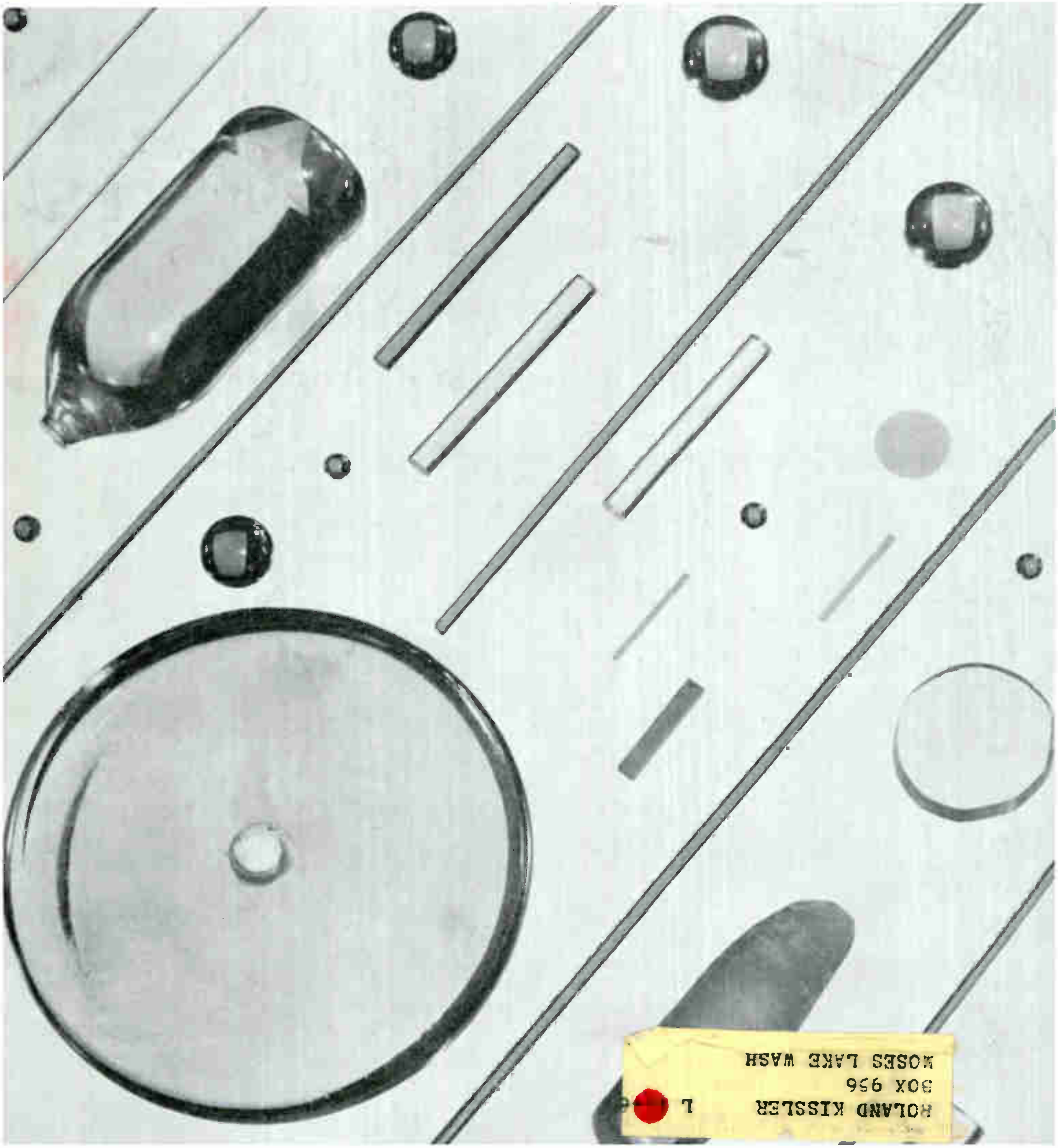
May 5, 1961

electronics

Ruby crystals (many forms shown below) and other maser materials are important components in microwave and optical electronics. See p 88

Solving problems of all-magnetic logic design. See p 61

A McGraw-Hill Publication 75 Cents



Now! GENERATE PRECISE SIGNALS

TO 40 KMC

with these new, inexpensive

FREQUENCY DOUBLER SETS!

For convenient, economical, reliable signal generation to 40 KMC, use these new hp Frequency Doubler Sets and either your own existing signal sources or one of the dependable, bench-proven hp signal generators on the next pages.

hp Model 938A supplies power from 18 to 26.5 KMC when driven by a 9 to 13.25 KMC source; hp Model 940A supplies power from 26.5 to 40 KMC when driven by a 13.25 to 20 KMC source.

The hp 938A and 940A have the same output versatility as the driving source. These broadband instruments accept cw, pulsed or swept input signals from signal generators, swept signal sources or klystrons.

Each contains a broadband crystal-harmonic generator, plus a dual rotary vane attenuator, for generating and accurately setting the output level 0 to —100 dbm. Output power depends on input power and is typically 0.5 to 1.0 mw when the driving source is an hp 626A or 628A Signal Generator or an hp 686A Sweep Oscillator. Output power is known, even though an uncalibrated signal source is used, since the output monitor is accurate to ± 1 to ± 2 db, depending on model and frequency.

hp 938A/940A conversion loss is approximately 17 db at 10 mw input. Maximum input power 200 mw, saturation output 2 mw. Attenuator accuracy ± 2% of reading or 0.2 db (whichever is greater). Attenuator range 100 db; output SWR less than 1.2 at 10 db or more attenuation. Sturdy construction permits signal source to be mounted on top of Doubler Set, presents output at convenient bench level. hp 938A, $1,500.00; hp 940A, $1,500.00.

Check these Precision hp SIGNAL GENERATORS

FULL COVERAGE

hp 606A Standard Signal Generator 50 KC to 65 MC

Output adjustable from 3 v full range to 0.1 μv rms (+23 to −120 dbm). Feedback assures power into a 50 ohm load constant within ± 1 db over the frequency range. Reliable internal crystal calibrator permits checking points at 100 KC and 1 MC intervals with an error of less than 0.01%. Very low distortion, broad modulating capabilities. Typical hp speed, ease of operation. hp 606A, **$1,350.00.**

VHF SIGNAL GENERATORS

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Highest stability, low incidental FM and frequency drift. Calibrated output 0.1 μv to 0.5 v throughout range. Built-in crystal calibrator provides frequency check accurate within 0.01% each 1 and 5 MC. Master-oscillator, buffer and output amplifier circuit design. Direct calibration, ideal for aircraft communications equipment testing. hp 608D, $1,200.00.

hp 608C—vhf Signal Generator

High power (1 v max.), stable, accurate generator. 10 to 480 MC. Ideal for testing receivers, amplifiers, driving bridges, slotted lines, antennas, etc. hp 608C, **$1,100.00.**

UHF SIGNAL GENERATORS

hp 612A—450 to 1,230 MC

Same high output power, low incidental FM, broad modulation capabilities as hp vhf signal generators. Frequency, output directly set on large precisely calibrated dials. hp 612A, $1,300.00.

hp 614A—800 to 2,100 MC

Easy to use, direct-reading, one-dial frequency control, high stability and accuracy. Ideal for measuring receiver sensitivity, signal-noise ratio, conversion gain, SWR, transmission line characteristics. hp 614A, $1,950.00.

hp 616B—1,800 to 4,200 MC

Ruggedly built, compact to save bench space, offers same hp precision, ease of operation, compactness of the other hp uhf instruments. hp 616B, $1,950.00.

SHF SIGNAL GENERATORS

hp 618B—3,800 to 7,600 MC
hp 620A—7,000 to 11,000 MC

These instruments provide the simple, versatile operation and varied pulsing capabilities common in hp signal generators to the lower regions of the shf range. The 618B and 620A may be synchronized with an external sine wave or with positive or negative pulse signals, as may other hp signal generators. hp 618B, $2,250.00; hp 620A, $2,250.00.

