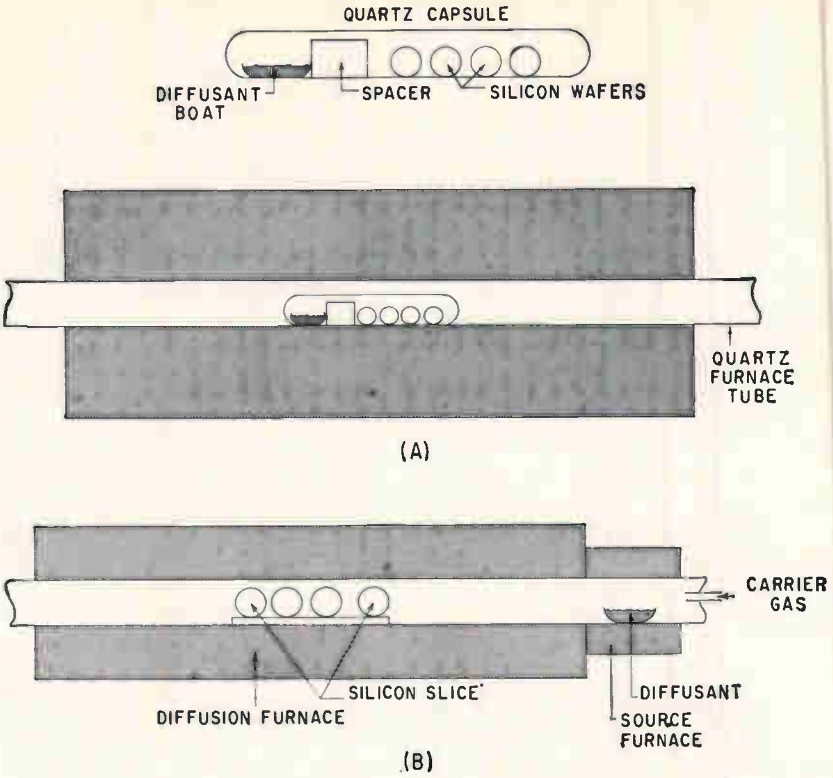

FIG. 4—Diffusion equipment showing (A) closed-tube system and (B) open-tube system

Diodes and transistors may be fabricated by either diffusion or alloying. The diffusion process is extremely flexible; it is currently used for some of the highest power and highest frequency devices. For this reason, and because of the excellent reproducibility of diffused devices, most semiconductor networks which have been produced use diffused structures. Diodes produced have been similar to the 1N645 and 1N659 series, while most of the transistors produced have been electrically similar to the 2N702 and 2N703.

Many other types of devices may be formed in a semiconductor network. Unipolar or field-effect transistors, tunnel diodes, *pnpn* devices, varactors, solar cells and thermoelectric elements are all possible.

The processes used in fabricating any semiconductor device are largely determined by yield considerations consistent with the desired operating characteristics of the finished unit. These characteristics include not only the electrical parameters, but such items as reliability and temperature stabilization. In fabricating Solid Circuit networks there are two additional considerations: design versatility and functional optimization. Since each semiconductor network is a complete circuit rather than a single component, an almost infinite variety of designs is possible. To satisfy any percentage of the possible applications, a large number of different types needs to be fabricated.

Semiconductor network processes must therefore lend themselves to design change without costly and time consuming mechanical tooling. On the other hand, the processes must allow the circuit to be functionally optimized. Complete optimization of a transistor is always opposed by design compromises. For example, the transistor designer must compromise between low base resistance and high current gain. The circuit designer, however, may use transistors with both low base resistance and high current gain in the same circuit to achieve better performance. For the same degree

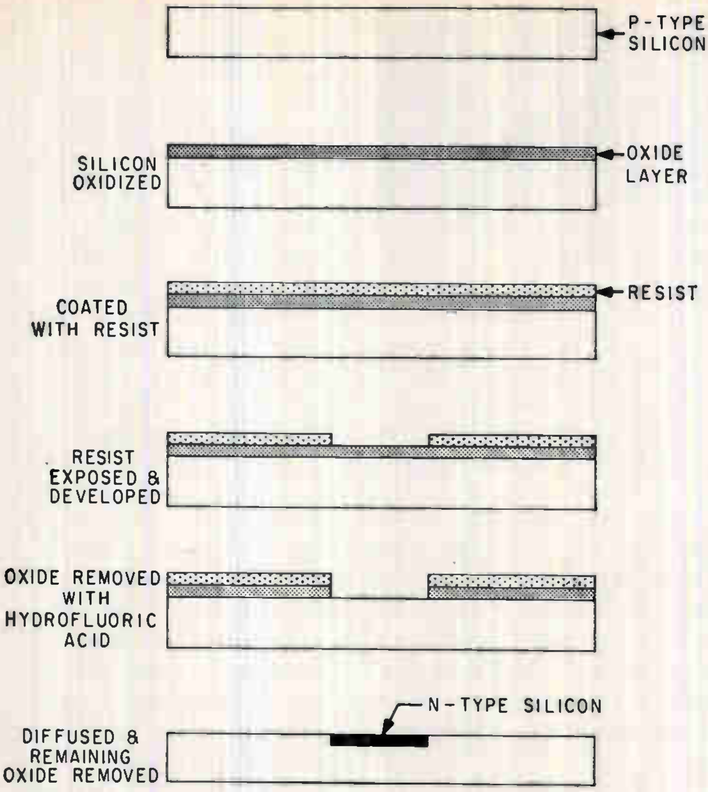

FIG. 5—Five-step process to form oxide mask for selective area diffusion

optimization in a semiconductor network, both transistor characteristics must be fabricated on the same semiconductor wafer. This introduces an additional degree of process control that is not necessary in conventional transistor production.

To unconditionally meet the foreing considerations and make practical the production of semiconductor networks, unique combinations of techniques which include photographic resist, oxide masking and gaseous diffusion have been used. Although many of these techniques have been used in mesa transistor fabrication, their full technological capability becomes apparent in semiconductor networks.

The sequence of operations, outlined in Fig. 3, will be recognized by semiconductor device engineers as being applicable to many types of devices. Since the basic techniques are well known, they will be only briefly reviewed here; the major emphasis will be placed on their adaptation to semiconductor networks. It is significant to note the steps in which the units are simultaneously processed versus those in which they are individually processed. For uniformity, reliability, and good yield, as many of the steps as possible should involve simultaneous processing, that is, fabrication of large numbers of units at the same time under the same conditions and on the same wafer.

The semiconductor material is grown as a single crystal and then sliced, lapped, and polished in exactly the same way as other devices. This processing step can be eliminated if dendritic crystals become economical to produce. Whereas both silicon and germanium have been used for semiconductor networks, silicon appears to be superior because of higher intrinsic resistance, ease of forming selective masking against diffusion, and better results in surface stabilization. Diffusion masks have been formed on germanium by using evaporated coatings, but this adds complexity to the operation. The remainder of this article will therefore be limited to the use of silicon material.

For a given geometry, resistivity of the starting material affects the value of any bulk resistors in the finished device; therefore, material resistivity must be accurately controlled. A resistivity measuring bridge is used to sort silicon wafers before fabrication is started. Material resistivities around 10 ohm-cm are satisfactory for the resistance values found in most computer-type applications. Also, resistivities in this range have been quite insensitive to subsequent processing.

Controlled amounts of impurities must be introduced into a bulk semiconductor to form *p-n* junctions. Two common techniques for adding these impurities are alloying and diffusion. In alloying, an impurity metal such as aluminum is first deposited on the semiconductor surface. The wafer is then heated to melt the metal and dissolve some of the semiconductor. Upon cooling, the molten region solidifies in single-crystal form with the same orientation as the original semiconductor. Included in the crystalline lattice of the recrystallized region are impurities of the deposited metal which give the regrown region the desired conductivity type. For *p-n* junction formation this would be a type opposite to the bulk type. Because alloying is a melting and freezing process, it occurs rapidly and is somewhat difficult to control in depth. The amount of impurity included in the regrown layer is a function of the metallurgical properties of the metal-semiconductor system (phase diagram) plus the thermodynamics of the heat cycle (departures from equilibrium). In practice, these considerations limit the impurity concentrations to a narrow range of values.

Diffusion, as contrasted with alloying, is a relatively slow method of introducing impurities into a semiconductor so that better depth and concentration control are obtained. The diffusion process consists of heating the silicon to approximately 1,200 C in the presence of an impurity gas. The gaseous impurities strike the surface and diffuse into the wafer to form an *n*- or *p*-type layer, depending on the characteristics of the impurity. In diffusing *n*-type junctions into *p*-type parent silicon the diffusant may be: antimony, arsenic, bismuth or phosphorus. In diffusing *p*-type junctions into *n*-type parent silicon the diffusant may be: aluminum, boron, gallium, indium or thallium. Selection of a particular diffusant depends on what penetration and surface concentration of impurity atoms is desired. Different impurities diffuse at different rates; thus two impurities may be diffused simultaneously to form two *p-n* junctions at the same time. Diffused junction depths in silicon may be accurately controlled from hundredths of a mil to several mils.

To control the surface concentration it is necessary to control the number of impurity atoms which reach the silicon surface during the diffusion cycle. This can be done by vacuum sealing the diffusant together with the wafers in a tube (closed-tube method); or by controlling the temperature, and hence the vapor pressure, of the diffusant independent of the silicon temperature (open-tube method); or by applying the diffusant directly to the wafers before heating (paint-on method). Each diffusion technique has certain advantages. The method used depends on the device to be fabricated and the accuracy that is needed to secure good control on the device parameters.

A closed-tube diffusion furnace is sketched in Fig. 4A. The silicon wafers are placed in the quartz capsule, the spacer is inserted, and then the small quartz boat containing the diffusant is inserted. The quartz tube is then evacuated, sealed and placed in a furnace so that the wafers and diffusant are at the same temperature. This process has been used in transistor production for several years.

A sketch of open-tube diffusion equipment is shown in Fig. 4B. Open-tube diffusion requires two furnaces in tandem. The smaller furnace is the source furnace and the larger furnace is the diffusion furnace. A carrier gas—argon, hydrogen, nitrogen or oxygen—flows at a controlled rate into the quartz

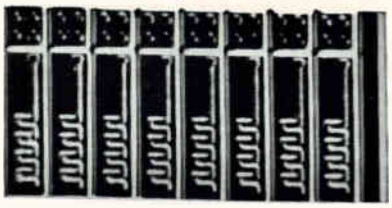

FIG. 6—Example of selective etching using photoresist

furnace tube at the source-furnace inlet side. The diffusant is heated in the source furnace and evaporates at a controlled rate. The carrier gas picks up the diffusant as it passes over the heated source boat and carries the diffusant to the heated semiconductor wafers where it is deposited. The wafers are at a higher temperature than the evaporating diffusant. Temperature is controlled in both the source and diffusion furnaces with the same accuracy as in the closed-tube furnace.

The paint-on method utilizes a diffusant-enriched solution which is painted on the semiconductor wafers. In some cases the wafers may be dipped into the solution. The wafer is then placed in a furnace and diffusion occurs at an elevated temperature.

The junction area of alloyed devices can be controlled by limiting the regions where the impurity metal is deposited. In diffused structures the junction areas may be controlled by forming an oxide mask on the silicon.[1] If silicon is heated in an oxidizing atmosphere, the resultant layer of oxide will mask against diffusion impurities such as boron and phosphorus. By selective removal of this silicon-oxide layer, which forms uniformly over the surface, area control of the diffused layers can be achieved.

The selective removal of an oxide mask is accomplished by photoetching techniques similar to those used in making etched-circuit boards. This process is illustrated in Fig. 5 for the special case of an *n*-type diffusion into a *p*-type silicon wafer. The photographic resist is applied in liquid form, usually by dipping the material in resist. After drying, the resist forms a thin plastic film which is photographically sensitive to ultraviolet light. Exposure is accomplished by contact printing through a photographic negative that has been produced by laying out the desired pattern at 50 to 100 times actual size and then photographically reducing it. Thus the only tooling required to produce a different oxide mask is to change the photographic negative. Typical reduced negatives have opaque areas with dimensions on the order of one mil.

The photographic exposure jig permits alignment of the negative with respect to patterns already on the wafer. Exposure of the photoresist causes it to be insoluble in the developer. Therefore, resist under the opaque areas of the negative will be removed by the developer while resist under the clear areas will remain. If the wafer is now placed in a hydrofluoric acid bath, the oxide will be removed where it is unprotected by the resist. Hydrofluoric acid attacks only silicon oxide and not the underlying silicon or the photoresist.

In addition to controlling the junction geometry, oxide masking also may be used to control the impurity concentrations. By oxide masking certain areas during only part of the diffusion cycle, while exposing other areas during the entire cycle, surface layers of different concentrations and depths may be obtained. For example, a series of diodes having different breakdown voltages can be formed on the same wafer.

The active areas are completed once the junctions have been

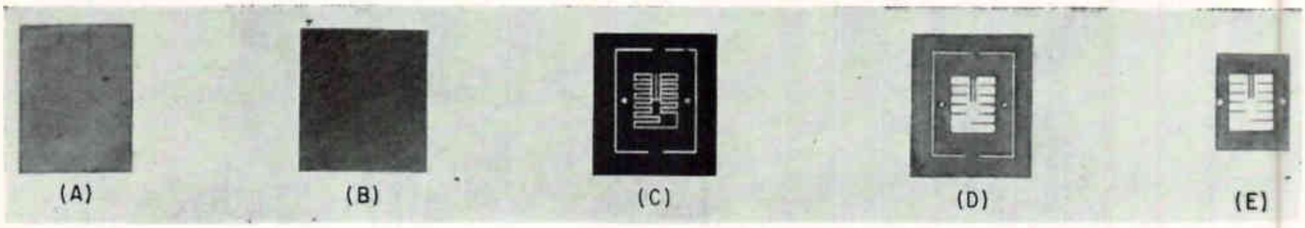

FIG. 7—Process steps in making a semiconductor network lead frame showing (A) cleaned metal, (B) metal coated with photoresist, (C) photoresist exposed and developed, (D) lead frame after chemical etching and (E) lead frame cut and plated

formed. In the finished device, electrical connections must be made to these various p- or n-type layers and to the bulk material. Often the current path is through the semiconductor itself, but ultimately some outside connection is required. Two steps are involved in making these connections: first, a nonrectifying low-resistance metallic contact is made to the semiconductor; second, leads are attached to these contacts. The contacts are made by depositing metal on the semiconductor surface and then forming an alloy by heat treatment. This is the same process previously discussed for making alloyed p-n junctions, only in this case the impurity metal involved is of the same conductivity type as the semiconductor. Thus p-p^+ or n-n^+ junctions are formed (the + notation indicates a much higher impurity concentration).

This process, like the others involved in semiconductor network fabrication, is easy to change for different designs. The contact placement will be different for each type of circuit and the metals will vary with the conductivity type of the semiconductor layers. Fortunately, both electrochemical and vacuum deposition may be adapted to this requirement by using photo processing techniques. In the case of electroplating metals, a photoresist mask can be photographically formed directly on the unoxidized semiconductor. The resist mask then confines the current flow, and hence the deposition, to only those areas not masked. Vacuum deposition is done most conveniently through a metal mask that limits the deposited contacts to those areas not covered by the mask. Metal masks are etched from thin sheet stock using a photoresist coating to limit the etching. Here again, the only change in tooling for a new circuit is a new photographic negative.

After forming the junctions and making the contacts, the wafers may be separated into individual pieces having the required geometry. This geometry is largely determined by the desired current paths within the semiconductor and will vary from one circuit design to another. Sawing, or scribing and breaking the wafers, are logical methods of separation; but they are limited to straight-line geometry.

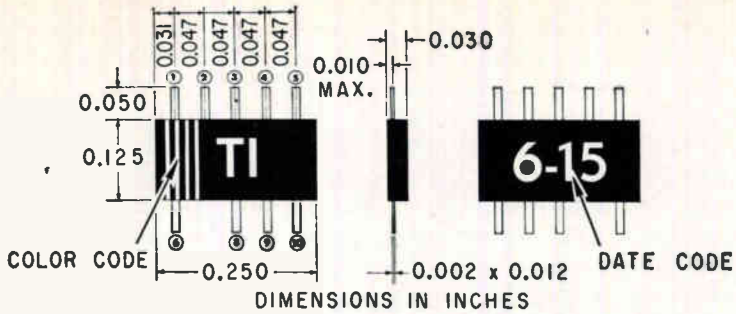

FIG. 8—Outline dimensions of hermetically sealed Solid Circuit network package after attaching cover to header

Ultrasonic cutting is possible, but it requires expensive tooling for design changes. The most satisfactory technique is to etch the units apart using photographic processing. In particular, a photoresist mask is applied as in the oxide removal procedure, but an etch that will attack the silicon is used. The wafer will be etched completely through where it is not protected by the resist, thus separating the units. At this step in the process, mesa areas are fabricated where desired by etching away unwanted diffused layers. The example in Fig. 6 illustrates the complexity of design that can be accomplished by photoetching techniques.

The individual units are now ready to have leads attached. For the bulk material, the leads are Kovar strips upon which the unit rests. For the diffused layers, lead wires are thermal-compression-bonded to the deposited and alloyed contacts. The Kovar strips are formed in a picture-frame assembly by photoetch techniques as illustrated in Fig. 7. Different circuits may require a different placement of the leads, and by photoetch fabrication the need for costly stamping dies is eliminated. A mounting base, which corresponds to the header of a conventional transistor, is formed by sandwiching the Kovar lead-frame between a ceramic and a Kovar ring. Conventional high-temperature glass-to-metal sealing techniques are used for this step. Some base pieces are loaded into a graphite fixture in preparation for firing. After firing, the leads are gold plated and the individual silicon units are placed in position. The units are then run through an alloying cycle to bond the semiconductor to the gold-plated Kovar. In a conventional mesa transistor this step would correspond to alloying the collector to the header.

Connections to the diffused layers are made by thermal compression bonding as shown in the opening photograph. Gold wires are positioned over the contacts, and a fine chisel is used to press each wire into the contact. Heat is simultaneously applied to raise the temperature to about 300 C, thus forming the bond. These connections are both mechanically strong and electrically reliable. Although thermal compression bonding requires considerable skill, it is a technique used in mesa transistor fabrication to make emitter and base connections.

The header to which the semiconductor pieces are fastened is also part of the package. All that remains is to attach the cover. Outline dimensions of the finished hermetically sealed package are shown in Fig. 8.

A variety of semiconductor networks can be manufactured using the processes described herein. With the stated restrictions on component values, those circuits that require large value resistors and capacitors, or any inductance, are not being offered at present. Typical circuits that have been fabricated and tested are shown in Fig. 9. In the case of logic elements, inverters and binary counter stages, the switching speeds frequently exceed the performance of a breadboard circuit with conventional components. This merely points out that when a transistor wafer is designed into a semiconductor block instead of mounting it on a header, the decreased collector capacitance and elimination of lead inductance enable a faster switching response.

In designing a semiconductor network, the material selection and diffusion layers are chosen to produce an optimum transistor structure for the particular circuit application. Since the transistor is an integral part of the circuit, exact operating conditions are known. Thus the transistor design may be accurately tailored to a particular application, which reduces the required number of compromises. This procedure may be used to improve the performance of a circuit or to maximize the yield of acceptable devices. For circuits requiring both transistors and diodes, the normal design procedure is still to optimize transistor performance.

The diode characteristic of an emitter-base junction usually differs from that of a collector-base junction. In particular, the emitter junction is relatively abrupt and has a low breakdown voltage, while the collector junction is more gradual and may have a high breakdown voltage. At the same time that each transistor junction is being formed by diffusion, any number of individual diodes with characteristics like either of the transistor junctions may be formed elsewhere on the wafer. Special diffusions also may be used on the same wafer to produce other devices.

As an example of the design procedure, consider the NOR circuit shown in Fig. 10A. The circuit has four diodes, three resistors, a capacitor and a transistor. All component values are within specified design limits; therefore, the circuit can be translated directly into a semiconductor network. It is desirable to change the lumped resistor-capacitor combination shown in the transistor base circuit to a distributed R-C network. Also, since the polarity of voltage applied to the capacitor does not change, a *p-n* junction-type capacitor may be used.

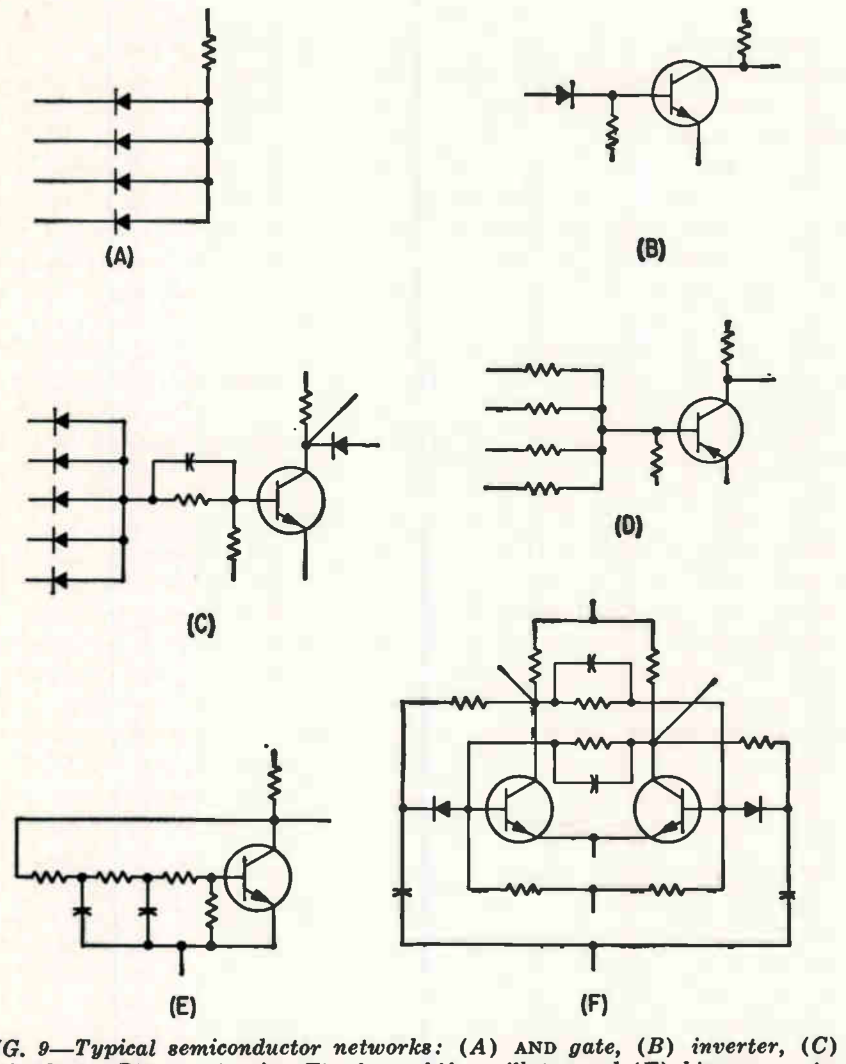

FIG. 9—Typical semiconductor networks: (A) AND *gate, (B) inverter, (C) logic block, (D)* NOR *circuit, (E) phase-shift oscillator and (F) binary counter*

Although this circuit can be designed on a single wafer, in practice it is desirable to separate the resistors in the input circuit from the collector load resistor. When this is done, all the resistors are formed from two pieces of material. Typical values for R_A, R_B and R_C are 4,000, 10,000 and 2,000 ohms respectively. For 10 ohm-cm silicon, 2-mils thick, the required areas for these resistors will be 10 by 20 mils for R_A, 10 by 50 mils for R_B, and 10 by 10 mils for R_C.

These resistors may be arranged, along with the other necessary components, in the configuration shown in Fig. 10B. The starting wafer of *n*-type silicon forms the transistor collector region, all resistors and the cathode of each diode. A diffused *p*-layer is then used to form the transistor base region, the diode anodes and the capacitor overlying R_A. Next, an *n*-type diffusion is required for the transistor emitter region. These fabrication steps are applied to a large-area silicon wafer, typically 210 by 440 mils. After appropriate contacts are deposited, the wafer is separated into enough silicon bars to make 16 complete NOR circuits. This is a practical production process because it provides many units with identical characteristics. It is not an attempt to fabricate just one sample unit. The final step is to provide input and output connections and a few jumpers to connect some of the internal elements as shown in Fig. 10C. The latter connections are made with thermally bonded gold wires.

There are many alternate layouts which are theoretically possible for this design example. The proper selection of an optimum layout requires a thorough knowledge of available manufacturing techniques and their limitations. This job is performed by a semiconductor-network design engineer.

It is possible to design large digital systems using semiconductor networks that have already been fabricated and tested. However, before any large systems can be constructed, it will be necessary for the equipment manufacturer to develop methods of handling, testing and connecting devices an order of magnitude smaller than those to which he is accustomed. Tweezer handling and assembling under magnifica-

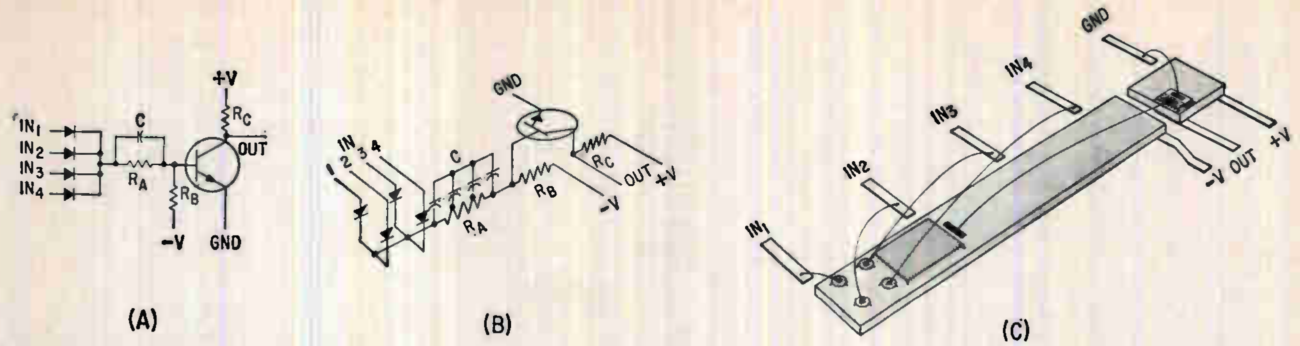

FIG. 10—Development of a semiconductor network: (A) schematic diagram of NOR *circuit, (B) three-dimensional schematic of* NOR *circuit and* (C) NOR *circuit semiconductor network*

tion will be required if full advantage is to be taken of the small size of the individual units. Manufacturing techniques of this type, which are now routine in many branches of the electronics industry, will have to be adopted by the equipment manufacturer. Alternatively, the device manufacturer may be asked to subassemble a number of individual units into a larger package more easily handled.

Other new techniques will be required for testing the devices. Input and output conditions may be set, for instance, and the device subjected to varying environmental conditions to determine its acceptance or rejection. Only one set of tests will be necessary for each circuit, which greatly reduces the testing requirements. This type of testing will, however, require detailed knowledge of the performance actually needed in a given application.