May 5, 1961

electronics

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W. W. MacDONALD, Editor

BUSINESS

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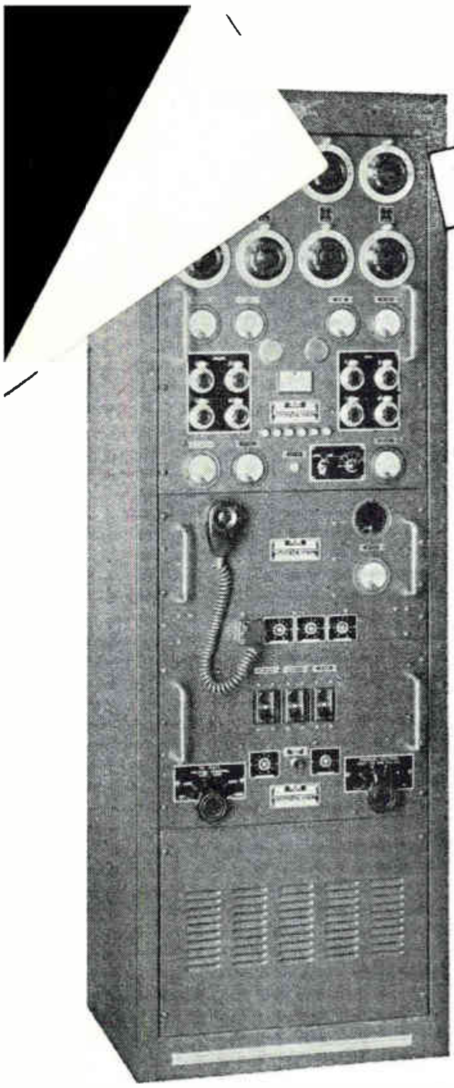

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AEROCOM 1046 TRANSMITTER

1000 W CARRIER POWER WITH HIGH STABILITY

The Aerocom 1046 Transmitter is designed to give superior performance for all point-to-point and ground-to-air communications. It is now in use throughout the world in climates ranging from frigid to tropical (operates efficiently at −35° to +55° Centigrade).

As a general purpose High Frequency transmitter, the 1046 supplies 1000 watts of carrier power with high stability (above −10° Centigrade: ±.003% for telegraph and telephone. Temperature controlled oven for FSK). Multichannel operation is provided on telegraph A1, telephone A3 and FSK (Radio Teletype). It can be remotely controlled using one pair of telephone lines plus ground return with Aerocom Remote Control Equipment. Front panel switches and microphone are included for local control.

Four crystal-controlled frequencies (plus 2 closely-spaced frequencies) in the 2.0 - 24.0 megacycle range can be used one at a time, with channeling time only two seconds. Operates into either balanced or unbalanced loads. The power supply required is nominal 230 volts, 50 - 60 cycles, single phase.

The housing is a fully enclosed rack cabinet of welded steel, force-ventilated through electrostatic filter on rear door.

Telegraph keying (A1): Up to 100 words per minute. Model 1000 M Modulator (mounts in transmitter cabinet) is used for telephone transmission; a compression circuit permits the use of high average modulation without overmodulation. Model 400 4 Channel exciter is used for FSK.

Output connections consist of 4 insulated terminals (for Marconi antenna) and 4 coaxial fittings Type SO-239, which can be used separately or in parallel in any combination. For 600 ohm balanced load, Model TLM matching network is used, one for each transmitter channel.

As in all Aerocom products, the quality and workmanship of Model 1046 are of the highest. All components are conservatively rated. Replacement parts are always available for all Aerocom equipment.

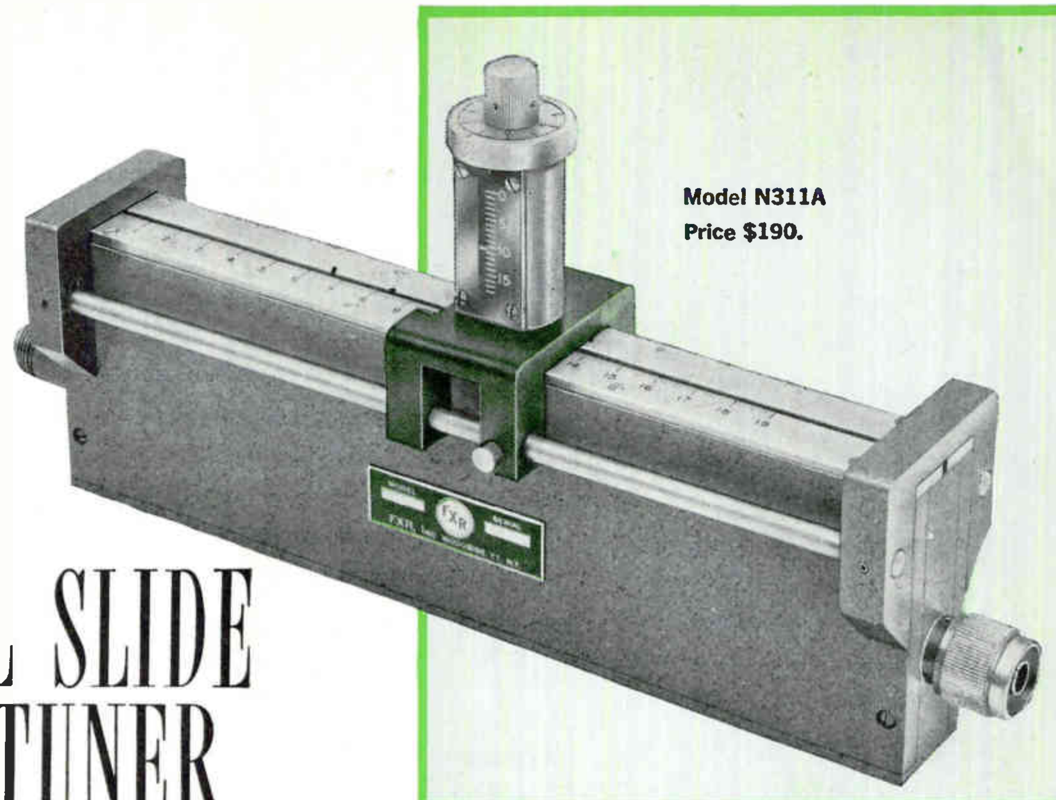
Complete technical data on Aerocom Model 1046 available on request.

AER-O-COM

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

FIRST FROM FXR

COAXIAL SLIDE SCREW TUNER



Model N311A
Price $190.

covers from 1.0 to 10.0 Gc

VSWR's up to 10:1 matched to 1.00

- First coaxial tuner covering frequency range from 1.0 to 10.0 Gc
- Matches VSWR's of 10:1 to 1.00
- Insertion loss less than 1 db when correcting mismatch of 3:1
- Corrects mismatch of any phase
- Standard Type N Connectors (jack to plug) for universal utilization

FXR's new, broadband coaxial slide screw tuner, Model N311A, tunes throughout the entire frequency range from 1.0 to 10.0 Gc over which VSWR's as high as 10:1 can be matched. An FXR first, this new tuner saves measurement time and equipment investment.

RF leakage is minimized by means of a special poly-iron choke mounted along the tuner's slot. Graduations on the body and probe permit quick, accurate resets.

The N311A coaxial tuner, paralleling similar achievements in waveguide slide screw tuner development, is another illustration of FXR's widely acknowledged capabilities in the field of precision microwave test instrumentation.

Write or call now for data sheets on Model N311A and other units in the extensive FXR line of precision slide screw tuners.

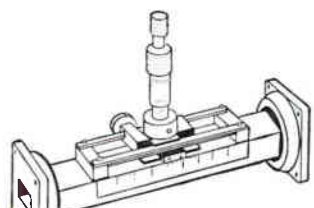
FXR's COMPREHENSIVE LINE OF PRECISION WAVEGUIDE TUNERS

WAVEGUIDE TYPES

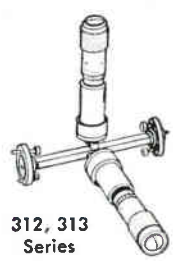
Slide Screw Tuner Model & Price	E/H Tuner Model & Price	Freq. Range Gc	Waveguide Type RG-( )/U
L310A $250.	—	1.12 to 1.70	69
R310A $325.	—	1.70 to 2.60	104
S311A $150.	S312A $270.	2.60 to 3.95	48
H311A $140.	H312A $210.	3.95 to 5.85	49
C311A $135.	C312A $180.	5.85 to 8.20	50
W311A $130.	W312A $150.	7.05 to 10.0	51
X311A $125.	X312A $130.	8.20 to 12.40	52
Y311A $130.	Y312C $135.	12.40 to 18.00	91
—	K312C/CF $155.	18.00 to 26.50	53
—	U312B/BF $170.	26.50 to 40.00	96
—	Q312B $235.	33.00 to 50.00	97
M311A $225.	M312C $245.	50.00 to 75.00	98
—	E312C $390.	60.00 to 90.00	99
—	F313A $775.	90.00 to 140.00	138
—	G313A $775.	140.00 to 220.00	135

All prices and characteristics subject to change without notice.

DELIVERY FROM STOCK



311 Series



312, 313 Series

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electronics
May 5, 1961 Volume 34 Number 18

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CROSSTALK

A WISE GOVERNMENT MOVE. Labor Secretary Arthur J. Goldberg has announced his intention to set up an Office of Automation & Manpower in the Labor Department to cope with the problems of changing U. S. industry over to automatic controls. As presently conceived, the new office would serve an important function in future industrial development.