For breadboard work with semiconductor networks, individual units are usually mounted on small etched-circuit cards. These may be inserted in test fixtures, or connected to form subsystems. Units mounted on two types of cards are shown in a photograph. For testing unmounted units, a more elaborate jig is required, as shown. The device to be tested is loaded on the slide and inserted in the fixture where the leads are contacted by 10 spring-loaded probes.

Because of the very small size of finished units, almost any form of interconnection will permit a worthwhile reduction in size and weight when compared to an assembly of conventional components. However, some effort is required to design a system where the interconnections require less volume than the semiconductor networks. One way to achieve this is to stack the units as shown in Fig. 11. The front cover illustrates the interconnection of semiconductor networks to form a unit of equipment. Connections between networks are provided by sheets of 2-mil-thick copper-clad Teflon. Because of close spacing between the leads, all of the wiring cannot be provided in a single plane. Multiple sheets are therefore used. Each required supply voltage is connected to a separate sheet that has a grid pattern with holes providing electrical and mechanical clearance for the leads. A lead may either pass straight through a sheet and be insulated from it, or be bent over and welded to provide an electrical connection. After all supply voltages have been connected, the top sheet is added to form the signal paths. If crossovers are necessary, a second signal sheet may be used. When semiconductor networks are to be assembled in this manner, the designer should attempt to alternate the location of supply and signal leads on each package, thus increasing the spacing between adjacent terminals on the top sheet. Note that individual sheets may be used for shielding or as a ground plane. Also, this assembly technique may be useful for semiconductor network vhf applications, where the copper-clad Teflon sheets could become two-dimensional strip transmission lines.

Of course, other methods may be used for interconnection. In general, schemes which attempt to lay the units out flat will require considerably more space. A volume equal to that of the unit will be required for the lead connections, while the wiring will require still more volume. This additional volume will not be a total loss, however, if used to provide better heat transfer within the equipment.

The price of success in miniaturization is heat density. In particular, when electronic equipment is re-packaged and reduced in size without changing the circuits, the heat dissipation per unit volume significantly increases. A number of approaches to this problem are being pursued. First, semiconductor networks are designed for minimum power consumption. Second, each hermetically sealed package is shaped to have a high surface-area-to-volume ratio for efficient heat dissipation. Finally, since each semiconductor network occupies so little volume, conduction paths to heat sinks can easily be provided. For the stacked subassembly in Fig. 11, this may be done by placing between the units metal strips which are tied to heat sinks on the two open sides of the subassembly. Furthermore, the degrees of design freedom offered by semiconductor networks may produce new circuits that require much less power for operation.

The "standard" method for comparing packing efficiencies of different microelectronics approaches is to note the density of components per cubic foot. This is usually scaled up from one complete circuit or assembly of parts and often excludes the volume required for lead wires, interconnections, environmental protection and heat sinks. Considering just the heat dissipation problem, if we had one million components per cu ft and each component dissipated 10 mw, there would be 10 Kw of heat to be disposed of in each cubic foot. Obviously, the component density figure is not a realistic measure of the

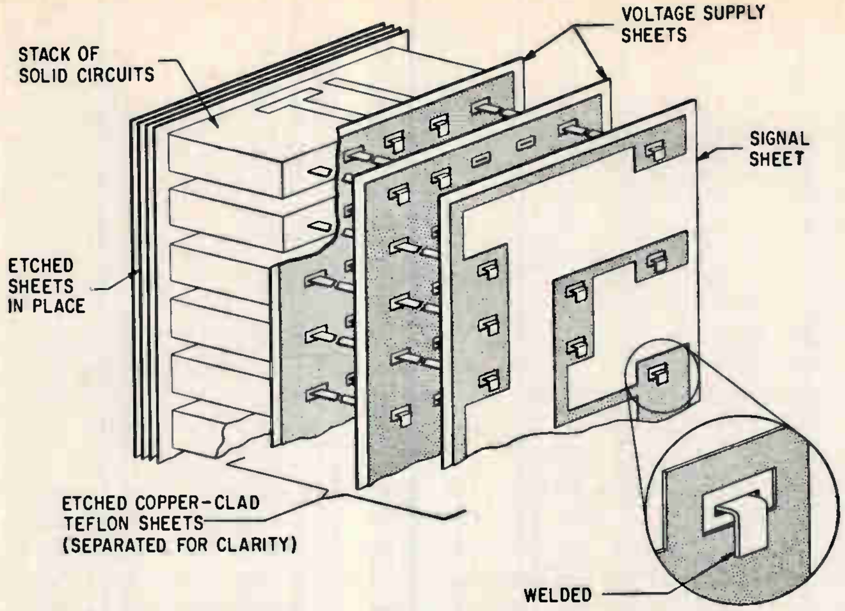

FIG. 11—One method of interconnecting semiconductor networks

number of components which could be connected and operated in a volume of 1 cu ft.

As each new microminiaturization idea is announced, the stated figure for component density is usually larger than any previously reported. At the present time, the highest number quoted is 100 million components per cu ft. These estimates of component density are not meaningful because the assumptions used in the calculation are never explained.

It may be of interest to "play the numbers game" for a Solid Circuit. The bare silicon bars in Fig. 10C have the equivalent of 9 components in a 2 by 10 by 80-mil space—this amounts to 9,700 million components per cu ft. When we allow space for the internal lead wires this number reduces to 260×10^6 parts per cu ft. Mounting this semiconductor network in the hermetically sealed package shown in Fig. 8, we have a density of 16×10^6 parts per cu ft. Finally, if we allow a volume for external connections equal to that of the package, we end up with 8 million components per cu ft. The reality of this last number has been demonstrated by the interconnection of 13 networks that contain the equivalent of 85 components in an operating subassembly that occupies 0.02 cu in. and weighs 1.5 gm. This amounts to 7.3 million components per cu ft.

There is apparently no satisfactory method for measuring the degree of miniaturization. However, the application of semiconductor networks can produce equipment that is at least an order of magnitude smaller and lighter than equipment developed with other microminiaturization approaches.

Semiconductor networks combine the knowledge of semiconductor materials, established device fabrication techniques, and the logical approach to network analysis or synthesis that is familiar to all circuit designers. As a result, many types of Solid Circuit networks can be readily produced today. Although complete life test data is not available to support the claim that reliability has been significantly improved, the following reasons are proffered:

(1) The purity level and order of lattice arrangement for the starting material is carefully controlled, whereas in other approaches many dissimilar materials of varying or unknown degrees of purity are used.

(2) By using a single material, up to 80 percent of the connections required for a conventional circuit are eliminated. The various regions which form circuit elements are continuous within the one bulk material. This minimizes the mismatch in thermal expansion coefficients which usually is the cause of catastrophic failures. Besides reducing the number of solder joints between lead wires on individual components, we are also reducing the number of junctions where each lead wire is attached to the actual circuit element (such as where a resistor lead is bonded to the carbon rod or metal film; or where a capacitor lead is attached to the metal foil or silvered-mica plate). The use of metal contacts alloyed into the semiconductor also reduces the interfaces between dissimilar materials.

(3) The small number of required process steps permit accurate process controls to be economically applied. All the fabrication steps are performed in one plant and on one production line; therefore, complete statistical methodology will be used.

(4) Since the entire circuit is hermetically sealed, both active and passive elements are protected against environmental conditions.

(5) Because of the very small mass, semiconductor networks are difficult to damage by shock or vibration.

Today, semiconductor networks are not commercially available in all types of circuits. Many of these circuits were developed as a compromise between the electrical characteristics and cost of conventional components, thus they may not be optimum for the different electrical characteristics and economic factors of the Solid Circuit. Nevertheless, this approach to microelectronics is adequate in many cases. For example, with the large number of repetitive functions in present-day digital computer circuits, complete systems can be constructed with only a few semiconductor network building blocks. The most attractive semiconductor networks of the future may have no real counterpart using conventional components, or they may, in retrospect, be considered impractical for the present state of technology.

The authors acknowledge the help of D. W. Alford, J. C. Brixey, A. D. Evans, J. E. Hull and M. R. Sherman in the preparation of this article.

The words Solid Circuit, as used throughout this article, have been adopted and used by Texas Instruments Incorporated as the trademark for its semiconductor network products.

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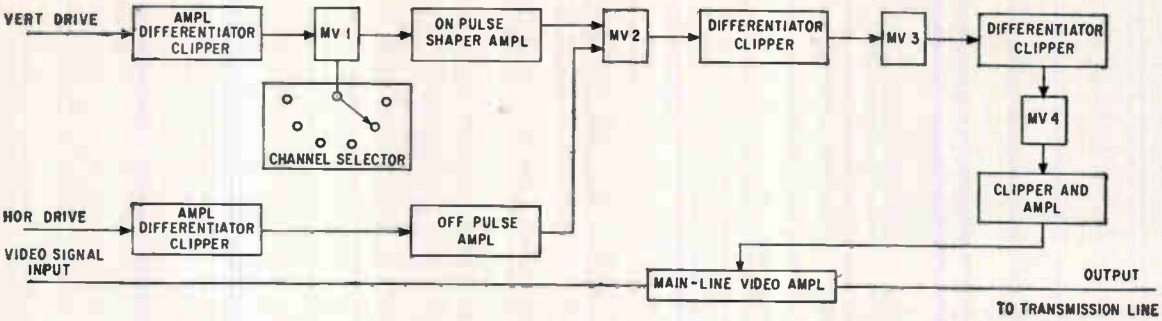

FIG. 1—Remote transmitter's control pulse is originated by the blanking signal and the chanel is selected by the channel selector switch, which controls the pulse width of multivibrator MV_1

Remote Tv Control

BY BLANKING-INTERVAL PULSES

Local program matter is keyed-in by a remote transmitter which sends control pulses during the vertical blanking interval. Control signals are decoded at subsidiary stations where they govern programming

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THIS SYSTEM comprises a special transmitter to generate the control pulses, and a receiver at each station, to be controlled, to decode these pulses and translate them into the appropriate switching actions. Six control channels are available, permitting transmission of six different instructions. Thus, the control system can introduce special program matter such as a film projector, outside broadcast, weather forecast, or other special effects. Extending this principle, control pulses received by remote booster stations can turn the transmitter off or on, or initiate other operations peculiar to that station.

According to the Japan Television Technical Standards, the vertical blanking interval corresponds in duration to twenty-one horizontal scans. Although the picture is not seen during this blanking interval, the horizontal synchronizing pulses continue to be transmitted to preserve system synchronism. The period of the first fifteen sweeps is allotted to special purposes, leaving a final period of six sweeps during which control signals can be broadcast.

The actual control signal is transmitted in the interval between horizontal sync pulses. Since there are six such unallocated intervals, six control channels are available. At the receiving station, the control signals are passed through special circuits where they energize switching relays to carry out the operations mentioned above.

The main function of the transmitting section of the control system is to insure that the control pulses are generated in the correct time interval—or channel. Furthermore, these pulses must occur at a fixed period within that chosen channel, that is, at a definite time-delay after the preceding horizontal synchronizing pulse. Channel selection is provided by a 6-position switch that sets the delay (500 to 2,000 μsec) of the channel-selecting monostable multivibrator $MV1$ (Fig. 1). This multivibrator is triggered at the start of the vertical blanking interval and produces an output pulse that determines in which channel the control pulse shall be transmitted. Thereafter, horizontal sync pulses take over the timing to provide accurate synchronization of the final transmitted pulse.

Channel five will be discussed so that the circuit description can be specific rather than general.

The transmitter block diagram is shown in Fig. 1, and its associated waveforms in Fig. 2A. The vertical blanking waveform triggers channel selecting multivibrator $MV1$ and the multivibrator returns to its stable OFF condition after the preselected delay. Return to the OFF state is shown in Fig. 2A at time A, just before the sync pulse that marks the beginning of the fifth channel interval.

After amplification, differentiation, clipping and further amplification, the output from the channel-selecting multivibrator provides a positive going trigger for bistable multivibrator $MV2$. This bistable circuit is turned to its ON state.

Thus far, a pulse has been generated that occurs shortly before the selected channel interval. Since the actual control pulse must be transmitted midway (approximately) between transmissions of sync pulses, further delay is necessary.

Shortly after MV 2 is turned ON by the output from the channel-selecting multivibrator, the (next)

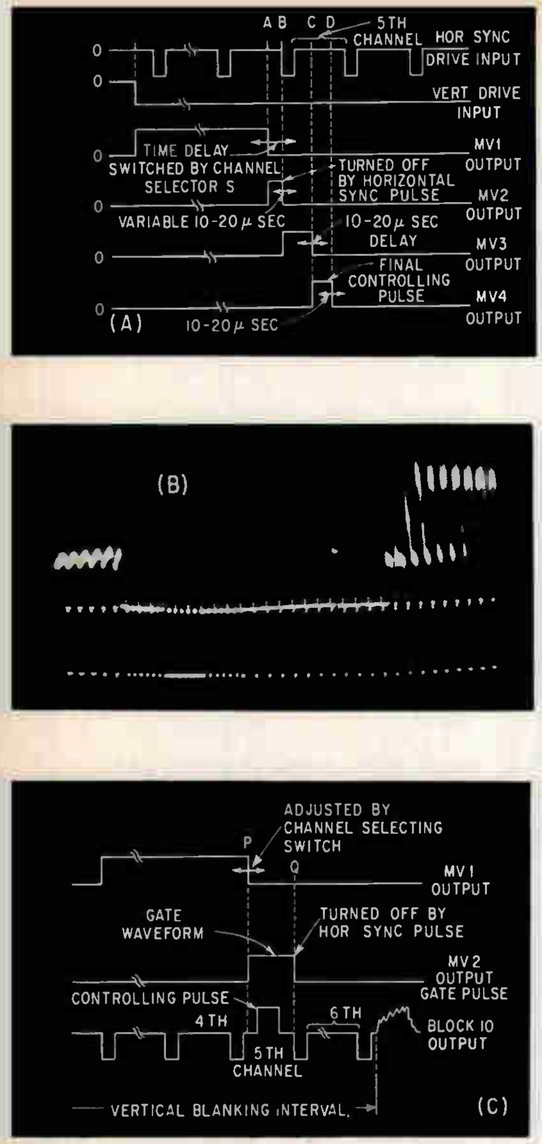


FIG. 2—Waveforms of the transmitting section of the control system (A); photograph of the composite video and control waveform (B); waveforms leading to the decoding of the control pulse in the receiver (C)

sync pulse is generated by the picture control circuits. This sync pulse is amplified and shaped, then used to return the *MV*2 to its OFF state. In going OFF, multivibrator *MV*2 produces a positive-going output coincident with the leading edge of the sync pulse shown at *B* in Fig. 2A.

The output at *B* from the bistable multivibrator is amplified and shaped and turns a monostable delay multivibrator, *MV*3, ON. This multivibrator is timed to return to its OFF state about 10 to 20 microseconds after being turned ON, so its output will occur between the correct pair of sync pulses at time *C*.

When *MV*3 returns to its OFF state it produces a positive output. After amplification, the *MV*3 output pulse is differentiated and clipped to provide a positive trigger for the final pulse generator circuit.

The final pulse generator, *MV*4, is a monostable multivibrator having an output adjustable between the limits of 10 and 20 microseconds. When triggered by *MV*3 it develops the controlling pulse shown at *CD* in Fig. 2A. After amplification, this final modulating pulse is fed to the cathode of the main-line video amplifier, causing control pulses to be broadcast with picture signals.

The control system receivers are located wherever they are required to introduce program changes at the command of the main transmitting station. The receiver interprets the transmitted signal and carries out the preselected switching functions by magnetic relays.

The receiver decodes the incoming control pulse by generating a gating waveform during the channel interval that is being interrogated. If, or when, the control pulses occur in this same channel interval, they are passed through the gating circuit, and ultimately operate the switching relays already mentioned.

As in the transmitting sections, the vertical blanking pulse triggers a channel-selecting monostable multivibrator (*MV*1, Fig. 3A) whose timing is set by the channel selector

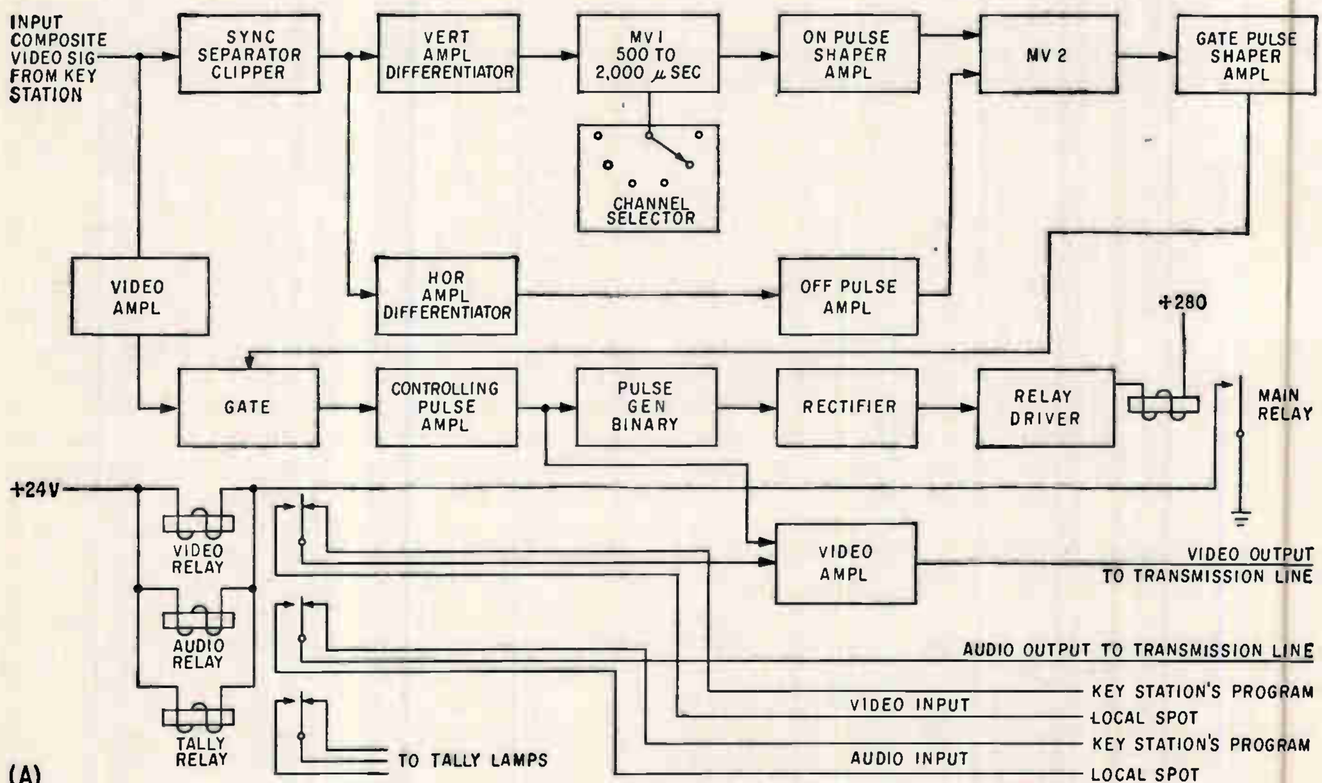


FIG. 3—Receiver diagram shows how the control pulse is gated to the relay circuit where it produces the transmitter

switch. Receiver waveforms are shown in Fig. 2C. In the receiver, however, unlike in the transmitter, the delay period is adjusted so that the trailing edge of the channel-selecting waveform arrives just after the sync pulse that marks the beginning of the selected channel. (In the transmitter section it occurs just before this sync pulse.)

Output from *MV*1 triggers bistable multivibrator *MV*2, turning this to its ON state. Output from *MV*2, whose leading edge is shown at *P* in Fig. 2C, provides the gating waveform. At the end of the fifth channel interval, *MV*2 is returned to its OFF state by the following sync pulse. The bistable multivibrator is ON from shortly after the sync pulse at the beginning of the scan until the arrival of the pulse at the end of it. In doing so, it adequately spans the fifth channel interval.

The positive going waveform from the gate pulse shaper amplifier is fed to the suppressor grid of the gate (Fig 3A and B). The video signal input, containing the control pulse, is fed to the control grid of the gate. If the gate and control pulses occur in the same interval, that is, in the same channel, the control pulse will be amplified by the gate tube and appear at its anode as a negative-going pulse.

Assuming that the gate and control pulses coincide, the amplified output from the gate pentode is fed to the cathode of a pulse generating binary circuit. This binary circuit converts a pulse of some 10 to 20 microseconds width to a much wider pulse. Output from the binary is fed to a rectifier. The positive output from this rectifier overcomes the cathode bias on the relay driver, causing it to conduct, thereby energizing the relay in its anode circuit.

The pentode-driven main relay operates auxiliary relays, which perform the required switching functions.

Provision is made for the local booster station to pass on the control signal even when this station is sending out its own local program. This is done by feeding the amplified output from the gating circuit to the local stations, video amplifier, where it inserts the control pulse in the transmitted output.

In designing this device, the authors are indebted to many friends of JOBK-TV for their friendliness and cooperation, and are especially grateful to Mr. Kajiki, Chief of Tv Technical Section, and to Mr. Osugi, Chief of Tv Control Division, for their guidance and encouragement.

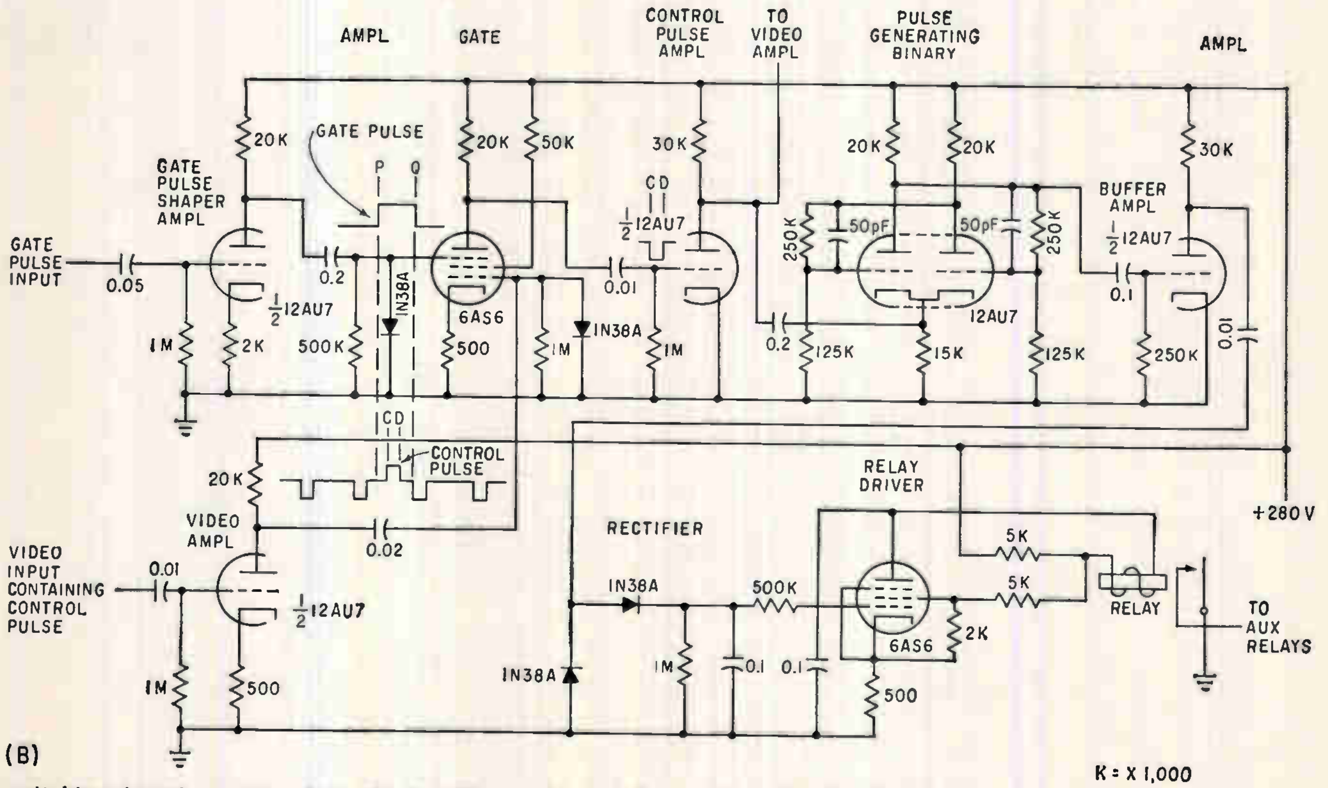
INCREASING FLEXIBILITY

The aove description has shown how this system switches between remote and local-station broadcast.

Perhaps additional modifications might permit a system to have even more flexible control over a local station's program matter.

Suppose the control station wants to switch all locals stations that are on channel 5 to field-pickup transmission, then local broadcast, and then switch back to remote broadcast.

Provision could be made at the transmitter to send a control pulse at a 30-cps rate, rather than a 60-cps rate. Additional circuits, including a 30-cps filter, at the receiver could switch a control relay that would switch the local station to field pickup during the time the control pulse is being transmitted at a 30-cps rate. When the control transmitter starts sending its control pulse at a 60-cps rate, it switches local stations to local broadcast. When the control transmission stops, local stations switch back to remote broadcast.



(B)

switching functions (A); Only the decoding portion of the receiver circuit (B) differs markedly from the transmitter

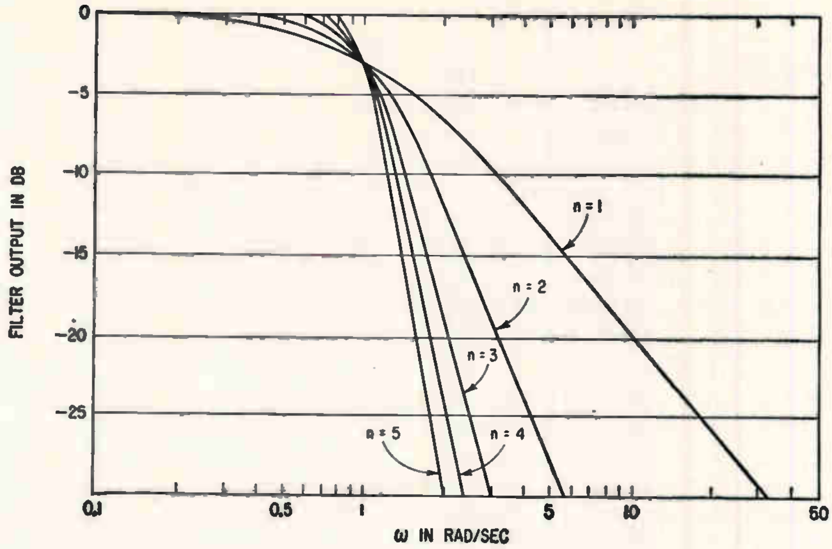


FIG. 1—Frequency response curves for Butterworth low-pass filters with 1 rad/sec cutoff frequency

Selecting R-C Values For

Filters characterized by no output at infinite frequency or at zero frequency can be realized with R-C circuit configuration. Symmetry of network voltage transfer function allows R-C component values to be determined by coefficient-matching technique

PROBLEMS of weight, small dynamic range and sensitivity to hum are definite limitations to the physical realization of electrical filters using passive R-L-C components only. Moreover, specifications that call for very low filter cutoff frequencies make design with inductance in the circuit especially impractical. A remedy for these difficulties lies in the use of so-called active R-C networks.

An active R-C network has no need of inductance as a circuit parameter; instead, resistors, capacitors and vacuum tubes (or transistors) are arranged in suitable feedback configurations for filter design realization. Many useful applications can be found in the literature.[1,2] Furthermore, several manufacturers now market adjust-

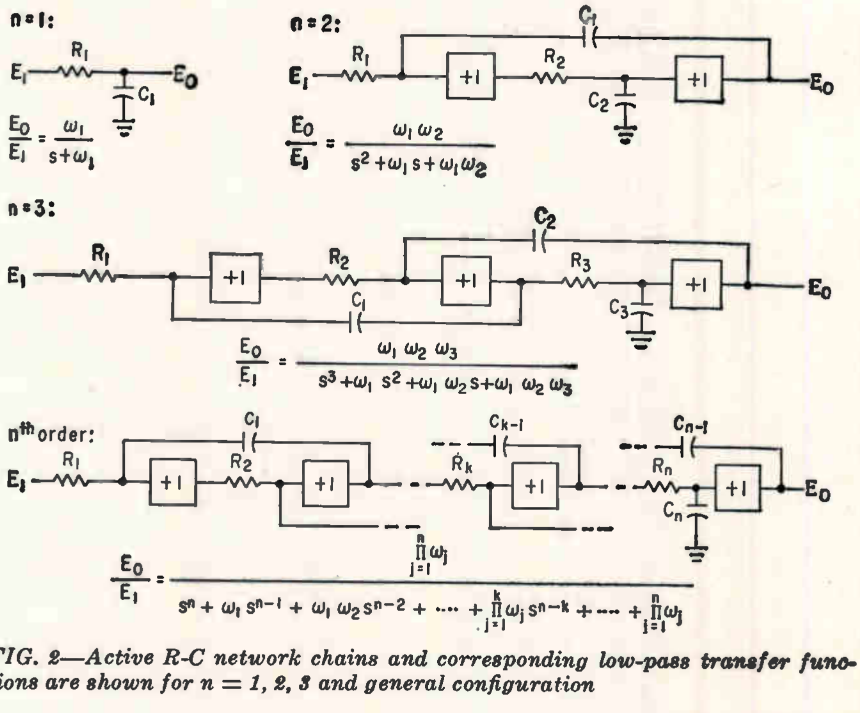


FIG. 2—Active R-C network chains and corresponding low-pass transfer functions are shown for n = 1, 2, 3 and general configuration

TABLE I—BUTTERWORTH LOW-PASS FILTER TRANSFER FUNCTIONS[4]

Order	Expanded Form	Factored Form
$n = 1$	$\frac{E_0}{E_1} = \frac{K}{(s+B)}$	$\frac{E_0}{E_1} = \frac{K}{(s+B)}$
$n = 2$	$\frac{E_0}{E_1} = \frac{K}{(s^2+1.414Bs+B^2)}$	$\frac{E_0}{E_1} = \frac{K}{(s^2+1.414Bs+B^2)}$
$n = 3$	$\frac{E_0}{E_1} = \frac{K}{s^3+2Bs^2+2B^2s+B^2}$	$\frac{E_0}{E_1} = \frac{K}{(s+B)(s^2+Bs+B^2)}$
$n = 4$	$\frac{E_0}{E_1} = \frac{K}{(s^4+2.613Bs^3+3.414B^2s^2+2.613B^3s+B^4)}$	$\frac{E_0}{E_1} = \frac{K}{(s^2+0.7653Bs+B^2)(s^2+1.8477Bs+B^2)}$
$n = 5$	$\frac{E_0}{E_1} = \frac{K}{(s^5+3.236Bs^4+5.236B^2s^3+5.236B^3s^2+3.236B^4s+B^5)}$	$\frac{E_0}{E_1} = \frac{K}{(s+B)(s^2+0.618Bs+B^2)(s^2+1.618Bs+B^2)}$

Active Filters

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able filters of the active R-C type.

In spite of the progress already made in the field of active filter theory, there is still needless complexity associated with active R-C filter design. This article describes a novel R-C circuit configuration that affords easy realization of a useful class of filters. These filters are characterized by zeros of transmission (no output) at infinite frequency (low-pass type) or at zero frequency (high-pass type). Bandpass and band-rejection filters can also be realized by proper combination of low- and high-pass sections.

The usefulness of the basic configuration results from the symmetry of the network voltage transfer function (ratio of the Laplace transform of output voltage to the Laplace transform of input voltage), allowing R-C component values to be readily determined by the technique of coefficient matching. Also important is the fact that, for most designs, interstage buffering can be accomplished by simple cathode or emitter followers.

Specifications for a filter design are usually given in terms of bandwidth, center frequency (for a bandpass filter), allowable ripple of the frequency characteristic in both pass and stop bands, and, rate of attenuation beyond the cutoff frequency. (Cutoff is usually the frequency at which the filter output is 3 db below the normal pass band level.) Sometimes the filter transient response is a critical factor and additional specifications must be given to define percent overshoot, rise time and settling time.

Once the necessary transfer function has been determined, the designer has the choice of using either passive R-L-C or active R-C networks for realization. While the purpose of this article is to describe a novel, active R-C circuit configuration for easy realization of filter transfer functions, it is not feasible to discuss the determination of a transfer function from a given set of specifications. For this reason, a particular set of filter functions, widely used in engineering practice, will form the basis for the following discussion of active R-C realization. This set, representing the Butterworth filter functions, is characterized by a frequency response that is maximally flat within the pass band with an attenuation rate beyond the cutoff point of 6 db per octave per section. In addition, the transient response of a Butterworth filter is usually satisfactory for most applications, although the percent overshoot becomes greater as the order (number of sections) of the filter increases.

In Table I, Butterworth low-pass filter transfer functions are listed for orders through $n = 5$. The filter bandwidth, B, is given in radians per second. Shown in Fig. 1 are the corresponding frequency response curves found from the filter transfer function by setting $s = j\omega$. (The complex frequency variable of the Laplace tranform is $s = \sigma + j\omega$.)

Easy realization of filter transfer functions like those listed in Table I can be accomplished with the active R-C network chains shown in Fig. 2. The +1 symbols are unity-gain buffer stages; for analysis it can be assumed that the input impedance is infinite and the output impedance is zero. The distinguishing topological feature of the network is the "chaining" of feedback elements (capacitors in the low-pass case) from the output of one stage to the input of the preceding one, except for the last section where the feedback element is grounded.

Network transfer functions can be derived in each case by applying Kirchoff's current law ($\Sigma i = 0$) to each independent node and solving the resulting set of simultaneous equations. Figure 2 includes the voltage transfer functions for $n =$

1, 2, 3 and the general nth order configuration where s is the complex variable ($s = \sigma + j\omega$) and ω_k is the frequency constant for the kth section ($\omega_k = 1/R_kC_k$). It is important to notice the basic symmetry of the transfer function denominators; that is, the fact that the frequency constants are introduced one by one, from left to right. It is this fact that allows for easy filter realization, which is done merely by matching the denominator coefficients of the circuits of Fig. 2 to corresponding coefficients of the desired filter transfer functions of the same order (as in Table I). For instance, a low-pass filter having a desired transfer function

$$\frac{E_0}{E_1} = \frac{K}{s^n + a_1 s^{n-1} + a_2 s^{n-2} + \cdots + a_k s^{n-k} + \cdots + a_n} \quad (1)$$

can be realized with the nth order chain of Fig. 2. Transfer function, repeated here for convenience, is

$$\frac{E_0}{E_1} = \frac{\prod_{j=1}^{n} \omega_j}{s^n + \omega_1 s^{n-1} + \omega_1\omega_2 s^{n-2} + \cdots + \prod_{j=1}^{k} \omega_j s^{n-k} + \cdots + \prod_{j=1}^{n} \omega_j}, \quad (2)$$

where the Π indicates a continued product $\left(\prod_{j=1}^{k} \omega_j = \omega_1\omega_2\omega_3 \cdots \omega_k\right)$. The frequency constants can now be determined by equating corresponding denominator coefficients in Eq. (1) and (2); thus, $\omega_1 = a_1$, $\omega_1\omega_2 = a_2 \ldots \prod_{j=1}^{n} \omega_j = a_n$, and $\omega_2 = a_2/a_1 \ldots \omega_n = a_n/a_{n-1}$.

The designer can now choose the value of either R or C for a section while determining the other from the relation $\omega_k = 1/R_kC_k$. In addition, it is seen that, ideally, the insertion loss in the pass band is 0 db for the R-C chain. One design consideration is to negate the effect of finite follower input and output impedance by proper choice of section impedance level. This is hardly a design restriction, however.

The procedure just outlined has been applied to the realization of a fifth-order Butterworth low-pass filter with cutoff frequency at 25 cps. Several identical units were built for the purpose of filtering the output channels of a narrow-band speech-compression system. A simple diagram for realization of the fifth-order filter is shown in Fig. 3A. Design values were determined by matching coefficients of the transfer function for $n = 5$ in the first column of Table I to those for the fifth-order R-C chain transfer function to obtain $\omega_1 = 3.236\,B$, $\omega_1\omega_2 = 5.236\,B^2$, and so forth. This yields $\omega_2 = 5.236B/3.236$, $\omega_3 = B$, $\omega_4 = 3.236B/5.236$, $\omega_5 = B/3.236$, and, finally, $C_1 = 0.309/BR_1$, $C_2 = 0.618/BR_2$, $C_3 = 1/BR_3$, $C_4 = 1.62/BR_4$, and $C_5 = 3.24/BR_5$.

The final filter realization is shown in the circuit diagram of Fig. 3B, for $B = 25 \times 2\pi$ radians per second and $R = 100{,}000$ ohms. Even with all resistor values set equal, the spread of the C values is only about ten to one. A frequency response characteristic for the circuit is shown in Fig. 3C, along with the time response to a 5-cps square wave. Although R-C component values were adjusted to ±1 percent, the cathode follower gains were slightly less than unity. Even so, the average cutoff frequency for those units tested was only 4 percent below design value of 25 cps. The average insertion loss in the pass band was 3 db.

High-pass filters (zeros of transmission at zero frequency) can also be realized using the techniques outlined thus far. The basic active R-C configurations of Fig. 2 need to be modified only to the extent of interchanging the resistors and capacitors. The transfer functions for the high-pass forms exhibit a sort of reverse symmetry; for example, for the nth order configuration.

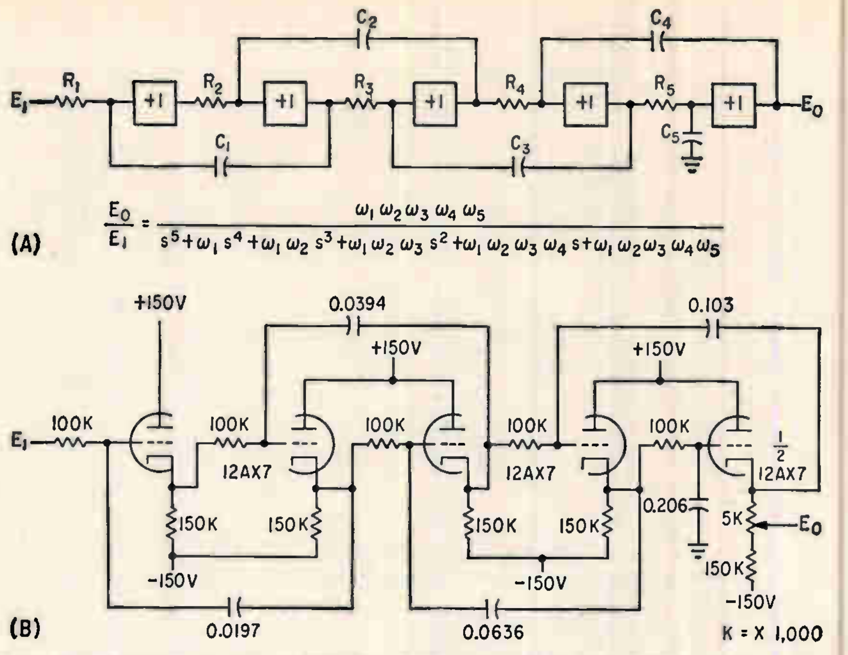
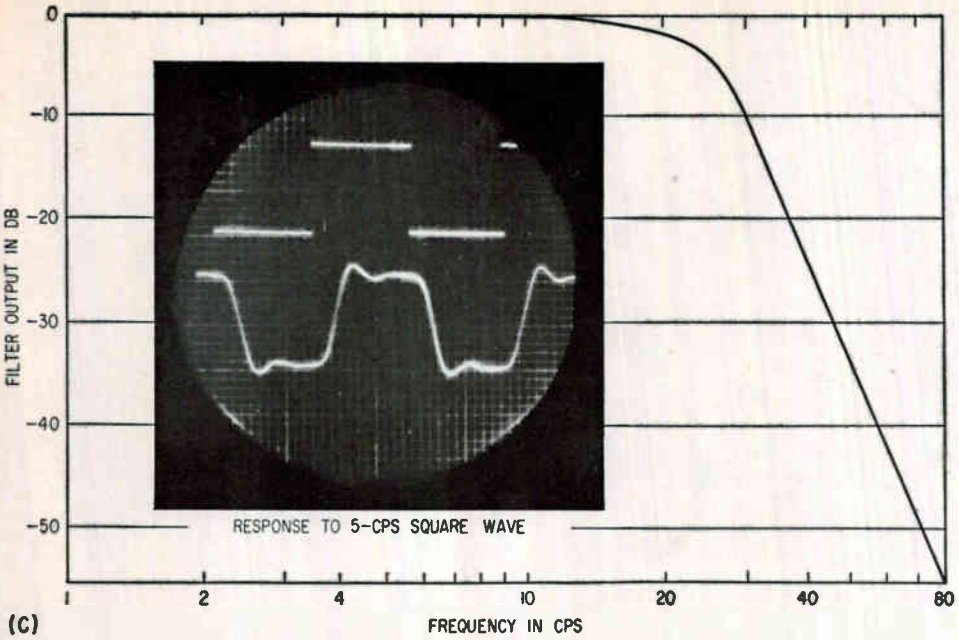


FIG. 3—Network configuration for fifth-order low-pass filter (A) leads to

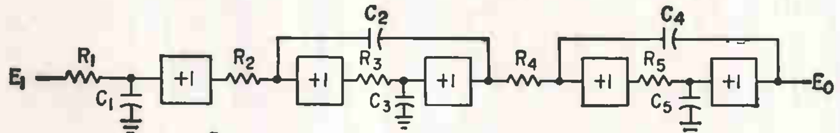
TABLE II — FUNCTIONS FOR NON-UNITY GAIN BUFFERS

Order	Transfer Function (E_0/E_1)
$n = 2$	$\frac{K^2\omega_1\omega_2}{s^2+[\omega_1+(1-K^2)\omega_2]s+\omega_1\omega_2}$
$n = 3$	$\frac{K^3\omega_1\omega_2\omega_3}{s^3+[\omega_1+(1-K^2)(\omega_2+\omega_3)]s^2+[\omega_1\omega_2+(1-K^2)(\omega_1\omega_3+\omega_2\omega_3)]s+\omega_1\omega_2\omega_3}$
$n = 4$	$K^4\omega_1\omega_2\omega_3\omega_4/\{s^4+[\omega_1+(1-K^2)(\omega_2+\omega_3+\omega_4)]s^3+[\omega_1\omega_2+(1-K^2)(\omega_1\omega_3+\omega_1\omega_4+\omega_2\omega_3+\omega_2\omega_4+\omega_3\omega_4)]s^2+[\omega_1\omega_2\omega_3+(1-K^2)(\omega_1\omega_3\omega_4+\omega_1\omega_2\omega_4+\omega_2\omega_3\omega_4)]s+\omega_1\omega_2\omega_3\omega_4\}$



(C)

actual circuit (B) with frequency and transient response as shown in (C)



$$\frac{E_0}{E_1} = \frac{\omega_1\,\omega_2\,\omega_3\,\omega_4\,\omega_5}{(s+\omega_1)\,(s^2+\omega_2 s+\omega_2\omega_3)\,(s^2+\omega_4 s+\omega_4\omega_5)}$$

FIG. 4—Alternate form for fifth-order low-pass filter

$$\frac{E_0}{E_1} = \frac{s^n}{s^n + \omega_n s^{n-1} + \omega_n\omega_{n-1}s^{n-2} + \cdots + \prod_{j=k+1}^{n} \omega_j s^{n-k} + \cdots + \prod_{j=1}^{n} \omega_j} \quad (3)$$

It should be noted that the frequency constants are introduced here in reverse order to that of the low-pass case. Transfer functions for Butterworth high-pass filters are the same as those listed in Table I except that the numerators are multiplied by s raised to a power equal to the order of the filter. For instance, the third-order Butterworth filter transfer function becomes for the high-pass case

$$\frac{E_0}{E_1} = \frac{Ks^3}{s^3+2Bs^2+2B^2s+B^3} \quad (4)$$

Component values can again be determined by coefficient matching as outlined previously.

Bandpass filtering can be accomplished effectively by cascading the desired order low- and high-pass filters. Actually, in classical filter theory the bandpass filter transfer function is usually determined from a low-pass prototype transfer function by replacing the variable s by $(s^2 + \omega_o^2)/s$, where ω_o is the center of the band. Unfortunately, the resulting transfer function cannot be realized with the active R-C chain unless inductance is added to the network. In practice, however, merely cascading low- and high-pass sections is satisfactory for most bandpass applications. Band-rejection filtering can be accomplished similarly by suitably adding the outputs of low- and high-pass sections of the desired order.

Any of the filter functions discussed previously can be alternately realized by cascading the proper number of first and second order networks shown in Fig. 2. To use this method, the denominator of the desired transfer function must be expressed as the product of linear and quadratic factors, as shown in the second column of Table I.

It should be noted that when networks are cascaded with proper buffering, the overall system transfer function can be determined by multiplying individual network transfer functions together.

As an illustration of the alternate procedure, the fifth-order Butterworth low-pass filter derived previously will be redesigned. Shown in Fig. 4 is the necessary combination of first and second-order chains for realizing a fifth-order filter. The resulting transfer function, shown in Fig. 4, can be matched to the transfer function for $n = 5$ in the second column of Table 1 to obtain $\omega_1 = B$, $\omega_2 = 0.618B$, $\omega_2\omega_3 = B^2$, $\omega_4 = 1.618B$ and $\omega_4\omega_5 = B^2$. This yields $\omega_3 = B/0.618$, $\omega_5 = B/1.618$, and, finally, $C_1 = 1/BR_1$, $C_2 = 1.62/BR_2$, $C_3 = 0.618/BR_3$, $C_4 = 0.618/BR_4$, and $C_5 = 1.62/BR_5$.

When all resistor values are set equal, the spread of capacitor values is only three to one. The disadvantage of this method, however, is the necessity for factoring the desired transfer function denominator, which is a tedious process for a high-order filter.

An analysis of the circuit configurations given in Fig. 2 for buffer stages of gain K shows that the transfer functions are modified as indicated in Table II. From Table II, it is seen that the effect of nonunity gain buffers appears in predictable fashion and can be deduced for any number of stages.

It was found that the use of simple cathode followers (12AX7's) in the design of the fifth-order Butterworth low-pass filter contributed less than 4 percent error in cutoff frequency and much less than that in attenuation rate beyond the cutoff point. It would be expected, though, that the gain-stability problem would be more critical in the case of a bandpass design. However, if specifications are tight, it is possible to employ augmented cathode followers[3] to achieve stable unity-gain buffer stages.

This work was originally done under contract with AFCRC. The author wishes to thank S. H. Chang and R. E. Scott for their encouragement and helpful criticism.

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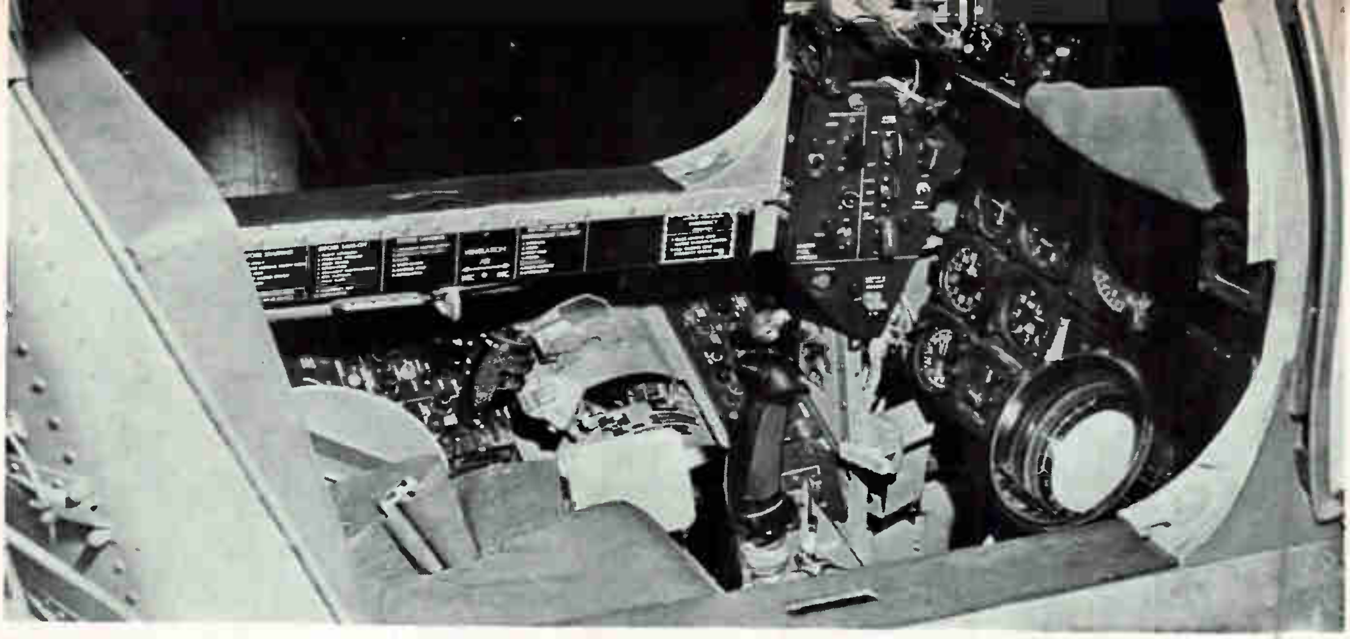

Pilot's cockpit of simulator. In operation, radar scope at lower right displays data from GCI

Using Ground-Control Radar

TO IMPROVE FLIGHT SIMULATION

By PAUL W. STAIGER,
Field Service Engineer, Melpar, Inc., Falls Church, Va.

A PILOT TRAINING in a flight simulator learns to fly by instruments and his instruction includes making GCI (Ground Controlled Intercept) interceptions of enemy aircraft. However, he doesn't normally come under the control of a GCI director until he flies an aircraft. The system to be described ties an F-86 Flight Simulator into standard operational GCI equipment, the simulator being over two miles away from the GCI site.

As in the normal case, a flight-interception problem is set up in the simulator by an instructor. Interceptor and target positions are recorded by pens on a plotting board which the pilot does not see. (Fig. 1). The lower left corner of the plotting board is the reference point, the GCI site, from which the pens may record distances up to 150 miles in north and east directions from the GCI site.

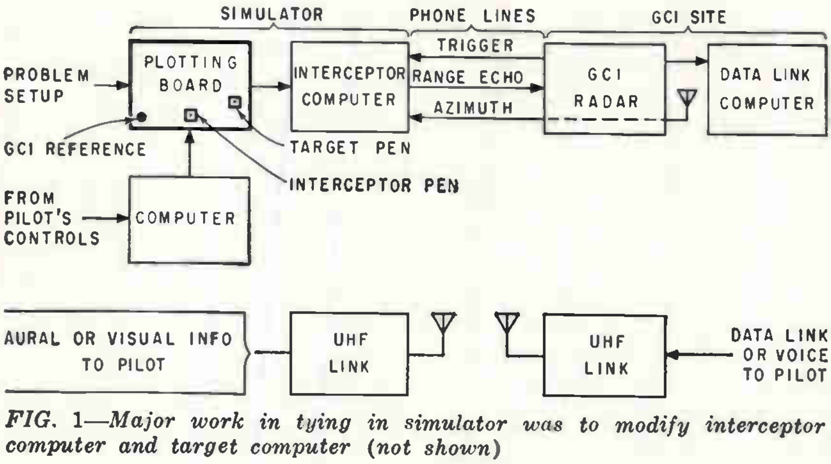

FIG. 1—Major work in tying in simulator was to modify interceptor computer and target computer (not shown)

Interceptor and target-position computers convert information from the plotting board into range and azimuth data. Since the target computer is the same as the interceptor computer, only the interceptor computer is shown in Fig. 1 and only it will be discussed.

Telephone lines between GCI site and interceptor carry trigger pulses from the GCI radar to the interceptor computer. Ensuing range-echo pulses from the computer are gated to the GCI only when GCI-radar-antenna aximuth is the same as the azimuth of the interceptor. Thus, the range echo pulse provides azimuth information and range.

The GCI director sees interceptor and target positions on his scope, and uses the data-link computer to calculate the interception solution. A uhf link carries steering information to the pilot; this information is either voice instruction or instrument display. The uhf link also enables the GCI director and pilot to discuss a problem.

As indicated in Fig. 2, a computer sums voltages that are determined by the positions of power, aileron, elevator, and rudder con-

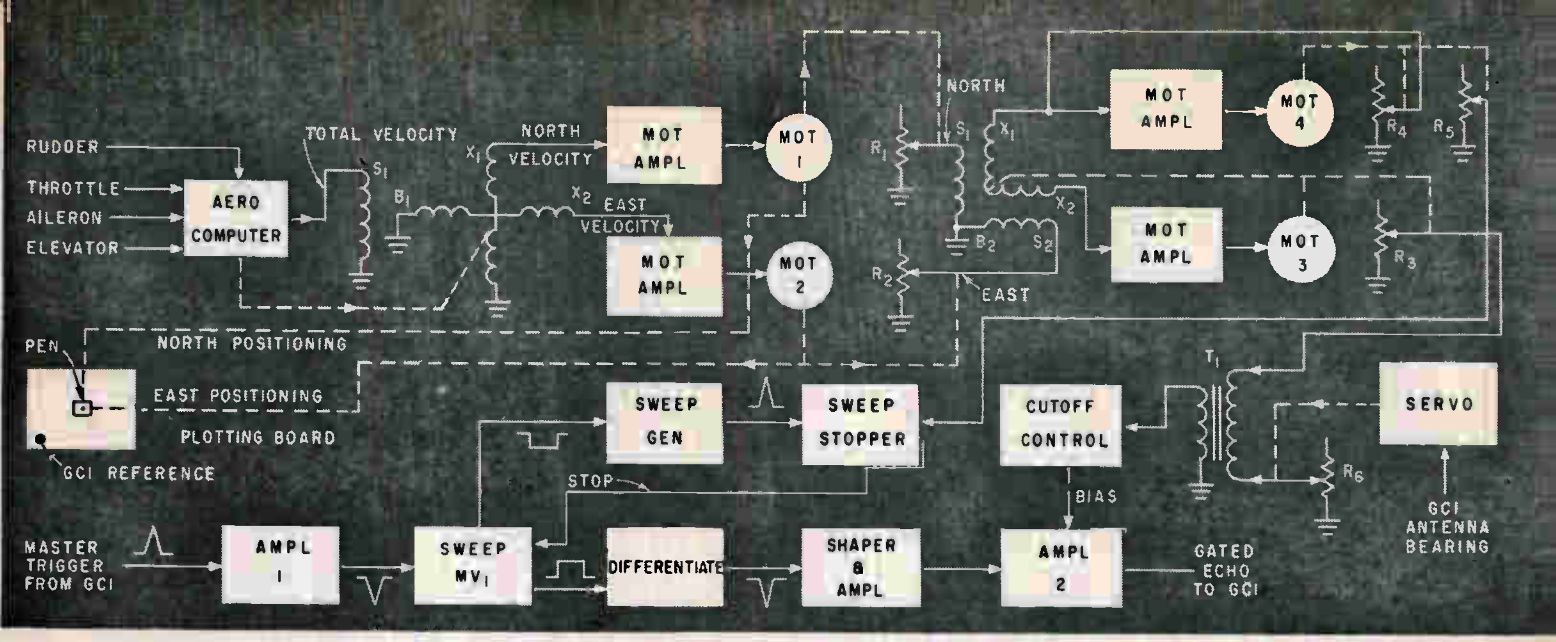

FIG. 2—Simulator-GCI tie-in of interceptor. Target tie-in arrangement, which is not shown, is similar

trols. The total velocity (amplitude) and heading (phase) go to resolver B_1, which resolves velocity into north and east components.