In the Secretary's words, the OAM will "examine employment and unemployment by industry, occupation and area, to follow current and anticipated technological changes . . . Consider and develop educational and guidance programs to allow workers who may be displaced by automation to find employment without suffering a long period of unemployment . . . (and) Develop proposals for both training and retraining, for both placement and replacement of workers coming into the new economy, and those who must change their places within it."

Such a move should be strongly supported by the electronics industry. It is vastly more sensible than the blind pouring of funds into depressed areas, or such makeshift proposals as reductions in workweek so as to spread work around. It is certainly far more intelligent than permitting the development of mindless resistance to automation *per se*, such as has been noted in some statements in recent months.

Mr. Goldberg has asked management "to stop automatically resisting proposals to ease the human burden of automation." This is not only a humanitarian request; it is a practical one. The wider the distribution of the fruits of human progress, the more stable the civilization. Besides, as engineers we should rejoice in the thought that the products of our inventiveness and labor may make life easier and the world pleasanter for more and more people. If management does not help smooth the path, automatic industrial controls will be resisted first by labor, then by the electorate, and certainly by any government sensitive to the demands of either.

The Secretary has also asked labor to abandon restrictive practices and to concentrate with management on development of "devices to create labor mobility." This too is sound counsel, and it is to be hoped that it is accepted and acted upon.

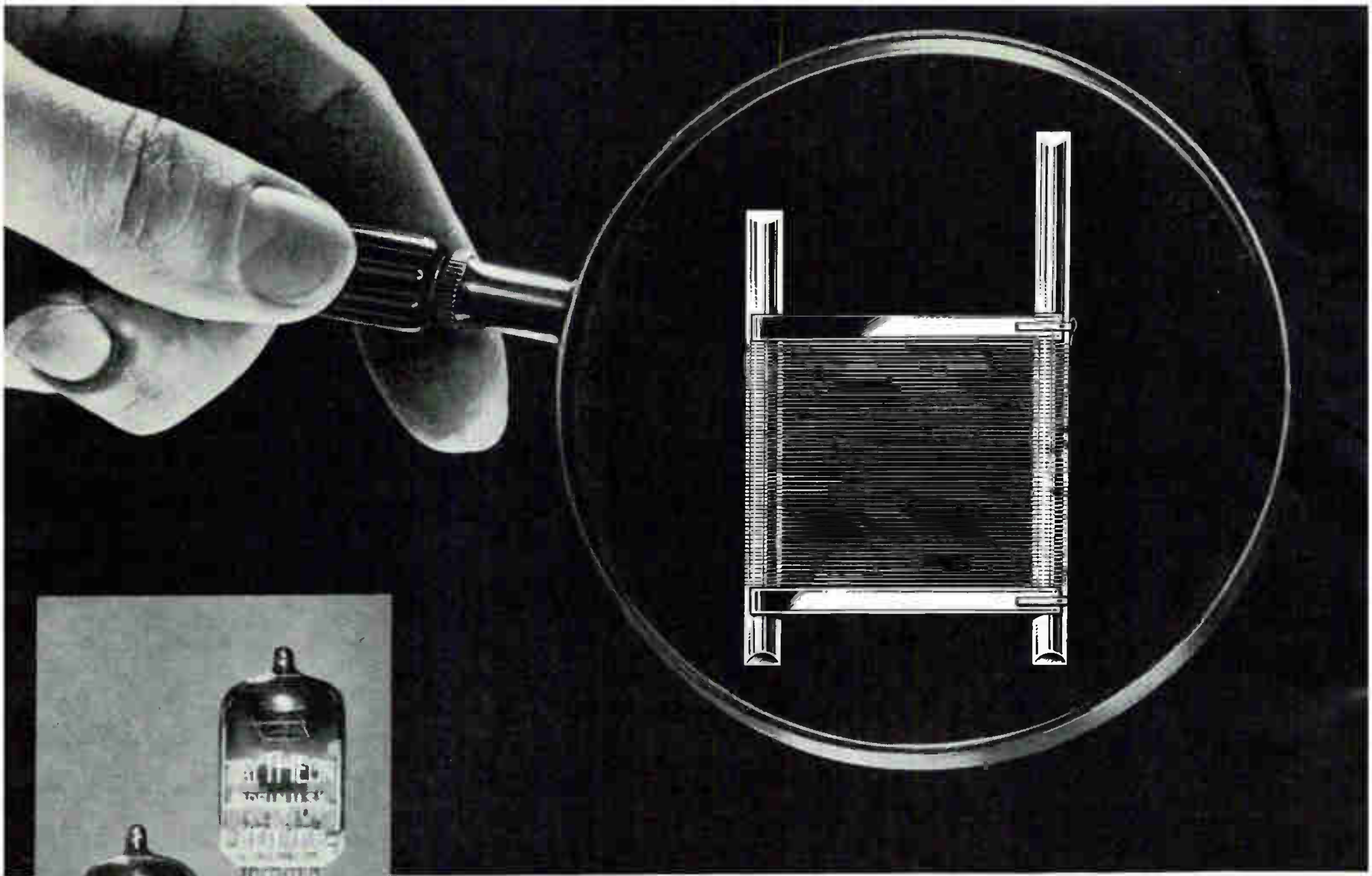
If management, labor and the government combine to find ways of retraining and replacing workers, and smoothing the path toward the automation of U. S. industry, it will help us more rapidly achieve the era when production can truly be given over to the machine, and man can devote his energies to the higher problems for which he is fitted. More immediately and materialistically, the level of productivity and the standard of life will be improved. It is in the specific and the general interest of the electronics industry to aid in this program as much as possible.

Coming In Our May 12 Issue

3-D MEMORY DESIGN. In large-scale memories, three dimensional selection can be less costly than two dimensional, which is used in small, fast memories. In our next issue, C. A. Allen, G. D. Bruce and E. D. Councill of IBM in Poughkeepsie describe the design of a megabit 3-D core storage unit. The memory, whose development was originated as part of the Stretch computer program, handles 16,384 words, each of 72 bits length. Memory cycle time for selecting any random word is 2.18 microseconds.

NETWORKS. Transformation of networks containing various combinations of inductors, capacitors and resistors can be tedious. Thus, we're sure you'll welcome the reference sheet in next week's issue by H. J. Blinchikoff of Westinghouse Electric in Baltimore. He presents a series of charts for transforming canonic one-terminal-pair R-C and R-L circuits. Incidentally, if you need charts for transforming combinations of inductors and capacitors, you'll want to look at the reference sheet by Blinchikoff and A. Zverev. It appeared in our June 26, 1959 issue (p 52).

CIRCLE 5 ON READER SERVICE CARD→



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Raytheon frame grid tubes provide your designs with greater performance and reliability—higher gain bandwidth product and lower noise than available from types with conventional grid construction. These tubes feature perfect pitch frame grids with high uniformity of spacing and characteristics, manufactured by the most precise equipment in use today. For example, tolerances are held to an almost unheard of ±0.0002"!

Rigidity is attained through optimum design, making the Raytheon frame grid construction highly reliable. The results are better uniformity and a reduced spread of characteristics—important contributions to the improvement of your circuit designs.

Bring to your circuit designs the many important advantages offered by Raytheon's growing family of frame grid tubes. For technical data, please write to Raytheon, Industrial Components Division, 55 Chapel Street, Newton 58, Massachusetts.

Raytheon Frame Grid Types—Gm				
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COMMENT

Medical Electronics

I enjoyed reading your three articles on medical electronics (p 49, Jan. 20; p 46, Feb. 3, and p 54, Feb. 24), and wish to compliment you on the fine presentation. I was impressed with the amount of research you must have carried out to produce such a comprehensive series . . .

L. A. GEDDES
BAYLOR UNIVERSITY
HOUSTON, TEXAS

Britain's Electronics

A short report entitled "World Electronics Production" (p 97 of "Our Industry—Today and Tomorrow," Jan. 6) has come to my attention. The impression given here is that Britain lags behind France, Japan and West Germany, whereas the true position, as is well known in Europe, is that Britain is second to the U. S. in electronics, and in relation to size and population Britain is by far the largest exporter of electronic goods in the world.

It is felt that a statement such as that referred to is damaging to the British electronics industry and all the more so by reason of the world-wide influence of your journal.

H. E. F. TAYLOR
ELECTRONIC ENGINEERING ASSOCIATION
LONDON W1, ENGLAND

. . . I have just been reading "Our Industry—Today and Tomorrow" in your Jan. 6 issue. I would like to congratulate you on this remarkable effort. We are naturally particularly interested in following the structural changes and marketing trends of the U. S. electronics industry, as so often these herald similar changes in this country.