North and east servos (*MOT* 1 and 2) drive the interceptor pen in the required direction by pulleys and spools. The rate at which the pen drives up or down (north or south) and right or left (east or west) depends upon the amplitude and phase of the velocity input to resolver B_1.

The north and east servos each drive potentiometers indexed for zero output voltage when the pen is at the bottom of the plotting board and the carriage is at the left side. Output of these potentiometers (R_1 and R_2) represents the distance that the interceptor pen is north east of the GCI reference point.

Modification of the simulator begins at this point, with the application of potentiometer outputs to the stator windings of resolver B_2.

The voltage induced in rotor winding X_2 is fed through a motor amplifier to *MOT* 3, which positions X_2 to null out the induced voltage. The arm of R_3 is also positioned by *MOT* 3. Null positions of rotor winding X_2 and the voltage at the arm of R_3 represent interceptor bearing from GCI. After the rotor of B_2 has reached a null position, the voltage induced in rotor winding X_1 represents the vectorial sum of the voltages corresponding to the interceptor north and east positions.

The voltage from X_1 is fed through a motor amplifier to *MOT* 4, which positions the arms of R_4 and R_5. Motor 4 rotates until the feedback voltage from R_4 nulls out the voltage from rotor winding X_1. This action also positions the arm of R_5, whose voltage corresponds to the interceptor range from GCI.

The master trigger pulses from GCI go to isolation amplifier 1, which is coupled to a sweep multivibrator, MV_1. Upon application of the master trigger, MV_1 flips, triggering the sweep generator. The sweep's sawtooth output is linear, and if allowed to charge to maximum, charges to +250 v d-c in 2,460 μsec (200 miles). A sweep stopper circuit receives this positive-going sawtooth.

Potentiometer R_5 has 250 v d-c across its terminals; since its output is directly proportional to range, zero range is equivalent to zero v d-c and a 200-mile range corresponds to +250 v d-c. When the sawtooth voltage, which represents the GCI radar sweep range, and the output of R_5, which represents the interceptor range from GCI, become equal, the sweep stopper triggers. Sweep multivibrator MV_1 now flops, stopping the sweep.

The trailing edge of each square-wave output of MV_1 occurs at the time that corresponds to the interceptor range echo. By applying this square wave to a differentiating circuit, and then to a shaping amplifier, the leading edge is removed and the trailing edge shaped. This shaped range pulse is then applied to amplifier 2 of a radar echo-gating circuit. Amplifier 2 is normally biased at cutoff by a cutoff control.

The echo-gating circuit prevents the interceptor range echo from appearing on the GCI scopes as a continuous ring. A range echo goes to GCI only when the GCI antenna bearing agrees with the bearing of the interceptor pen to the GCI reference point on the plotting board.

Since the GCI antenna bearing must be available at the simulator site, synchronous voltage is transmitted from the GCI antenna-drive motor over telephone lines to a repeater servo at the simulator site. Potentiometer R_6 is coupled to this servo and used to represent the bearing of the GCI antenna and sweep.

The antenna-bearing voltage from R_6 goes to one end of T_1; the other end of T_1 receives the interceptor-bearing voltage from R_3. When the voltage from R_6 is equal in amplitude and phase to the voltage from R_3, no voltage is induced in the secondary of T_1. Absence of this voltage causes the cutoff control to remove the cutoff voltage applied to amplifier 2, permitting the interceptor radar echo to be amplified by amplifier 2 and to go to the GCI.

The author acknowledges the assistance of R. F. Rundell in the preparation of this manuscript. The U. S. Air Force, Moody A. F. Base, Georgia, sponsored the work described in this article.

GAIN-PHASE MEASUREMENTS IN

Feedback Amplifiers

Test circuits show how to accurately measure gain and phase angle characteristics of closed-loop amplifiers

By M. SCHREIBMAN
Industrial Test Equipment Co., New York, N. Y.

PRECISE MEASUREMENT of gain and phase angle characteristics is an important consideration in the development of synchro, computer, resolver and other closed-loop amplifiers. Usually the function of these amplifiers is to provide a constant overall gain and a phase shift close to zero or 180 degrees. Often the precision called for in both gain and phase shift makes it impossible to use ordinary methods of measurement and so it is necessary to use special measuring techniques.

A particular, but often used type of closed-loop amplifier, is that in which unity gain and zero phase shift are simultaneously required. If such an amplifier could be built perfectly and be free of distortions, the output signal would be identical to that of the input.

If the output of this ideal amplifier were connected in a series opposing manner to the input of the amplifier, as illustrated in Fig. 1A, the difference voltage appearing at the input to the detector would be zero. However, since a distortionless amplifier is not feasible, there will generally be a fair amount of distortion contained in the difference voltage. Also, if the amplifier does not maintain a perfect unity gain, there will be an in-phase voltage component appearing in the difference voltage. Similarly, if the amplifier does not maintain a perfect zero-degree phase shift, there will be an additional quadrature voltage component appearing in the difference voltage.

For the small angles considered, these differences in in-phase and quadrature components are directly proportional to the respective errors in amplitude ratio and phase shift of the amplifier. If the detector shown in Fig. 1A could measure the in-phase and quadrature components of the difference voltage independently, the error in amplitude ratio and total phase shift could then be read directly.

To illustrate this application, consider an amplifier, connected as shown in Fig. 1A, which has a nominal gain of one and a nominal phase shift of zero degrees. To add realism, assume the noise and harmonic distortion is 0.1 percent.

When a signal of 10 v is applied to the input of the amplifier, the difference voltage components as read on the detector are +10 mv in phase and +17 mv quadrature. The actual ratio of output to input of the amplifier is 10.01 v/10 v or 1.001, the phase shift is 17 mv/10 v or 0.0017 radians (0.1 degrees), and the magnitude of the noise and harmonic distortion components appearing in the difference voltage is 10 mv. Since this is the same order of magnitude as the fundamental components being measured, it would be necessary for the detector to reject these undesirable signals to a point where the measurement accuracy is not affected.

The interesting feature of this type of measurement is its accuracy. All errors in measurement apply only to the difference voltages. For example, if in the preceding example the accuracy of measurement of the difference component was limited to 10 percent, the maximum error in the overall measurement would be 0.01 percent for gain and 0.01 degree for phase shift.

If the output of the amplifier is nominally 180 degrees out-of-phase with the input and a common ground exists between the two, the circuit of Fig. 1B can be used. In this circuit, precision matched resistors R_1 and R_2 are used to derive the difference voltage. The two resistors used should be of the same type so that their reactances will be matched. The value of the resistors should be as low as possible, but not low enough to load down the amplifier. Generally, 100,000 ohm to 500,000 ohm resistors are suitable.

If the input and output of the amplifier have a common ground and the nominal phase shift is zero degrees, then the circuit configurations shown in parts C and D of Fig. 1 will apply. In Fig. 1C, isolation transformer T_1 is used to transfer the difference voltage to the detector. This arrangement permits grounding of the detector circuit, a condition which should always be adhered to when measuring small difference voltages. The transformers used in this case should have a low phase shift and a known transformation ratio. However, these characteristics are not critical as they will have only a

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second order effect on the accuracy of the measurement. Since it is possible for the transformer to load the output of the amplifier, the circuit in Fig. 1C should only be used when the output impedance of the amplifier is low, that is, 100 ohms or less.

If the output impedance of the amplifier is high, the circuit of Fig. 1D can be used. Here, the transformer does not load the amplifier, but the errors in the transformer will add directly to the errors of the measurement. Thus, a transformer should be used which has zero phase shift and a precise 1:1 transformation ratio. A transformer with characteristics which closely approximate these requirements can be used if the characteristics are precisely known. The transformer error can then be subtracted from the measurements.

Another method of deriving the difference voltage is to use an electronic difference amplifier as shown in Fig. 1E. Only the highest quality difference amplifier can be used because it must resolve accurately a difference voltage which may be in the order of 0.01 percent of the input voltages. Any errors in the difference amplifiers will add directly to the measurement error.

In some cases the required amplifier gain may be greater or less than unity. Since the method which has been described is perfectly general, it will apply to these cases as well. Parts F through J of Fig. 1 illustrate typical circuits for measuring amplifiers with gains of other than unity.

In Fig. 1F, precision resistors R_1 and R_2 are selected so that the ratio $R_2/(R_1 + R_2)$ is equal to the nominal gain of the amplifier. In this case, of course, it would be some value less than one. Care should be taken to select resistors having a minimum capacitive or inductive reactance in order to prevent phase shifts in the attenuator.

In Fig. 1G, the attenuator is placed across the output. In this case gains greater than one can be measured and the resistors are chosen so that $R_2/(R_1 + R_2)$ is equal to the inverse of the gain of the amplifier. The sum of the resistances of R_1 and R_2 should be high enough not to change the amplifier characteristics because of their loading effect.

Figure 1H is essentially the same as Fig. 1B. This circuit can be used equally well for amplifiers with gains of greater or less than unity. The ratio of $R_2:R_1$ should be the same as the nominal gain of the amplifier.

The circuit of Fig. 1I is used for amplifiers with gains of less than unity and where a common ground exists between input and output. The attenuator resistors are selected in the same manner as for the circuit of Fig. 1F.

The circuit configuration in Fig. 1J utilizes a precision transformer for measurements of amplifiers with gains of greater or less than unity. The transformation ratio of the transformer should be equal to the inverse of the nominal gain of the amplifier.

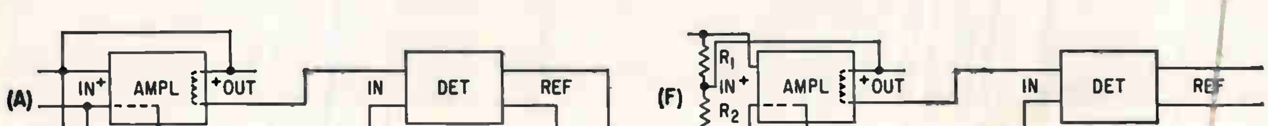
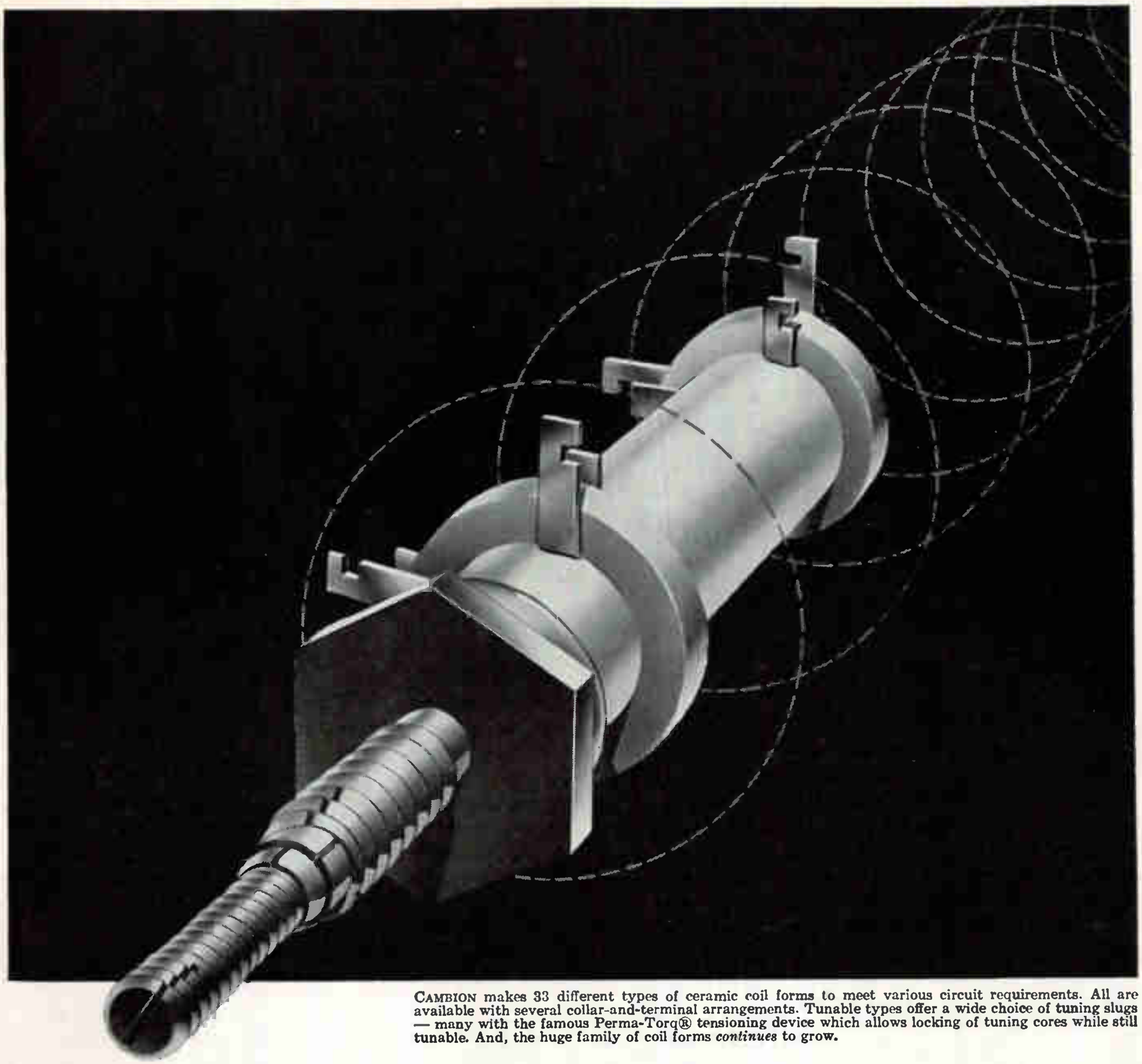


FIG. 1—Test connection for measuring quadrature components and phase shift of amplifiers with units gain (A through E) and gain other than unity (F through J)



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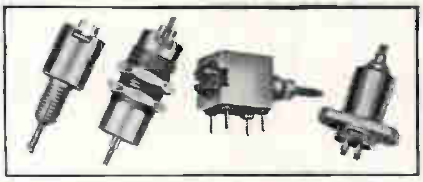

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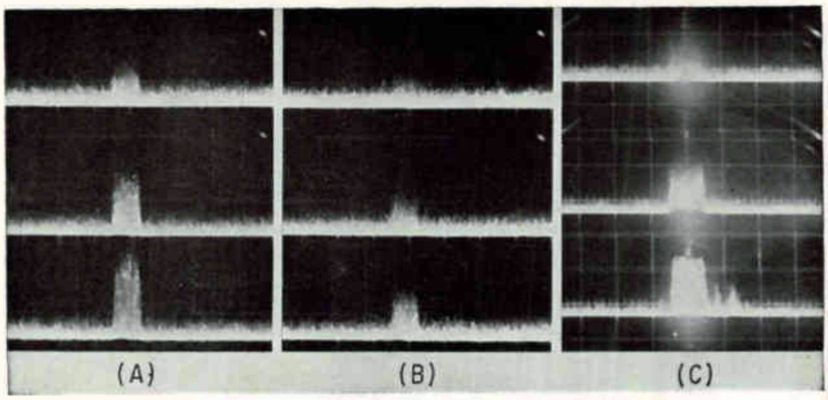
Synchronous Pump Ups Noise Figure

FIFTY-PERCENT increase in effective range of a coho MTI radar was achieved in recent tests at Rome Air Development Center. An electron-beam parametric amplifier operated in a synchronous pumping mode improved receiver sensitivity as much as a five-fold increase in transmitted power.

The equipment was developed by Zenith Radio Corp., and application of synchronous pumping was originally suggested by K. G. Eakin of RADC. The electron-beam parametric amplifier was developed by a research team headed by R. Adler, associate director of research at Zenith, in association with G. Wade, Stanford Electronics Laboratory.



Synchronous detector outputs for large signal (A) and small signal (B) are shown with linear detector output (C). Top traces are for normal receiver, middle traces for nonsynchronous pumping and bottom traces for synchronous pumping

Synchronous Pumping

Conventionally beam-type parametric amplifiers are operated with a pump frequency nearly, but not exactly, twice signal frequency. It had been believed that a pump frequency exactly double the signal frequency (synchronous pumping) would impair performance. It was assumed that noise picked up by the idler channel would be injected into the signal channel. A slight change in frequency was felt necessary to stay outside the passband.

Tests of the equipment confirmed that synchronous pumping permits full use of the low-noise potential of the amplifier in high-performance radars. Minimum detectable signal measurements were made of the bipolar and unipolar video output of the MTI synchronous detector and the video output of the normal linear detector. With synchronous pumping, average improvement in sensitivity was 10 db on the synchronous detector channel and 9 db on the linear detector channel. These figures exceeded the expected 7-db improvement, probably because effective antenna temperature was less than 290 K.

The photographs compare A-scope displays of synchronous and linear detector outputs with nonsynchronous and synchronous pumping. In each case, i-f gain was adjusted to equalize noise levels. For nonsynchronous pumping, an independent signal generator replaced the synchronous pump generator.

The quadrupole amplifier was inserted directly between duplexer and mixer of the existing radar. Since the tube is unidirectional, no circulator or isolator is needed. Input and output impedances are resistive and independent of gain. The existing impedance match is not disturbed nor is stability of the receiving system impaired.

Frequency response of the amplifier used is flat over about 80 Mc centered at 1,300 Mc. It is normally operated at about 20 db gain, although gain can be adjusted from −1 db to more than 30 db by varying pump power.

Bandpass is independent of gain, and at 20-db gain there is only about 1.3 db change in gain for a 10 percent change in pump power.

The broadband noise figure of the amplifier tube is 1.3 db. Without the amplifier, radar system noise figure was 8.5 db; with the amplifier, system noise figure was 1.6 db. No allowance for idler channel effects need be made with synchronous pumping.

Application to Coho

The particular tube used in the tests was developed by R. L. Cohoon at Zenith. In a coho MTI radar system using the new amplifier and synchronous pumping, it is possible to derive a synchronous signal for pumping the parametric amplifier so that signal and idler coincide exactly.

Under these conditions, signal and idler add coherently in the detector and cooperate in producing the output. Since the coherence applies to noise inputs and to the desired echoes alike, no reduction in signal-to-noise ratio results from the presence of the idler channel. Therefore performance attained is characterized by the so-called broadband noise figure of the parametric amplifier, which can be very low.

The pumping signal is generated by doubling the stalo (1,324 Mc) and coho (30 Mc) signals available in the radar and mixing the resulting frequencies. An amplifier and filter select the difference (2,588 Mc), which is exactly twice transmitter frequency (1,294 Mc), and apply it through a phase shifter to the quadrupole pumping structure. With a linear detector, pump phase is of no importance, but an optimum phase exists when MTI is used.

Improvement in sensitivity applies to both the MTI channel using the synchronous detector and to the normal channel with a linear detector because both signal and idler

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SC-32-1.5	0-32	0-1.5	
2SC-32-1.5	0-32	0-1.5	
Dual Output	0-32	0-1.5	
SC-32-2.5	0-32	0-2.5	
SC-32-5	0-32	0-5	
SC-32-10A	0-32	0-10	0.01%
SC-32-15A	0-32	0-15	
SC-60-2	0-60	0-2	
SC-60-5	0-60	0-5	
2SC-100-0.2	0-100	0-0.2	
Dual Output	0-100	0-0.2	
SC-150-1	0-150	0-1	
SC-300-1	0-300	0-1	
SC-18-0.5	0-18	0-0.5	
SC-18-1	0-18	0-1	
SC-18-2	0-18	0-2	
SC-18-4	0-18	0-4	
SC-36-0.5	0-36	0-0.5	0.1%
SC-36-1	0-36	0-1	
SC-36-2	0-36	0-2	
SC-3672-0.5	36-72	0-0.5	
SC-3672-1	36-72	0-1	
PSC- 5-2	0-7.5	0-2	
PSC-10-2	7.5-12.5	0-2	
PSC-15-2	12.5-17.5	0-2	0.02%
PSC-20-2	17.5-22.5	0-2	
PSC-28-1	22.5-32.5	0-1	
PSC-38-1	32.5-42.5	0-1	
HB-2	0-325	0-200 ma.	
HB-4	0-325	0-400 ma.	0.1%
HB-6	0-325	0-600 ma.	
SR12-50	5-13	0-50	
SR28-50	24-32	0-50	0.1%
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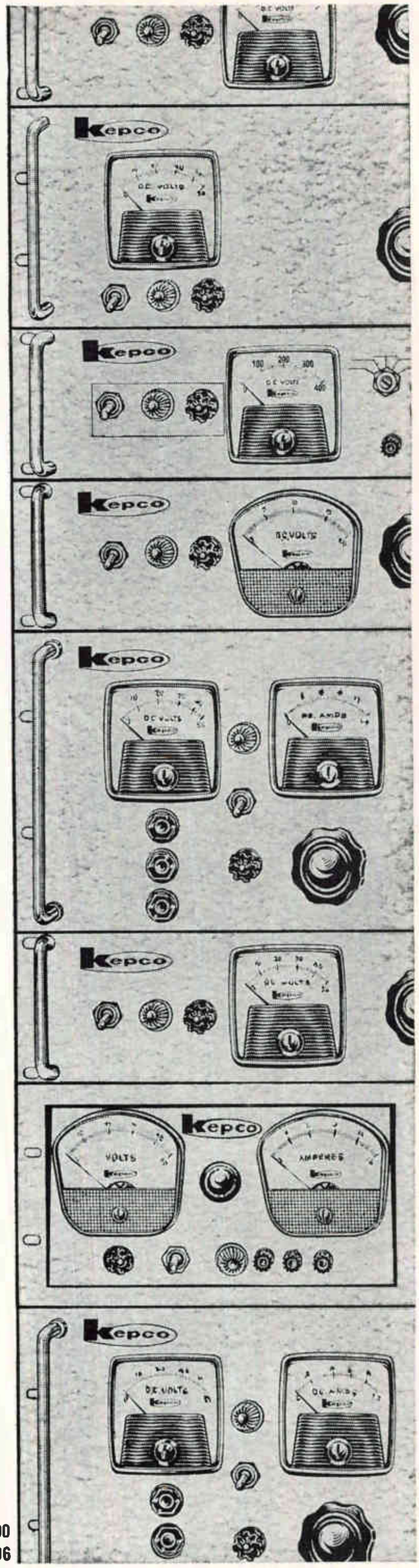
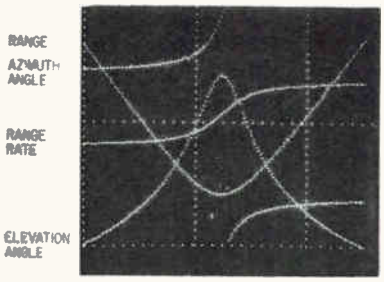


CIRCLE 93 ON READER SERVICE CARD



Transponder beacon enabled horizon-to-horizon radar tracking of Tiros I. Display shows data for first pass

1⅛ hours apart, permitted an accurate determination of the orbit parameters of the new satellite less than 6 hours after launch.

Radar data at 25-30 pps were converted to binary form. The digital data were then fed into the CG24 real-time computer.

The computer averaged the raw data over 6-sec intervals to eliminate extreme variations. The averaged data was accurately time indexed and stored. Data for TWX were punched directly on teletype tape for immediate transmission.

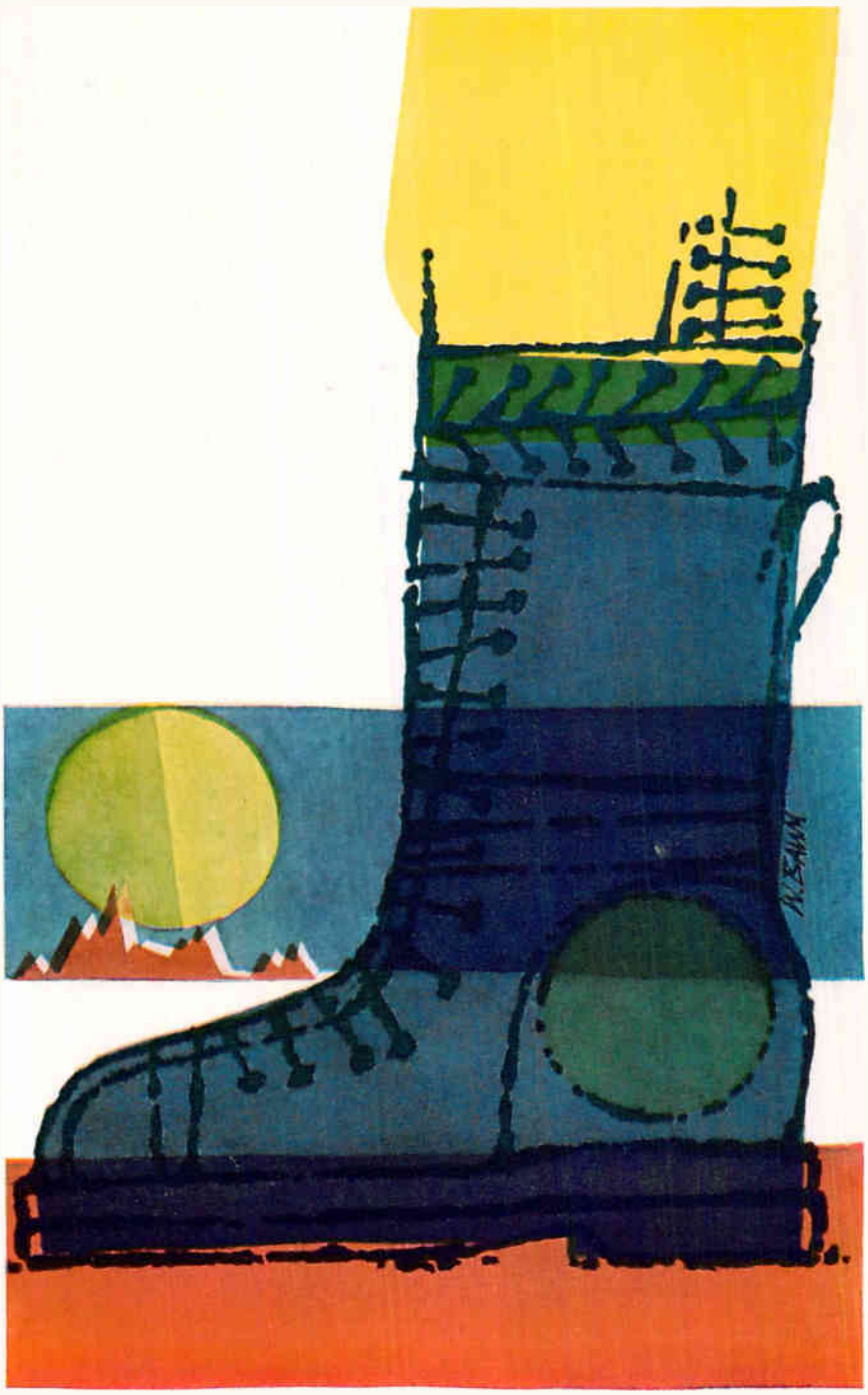
The computer display for the first pass is shown in the photograph. Range, Doppler-acquired range rate, azimuth and elevation angles are displayed for a tracking period of about 15 minutes. The large divisions on the horizontal time scale cover 6 minutes each.

Slant range starting at the upper left at about 1,660 nautical miles drops smoothly to a closest approach of about 400 nautical miles. It then rises symmetrically out to the far horizon. During the 7½-minute approach, the target traveled from near Fort Worth to near Montreal. Azimuth angle changed from 360 to 0 degrees just beyond closest approach. Range rate is zero.

The data acquired during the launch phase and during the second pass were comparable.

Transponder Electronics

The transponder uses 40 transistors and diodes. The r-f package contains a filter, duplexer. mixer, 30-Mc i-f amplifier, second detector, local oscillator and transmitter. A second package contains the video bandwidth filter, video amplifier, pulse-width discriminator, time-delay pulse generator, modulator and batteries.



components of the target echo are present within the passband of the i-f amplifier. Under these conditions, precise coherence is no longer necessary to obtain performance corresponding to the broadband noise figure; synchronization of the pumping source merely ensures that the idler channel will be accepted by the subsequent system.

Tiros I Tracked From Horizon to Horizon

ACQUIRING information to compute orbit parameters for Tiros I was greatly aided by a uhf transponder beacon. Installing the beacon in the third stage permitted tracking beyond its skin-track capability. The quality of radar data was improved and horizon-to-horizon coverage was provided.

The Millstone Hill Radar Observatory, Westford, Mass., built and operated by MIT Lincoln Laboratory for USAF, has been tracking many Cape Canaveral launchings. Because of the highly sensitive radar receiver at this site, an output of only 10 mw was required from the beacon transmitter. This signal enabled Tiros I to be tracked 1,700 nautical miles to the radar horizon from Millstone Hill.

The beacon was developed from conception to breadboard installation in six weeks. It was built under subcontract to Texas Instruments Inc. with collaboration of Lincoln Laboratory in the engineering development. The system was first successfully tested in the ill-fated Transit I last September.

Tracking Data

As a member of the NASA team for this operation, with the Air Force Ballistic Missile Division and Space Technology Laboratories, Millstone tracked the launch phase and two subsequent passes. The tracking permitted observation of stage separation, spin rate and orbit injection parameters. Processed tracking data were dispatched by Space Net TWX to STL and the NASA Computation and Control Center in Washington within minutes after the end of each run. The Millstone data from the three sets of observations, a little more than

Micro-Energy Switch for Logic Circuits

ONE OF THE PROBLEMS encountered in high-speed computer logic circuits is to find high-speed switching components that will perform at much lower energy levels.

With the exceedingly high packing densities now demanded in microminiaturized equipment, power dissipation levels can cause an intolerable amount of heating. And the search is on for high-speed switching transistors that can be optimized for operation at low collector voltages and low collector currents.

Further, it has been recognized for some time that, for maximum reliability, transistor power dissipation should be held to an absolute minimum.

Last week at the Western Joint Computer Conference in San Francisco, engineers were offered a practical solution to these problems. In a technical symposium aimed at designed engineers, Philco men pointed out the capabilities and implications of switches they are now developing that promise to operate at the repetition rates of today's most modern high-speed switching transistors, but can do this in circuits that operate at much lower power levels. And Philco feels that this micro-energy concept is an important step in scaling down the size of high-speed highly reliable logic circuits. The company visualizes a whole family of perhaps ten or twelve transistors for this purpose, based on the MADT construction.*

In a conventional transistor, the factor that limits operation at low energy levels is the junction capabilities. By using well chosen resistivity profiles of the MADT, and by improved geometry and advanced metallurgy, the Philco design makes it possible to design high-speed logic circuits that operate with an overall power consumption of less than one-third that of conventional transistors. And micro-energy switches now in design stages will widen this gap considerably.

* Trademark, Philco Corporation, for Micro Alloy Diffused-Base Transistor

TABLE I—CHARACTERISTICS OF MICRO-ENERGY TRANSISTOR

Symbol	Characteristics	Test Conditions	Typical	Max
I_{CBO}	Coll Cutoff Curr	$V_{CB} = -5$ v	1	3μa
V_{CE}	Coll Voltage	$I_C = -2$ ma, $I_B = -0.2$ ma	0.095	0.13 v
h_{FE}	D-c Current Gain	$V_{CE} = -0.20$ v, $I_C = -2$ ma	40	25 (min)
V_{BE}	Base Input Volt	$I_C = -2$ ma, $I_B = -0.2$ ma	0.285	
C_{ob}	Output Capac	$V_{CB} = -6$ v, $I_E = 0$ ma[a]	1.6	2 $\mu\mu$F
f_T	Gain Bandwidth	$V_{CE} = 1$ v, $I_C = 1$ ma	175 Mc	125 Mc (min)

V_{CB} Max.......... 12 v	I_C.............. 100 ma	Storage Temp..... 100 C
V_{CES} Max......... 10 v	Max Diss (25 C). 35 mw	a — f = 4 mc

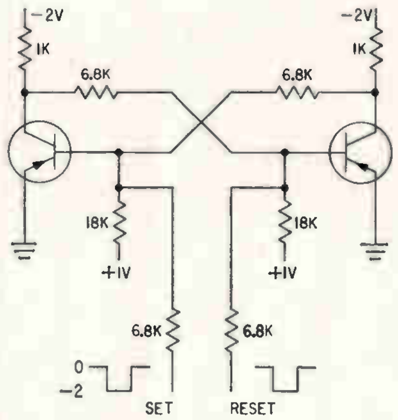


FIG. 1—Two micro-energy transistors used in a 5 Mc resistor transistor logic flip-flop

The first micro-energy switches to be supplied by Philco will come in a TO-18 package, but the devices will be offered in considerably smaller hermetically sealed packages in the near future. Samples of the first micro-energy switch, packaged in the TO-9 case are available at the present time for designers use in ultra high reliability, low-current low-voltage saturated switching circuits. The switch works at frequencies in excess of 15 Mc. Polarities are similar to pnp junction types. It is intended as a logic element in high-speed computers, data processing and automation equipment. Given no numbers yet, characteristics of the first device are shown in Table I.

This first switch, offered by the Lansdale Tube Company, Division of Philco Corporation, Lansdale, Penn., features an emitter transition capacity less than one-third that of presently available modern high-speed switching transistors, a collector capacity approximately one half that of modern switching units, a gain-bandwidth product specified greater than 125 Mc at a collector voltage of 1 v, a collector current of 1 ma, and a beta characteristic which optimizes at approximately 1 ma. The minimum saturation current gain of the transistor is 25 at a collector current of 2 ma.

This first switch will operate at pulse rates in excess of 10 Mc when switching collector currents as small as 1 ma from collector supply voltages as small as 1 v. A low cost germanium device with a maximum temperature rating of 100 C, the switch has been designed for automated production and will be available in prototype design quantities within 60 days. Use of this device in microenergy circuits leads to total device dissipations in the order of 200 microwatts. Dissipation is so low as to be negligible in its effect on reliability.

Figure 1 shows two micro-energy transistors used in the familiar NOR flip-flop circuit to obtain scaled down current and voltage.

Micro Memory-Stacks

TWO SERIOUS LIMITATIONS of memory systems using ferrite cores have been their large size and their narrow temperature range.

Both of these drawbacks are

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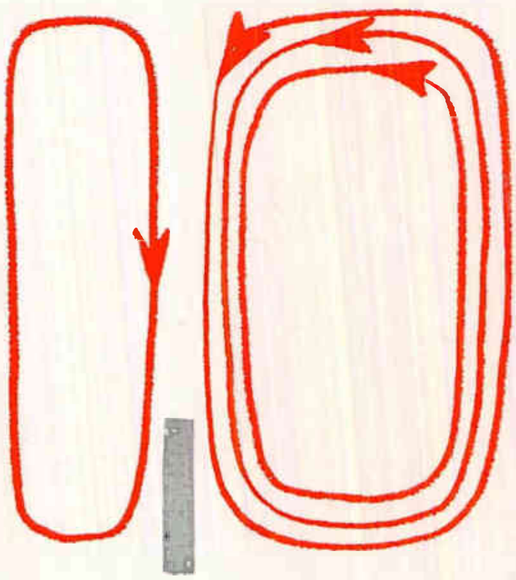

brush INSTRUMENTS

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eliminated by a series of memory devices developed by the Applied Logics Department, General Ceramics Division of Indiana General Corp., Keasbey, New Jersey.

The new memory arrays called MICROSTACKS, are designed for data processing systems that operate under environmental extremes, and their novel construction eliminate the need for temperature-controlled equipment for the entire memory system.

The size of conventional memory stacks is reduced 50 to 1 by a system of arranging the cores on mats, threading the cores with continuous wires, and then folding the planes one upon the other.

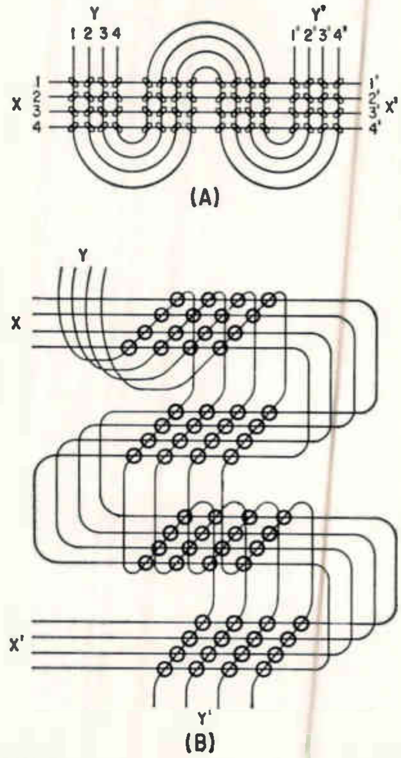


FIG. 1—Method of stringing the ferrite cores (A) and folding the planes (B) reduces the size of conventional memory stacks two percent of their volume to ten

As shown in Fig. 1, the mats are arranged side by side and spaced about ⅛ in. to 3/16 in. apart. The *X* lines are threaded directly through the mats in a horizontal plane. The rest of the *Y* lines follow the paths shown. The sense and inhibit lines (not shown in the diagram) are then inserted in each mat. Each mat is covered with a suitable insulation that cushions the cores against damage or pressure.

The stacks are folded one upon the other, as in Fig. 1B. The folded memory plane is placed in its housing and the leads are brought out to a terminal board or a connector.

Two thermistors are placed in the folded memory, and the unit is covered on all six sides by a heating pad. Encased in its heater pad, the unit is insulated with pads of polyurethane.

Storage capacity of conventional stack (left) is provided by MICROSTACK *unit (center). Complete unit, surrounded by temperature-controlled circuit and insulation is at right.*

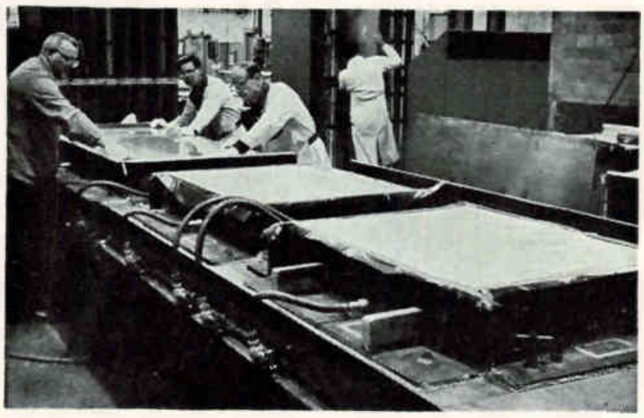
The memories operate between −55 C and 125 C and a unit consisting of twelve 16 x 16 memory planes occupies but 12.5 cu in.

One design functions at 85 C ± 7 deg in an ambient from −55 C to 85 C. Temperature control is achieved by heating the planes to the maximum ambient and maintaining that temperature throughout the entire ambient range. According to engineers in the division that makes these MICROSTACKS available, it is simpler, less expensive, and requires less equipment to heat the plane rather than to use air conditioning to do the same job.

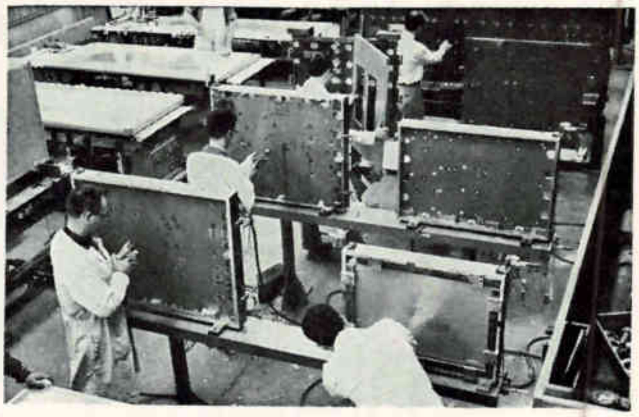
The company is working on several other units for other ambients, and for other applications.

The temperature-controlled circuit requires a regulated 3 or 4 v d-c supply at a max of 100 ma and an unregulated 25 v d-c supply at a max of 325 ma.

These MICROSTACKS were designed to meet all of the necessary military temperature requirements.



Vacuum bonding frames handle up to 10 foam sandwiches



Multipurpose drilling fixtures also guide assemblers

Fixtures Help Make Bulky Units

ASSEMBLY FIXTURES are frequently employed to maintain dimensional tolerances and reduce the time and cost required to fabricate normal-sized electronic equipment housings. Such fixtures can also be used for bulky assemblies, with comparable advantages.

Twin Coach Co., Buffalo, N. Y., has developed several multipurpose fixtures for electronic equipment shelters and consoles. The type described has foam sandwich walls bonded with epoxy and has tolerances of 0.015 inch in completed dimensions and in wall skin parallelism. Methods may be modified when the sandwiches are poured foam or honeycomb materials.

After detailed parts are formed or purchased, the structural members of each panel are bonded to the skins and the foam. The epoxy the firm most commonly uses for this type of structure is EC 1838 (Minnesota Mining and Mfg.), loaded with aluminum dust to maintain electrical conductivity.

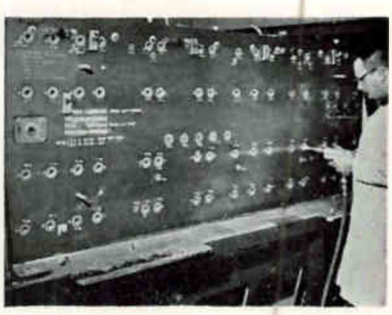
The epoxy is applied on a spreader table equipped with an automatic applicator. The spreader is supported on a gantry which moves the length of the table. Self-feeding adhesive applicators move back and forth and deposit adhesive in front of the comb. Coating thickness is adjusted by micrometer settings. The spreader is reported to spread more evenly than hand-combing and at 7 or 8 times the manual rate. The speed also assures use of the epoxy within its pot life.

Assemblers lay precut foam and structural members in place on the panel skin, using templates as reference layouts. The second skin is placed on top and the panel assembly is moved into a vacuum bonding fixture. The epoxy cures in 12 hours at room temperature while in the bonding fixture.

The bonding fixtures are designed to accommodate a variety of panel sizes and each fixture will hold 4 to 10 panels. The fixtures are loaded with divider plates of ⅛-inch aluminum between panels. Mylar is installed as a blanket over the top panel and sealed to the fixture top with tape. Vacuum is drawn with a pump. Another pump is held on standby in case the first pump should fail; vacuum is frequently checked by quality control personnel.

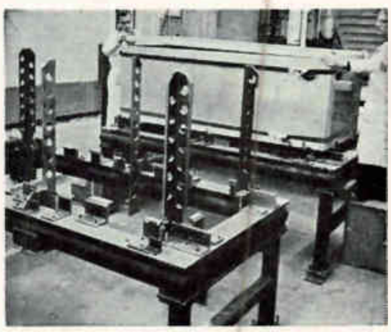
As the photo indicates, this fixture's construction is massive. The base plate is 2-inch steel milled on a planing mill to a surface of plus

Foam and structural parts being assembled on panel skins



Closeup of multipurpose drill fixture

Epoxy pots inserts in place



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The three models of Kay *DRD Attenuators* listed at the right hand side of the table offer the convenience of a direct-reading dial. Attenuation can be varied from 0 db to 119 db in one-db steps by operating two rotary switches. The standard Kay *Attenuators* operated by six or nine toggle switches are listed at the left. All models are set in lightweight cast bronze housings and offer reduced maximum total error and a negligible insertion loss.

	STANDARD TOGGLE SWITCH MODELS			DRD MODELS
	MODEL / CAT. NO. 20* 430-B 21† 440-B 22‡ 450-B	MODEL / CAT. NO. 20-0* 431-B 21-0† 441-B 22-0‡ 451-B	MODEL / CAT. NO. 30-0* 432-C 31-0† 442-C 32-0‡ 452-C	MODEL / CAT. NO. 40-0* 433-A 41-0† 443-A 42-0‡ 453-A
Z_{in} Z_{out}	*50 ohms nom. †70 ohms nom. ‡90 ohms nom.			
DB Switched	41 db in 6 steps		101 db in 9 steps	119 db total in 1 db steps
Steps	20 db, 10 db, 5 db, 3 db, 2 db, 1 db		Same as 41 db units, plus 3 extra 20 db steps	1 db and 10 db
INSERTION LOSS	10 db	Zero db at low frequencies; approx. 0.1 db at 250 mc; approx. 0.2 db at 500 mc		
Maximum Total Error (includes insertion loss)	At full attenuation: 0.5 db at 250 mc; 1.2 db from 250 to 500 mc		At full attenuation: 0.9 db at 250 mc; 2.0 db from 250 to 500 mc	
	BETTER ACCURACY AT LOWER FREQUENCIES AND/OR USING FEWER ATTENUATION STEPS			
Frequency Range	DC to 500 mc; useful to 1000 mc			
SWR	1.2 max. up to 250 mc; 1.4 max., 250 to 500 mc			
Maximum Power	½ watt			
Connectors	BNC type UG-185/U			
Dimensions	2" x 7" x 2"		2" x 9¾" x 2"	5" dia. x 2¼"
Weight	2 lbs.		3 lbs.	4¼ lbs.
Prices	$75.00	$70.00	$100.00	$225.00

All prices f.o.b. factory.

NOTE: Kay *Attenuators* can be made on special order in 0.5 db steps, and to customer's choice of insertion loss, attenuation range. and impedance rating.

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nothing, minus 0.007 inch. The angle steel is gridded on the inside to facilitate evacuation. The fixtures are mounted on support pillars used for heavy aircraft fixtures.

Twin Coach reports that this fixture permits optimum quality control without the expense of individual bonding molds. The fixture cost $3,000 to make; by comparison, a multiple opening press would cost some $50,000, plus supplementary equipment.

Completed consoles

After being bonded, panels are drilled and fitted with attached extrusions and details. The drill fixtures also serve as assembly fixtures, eliminating special coordination of drilled holes in panels and matched parts. The drill plates have holding blocks which locate and hold attachments, so they can also be drilled. The fixture is color-coded for drilling of various panels.

After drilling, the extrusions are fastened and the inserts are potted in place with epoxy.

The main assembly fixture is a close-tolerance aircraft type (see photo). The panels are assembled around the fixture, held in position and bonded. At the next stations, subassembly details and hardware are installed and the seams sealed. A Pyle pressure gun is used to apply waterproof sealants. The shelter is then primed.

Air Cools PC Parts In Hand Soldering

LOW-PRESSURE AIR has been found by Automatic Telephone and Electric Co., Liverpool, England, to be the most efficient method of keeping components cool during the manual soldering of printed circuit boards. A box-shaped fixture is used to hold the board, as shown in cross section in Fig. 1. Connections

2N696 → 2N717
2N697 → 2N718

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With maximum power dissipation of 0.4 watt at a free air temperature of 25°C (or 1.5 watts at a 25°C case temperature), the small packaging still gives more than adequate power handling capability for the majority of applications. All other specifications are identical to those given in the 2N696 and 2N697 data sheets.

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are soldered with a 25-watt miniature iron.

Two methods are used by the company to replace printed circuit board components. In the factory, the component leads are cut close to the component body. The leads

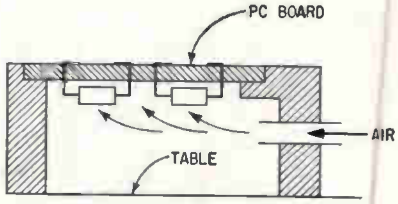


FIG. 1—Air-cooled soldering fixture

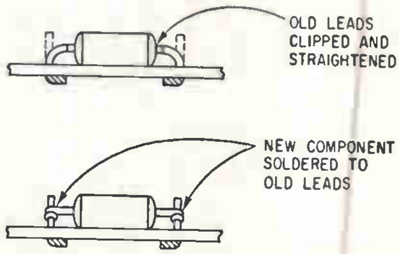


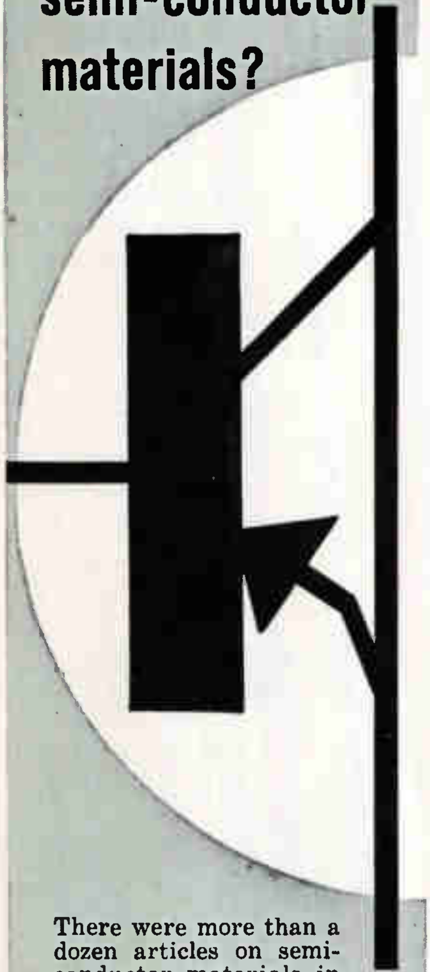
FIG. 2—Old leads serve as stake for new component

are straightened, the solder heated and the leads removed. In the field, leads are also clipped and straightened, but not removed. Leads of the new part are wrapped 1½ turns around the old leads and soldered (Fig. 2).

Vibratory Finisher Uses Air Suspension

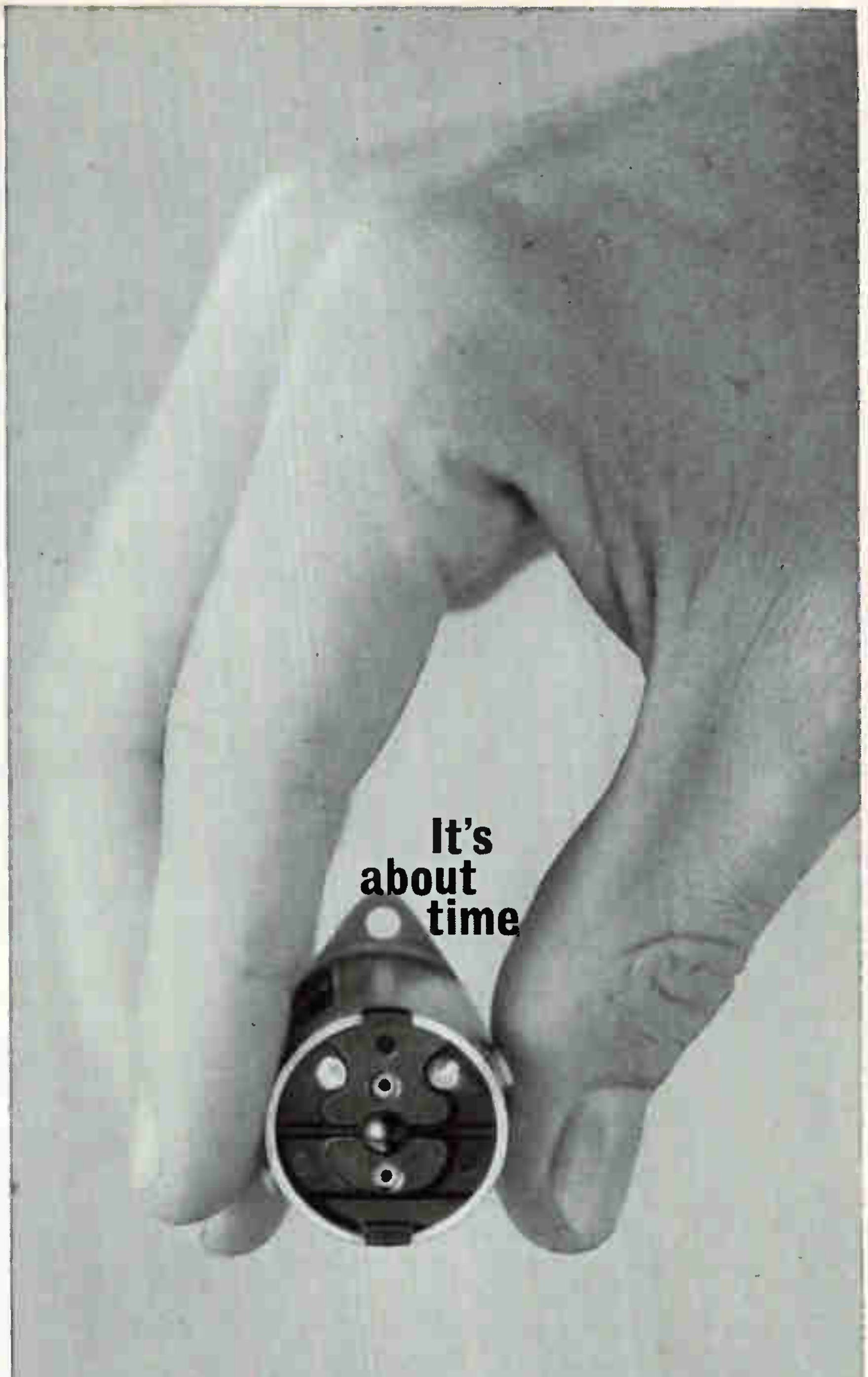
AIR SUSPENSION helps regulate vibratory amplitude of vibratory finishing equipment made by Pangborn Corp., Hagerstown, Md. Four rubber air cushions are mounted above the vibrating platform and four are mounted below. Each series is pneumatically interconnected, allowing amplitude to be varied by varying the air pressure. Amplitude is also changed by adjustable weights on the motor-driven eccentric shaft. Vibratory finishing is used for the same purposes as tumbling or barrel finishing. It can be used to finish both large and fragile parts without damage since there is no sliding or rolling action. The parts being finished are suspended in the media.

do you know what's expected from semi-conductor materials?