Unfortunately, as you may have discovered, there are few if any economic experts here who are able or willing to write authoritatively on the economics of the industry. Indeed, our statistics are in such a state of chaos that this is not surprising.

It seems that the British industry's lack of ability to project itself in the best light is reflected in the article "World Electronics Production" on p 97 of the Jan. 6 issue. I am greatly disturbed to note that the authors of this report consider that Britain shares only 4.1 percent of the world electronics market. To suggest that Britain follows West Germany, Japan and even France is most misleading, and in view of the influence of your journal, most damaging to our overseas reputation.

In actual fact, the gross output of the electronics-based industries in the United Kingdom in 1960 is estimated to have reached £500 million ($1.4 billion), and exports, according to our own researchers, reached £97.5 million ($273 million). These figures are far in excess of those for Western Germany, Japan or France . . .

Our own investigations, in fact, show that Britain can claim an even greater share of the market (than accepted statistical evaluations indicate). It is certainly generally recognized on the continent that in Free-World electronics the United Kingdom comes next to the U. S. It seems a great pity that this view was not shared in the U. S., and I hope that you will be able to rectify this in a future issue . . .

C. C. GEE
ELECTRONICS WEEKLY
LONDON WC2, ENGLAND

We did indeed understate the volume of UK output and are grateful for the correction and for amplifying data since made available to us. As colleague Gee points out, there are few economic or marketing experts in the United Kingdom who are willing to write authoritatively on the economics of the industry there. We formed our estimates with fragmentary data from which we made extrapolations; our data were more accurate in the case of the industry on the continent than in Britain's case.

The recent tour of our chief editor through Europe, including Great Britain, has resulted among other things in improvement in our sources and channels of information on such subjects.

"Frankly, we've been first in High-Power Signal Generators but last in advertising"

FACT FILE

BORG-WARNER CONTROLS R-F TEST INSTRUMENTS

...engineered to exacting laboratory requirements

FIRST IN HIGH-POWER SIGNAL GENERATORS SINCE 1946

In 1946, we introduced the high-power signal generator, providing 10,000 times more power than any previous generator. Today, we manufacture a complete line of R-F test instruments (from 85 KC up to microwave) that are in wide use by government agencies (including the National Bureau of Standards), by the Armed Forces and by major industries.

BORG-WARNER CONTROLS' *Mobile Testing Units guard the day-to-day accuracy of* **SAGE**... *America's electronic defense against air attack.*

These traveling radar orientation units...used for periodic checking of overall SAGE subsectors...include Borg-Warner Controls high-power transmitters/receivers, communication equipment and associated test equipment and antennae.

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HOW TO INCREASE CIRCUIT

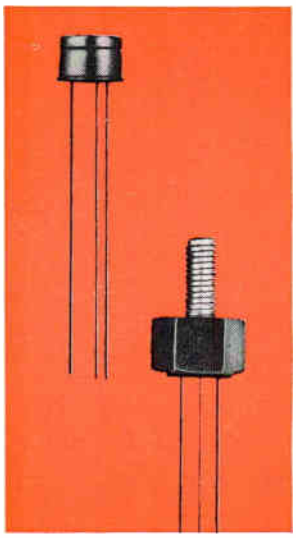
HIGH VOLTAGE/

MILITARY SERVOS

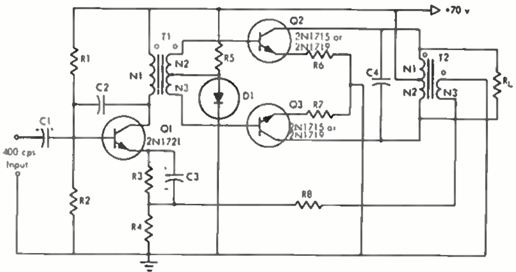
TI 2N1714 AND 2N1718 SERIES GIVE YOU EXCLUSIVE "THERMOSLUG" PACKAGE/GUARANTEED 10-WATTS AT 100°C CASE/GUARANTEED $BV_{CEO(sust)}$ OF 60 AND 100 VOLTS.

TI 2N1722 AND 2N1724 SERIES GIVE YOU EXCLUSIVE 0.5 OHM R_{CS}/GUARANTEED 80-VOLT $BV_{CEO(sust)}$/GUARANTEED BETA AT TWO CURRENT LEVELS.

Now — four improved N-P-N silicon power transistor series to meet high voltage/high temperature requirements — particularly where your present devices are taxed beyond their temperature and voltage capabilities! These new power devices give you a wide choice of excellent power characteristics *plus* dissipation ratings from 10 to 50 watts at *100°C* case temperature. Specify these new power transistors *today* for your power converters, servo amplifiers, regulated power supplies, relay drivers, inverters, choppers, and high-current, medium-speed switching designs in missile, airborne and communications applications.



7.5 watt, 400 cps servo amplifier*



Circuit Characteristics at 7.5w Power Output:

Power Gain — 45 db min
Voltage Amplification — 44 ± 2 db
Input Resistance — 1.9 KΩ min
Total Harmonic Distortion — 5% max
Ambient Temperature Range: —55°C to + 125°C.

TI 2N1714 AND 2N1718 SERIES The N-P-N 2N1714 and 2N1718 "Thermoslug" series give you *10-watt* dissipation at *100°C* case temperature with minimum voltage ratings of 60 and 100 volts. You get guaranteed d-c betas of 20 — 60 and 40 — 120, with a low V_{BE} of 1.6 volts maximum plus exclusive guaranteed low-current and low-temperature betas. Electrically identical, both the 2N1714 and 2N1718 series are available in either the "Thermoslug" TO-5, or the double-ended stud high-efficiency package.

Use TI 2N1714 and TI 2N1718 series to replace these transistor series in your new designs: 2N497, 2N545, 2N1479, and 2N696.

**For more information on this and other power transistor applications, write for TI data sheet 61433.*

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• Intermediate Power • Power • High Power • Industrial

17905

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EFFICIENCY IN YOUR

HIGH TEMPERATURE

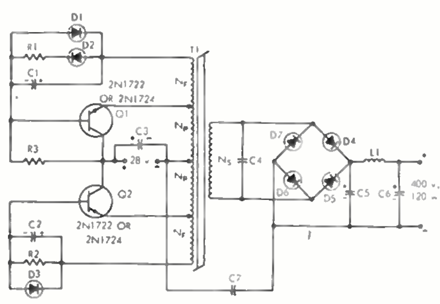
& POWER SUPPLIES

Intermediate Power	BV_{CEO}	h_{FE}	h_{FE}	V_{BE}	$V_{CE\ (sat)}$	BV_{EBO}
	$I_C = 30$ ma	$I_C = 200$ ma	$I_C = 10$ ma	$I_C = 200$ ma	$I_C = 200$ ma	$I_E = 10\mu a$
2N1714, 2N1718	60 v min	20 min 60 max	10 min	1.6 v max	2.0 v max	6 v
2N1715, 2N1719	100 v min	20 min 60 max	10 min	1.6 v max	2.0 v max	6 v
2N1716, 2N1720	60 v min	40 min 120 max	20 min	1.6 v max	2.0 v max	6 v
2N1717, 2N1721	100 v min	40 min 120 max	20 min	1.6 v max	2.0 v max	6 v
High Power	$I_C = 200$ ma	$I_C = 2$ a	$I_C = 100$ ma	$I_C = 2$ a	$I_C = 2$ a	$I_E = 10$ ma
2N1722, 2N1724	80 v min	20 min 90 max	20 min	2.0 v max	1.0 v max	10 v

TI 2N1722 AND 2N1724 SERIES You get high power, high frequency response, high voltage, and low R_{cs} with TI 2N1722 (square-flange) and 2N1724 (double-ended stud). These high-current silicon power devices give you *50 watts* of power dissipation at *100°C* case temperature, guaranteed $|h_{fe}|$ greater than 1 at 10 mc, and 80-volts $BV_{CEO(sust)}$. The maximum V_{BE} of 2 volts and maximum R_{cs} of 0.5 ohms, both guaranteed at 2-amps collector current, improve overall circuit efficiency.

Use TI 2N1722 and TI 2N1724 to replace these transistor series in your new designs: 2N389, 2N1487, 2N1511, 2N1660, 2N1015 and 2N1616.

120 watt, 10 Kc dc-dc converter⁺



Circuit Characteristics at 120 w Power Output:
Input Current — 5a
Total Efficiency — 85%
Self-Starting and Short-Circuit Protected
Output Ripple — 0.6 v max.