There were more than a dozen articles on semiconductor materials in **electronics** in recent months. Each was specially edited to give you all key facts, ideas or trends—and there's more coming! Accurate **electronics'** reporting tells you what's happening now . . . what's *expected* in materials and components. Don't miss dozens of articles on basic subjects edited to keep you informed, help make your research, development, sales and marketing plans pay off. It pays to subscribe to **electronics** (or renew). Fill in box on Reader Service Card now. Easy to use. Postage free.

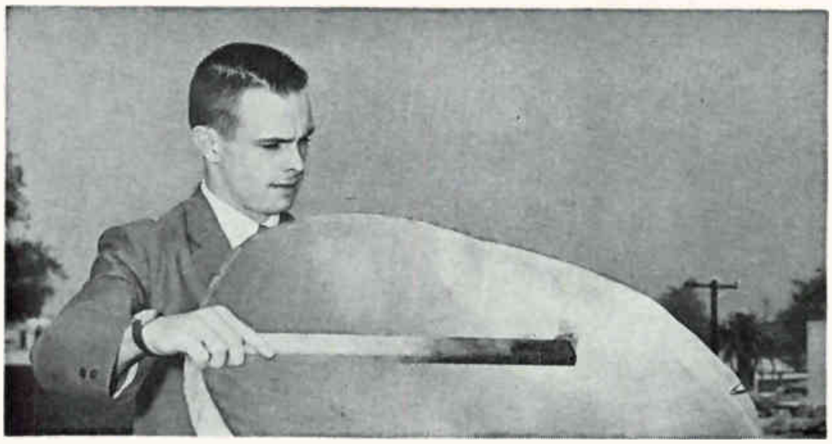
FIND WHAT YOU NEED IN electronics



Whether an interval is a month or a microsecond, you can measure it, divide it, record it, or use it for control with an A. W. Haydon Company custom-designed or standard timer. Every type, every size, every class ... timing motors, time delay relays, interval timers, repeat cycle timers ... you name it, we make it. If you ever have a specific timing problem, the least you can do for yourself is get our literature. In fact, why not send for our Bulletin on the 14100 Series DC Motor (above) right now. This two-ounce sub-miniature DC Timing Motor is less than 1" in diameter, 1⅜" long. Used to drive a miniature tape recorder in the Vanguard II weather satellite (expected to remain in orbit for 200 years), it represents the high capability of The A. W. Haydon Company in timing devices.

THE AW HAYDON COMPANY
223 North Elm St., Waterbury, Connecticut

New On The Market



Solar Concentrators

WEIGH 0.3 LB PER SQUARE FT

SOLAR CONCENTRATORS weighing less than 0.3 lb per square foot, with concentration efficiencies approaching 90 percent, have been developed by the Energy Research Division of Electro-Optical Systems, Inc., 170 N. Daisy Ave., Pasadena, Calif.

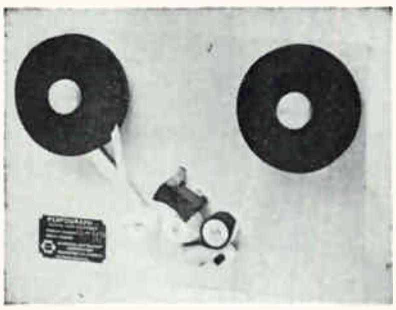
The concentrator is designed to meet the needs of auxiliary power systems for space.

Shape of the concentrators is either a parabolid of revolution or a Fresnel mirror. Structure of the concentrators is either rigid-deployable or nonrigid. Nonrigid types are either folding or inflatable, while the rigid-deployable is primarily a folding unit.

Aluminum, beryllium, and nickel are among the metals being used in making the concentrators. Plastics such as Mylar are also being used. Rigidity of the reflective surface is obtained by a lightweight, rigidizing foam applied to the back. Fabrication techniques include explosive forming, spinning, electroforming, stretch forming and Andro Forming.

Experimental solar concentrators are approximately three feet in diameter. However, this size will be increased to a 5-to-10-foot range in the near future. Such concentrators are capable of providing a temperature of 1,200 to 2,500 deg F while supplying an adequate amount of heat energy for solar power systems of either the static or dynamic type. Lifetime efficiency of the concentrators is expected to exceed one year in a space environment.

CIRCLE 301 ON READER SERVICE CARD



Punched Tape Recorder

UP TO EIGHT CHANNELS

NEW SMALL DATA recorder for industrial and military uses stores information in digital form on a narrow paper tape by perforating the tape electronically with patterns of small holes. Up to eight channels and digital coding may be used. The data may later be automatically interpreted by a photoelectric tape recorder at a data processing center.

The device, known as the Perfograph is made by Advanced Instrument Corporation, 700 South 4th St., Richmond, Calif. The recorder is small in size and low in power consumption. It operates for several months on small dry batteries. Its simplicity and low cost allow it to be used as a general-purpose, portable unit suitable for in-plant industrial and commercial information gathering. The unit is the heart of a complete system for machine-acquisition, storage, transmission and reduction of data; here, the recorder is used in remote-area weather stations. Special high-speed recorders have been developed for missile applications and other military requirements.

CIRCLE 302 ON READER SERVICE CARD

Transistorized Tv Tuners

HAVE LOW NOISE FIGURE

CONSTRUCTION of transistorized television tuners with high gain and low noise figure has resulted from a joint development effort of the Lansdale Division, Philco Corp., Lansdale, Pa. and the F. W. Sickles Division of General Instrument Corp. A standard Sickles mark 6 tuner was modified.

The tuners use new low-noise MADT germanium transistors. The units are scaled-down versions of Philco MADT transistors presently being mass produced. Availability

of the new units is expected in the near future. The new transistors have noise figures less than 3.5 db at 200 Mc with the best units as low as 2.6 db.

The transistorized tuner has a noise figure that varies from a maximum of 4.6 db on high tv channels to 3.3 db on low channels. Power gain varies from 32 db on the high channels to 45 db on low channels.

CIRCLE 303 ON READER SERVICE CARD

Ga Arsenide Transistor

WITHSTANDS 250 DEG C

A GALLIUM-ARSENIDE transistor capable of withstanding the extremely high temperatures encountered in jet aircraft, missiles and space vehicles has recently been announced by Radio Corp. of Amer-

ica, 30 Rockefeller Plaza, New York.

The transistor is a developmental diffused-junction drift-field type.

The gallium-arsenide transistor works at temperatures exceeding 250 degrees C as compared with 175 degrees C for silicon transistors.

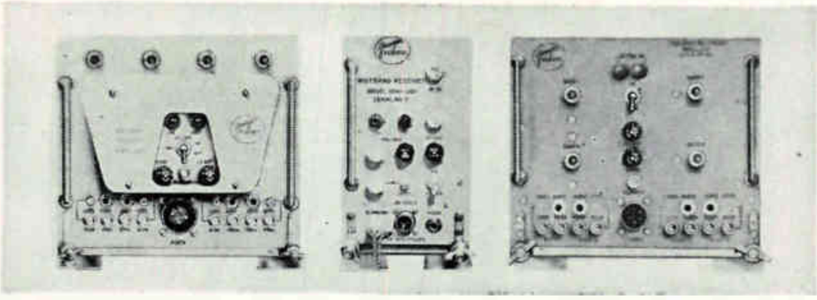
The transistor has an alpha cutoff frequency of approximately 100 Mc. The voltage capabilities of the junction compare favorably with those of silicon transistors. The transistor operates at current levels up to 80 ma and its general behavior is similar to a silicon unit.

CIRCLE 304 ON READER SERVICE CARD

slow, the resulting curve will be the envelope of the vibration curve. Thus the amplifier can be used for data reducton.

The input impedance is over 1,000 megohms. Bandwidth is from 5 cps to 5 Kc. The output is d-c coupled, at an impedance of less than 1 ohm, from d-c to 5 Kc. The unit has an integral, regulated power supply.

CIRCLE 306 ON READER SERVICE CARD



Broad-Band Pulse Receivers

COVER 45 TO 10,750 MC BAND

INTERCEPTION and analysis of pulsed signals in both airborne and ground installations is the job of a new series of wide open broadband pulse receivers announced by Granger Associates, 974 Commercial St., Palo Alto, Calif. Three of these new receivers cover the entire 45 to 10,750 Mc spectrum with sensitivities approaching those of superheterodyne equipment.

All of these receivers employ r-f preamplifiers with specially designed crystal-video circuits. In the frequency range between 45 Mc and 550 Mc, stagger tuned preamplifiers are used. Above 550 Mc, permanent magnet-focused traveling wave tubes are used. Video amplifiers are completely transistorized, as are their power supplies. Output of each channel is separately available for video analysis, and—in stretched form—for recording. Provisions for blanking are also included.

The receivers are available in either relay rack or standard aircraft ATR packaging. Power requirements are 109 to 121 v a-c; 50 to 800 cps for rack mounted versions and 360 to 800 cps for airborne versions. ATR cases are provided with stock trays. Rack mounted packaging is for standard 19-in. relay racks.

CIRCLE 305 ON READER SERVICE CARD

Silicon Rectifiers

SEALED UNITS

SOLITRON DEVICES, INC., 67 S. Lexington Ave., White Plains, N. Y. Line of diffused silicon rectifiers are hermetically sealed by a new process of pressure molding under heat and vacuum. The axial type units are available now in matched sets, from 1,600 v piv to 10,000 v piv at 50 ma to 350 ma. Company also manufactures these rectifiers from 25 v piv to 1,000 v piv at 750 ma. On all types, the cathode is always the chamfered edge.

CIRCLE 307 ON READER SERVICE CARD

Peak Following Amplifier

PROVIDES UP TO 100 MA

A PROPORTIONAL d-c level for each peak of acceleration is produced by the model V63 peak following amplifier developed by Video Instruments Company, Inc., 3002 Pennsylvania Ave., Santa Monica, Calif. The device is used to amplify signals from crystal type accelerometers. The device makes it possible to use peaks of sine waves or random waves as control functions.

In vibration tests, safe limits can be established by a reference voltage. Whenever the d-c output level of the amplifier exceeds the reference voltage, a relay is energized and can be used to shut down the test, or sound an alarm, before the test becomes destructive.

The amplifier provides up to 100 Ma. This output makes it possible to drive high-frequency recorders. If the chart speed is sufficiently

Submersion Actuators

WORK UNDER SALT WATER

AUTOMATIC SAFETY release is provided by an actuator that when submerged in salt water, closes an electrical circuit to release compressed gas for inflating aircraft life rafts, escape capsule flotation bags and flotation bags for missile nose cones. The product was developed by Kidde Aero-Space Division, Walter Kidde & Co., Belleville, N. J.

Salt water acts as an electrolyte in the actuator. It completes a circuit thus firing a cartridge or explosive squib to open a passage in a valve on the compressed gas con-

SOLA AC and DC voltage regulation

Continuous, automatic, maintenance-free

Sola Constant Voltage Transformers and Regulated DC Power Supplies provide dependable, regulated output voltage. Their output regulation is unaffected by wide variations in input voltage.

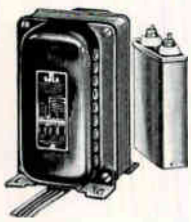
Sola CV Transformers are static-magnetic regulators with completely automatic, continuous regulating action. Their response to variations in input voltage is usually 1.5 cycles or less. They have no moving or renewable parts and require no maintenance.

Each Sola Regulated DC Power Supply incorporates a constant voltage transformer in combination with a semi-conductor rectifier and a high-capacitance filter section. This combination makes the power supply compact, dependable, and efficient; and assures sustained output voltage in the face of pulse or intermittent loads, or heavy, short-time overloads.

Sola Constant Voltage Transformers

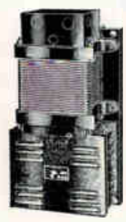
Standard Sinusoidal Type *provides voltage regulation of ±1% with primary voltage variations as great as ±15%. With less than 3% total rms harmonic content in their output voltage wave, these units are desirable for use with equipment having elements sensitive to power frequencies harmonically related to the fundamental. Available in nine ratings, 60va to 7.5kva.*

Adjustable Sinusoidal Type *provides ±1% regulated voltage output—one output adjustable from 0-130 volts and one fixed at 115 volts. Has less than 3% total rms harmonic content in output voltage. Portable for use in shop or laboratory, or mount on standard relay rack.*



Electronic Power Type *regulators provide ±1% regulated filament voltage at 6.0 and 6.3-volt levels; or a combination of plate and filament voltages regulated ±3% for ±15% input variations. Filament regulators are available in ratings from 2.3 to 25 amps. One model is specially designed for portable lab or shop bench use; it has a 30va rating. Combination plate/filament regulators, in three stock sizes, are designed to operate with commonly-used rectifier tubes.*

Normal-Harmonic Type *also provides ±1% regulation at somewhat less cost. This group has an average of 14% total rms harmonic content in its output voltages and is suited to equipment not extremely sensitive to voltage wave shape. The series includes those mechanical designs specially engineered for use as built-in components. Nineteen stock ratings range from 15va to 10kva.*



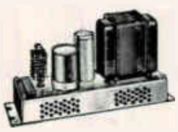
Custom-designed units *can be supplied in production quantities in ratings from 1va to 25kva to suit individual specifications. Custom designs can include special mechanical structures, various voltage ratios, special frequencies, compensation for frequency variations, multiple output voltages, three-phase service. Units can be manufactured to military specifications.*

For additional information on Sola Constant Voltage Transformers, write for Circular 7E-CV

Sola Constant Voltage DC Power Supplies

For intermittent . . . variable . . . pulse . . . or high-current loads

Compact, rugged Sola Constant Voltage DC Power Supplies provide output regulated within ±1% over line voltage variations as great as ±10%. Their output contains ripple voltage of 1% total rms or less. They have exceedingly low output impedance. Output is in the "ampere" range. The high, short-time overload capacity handles intermittent and pulse loads without serious voltage drop or damage to components.



Fixed-output-voltage designs *are available in six stock models with ratings from 24v @ 6a to 250v @ 1a. They are extremely compact, light-weight, and moderately priced in proportion to their power output and performance.*

Adjustable-output designs *provide a considerable range of regulated dc test voltages. Accessory handles offer portability and permit self-stacking. Six models are available with outputs ranging from 5v @ 7a to 400v @ 0.6a.*

For additional information on Sola DC Power Supplies, write for Circular 7E-DC

SOLA

SOLA ELECTRIC CO.

BPC

Sola Manufactures: Constant Voltage Transformers, Regulated DC Power Supplies, Constant Wattage Mercury Lamp Transformers and Fluorescent Lamp Ballasts

A Division of Basic Products Corporation

4633 West 16th Street, Chicago 50, Illinois, Bishop 2-1414 • In Canada, Sola Electric (Canada) Ltd., 377 Evans Avenue, Toronto 18, Ontario tainer. The released gas, such as carbon dioxide, flows through tubing to inflate the raft or flotation bag.

Circuit voltage can be either a-c or d-c. Typical is a 24 to 28 v d-c source which will pass a minimum of 8 amp through the actuator when immersed in a 3 percent by weight salt-water solution. Time to energize circuit upon submersion is 1 second or less; weight of actuator is 0.3 lb; dimensions are —$4\frac{15}{32}$ by $1\frac{13}{32}$ by $1\frac{13}{32}$ in. The actuator can be reused after rinsing it in fresh water.

CIRCLE 308 ON READER SERVICE CARD

Ceramic Insulators

FOR THERMOCOUPLES

SAXONBURG CERAMICS, INC., Saxonburg, Pa. Ceramic insulators for thermocouples used in temperatures up to 3,200 F are now available in lengths up to 48 in. Extruded from a 96 percent alumina composition, the tubing has a silica content of 1 percent or less. The o-d size range is from 0.040 to 1 in. with single or double holes as small as 0.015.

CIRCLE 309 ON READER SERVICE CARD

Decade Amplifier

LOW NOISE LEVEL

H. H. SCOTT, INC., 111 Powder Mill Rd., Maynard, Mass. Model 140-B decade amplifier features response from 1 cycle to over 3 Mc, 40 v output and 10 megohm input impedance. It has a very low noise level, and low output impedance; its self-contained power supply is electronically regulated. Gain of 1, 10, 100 and approximately 700 is selected by switch. The broader band of this unit makes it invaluable for geophysical work and vibration studies. It is available as a chassis unit, in a cabinet, or on a rack panel, and will sell for $99.50 to $105 net.

CIRCLE 310 ON READER SERVICE CARD

Rotary Switches

ADJUSTABLE SEGMENT

PRECISION LINE INC., 63 Main St., Maynard, Mass. New switch can be externally adjusted to open or close at any point within 0 deg to 355 deg. Limited adjustable range such as 0 deg to 180 deg and 2 pole types can also be made. Switches are enclosed in standard RR11 servo mount anodized aluminum housing. Ambient temperature range −50 to +150 C available. Voltage breakdown 1,000 v a-c. Life expectancy to 50 million cycles depending on current and type of load. Designed to pass MIL environmental requirements.

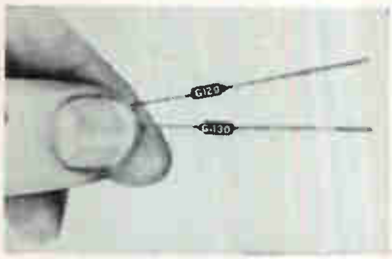
CIRCLE 311 ON READER SERVICE CARD

Storage Tube

DIRECT VIEW

ITT Laboratories, 3700 E. Pontiac St., Fort Wayne, Ind., announces the FW-211 miniature Iatron. With a new patented coaxial gun design it has been possible to combine high brilliance and low voltage requirements with small size and light weight. Used as a panel-mounted radar or infrared indicator in aircraft, its fast writing and high deflection speed permits accurate and instantaneous presentations. Other special features include full daylight viewing of electrical signals by image intensification and the ability to write, store and erase information at will. A display exceeding 4,000 foot-lamberts brightness is obtained at a phosphor voltage of only 8.5 Kv. The tube fits within standard case dimensions for a 2¾-in. dial instrument and meets all of the environmental requirements of MIL-E-5400.

CIRCLE 312 ON READER SERVICE CARD



Silicon Diode

HARD GLASS PACKAGE

TEXAS INSTRUMENTS INC., Semiconductor-Components Division, P. O. Box 312, Dallas, Texas, announces two new controlled forward characteristic silicon diodes (stabistors), the G129 and G130. They were designed for use in low level current applications where reverse characteristics are not required. The economically priced units are ideally suited for transistor bias networks, temperature sensing circuits, as meter protectors, signal limiters, and voltage stabilizers. The G129 is made by the diffusion process; and the G130, by the alloy process.

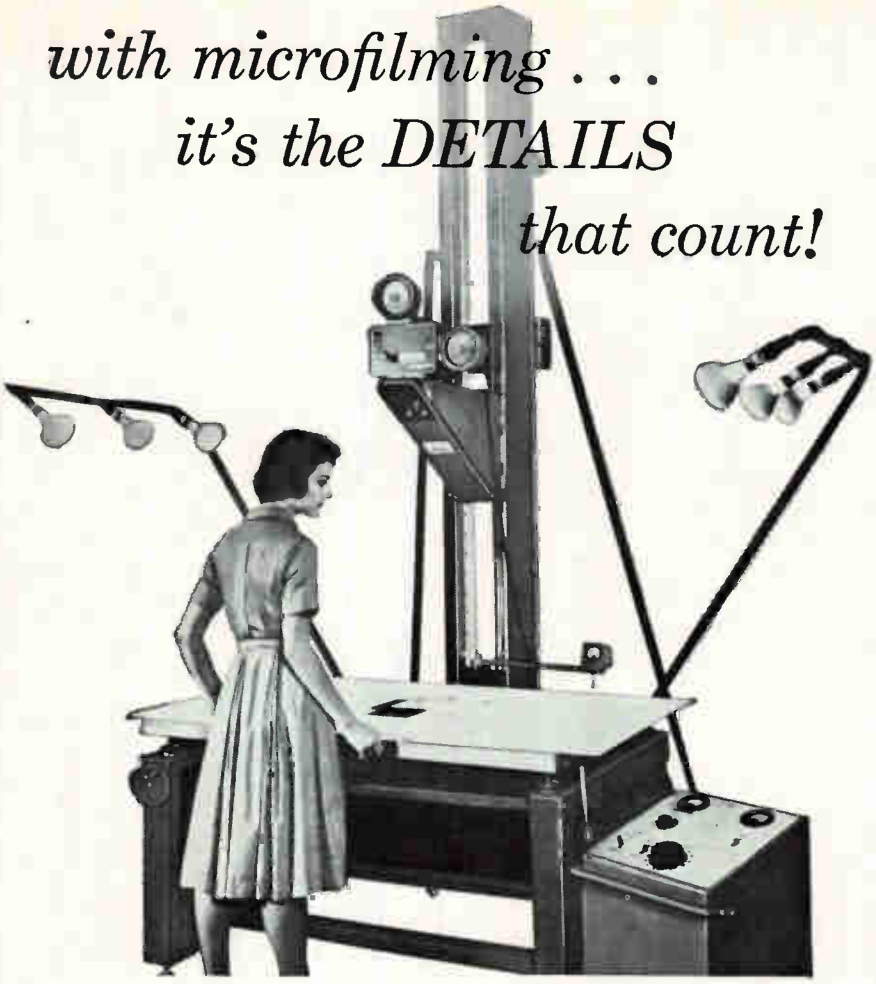
CIRCLE 313 ON READER SERVICE CARD

Connector

MICROMINIATURE

VIKING INDUSTRIES, INC., 21343 Roscoe Blvd., Canoga Park, Calif. New 4A series of Snap-E-Lock microminiature connectors feature up to 7 contacts within ½ in. diameter. Sockets are closed entry. Con-

with microfilming . . . it's the DETAILS that count!



And with a DEA-GRAPH camera from BRUNING, you get 120 lines per millimeter resolution at a 30 X reduction!

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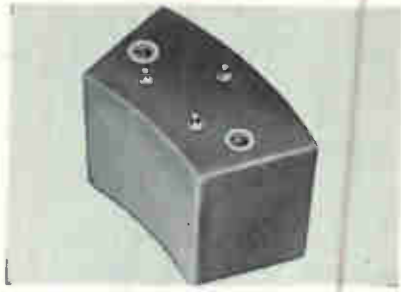
nectors are waterproof, and feature resistance to very high breakdown voltages. Positive locking is accomplished by the use of a lockband which latches automatically when the connector is engaged. Extremely small in size, available with 2, 3, 4, 5, and 7 contacts, in a variety of mounting styles and in glass seal types.

CIRCLE 314 ON READER SERVICE CARD



Electronic Timer
TRANSISTORIZED

THE SLOAN CO., 7704 San Fernando Road, Sun Valley, Calif., has in production a transistorized electronic timer capable of handling 25 amperes, 32 v inductive over an ambient temperature range of − 55 C to + 125 C. Designed primarily for applications where multiple pulsing can be used to trigger a number of programmed functions, model 303 timers are basically high current capacity, free-running pulse generators with externally adjustable period and pulse.

CIRCLE 315 ON READER SERVICE CARD

Delta Unit
CAPACITIVE TYPE

THE DECKER CORP., 45 Monument Road, Bala-Cynwyd, Pa. The 904-1 delta unit is a capacitive type general purpose displacement measuring system utilizing the T-42 ionization transducer. It permits noncontact static and dynamic measurements in the milli- to microinch region with an output of ±30

v (no amplification required). Unit has a sensitivity of 0.2 v/percent change of capacity and stability of 0.01 percent/hr. It provides an analog electrical output for indicating, recording and control. A full line of interchangeable probes and other accessories is available. Case size is 8 in. by 7¾ in. by 6 in.

CIRCLE 316 ON READER SERVICE CARD

Power Transistor

2 TO 1 BETA SPREAD

MOTOROLA INC., Semiconductor Products Division, 5005 E. McDowell Road, Phoenix, Ariz. Line of 5 ampere power transistors is intended for industrial switching control and amplifier applications from d-c through the a-f range. Collector-base breakdown voltages from 40 to 120 v and measured current gains from 20 to 150 allow operation of these transistors as switches at power levels up to 500 w. Because of transconductance as high as 10 ohms and a saturation resistance as low as 0.03 ohm they are extremely efficient for converter applications. Types 2N1529 through 2N1538 (medium gain) and 2N1539 through 2N1548 (high gain) are germanium *pnp*, alloy junction units with collector common to case.

CIRCLE 317 ON READER SERVICE CARD

R-F Toroids

HIGH Q

NORTH HILLS ELECTRIC CO., INC., 402 Sagamore Ave., Mineola, N. Y. The 1218 series r-f toroidal coils cover an inductance range from 1.5

mh to 18.7 mh, are hermetically sealed and shielded in a metal case. Typical Q values are 150 to 180 from 3 Mc to 12 Mc. The case is $2\frac{1}{32}$ in. o-d by $\frac{3}{4}$ in. high and mounted by a single 6-32 stud. Connections are brought out through two Teflon terminals. Units find application in r-f filters, r-f amplifiers, receivers and general communications equipment. Since the units are hermetically sealed, the inductance and Q do not vary with humidity.

CIRCLE 318 ON READER SERVICE CARD

Vane Axial Blower

FOR HIGH OUTPUT

GLOBE INDUSTRIES, INC., 1784 Stanley Ave., Dayton 4, Ohio. Type GR vane axial blower operates on 115 v a-c, 60 cps, and delivers 220 cfm of air at 1.75 in. H_2O static pressure, and 315 cfm at 0 in. back pressure. Maximum current at free air delivery is 1.8 ampere; speed is 8,000 rpm. Unit is designed to meet MIL specs. Blower measures $4\frac{3}{4}$ in. in diameter and is $6\frac{3}{8}$ in. long; weight is approximately 4.5 lb. Mounting is made with 6 bolts to the front flange. Unit can also be operated on d-c power since a universal motor is employed.

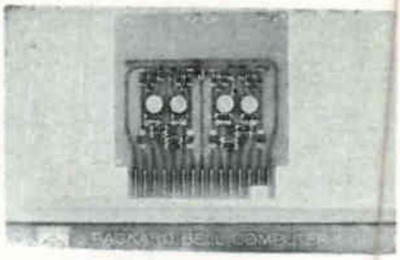
CIRCLE 319 ON READER SERVICE CARD

Ceramic Capacitors

DOUBLE-CUP DEVICES

Sprague Electric Co., North Adams, Mass. Designed for use in r-f circuits up to 10 Kv, type 90 C and 91 C Double-Cup high voltage ceramic capacitors find wide application in transmitters, electronic welding equipment, induction heaters, x-ray, diathermy, and other h-f circuits. Rugged mechanical construction and long leakage paths are a feature of the design. The special ceramic dielectric used has an extremely high Q and very stable retrace characteristics. A typical capacitor rated at 100 $\mu\mu$f at 5 Kv can carry a current of 16.6 amperes at 30 Mc.

CIRCLE 320 ON READER SERVICE CARD



Dual Flip-Flop

HIGH-SPEED

PACKARD BELL COMPUTER CORP., 1905 Armacost Ave., Los Angeles 25, Calif. The TF4 dual flip-flop is one of a series of new, high-speed (3 Mc), transistorized, digital modules. These devices use neither eyelets nor p-c connectors, and consequently eliminate two major causes of failure frequently encountered in etched circuit modules. Specifications include: Voltage, "One" . . . −7 to −10 v, "Zero" . . . 0 to −0.3 v; maximum rise time, no load . . . 0.04 μsec, full load . . . 0.08 μsec; maximum load per output, number of clocked or d-c gates . . . 7. Dimensions of the laminated epoxy mounting board are 3¾ in. by 4 in.

CIRCLE 321 ON READER SERVICE CARD

Power Supply

TRANSISTORIZED

POWER INSTRUMENTS CORP., 235 Oregon St., El Segundo, Calif., announces a completely transistorized laboratory power supply which features an automatic current limiting

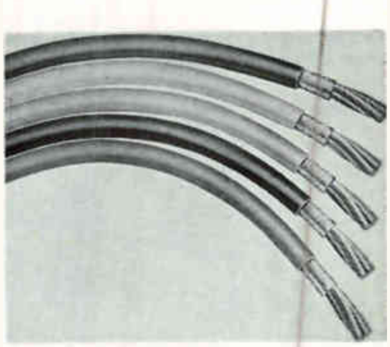
circuit as well as precision voltage regulation. Short circuit current can be selected (40, 100, 200 and 350 ma) on front panel. Voltage regulation is better than 0.1 percent. Voltage range 0-32 v d-c. Ripple is less than 1 mv. Output impedance is less than 0.2 ohm. Input 105-125 v, 50-400 cps.

CIRCLE 322 ON READER SERVICE CARD

Reset Timer
MULTIUNIT

ZENITH ELECTRIC CO., 152 W. Walton St., Chicago 10, Ill. A new multiunit reset timer panel provides automatic control of eight sequential operations. Known as model 8AZC, each timer is calibrated from 0 to 60 sec. Timing ranges up to 10 minutes can be supplied. Unit illustrated controls operations in a plastic vacuum molding machine. Each set of timers controls a complete operation which consists of draping the plastic sheet over the mold, heating and drawing it down with a vacuum action. It is operated by a limit switch and is fully automatic.

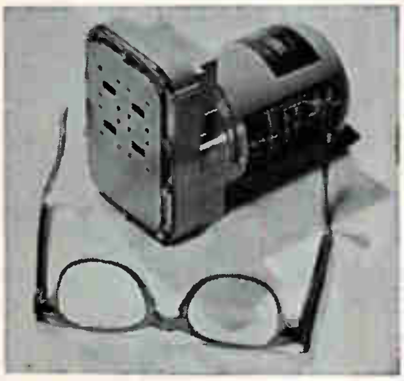
CIRCLE 323 ON READER SERVICE CARD



Color Coded Cables
PLASTIC JACKETED

LENZ ELECTRIC MFG. CO., 1751 No. Western Ave., Chicago 47, Ill. To promote the rapid and easy identification of cables, the company is introducing plastic jackets in the standard color shades adopted by the industry. Color coded in this way, the cables connecting the units of electronic equipment can be quickly identified as to function and circuit, before, during and after installation. The cables in color plastic jackets are available with any size and number of conductors.

CIRCLE 324 ON READER SERVICE CARD



Transfer Switch

K AND X BANDS

TRANSCO PRODUCTS, 12210 Nebraska Ave., Los Angeles 25, Calif., has in production a newly designed K-band transfer switch. Also available for X-band, the switch can be operated as spdt or double pole transfer. Both size and weight are said to be minimum presently available for waveguide transfer switches. Typical specifications of this 28 v d-c motor actuated switch are: vswr 1.05; insertion loss 0.07; crosstalk 80 db.

CIRCLE 325 ON READER SERVICE CARD

Frequency Counter

IN-LINE DISPLAY

BERKELEY DIVISION, Beckman Instruments, Inc., 2200 Wright Ave., Richmond, Calif. New frequency counters feature an in-line display with all digits formed on the sur-face plane. This display is not only readable from the front but from the top or from the side at angles as close as 30 deg to the face. The digits, 1½ in. high, are colored bright red so that the display will be clearly visible in high ambient

CIRCLE 121 ON READER SERVICE CARD

light. Price per digit is $30 to $45 more than the price of a counter equipped with the standard vertical column display.

CIRCLE 326 ON READER SERVICE CARD

D-C Amplifier
DIFFERENTIAL TYPE

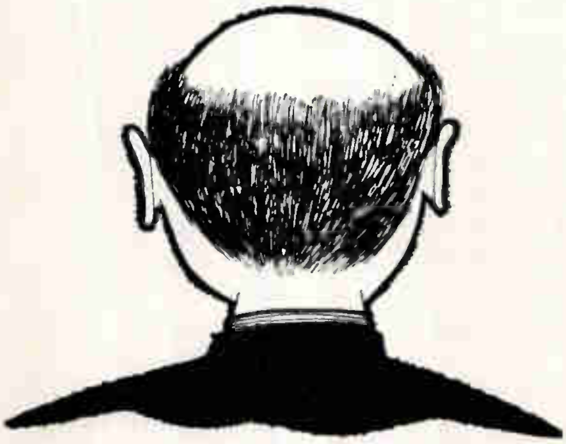
REDCOR DEVELOPMENT CORP., 14750 Arminta St., Van Nuys, Calif. Model 361 differential amplifier has a new input circuit that provides: common mode rejection of 120 db minimum, d-c to 150 cps, at amplifier gain of 1,000; allowable line unbalance 1,000 ohms either line; amplifier bandwidth d-c to 200 Kc minimum; input impedance from either input terminal 1,000 megohms minimum. These features allow wide-band amplification with common mode rejection equal to that of narrow-band amplifiers.

CIRCLE 327 ON READER SERVICE CARD

Amplifier-Converter
TRANSISTORIZED

THE MIRA CORP., 2656 No. Pasadena Ave., Los Angeles 31, Calif., has a new miniature data-amplifier converter with high input impedance for use in airborne instrumentation applications requiring the amplification and conversion of millivolt level a-c data signals. Unit converts a modulated carrier input to a d-c output, the polarity of which is determined by the phase of the input signal relative to an a-c reference voltage. Silicon transistors provide the unit with a gain

IT'S WHAT'S IN HERE THAT COUNTS



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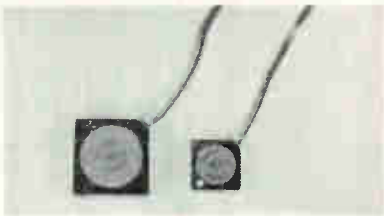
stability within ±1 percent of full scale over the temperature range of −55 C to 100 C. Typical applications for the model 3301 are: strain gage data systems, servo amplifier systems and synchro position tranmitter systems.

CIRCLE 328 ON READER SERVICE CARD



Trimming Pots
ALL-METAL UNITS

ANALOGUE CONTROLS, INC., 200 Frank Rd., Hicksville, N. Y., has available a full line of square trimming potentiometers. Overall dimensions are $\frac{3}{4}$ by $\frac{3}{4}$ by $\frac{3}{32}$ and $\frac{1}{2}$ by $\frac{1}{2}$ by $\frac{3}{16}$. The rugged all-metal units operate to 150 C. They are designed to meet or exceed MIL-E5272B and NAS710, and are available in all resistance ranges. A spring-loaded worm gear assures reliable zero backlash positioning with wiper position completely insensitive to shock and vibration. The wiper is of the non-bridging type, and therefore does not short the potentiometer terminations.

CIRCLE 329 ON READER SERVICE CARD

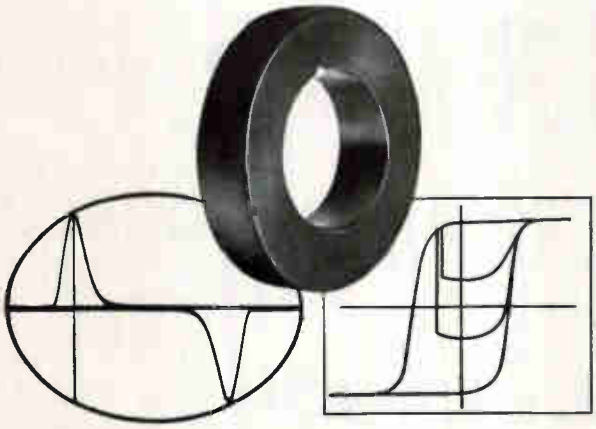
Tunnel Diodes
FIVE TYPES

SPERRY SEMICONDUCTOR DIVISION, Sperry Rand Corp., South Norwalk, Conn., announces types T101-T105 germanium tunnel diodes with peak currents ranging from 0.8 ma to 20.0 ma. Peak to valley current ratios on all types are in excess of 5.0 to 1, typically 8.0 to 1. Offering many inherent design advantages, including small size, reliability, radiation-resistance, wide temperature range and high cutoff fre-

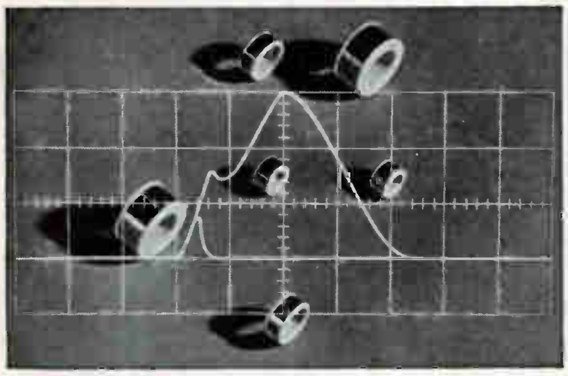
G-L Consistent

UNIFORMITY

Tape Wound Cores



Bobbin Cores



Not only G-L but our customers, too, claim consistent uniformity with every G-L Tape Wound Core and Bobbin Core. This consistent uniformity is the result of: an accuracy of control never before achieved in each and every step of the manufacturing process; the use of the highest quality raw materials and new and exclusive manufacturing technologies.

Prove our claims and the claims of our customers. Write, wire, call or teletype us about your requirements and for our technical bulletins.

G·L ELECTRONICS

2921 ADMIRAL WILSON BOULEVARD
CAMDEN 5, NEW JERSEY
WOodlawn 6-2780   TWX 761 Camden, N.J.

tion: 15 g to 3,000 cycles. Size: 1 in. in diameter by 2½ in. long, excluding mounting brackets and output connector. Weight: approximately 4 oz.

CIRCLE 336 ON READER SERVICE CARD

Waveguide Equipment
LARGE VARIETY

DOUGLAS MICROWAVE CO., INC., 252 E. Third St., Mt. Vernon, N. Y., has added a new and complete line of MACRAwave (large waveguide) test equipment and components. Units include adapters, test horns, attenuators, signal samplers, switches, tuners, wave meters, etc., supplied in the following EIA designated tubing sizes: WR77, WR975, WR1150, WR1500, WR-1800, WR2100 and WR2300.

CIRCLE 337 ON READER SERVICE CARD

D-C Power Supply
CURRENT-REGULATED

CAMBRIDGE PRODUCTS CORP., 141 Main St., Cambridge 42, Mass. Current-regulated d-c power supply is a combination of magnetic and semiconductor components designed to provide a precisely regulated, continuously adjustable, d-c current. Models are available with ratings up to 100 Kw with a choice of three current regulation accuracies: ±0.25 percent, ±0.1 percent, or ±0.015 percent. Features: low ripple current; self-protecting; two-hour, 125 percent load rating; self-contained; forced-air cooled; quiet operation.

CIRCLE 338 ON READER SERVICE CARD

sistors. The 2N511's have guaranteed maximum betas of 20 and 60, at rated collector currents after 100 hours bake at 100 C. In the 5-ampere 2N456 series, 30 to 90 betas are guaranteed. Emitter efficiency has been improved by increasing the ratio between the emitter and the base region resistivities.

CIRCLE 334 ON READER SERVICE CARD

Power Supply
STRAIN GAGE

VIDEO INSTRUMENTS CO., INC., 3002 Pennsylvania Ave., Santa Monica, Calif. Model SR150 isolated strain gage power supply is a solid-state unit featuring 0.1 percent regulation. Output is floating, at an internal impedance of less than 0.2 ohm. Noise to ground is less than 10 μv peak to peak, when measured with a 350 ohm bridge. Leakage resistance is in excess of 100,000 megohms. Price is $68.

CIRCLE 335 ON READER SERVICE CARD

Oscillator Cavity
C-BAND

TRAK ELECTRONICS CO., 49 Danbury Road, Wilton, Conn. New miniaturized C-band oscillator cavity, tunable from 5,350 Mc to 5,950 Mc is used in beacons, transponders, and similar applications. Power output is 10 w peak minimum over the band. Shock: 100 g for 3 millisec in each of three major axes. Vibra-

CIRCLE 127 ON READER SERVICE CARD

0 to 509 v and accurate to 0.1 percent. Utilizing this source and the unit's high input resistance increment reading meter, d-c voltages over the range 10 mv through 500 v may be read with an error of indication not exceeding 0.2 percent. Features include the ability to read out both positive and negative voltages with equal facility, high off-null input resistance and freedom from interference effects attendant with power line operated instruments. Price is $625.

CIRCLE 332 ON READER SERVICE CARD

Thermistor Kit
CONTAINS TWO TYPES

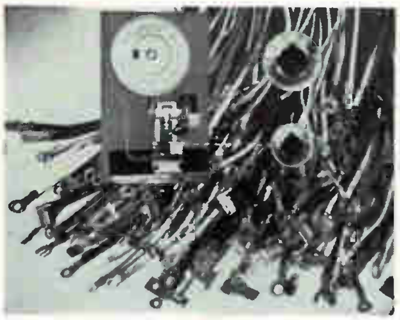
WALTER KIDDE & CO., INC., Main St., Belleville, N. J., has available an introductory kit of 12 thermistors priced at $15. Included are two types of thermistors. Type K are available with resistances from 1 K to 100 K at 25 C. They operate at ambient temperatures up to 300 C. Units are also available for use to 600 C. Type D are offered with resistances of from 0.100 K to 100 K at 25 C. These disk thermistors have a maximum operating temperature of 150 C. Standard types K and D have STD resistance tolerances of ± 20 percent. The units are recommended for problems involving temperature control, temperature compensation, time delay, and voltage regulation.

CIRCLE 333 ON READER SERVICE CARD

Power Transistors
HIGH BETA

TEXAS INSTRUMENTS INC., Semiconductor-Components Division, P. O. Box 312, Dallas, Texas. A new high-efficiency emitter makes possible increased beta specifications in six series (2N456, -511, -512, -513, -514, and -1021) of alloy-junction germanium power tranquency, they have a typical peak point voltage of 50 mv and typical valley point voltage of 250 mv. Operating and storage temperature range is from − 55 to + 100 C. The units have a 100 mw dissipation rating at 25 C.

CIRCLE 330 ON READER SERVICE CARD



Attaching Machine
HIGH-SPEED

KENT MFG. CORP., 188 Needham St., Newton 64, Mass. High-speed attaching machine installs a wide variety of terminal styles on any wire size, 22 through 10, by simply turning two selector dials. It will install ring, spade, fork, hook, snap-on or snap-in terminals, with or without insulation grip. A change in wire size is accommodated by turning selector dials which automatically provide the necessary adjustments in staking pressure, without any machine set-up changes on the part of the operator. Company also supplies a complete line of UL listed strip terminals in all sizes, shapes and styles.

CIRCLE 331 ON READER SERVICE CARD

D-C Voltmeter
INCREMENTAL TYPE

THE BELLEVILLE-HEXEM CORP., 638 University Ave., Los Gatos, Calif. Model 130 battery-powered incremental voltmeter incorporates an offset voltage source variable from

NEW BOOKS

Advances in Semiconductor Science

By HARVEY BROOKS.

Pergamon Press, New York, 553 p, $15.

THIS VOLUME is a compilation of the 137 papers presented at the Third International Conference on Semiconductors held at the University of Rochester, New York, 18-22 August 1959. Ordinarily one does not find the proceedings of a scientific meeting to be worthy of publication in book form, there generally being a prevailing lack of continuity and cohesiveness in the content of the average technical meeting. Such is not the case here; the present volume is an excellent chronicle of an outstanding scientific conference and should be a must for the library of all physicists and engineers engaged in advanced semiconductor research.

The book is divided into 20 sections corresponding to the various sessions of the conference. The topics range from basic solid state theory through recombination and transport phenomena to optical, magneto-optical, thermo- and galvano-magnetic effects. Except for the survey papers dealing with the broader aspects of the semiconductor field, many of the articles represent rather significant new work by already well established research workers. The subject matter is sufficiently diverse and the specific areas self-consistent so that the reader gains a fairly good insight into the latest developments and their effect on the general store of knoweldge in a particular field. In many cases this is augmented by virtue of the compilation of "from the floor" discussions at the end of each session.

Continuity is afforded through the truly excellent survey articles by the outstanding international authorities who cover the entire semiconductor field in their treatises. It is in this particular aspect that your reviewer finds this volume to be of great value.

The three papers of the opening session set the stage and present the theme of the conference as an entity. The status of semiconductor research is provided as a bench mark for the work to be discussed in the specific papers to follow. Bardeen discusses "Trends in Semiconductor Research," Joffe goes into "The Properties of Various Semiconductors," and Folberth and Welker cover "Binding and Semiconductor Properties of A^{III} and B^{V} Compounds."

Five articles comprising the summary session complete the picture bringing the material presented during the 18 specific sessions into proper perspective with respect to the introductory background and the prospects for the future. Brooks comments on the "Stationary States of Semiconductors," Ponder on "Fundamental Transition Processes," Apker reviews "Recombination, Trapping and Optical Phenomena," Brattain holds forth on "Surfaces," and, finally, Herring winds up with a remarkable dissertation on "Transport."

In addition to a Table of Contents, the book provides both subject and author indices. It is perhaps a little unfortunate that the five articles in French could not have been accompanied by translations for this volume.

All in all, the reviewer feels this book to be an essential reference tool for all those actively engaged in semiconductor research, if only for the benefit to be derived from the profound survey articles.—FRANK A. BRAND, *Chief, Physical Electronics Branch, Solid State Devices Div., Electronics Components Research Dept., U. S. Army Signal Research and Development Lab., Fort Monmouth, N. J.*

Physics for Students of Science and Engineering—Parts I and II

By R. RESNICK and D. HALLIDAY

John Wiley & Sons, Inc., New York, 1960, 594 *p*, $6.00.

THIS two-volume set stresses principles rather than specific procedures, thus organization and content differ from the traditional physics text for engineers and scientists. Part I deals with mechanics, wave motion and heat; Part II with electromagnetism, optics and quantum physics.

Many topics are treated in

greater depth than customary and contemporary material is woven into the basic framework. Omitted entirely or treated only indirectly are simple machines, surface tension, viscosity, calorimetry, change of state, humidity, pumps, practical engines, musical scales, architectural acoustics, electrochemistry, thermoelectricity, motors, a-c circuits, electronics, lens abberations, color, photometry and the like.

General nature of key ideas common to all areas of physics—such as conservation laws of energy, linear and angular momentum, and charge—are emphasized. Approach to quantum physics is not the traditional one, rather contemporary concepts are developed fairly rigorously.

Mathematically, the authors assume the user is at least taking a concurrent course in calculus. A number of thought provoking problems are given; none require extension of text material, contemporary applications or derivations, few can be answered directly from text or by plugging values into equations. Examples are presented with algebraic instead of numeric solutions.

Supplementary material of an advanced, historical or philosophical character is printed in small type. This feature plus the optional nature of some chapters permit use in physics courses of various lengths.

The mks instead of cgs system of units is used throughout. Illustrations are clear and readable, even a Pogo cartoon is included.

Although some college graduates will be shocked at the scanty treatment given their favorite topics, the reversion to basics is indeed welcomed by this reviewer.—WEB

THUMBNAIL REVIEWS

Servo Engineer's Handbook. Daystrom Transicoil, Division of Daystrom, Inc., Worcester, Pennsylvania, 128 p, $3.00. This approach to servos is by no means a complete handbook and to that extent the title is misleading. Principle elements of a servo are discussed in eight separate chapters. The emphasis is practical rather than theoretical, but there is some mathematical development.

Health Physics Instrument. By J. S. Handloser, Pergamon Press, New York, 182 p, $6.50. This first volume in the health physics division of an international series of monographs

covering entire field of nuclear energy contains descriptions, characteristics and uses of common types of radiation detectors. Content has been primarily designed for those beginning to use radiation and who wish information concerning basic health physics instrumentation procedures. Although the field is still open and new developments will come thick and fast, this book adequately fulfills the needs of the immediate and near future.

Principles of Frequency Modulation. By B. S. Camies, John F. Rider Publisher, Inc., New York, 147 p, $3.50. Written specifically for students, radio engineers and amateurs, this book discusses basic theory of f-m, interference, generation and detection of f-m waves, f-m receivers, and nonbroadcasting applications of f-m. Although treatment is adequate, the price seems too high for a comparatively brief, paper-back edition.

Advanced Engineering Mathematics. By C. R. Wylie, Jr., McGraw-Hill Book Co., New York, 1960, 696 p, $9.00. This completely rewritten second edition of the original 1951 book still sticks to the original objective —to provide an introduction to those branches of advanced mathematics currently important to engineers and physicists. Two new chapters on determinants and matrices, and finite differences are included. The long appendix and glossary devoted to a review of calculus have been omitted as is the chapter on fluid mechanics. Users with a good background in calculus will have no trouble following the text.

Electronic Computers—Principles and Applications. By T. E. Ivall, Philosophical Library, New York, 1960, 263 p, $15.00. This almost completely rewritten second edition now includes chapters on analog computer circuits, programming of digital computers and evolution of more intelligent machines. The book serves as a nonmathematic introduction to computers and has been written for technicians, engineers and students with some knowledge of electrical or electronics engineering. Although text is primarily devoted to describing circuits and construction, considerable emphasis is given to application of automation or control techniques in industry. Considering the technical level and brevity, the price seems out of line.

How to Get the Most Out of Your VOM. By Tom Jaski, Gernsback Library, Inc., New York, 1960, 224 p, $2.90. A technician's handbook, paperbound, slanted to take the mystery out of servicing with commercially-brought or kit-wired volt-ohm-milliammeters. Well organized and illustrated, with playdown on trade marks. Text emphasis is on solving practical problems generally encountered in lab or field.

Literature of

ROTARY SOLENOIDS Ledex, Inc., 123 Webster St., Dayton 2, Ohio. A basic information sheet on rotary solenoids has been released, graphically illustrating torque, speed of stroke, type of strokes, power take-off and available sizes.

CIRCLE 380 ON READER SERVICE CARD

MAGNETIC LATCHING RELAY Babcock Relays, Inc., 1640 Monrovia Ave., Costa Mesa, Calif. A subminiature magnetic latching relay having 10 ampere contacts and operating on as little as 100 mw is described in technical bulletin BR-A.

CIRCLE 381 ON READER SERVICE CARD

MERCURY SWITCHES Gordos Corp., 250 Glenwood Ave., Bloomfield, N. J., has released an 8-page technical catalog giving complete specifications on 21 special-purpose mercury switches.

CIRCLE 382 ON READER SERVICE CARD

CAPACITORS Airborne Accessories Corp., 1414 Chestnut Ave., Hillside 5, N. J. New high temperature Mica and Mylar motor-starting capacitors with working ranges from −65 F to +700 F and −75 F to +400 F respectively are described in product bulletin PS-6A.

CIRCLE 383 ON READER SERVICE CARD

STANDING WAVE AMPLIFIER PRD Electronics Inc., 202 Tillary St., Brooklyn 1, N. Y. Recent issue of "New From PRD" describes the 277-B standing wave amplifier, a specially designed high gain audio amplifier to be used with slotted sections in making standing wave measurements.

CIRCLE 384 ON READER SERVICE CARD

T-W AMPLIFIER Watkins-Johnson Co., 3333 Hillview Ave., Palo Alto, Calif., has published a technical bulletin on the WJ-211, a 2,000-4,000 Mc ultra low-noise traveling-wave amplifier.

CIRCLE 385 ON READER SERVICE CARD

HEAT SINK/DISSIPATORS Delbert Blinn, P. O. Box 757, Pomona, Calif. Technical bulletin No. 110 describes a heat sink which can be used to dissipate hundreds of watts of power with temperature rises of a few degrees C using forced convection or with a few watts of power with natural convection.

CIRCLE 386 ON READER SERVICE CARD

LOGARITHMIC CONVERTER F. L. Moseley Co., 409 North Fair Oaks Ave., Pasadena, Calif. A four-page application note describing the use of the model 60 B logarithmic converter as a computing element is now available.

CIRCLE 387 ON READER SERVICE CARD

QUALITY CONTROL Photocircuits Corp., 31 Sea Cliff Ave., Glen Cove, N. Y. A complete quality assurance system for the manufacture of printed circuits is described in an illustrated technical bulletin.

CIRCLE 388 ON READER SERVICE CARD

PLASTIC PRODUCTS Raybestos-Manhattan, Inc., Manheim, Pa. A 36-page catalog featuring plastic products of Teflon, Raylon and Kel-F has been issued.

CIRCLE 389 ON READER SERVICE CARD

TIME DELAY RELAYS Marstan Electronics Corp., 204 Babylon Turnpike, Roosevelt, L. I., N. Y. Bulletin 359 is a four-page brochure illustrating and describing solid state Economy series time delay relays for commercial, industrial and military usage.

CIRCLE 390 ON READER SERVICE CARD

POWER SOURCE. Krohn-Hite Corp., 580 Massachusetts Ave., Cambridge 39, Mass. Bulletin 501 illustrates and describes model LDS-1500, a 50-watt low-distortion variable frequency power source.

CIRCLE 391 ON READER SERVICE CARD

RESISTOR CATALOG. Electra Mfg. Co., 4051 Broadway, Kansas City, Mo., has available a 12-page catalog describing its line of four basic types of precision carbon film resistors. Catalog carries three histograms on each type. In graph form, these show the results of continuing temperature cycling, load life and moisture tests.

CIRCLE 392 ON READER SERVICE CARD

H-P: the personal touch

A SUPERVISORY development program under way at Hewlett-Packard is expected to provide the key to more "personal" personnel relations despite rigid expansion.