⁺*For more information on this and other power transistor applications, write for TI data sheet 61431.*

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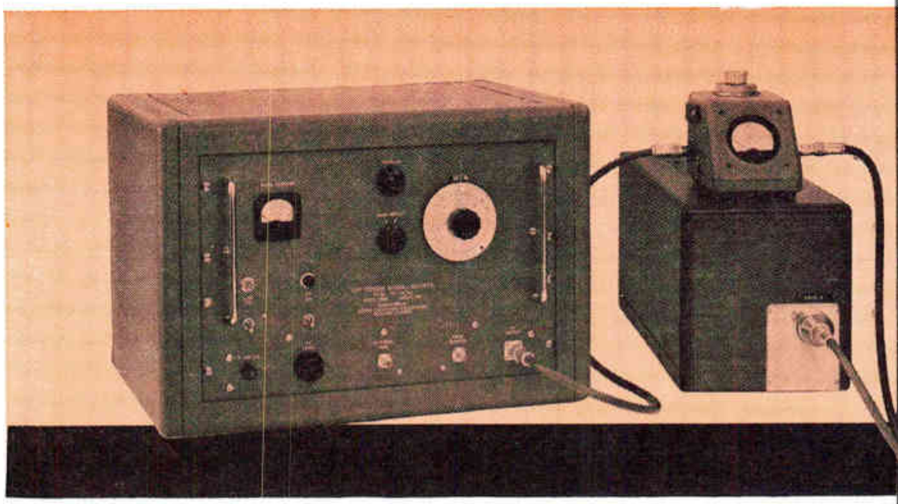
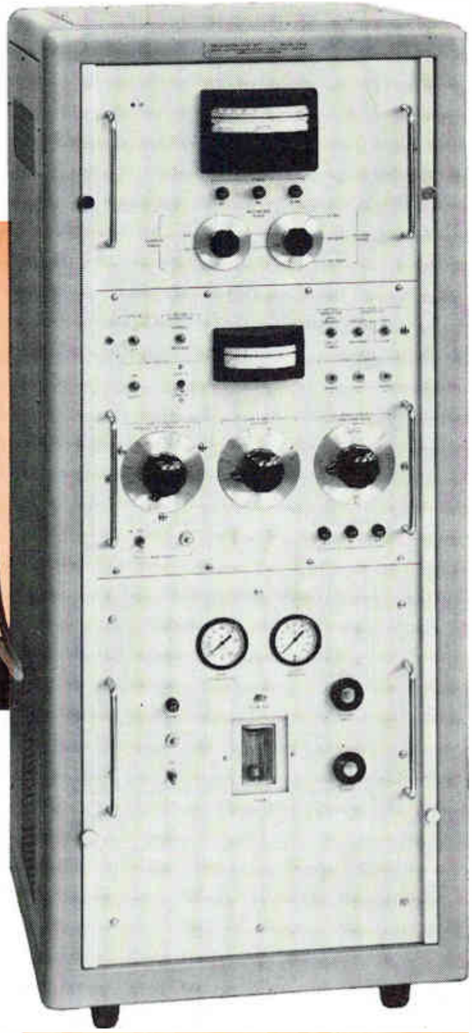
Ready for you now!

Primary standard accuracy for power measurements to 1,000 watts!





Sierra 290B Test Set

Laboratory setup above shows Sierra Model 215 Power Source being used in conjunction with Model 290B Calorimeter to calibrate Sierra Bi-Directional Power Monitor. Designed specifically for calibration purposes, 215 series Sources include four 50 watt models covering, collectively, 25 to 1,000 MC. Model 215A, 25 to 50 MC; Model 215B, 50 to 150 MC; Model 215C, 150 to 470 MC; Model 215D, 470 to 1,000 MC. Price (any model) $3,300.00.

For complete details, see your Sierra representative or write direct

Frequency coverage dc through 12.4 KMC.

Precise ac wattmeter, calorimeter and heat exchanger in one neat, rack unit. Separate dual loads for dc to 4 KMC, also C, XB, X bands. Direct reading linear scale.

Above are highlights of the new Sierra 290B Calorimetric Wattmeter Test Set—the industry's closest approach to absolute power measurements in this range.

Model 290B measures power in three distinct modes.

1. For power levels 30 to 1,000 watts, a null-balance mode provides measurement accuracies of 1% or better, with probable error as low as 0.5%.

2. For wider range power levels from 10 to 1,500 watts, a direct-reading mode provides excellent linearity in thermal readout and 2% to 3% accuracy. Readout is fast—60 seconds or less.

3. For expanded scale readings of highest resolution, the above two modes may be combined in a third mode to obtain the order of accuracy of the null-balance mode, together with the time-saving convenience of the direct readout mode.

Model 290B, $4,500.00. (Water loads, extra.)

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

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ELECTRONICS NEWSLETTER

New Alloy Magnets Are Superconductive

SCIENTISTS J. E. Kunzler and B. T. Matthias from Bell Telephone Laboratories told the 1961 spring meeting of the American Physical Society in Washington, D. C. that they had prepared a niobium and zirconium alloy to retain superconducting characteristics in magnetic fields up to 100,000 gauss at low kinetic temperatures.

They predicted that within a year a superconducting electromagnet would be built in the 80,000-gauss range. Within three years, they predicted one in the 200,000-gauss range would be built.

Size of an 80,000-gauss superconducting magnet will be only about 2-ft in diameter by three to four feet high, weighing a few hundred pounds. A conventional magnet of this size requires several rooms of equipment.

The cost of the new magnets will be roughly 50 percent lower than conventional magnets in initial cost and operation.

The availability of large magnetic fields will extend the operation of many electronic communication devices to higher frequencies, thus providing increased bandwidth for use in radio-relay communication systems. They will be of value in the field of thermonuclear fusion.

Scientists from RCA reported an Air Force sponsored new radio-frequency technique that may propel space vehicles on interplanetary flights. The technique uses ultra-high frequencies to accelerate electrons and ions. Successful experiments have already been conducted at frequencies of 140 and 330 Mc, with new experiments planned using 2,500 Mc. The experiments were described by G. A. Swartz, T. T. Reboul and G. D. Gordon.

Plasma is generated by successive electrical discharges from a pool of mercury, and released into a cylindrical chamber. Radio frequency-power is applied, producing an electrical field strongest near the plasma source and decreasing rapidly with distance. The charged particles in the plasma are accelerated swiftly from the stronger toward the weaker field. Resulting thrust can be used to propel an object in space. The scientists have raised the speed of ions in the plasma at the lower frequencies to nearly 40,000 miles per hour within a distance of two inches.

Patent Bills In Senate Opposed By EIA

PROPOSED LEGISLATION to require all Federal agencies to take title on patents of inventions developed in performance of government contracts is being opposed before Senate Patents Subcommittee in Washington by Electronic Industries Association witnesses. The government would be gaining property it had not paid for, the EIA said, under conditions that amount to confiscation.

The association spokesmen urged legislation reaffirming "traditional principles of private ownership of patents" with reservation of royalty free licenses assigned to the government.

EIA pointed out that inventions cannot be contracted for, since they are incidental to contract performance, thus cannot be predicted in advance of signing the contract. They also claimed a major stimulant to electronics industry growth would be lost due to the title claiming legislation, and that firms doing both government and commercial work would not put in to the government sponsored research their best and newest patentable ideas.

New Light Detector Tells Satellite Spin Axis

LIGHT DETECTING device sensitive enough to detect very weak light rays from the moon, yet rugged enough to withstand direct sunlight 10 million times stronger than moonlight, is in advanced development at IBM's Thomas J. Watson Research Center. Contract is with NASA's Goddard Space Flight Center.

Called the "moonlight photodetector," the device will be used in an optical sensing system for satellites developed at Goddard.

Ten times as sensitive as silicon solar cells and other similar semiconductor light detectors, the device has a silicon surface smaller than a pinhead. A 1.36-volt battery the size of a penny will keep it going for "several years."

The detector is activated by the series of light flashes received from the sun or moon as the satellite rotates. Flashes are converted to electrical pulses, transmitted to earth, fed into a computer which reveals the orientation of the satellite's spin axis.

The device uses some of the electronic properties of a semiconductor-electrolyte contact, consists of a silicon semiconductor and sulphuric acid for the liquid electrolyte—the latter chosen from many possible electrolytes because of its high degree of stability over a wide temperature range.

Semiconductor Materials To Undergo Space Tests

SPACE CONDITIONS as they affect semiconductor materials will be studied at a special facility being built in Stamford, Conn.

An Air Force contract has been awarded to CBS Laboratories to determine recommendations on which semiconductor materials are best suited for space applications. W. W. Gaertner, CBS vice-president of solid state research and development, will direct the program. He says semiconductors must be investigated throughly because their characteristics are sometimes strongly affected by many types of radiation encountered in different regions of the atmosphere and in space.

The new facility will be able to expose materials to radiation in the visible, ultraviolet and infrared spectra and to high-energy electron bombardment, under vacuum and temperature conditions prevalent in upper atmosphere and space enviroments.

Another Air Force study contract awarded to RCA is aimed at finding the ultimate limits of microminiaturization in semiconductors. Results to date indicate principal limiting factor is damage to lattice structures by background cosmic ray action.

Explorer 11 Carrying Complex Space Telescope

COMPLEX SPACE TELESCOPE was fired into orbit last week to explore radiation mysteries of the universe.

The 95-pound satellite named Explorer 11 (formerly S-15) was launched at Cape Canaveral in the nose of a 76-ft Juno 11 rocket. All four stages of the booster ignited successfully and propelled the payload into orbit at nearly 18,000 miles an hour.

More than two hours after launch the National Aeronautics and Space Administration announced that "tracking stations at Johannesburg, South Africa; Woomera, Australia; San Diego, Calif., and East Grand Forks, Minn., confirmed that the satellite is in orbit."

The telescope was aimed at a course which would swing it between 300 and 750 miles above the earth. Project officials said good signals were being received.

The success gives U. S. scientists the world's first astronomical observatory in space (ELECTRONICS, p 32, Apr. 14).

The assignment is to study radiation outside the air envelope which interferes with reception on earth.

Joint Electronics Firm Started In Italy

NEW COMPANY IN ITALY formed to design and install missile systems and other electronic gear has been announced as a joint venture of Vitro Corp. of America and Selenia S.P.A., a Raytheon Co. subsidiary.

The new company will be known as Vitroselenia and will be headquartered in Rome. Predicted sales volume for first three years of operation will total around $15 million, company officials say. Vitro and Selenia will each have a half interest in the new firm, will each provide three of its six directors.

Selenia is largest of Raytheon's European group of companies, with 40 percent interest held by Raytheon, remainder by Italian firms and interests. Selenia produces both commercial and military produces including big ship radar and Italian portion of NATO Hawk Missile.

Stowable Command Unit For Submarine's Bridge

NAVY'S PORTABLE COMMAND CENTER, a new unit by Scintilla Div. of Bendix, can be plugged in at bridge of surfaced submarine to provide all communication and information functions needed by sub's commander. Combining a number of instruments formerly installed on the bridge and thus subject to pressure-induced flooding, the new "suitcase" is stowed below deck during dives.

A single hull penetration plug-in connection on the bridge is provided, with actual command unit maintenance possible before surfacing. The company says the unit has been placed aboard the nuclear submarine *U.S.S. Shark*, launched early in January.

New Program Seeking Advances in Thermionics

THERMOELECTRIC PROGRAM started this week by Transitron and American Gas Association seeks development of low-cost thermoelectric couples to provide power for control of motors and fans on gas furnaces.

The joint effort parallels AGA-sponsored development projects in thermionic conversion and fuel cells to make gas heaters and other appliances independent of outside electrical current. Transitron is working on small power modules which can be designed into appliances.

Magnetic Resonance Seen As Nondestructive Test

NUCLEAR MAGNETIC RESONANCE may be an important tool in future non-destructive testing, according to a paper presented last week at a meeting of the Society for Non-Destructive Testing.

The speaker, T. J. Rowland of Union Carbide Corp., suggested the key to understanding the behavior of crystalline materials lies in understanding the properties of lattice imperfections. He said the proper interpretation of nuclear magnetic resonance measurements can reveal information on an atomic scale, on lattice strain effects and solute concentration and distribution.

Rowland based his observations on the fact that atomic nuclei in a magnetic field act like tiny magnets spinning about an axis whose orientation is determined by the field. As exciting frequency is varied, the behavior of the infinitesimal magnets can tell the trained observer of structural imperfections or compositional irregularities in the lattice.

England Constructing New Space Probe Ear

NEW FULLY-STEERABLE radio telescope will be built near Crowthorne, Berkshire, for the radio research station of Britain's Department of Scientific & Industrial Research.

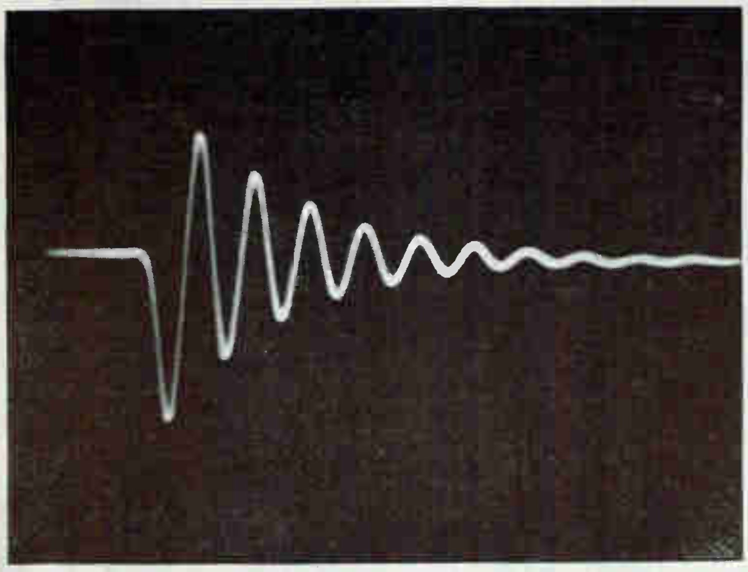
The telescope will use an 80-ft parabolic antenna, have "high-accuracy" and track faster than the 250-ft scope at Jodrell Bank.

The gear will act as ear to deep space probes using uhf and to radio noise from the sun and planets.

Ministry of Works will invite bids for the instrument this month, hopes to complete entire project by late 1963 at a cost of $700,000 including buildings, equipment and site services.

Energy Conversion Group Probes New Power Ideas

THE ENERGY CONVERSION Branch of the Advanced Concepts Division in the Navy's Bureau of Ships is investigating new concepts in the field of developing electrical power. In a classified paper read at the recent Fifth Navy Science Symposium, Lt. Cdr. F. W. Anders described the new approaches under investigation which include: energy conversion from oceanic waves by mechanical and pneumatic means, from elements contained in ocean water by biological means, from gasless fuels by thermoelectric means and from radioactive materials by radiolysis.



High resolution, distortion-free pictures just like this, and this same size, are yours immediately with the hp 196A Oscilloscope Camera plus new Polaroid® Land 10-second-developing, 3000 speed film

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You can mount or dismount Model 196A with one hand; change f-stop and shutter settings with the camera on the scope; tab pulling is easy; and you can keep your glasses on while viewing the image with both eyes.

Check the specifications for the hp 196A Oscilloscope Camera and ask your hp representative for a demonstration on your scope!

SPECIFICATIONS

Object/Image Ratio:	1 to 0.9 (accessory, $25.00 extra, provides 1:1 ratio)
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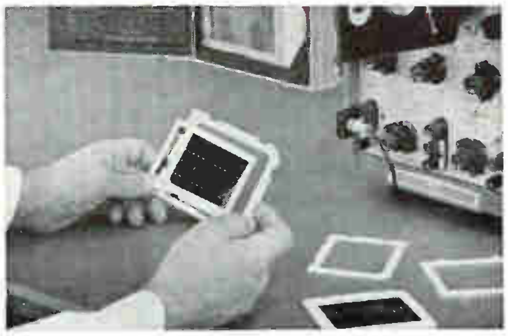

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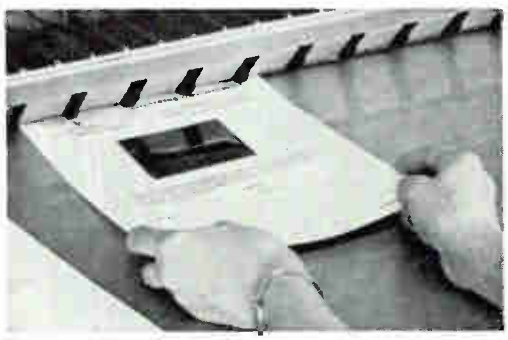

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WASHINGTON OUTLOOK

REVISED PENTAGON estimates show about $8.5 billion worth of new defense contracts covering production, R&D and construction scheduled for the April-June quarter up about $3.5 billion from January-March 1961. To a large extent, the increase reflects initial Kennedy administration additions to the military budget for Polaris and jet transport aircraft and the Democratic administration's antirecession speedup in the rate of contracting.

Projecting the rate of contract awards into fiscal year 1962, starting July 1, the Pentagon expects to place from $9 billion to $10 billion worth of new orders during July-December 1961 and from $12 billion to $13 billion in January-June 1962.

DEFENSE SECRETARY MCNAMARA tells Congress he and the three service secretaries will take a personal interest in the drive to boost the volume of military contracting to small business.

At present, the goal is to hike prime awards to small firms in the upcoming year by 10 percent. This would mean an increase of $344 million worth of contracting.