The fast-growing Palo Alto, Calif., electronics firm has seen its employee roster increase from fewer than 1,500 in 1957 to more than 2,400 today in the parent corporation alone. There are an additional 700 in outlying, recently-acquired subsidiaries and divisions.

This phenomenal growth, while a source of great satisfaction to top management of the company, has also provided a certain amount of apprehension. As late as 1957 Bill Hewlett and Dave Packard, founders, and Noel Porter, vice president and head of production, had personally handled the major part of personnel matters in the organization. They came to realize, however, that as the company grew larger they could not physically handle this type of task.

In 1957 Ray Wilbur was hired as personnel manager. His initial job, beyond setting up a personnel staff and system, was to pull together and coordinate the various training programs that had been initiated independently by different department supervisors.

The concept of a comprehensive supervisory program developed from the initial work with these training programs. In March, 1959, Wilbur hired Lee Seligson to organize and administer such a program.

The problem at H-P could be stated thusly: How can you maintain the personal touch of top management in a situation where literally scores of intermediate supervisors had been placed between top management and the rest of the employees?

The answer, in the view of Packard and Seligson, was to indoctrinate as many supervisors and managers as possible in the basic philosophy and objectives of top company management. A pilot program was set up. Its purpose was to train leaders for the future full-scale personnel and general management program.

Twelve top supervisors were selected for training as conference leaders. In 15 sessions of two hours each, held twice a week, the men were taught the principles of conference leadership, as well as the subject matter to be put across to lower-echelon supervisors.

In September 1959 the program started full swing in the manufacturing department, where expansion has been most feverish. Six groups of approximately 16 supervisors each were formed and each was assigned two conference leaders from among the 12 men who had taken the pilot course.

The first round ended last January, and in March a second group of 100 supervisors began the program. Second round, which includes improvements on the original program, will conclude by the end of this month.

What will the program eventually do for H-P? Says Seligson: "We do not expect to get merely a group of charming supervisors. But we can help our people to grow on the job, develop new managers, increase understanding of their role in the organization, and supply the rest of the employees with an environment that is satisfying to them."

Zitelli Receives Varian Appointment

LOUIS ZITELLI has been named manager, klystron development, at Varian Associates, Palo Alto, Calif. He joined Varian in 1950 as a research engineer, and in his new post will be responsibile for advanced development of all Varian klystrons.

Zitelli was a research assistant at Stanford's Electronics Research Laboratory for four years before joining Varian. In his new position he takes over the post formerly held by Richard Nelson, who was recently appointed head of Varian's Tube Division research and development at Palo Alto.

Appoint Dryden V-P, Engineering

PEARCE-SIMPSON, INC., Miami electronics manufacturer, announces the appointment of Robert E. Dryden as vice president, engineering. He will head the new R&D division of the company.

Dryden was formerly director of the instrumentation division of Radiation, Inc., Orlando, Fla. Under his direction, Pearce-Simpson will establish a complete research and development division devoted to the field of military and commer-

cial electronic test equipment. The new division will complement the recently announced line of test equipment which the company will manufacture under license agreement with Republic Aviation Corp.

Bourns Adds to Engineering Staff

APPOINTMENT of James A. Hyams to the engineering staff of Bourns, Inc., Instrument Division, Riverside, Calif., has been announced. He comes to Bourns from Canadair, Ltd., of Montreal, where for the past 2½ years he has held the position of design engineer.

Hyams' assignment will be in linear motion potentiometer group where he will be active formulating new designs for miniaturized instruments.

Control Hires W. J. Bradburn

APPOINTMENT of William J. Bradburn as a senior engineer has been announced by Control, a division of Magnetics Inc., Butler, Pa., producers of static-magnetic components for industrial control systems. He joins Control from the Louis Allis Co., Milwaukee, Wisc., where he was a development supervisor in the firm's control engineering department. He was with the company for eight years.

At Control, Bradburn will concentrate on the design of industrial control systems utilizing the company's standard lines of magnetic amplifiers, saturable reactors, and other associated static devices.

Carlson Takes New Position

APPOINTMENT of William K. Carlson as planning and controls manager for the Semiconductor Division of General Instrument Corp. is announced.

Carlson had been with the Raytheon Co. of Waltham, Mass., for nine years. Most recently he was associated with the Raytheon Semiconductor Division in various assignments in production management, planning and control. In his new General Instrument post, he will be responsible for planning and scheduling of production at the company's Semiconductor Division facility at Newark, N. J.

Lindenberg Joins Astatic Corp.

THE EXECUTIVE COMMITTEE of the Astatic Corp., Conneaut, Ohio, recently appointed Theodore Lindenberg director of engineering. He will direct the company's research, design, development and product engineering program.

Prior to joining Astatic, Lindenberg served as chief engineer of the Pickering Co., Plainview, L. I., N. Y., and was an engineer with the Fairchild Recording Equipment Corp., New York.

He developed and is the owner of over 20 patents in connection with audio equipment. He is a past president and member of the board of governors of the Audio Engineering Society.

THREE TOOLS FOR QUALITY CIRCULATION

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QUESTIONNAIRE — to delay acceptance until information concerning the subscriber — his function, his company, his title are definitely known.

REJECTED — whenever the order indicates that the individual is NOT within the editorial field of the publication.

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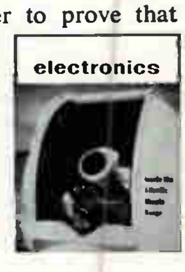

The Electronics Man "buys" what he reads in . . .

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CRYSTAL FILTERS

Within three years Hermes Electronics Co. has become the nation's leading producer of frequency selective devices utilizing piezoelectric crystal resonators. The growing demand for crystal filters and related devices has created a number of career opportunities for: Circuit Design Engineers, Crystal Physicists, and Network Theory Specialists.

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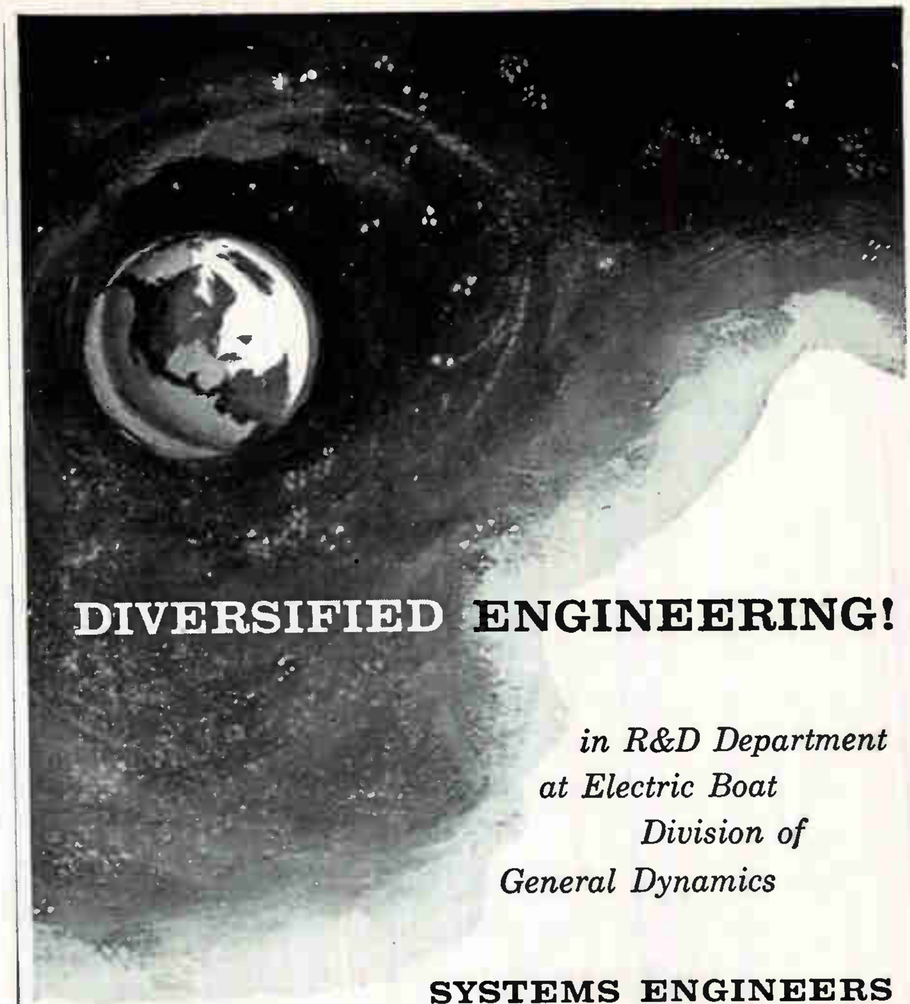

DIVERSIFIED ENGINEERING!

in R&D Department
at Electric Boat
Division of
General Dynamics

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To perform conceptual engineering and systems analysis on complex electro-mechanical and hydraulic systems, co-ordinate the technical efforts of detail engineering, and perform customer technical liaison.

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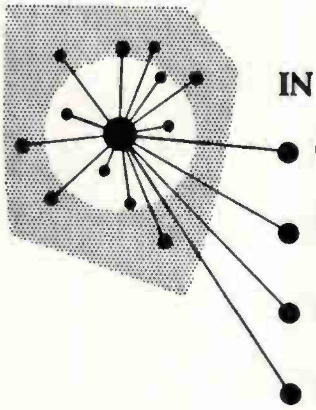

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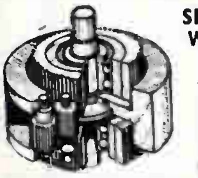

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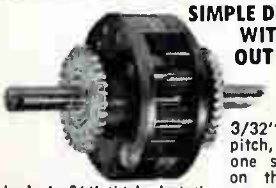

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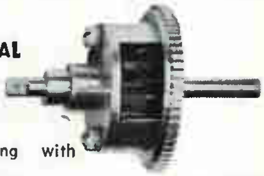

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SMALL DC MOTORS

(approx. size overall 3¾" x 1¼" dia.:)

5067043 Delco 12 VDC PM 1" x 1" x 2", 10,000 rpm.	$7.50
5067126 Delco PM, 27 VDC, 125 RPM, Governor Controlled	15.00 ea.
5069600 Delco PM 27.5 VDC 250 rpm	12.50
#5069625 120 rpm, mfr. Delco, 27 VDC governor controlled	$15.00
5069230 Delco PM 27.5 VDC 145 rpm	15.00
5068750 Delco 27.5 VDC 160 rpm w. brake	6.50
5068571 Delco PM 27.5 VDC 10,000 rpm (1x1x2")	5.00
5069790 Delco PM, 27 VDC, 100 RPM, Governor Controlled	15.00 ea.
#5069800 575 rpm, mfr. Delco, 27 VDC, PM reversible governor controlled, equipped with 27 VDC clutch	$17.50
5072735 Delco 27 VDC 200 rpm governor controlled.	15.00
5BA10A118 GE 24 VDC 110 rpm	10.00
5BA10AJ37 GE 27 VDC 250 rpm reversible	10.00
5BA10AJ52 27 VDC 145 rpm reversible	12.50
5BA10AJ50, G.E., 12 VDC, 140 rpm	15.00
5BA10FJ401B, G.E. 28 VDC, 215 rpm, 10 oz. in., .7 amp. contains brake	15.00
5BA10FJ421, G.E. 26 VDC, 4 rpm, reversible, 6 oz. in., .65 amp	15.00

400 CYCLE PM GENERATOR

Mfgd. by T K M Electric Corp.
Model #A-12
120/208 volts, 400 cycle, 1 or 3 phase, 1 kva, pf 0.8, rpm 8,000. Approx. dim. 6" x 5½". Internal spline drive. Price $100.00

400 CYCLE 1/3 PHASE GENERATOR

115 VAC. 3 KVA. Mfg. Bogue Elect. Mod. 2800S. External excitation 107 VDC. 1.1 amp. 3450 rpm. 1" shaft. $200.00

HONEYWELL VERTICAL GYRO MODEL JG7003A-1

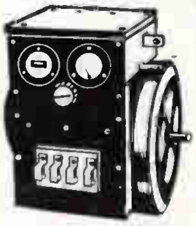
115 volts, 400 cycles, single phase, 35 watts. Pitch and roll potentiometer pickoffs 890 ohms, 40 volts max. AC or DC. Speed 20,000 rpm, ang. momentum 12,500,000 gm-cm ²/sec. Erection system 27 VAC, 400 cycles, time 5 min. to ½°. Weight 5.5 lbs. Price $35.00 each

SILICON RECTIFIERS

IN1551	1 amp.	100 volts	.80
IN1552	1 amp.	200 volts	.95
IN1553	1 amp.	300 volts	1.10
IN1554	1 amp.	400 volts	1.25
IN05K7	25 amp.	50 volts	2.50
IN1454	25 amp.	100 volts	3.00
IN1455	25 amp.	200 volts	3.50
IN1456	25 amp.	300 volts	4.00
IN1457	25 amp.	400 volts	4.50
IN1458	35 amp.	100 volts	3.50
IN1459	35 amp.	200 volts	4.00
IN05P7	50 amp.	50 volts	6.00
IN1462	50 amp.	100 volts	7.00
IN1463	50 amp.	200 volts	8.00
IN1464	50 amp.	300 volts	9.00
IN05R7	75 amp.	50 volts	9.00
IN1466	75 amp.	100 volts	10.00
IN1467	75 amp.	200 volts	11.00
IN1468	75 amp.	300 volts	12.50
IN1469	75 amp.	400 volts	14.00
05T7	100 amp.	50 volts	12.50
10T7	100 amp.	100 volts	13.00
20T7	100 amp.	200 volts	14.00
30T7	100 amp.	300 volts	15.00
IN05V7	150 amp.	50 volts	16.50
IN1474	150 amp.	100 volts	17.00
IN1475	150 amp.	200 volts	17.50
IN1476	150 amp.	300 volts	18.00
IN05X7	200 amp.	50 volts	19.00
IN1478	200 amp.	100 volts	19.50
IN1479	200 amp.	200 volts	20.00
IN1480	200 amp.	300 volts	21.00

400 CYCLE, 3 PHASE GENERATOR

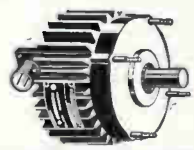
BY MASTER ELECTRIC Type AG, frame 364Y, 7.5 kw, 3428 rpm, pf .95 Star connected 120/208 3 phase, 22 amps. Delta connected 120 volt single phase 66 amps. Self excited. Complete with control box, voltage regulator, AC voltmeter and frequency meter. Shaft 1" dia., 2" long; overall dim. of unit: 21"x18"x 20".



Price $395.00 each

400 CYCLE PM GENERATOR

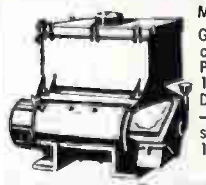
115/200 volts A.C. 1- or 3-phase, 200 watts. 4,000 r.p.m. Approx. dimensions: 4¾" dia.; 3" long; ½" shaft, AN connector. $75.00



400 CYCLE MOTOR GENERATOR

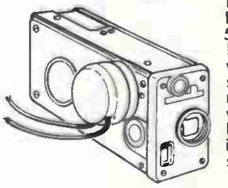
Mfgd. by General Electric
Model #5AT8324E5
Output 120/208 volts AC, 400 cycle, 11.75 kva, 32.6 amp., pf .85. Input 220/440 volts AC, 60 cycle, 3 phase, 15 h.p. Unit complete with motor starter and controls. Price $750.00

ONAN MOTOR GENERATOR SET



MG 075-G-1
Generator 115 VAC; 480 cycle; 5.3 amps; .6KW; PF 1.0; also 26 VDC; 100 watt; 3.8 amps; Driven by 115-230 VAC —2hp motor; 60 cycle; single phase; 3450 rpm; 10.5 amps.
Price $135.00

16mm SINGLE FRAME CAMERA



mfgd. by Bell & Howell (200 series) 50 ft. magazine load operates on 12 volt DC, has rotary solenoid, standard C mount, less lens and view finder; excellent for photographing records, nature study, etc.
Price $35.00 each

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ABOUT WATERLOO . . .

Shortly after Waterloo, the Duke of Wellington received a letter, postmarked St. Helena. It was from Napoleon. It read: "Excellency: I was amused to hear your recent remark that 'The Battle of Waterloo was won on the playing fields of Eton.' To have won an engagement in Belgium from a field in England, you must have been further back of the battle lines than I thought.

*"The real reasons for my defeat were two, and Eton was neither. In the first place, the radar broke down for two hours in the heat of battle. Not even a Napoleon can be expected to make radar work without Bomac tubes.**

"But I might easily have defeated you, faulty tubes and all, had I not been persuaded to partake of a bottle of Scotch on the evening before the battle. I have reason to suspect my drink was tainted. At any rate, on the day of Waterloo, I did not display my usual energy and decisiveness.

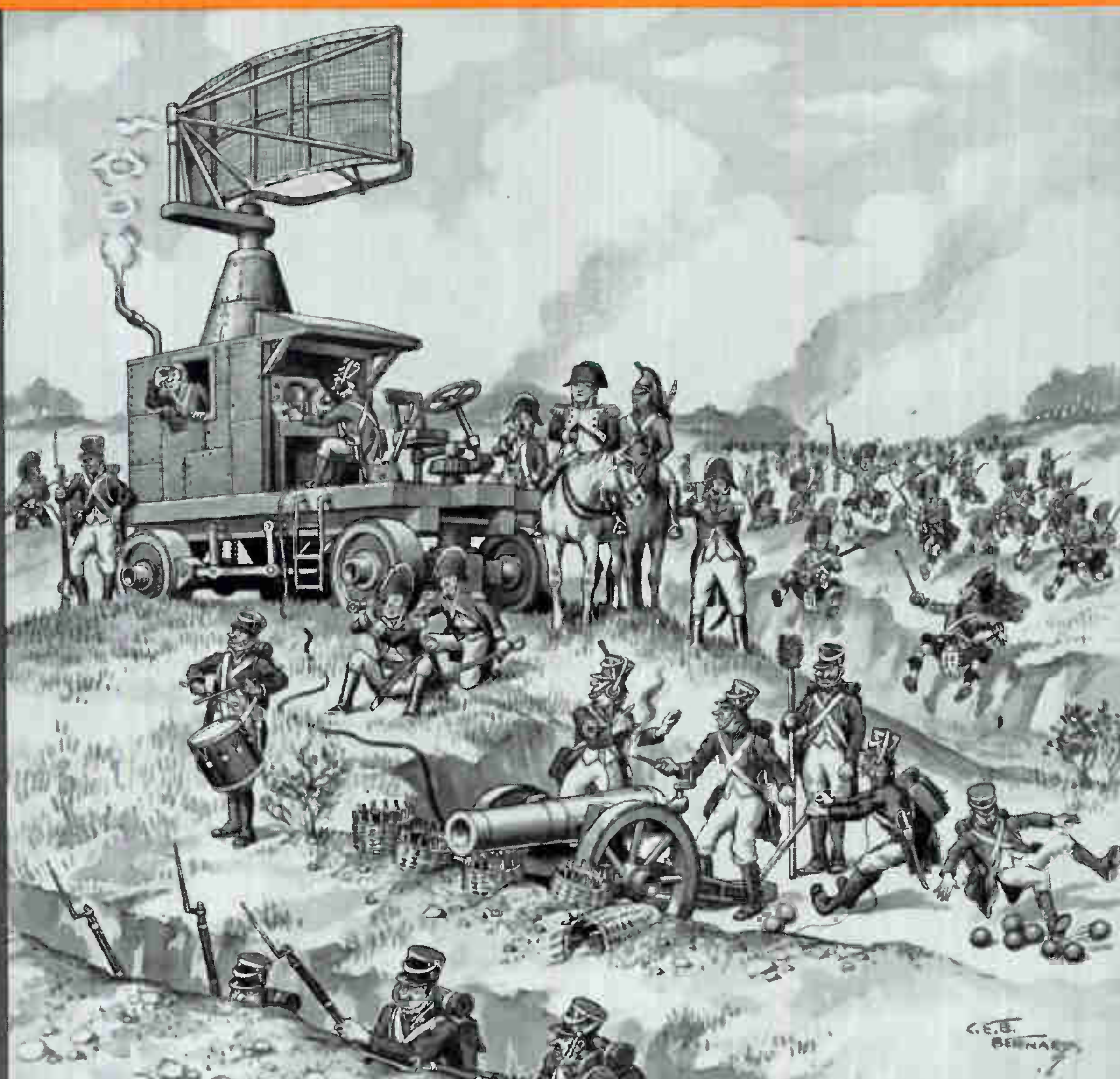
"It appears, in short, that you owe the battle to a bottle. (Signed,) N."

The Emperor received a brief reply by return boat. It read: "Excellency: In view of the fact that your loss at Waterloo appears to have been less a matter of Eton than of Drinking, I am withdrawing my original statement. I have released the following in its place, which I here submit for your approval:

'You can mix Scotch and Water
And Water and Scotch
But don't whatever you do
Make the mistake Napoleon did,
And mix Scotch and Waterloo.'

(Signed,) Wellington."

No. 19 of a series . . . **BOMAC LOOKS AT RADAR THROUGH THE AGES**



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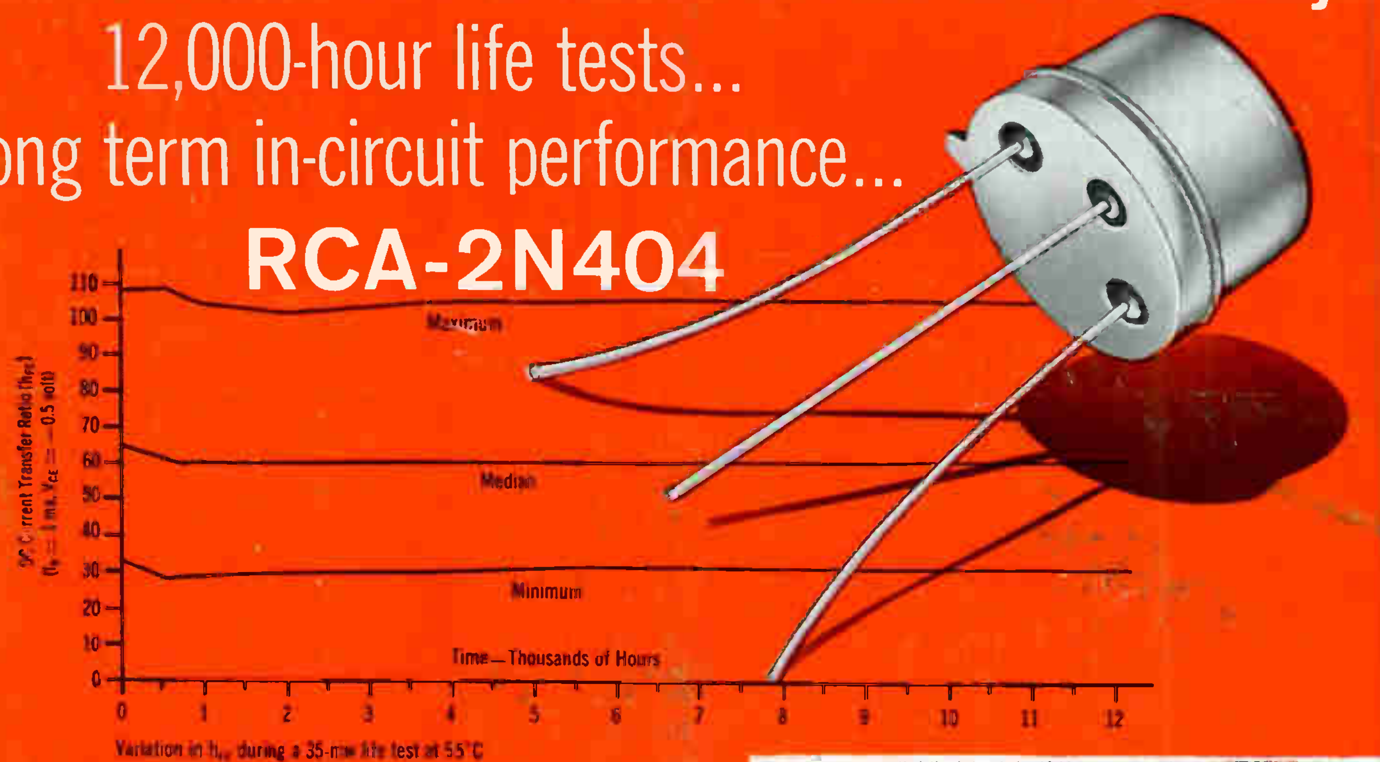
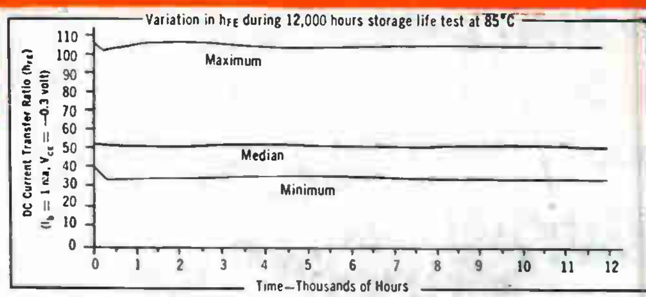
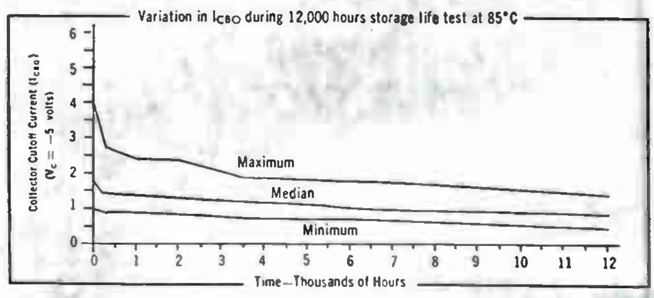
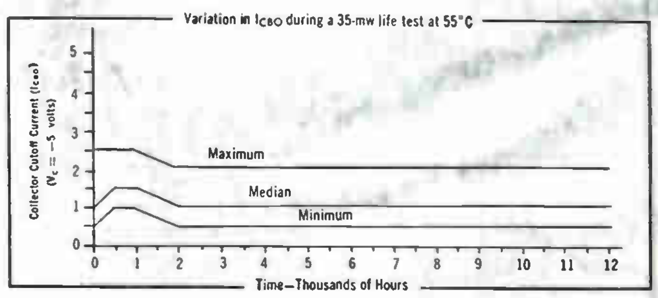
long term in-circuit performance...
RCA-2N404



Variation in h_{FE} during a 35-mw life test at 55°C







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Outstanding new achievements of operating reliability, long life, and stability are being made by the RCA-2N404 germanium p-n-p medium-speed switching transistor. Stringent long-term life tests and dynamic in-circuit performance checks, both at maximum ratings, provide additional proof of the bedrock reliability of the RCA-2N404.

Here are the results:

(1) Representative samples of the RCA-2N404 computer transistor have now passed 12,000 hours of operating life at *maximum* ratings. The curves at the right show the remarkable stability of transistor parameters over this exceptional time period.

(2) Samples from every lot of RCA-2N404 transistors are tested at *maximum* ratings for 1,000 hours. During 1959, almost 6,000,000 transistor test-hours at 85°C junction temperature were logged.

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