McNamara has set quotas for each service and major procurement agency, has ordered monthly reports to show the progress. He is also arranging broader contracting opportunities for small business by requiring weapon project officers to be more alert to the role of smaller firms and by increasing publicity on proposed procurement transactions. In addition, pressures on major prime contractors and subcontractors to farm out more work to small companies is being intensified.

In response to Senate Small Business Committee questioning, McNamara is also considering proposals to break apart major weapons systems into components and to award several prime contracts for each component, and to increase the rate of competitive advertised bidding as opposed to negotiated contracting.

But McNamara has reservations on both proposals. He calls the first one dangerous because it could diffuse responsibilities among too many contractors, thus complicate the integration of part designs. He says there's confusion over the alleged lack of competition in military procurement.

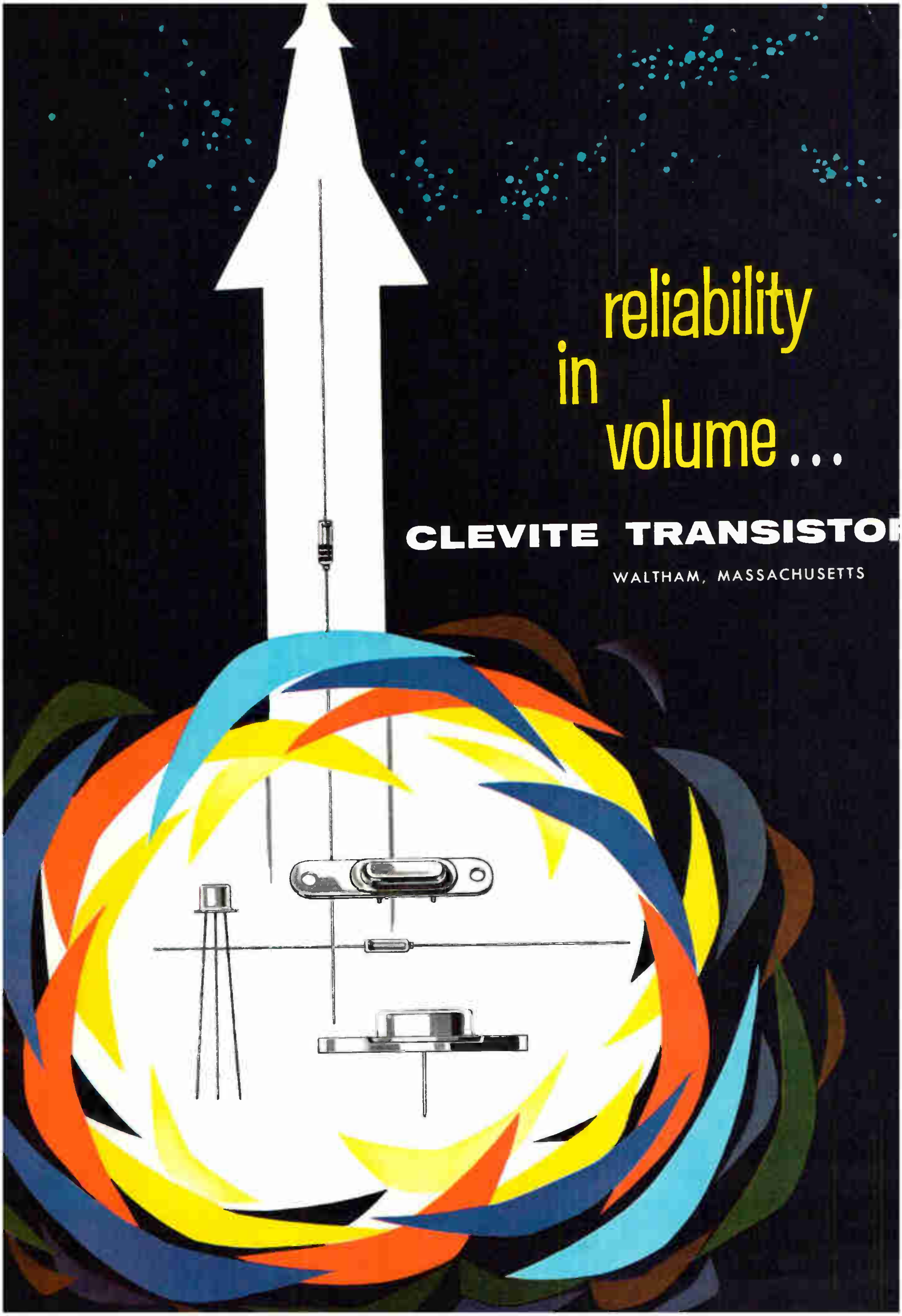
He refers to congressional criticism that the rate of advertised bidding is inadequate and the Pentagon's explanation that widespread competition exists even under negotiated contracting procedures.

Both the Pentagon and the Small Business Administration oppose the Proxmire Bill which is aimed at increasing small companies' share of military contracts by authorizing SBA to draft procurement rules for defense contracting agencies.

EIA has already gone on record in opposition to the bill. C. J. Harrison, chairman of EIA's small business committee and senior vice president of Rixon Electronics, told the Senate Banking Committee that administration cooperation rather than legislative action is preferable to assure that SBA and the defense procurement agencies work together to increase the share of contracts going to small firms.

CONGRESSIONAL SOURCES claim a substantial volume of identical bidding by industry has shown up in military contract reports from the Pentagon. But they won't specify the items involved and do say the reports do not necessarily indicate any collusion by contractors.

The overall question of identical bidding is under scrutiny on many fronts here. The Senate Antitrust Subcommittee, for instance, is investigating the matter, and the White House has ordered all federal agencies to report to the Justice Dept. when identical sealed bids on contracts of at least $10,000 are received.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CLEVITE TRANSISTO
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How to stablish rating values for power transistors

by RICHARD F. MOREY, JR.
Manager, Applications Engineering, Clevite Transistor Division of Clevite Corporation

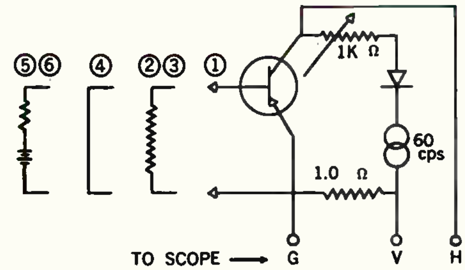

Fig. 2. Collector to emitter voltage test

Every manufacturer of power transistors provides ormation on the various circuit valves within which a en transistor will satisfactorily perform. These valves "ratings" are established on the absolute maximum tem and are defined so that "the rating values, if :eeded, will cause permanent impairment of the de- e." Since permanent damage can occur as a result of :eeding rating limits or as a result of an unqualified ing, Clevite Transistor exercises great care in the /elopment of ratings and the proof of their validity.

Clevite places particular emphasis on ratings for iction temperature, power dissipation, collector cur- t, and collector voltage. Each of these ratings is in-)endent and it is not generally possible to approach re than one rating simultaneously. Therefore, specific ts are performed such as "thermal resistance" to ablish maximum power dissipation and collector diode kage current I_{CBO} at both room temperature and high :rating temperature to establish maximum rated col- :or to base voltage. Figure 1 is a diagram of the ermal resistance test, while Figure 2 indicates the :ing configuration for establishing essential collector emitter voltage ratings.

)ther tests are performed to determine collector cur- t and junction temperature. High-temperature- rage life tests to establish maximum junction tempera- e are further supplemented by Clevite's process of ng transistors at temperatures in excess of the eventual ximum rating.

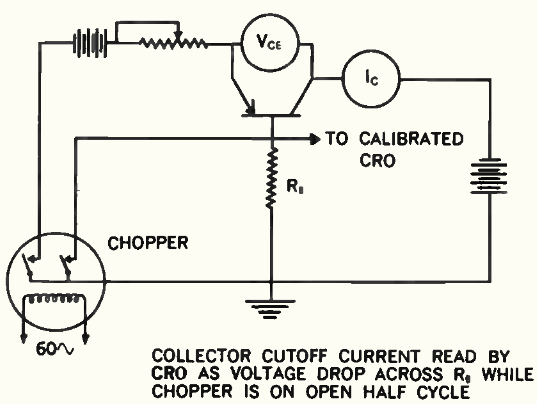

Fig. 1. Thermal resistance test

erhaps the most important tests are the collector to tter breakdown tests ($V_{CES\,(sus)}$ and $V_{CEO\,(sus)}$) which used to determine the maximum collector to emitter age. Figure 3 indicates a typical germanium power sistor operating in breakdown region. Observe that bias applied between emitter and base differs for each he seven curves. This bias differential causes the curves to differ significantly. Curve 1 breaks down sharply at 45 volts, while curve 6 breaks down initially at 118 volts, but upon transversing the curve, the voltage drops and another breakdown occurs at a point slightly greater than 60 volts. Curves 2, 3, 4, and 5 are somewhere between.

Curve 7 is simply the curve of the collector to base diode and is shown here for reference purposes.

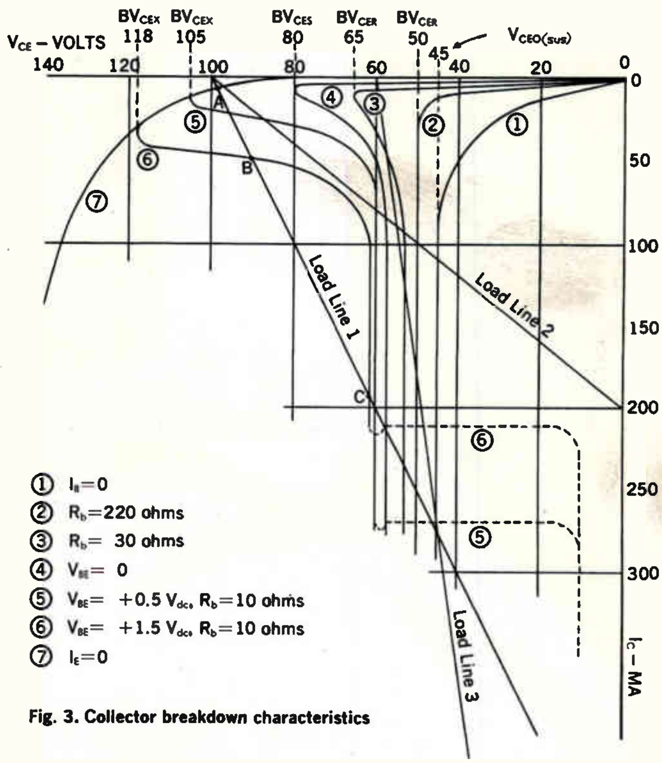

Fig. 3. Collector breakdown characteristics

It may be noted in a particular instance, such as curve 1, that at some voltage (in this case 45 volts) collector current increases without limit. This is the voltage at which collector multiplication causes the overall current gain (alpha) to equal unity.

The remaining curves serve to indicate the effect of a change in bias at different voltage and current conditions.

The tests and data shown here are only a segment of the total program undertaken by Clevite Transistor to assure a continuous high standard of product quality . . . "reliability in volume."

Detailed Technical Data Bulletins are available on all Clevite's Power Transistors and Diodes. To obtain technical information, please request Application Bulletins 1 & 2.

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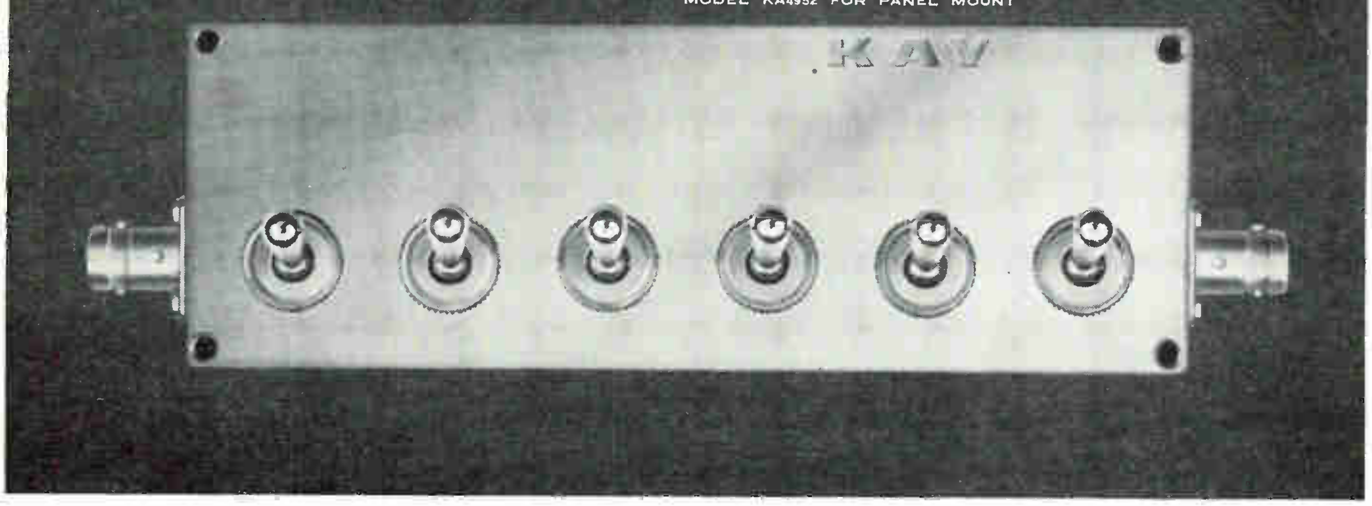
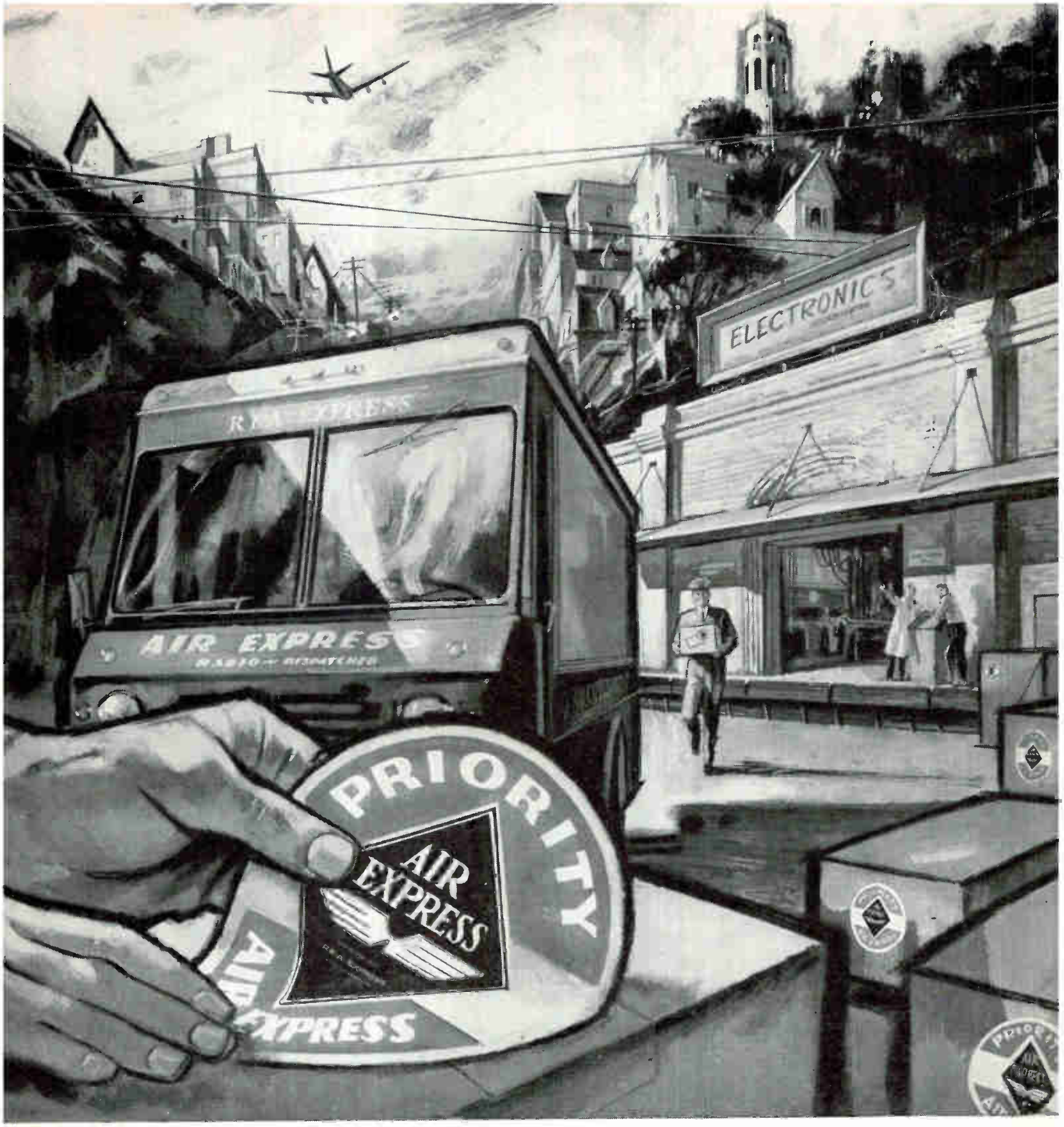


CIRCLE 21 ON READER SERVICE CARD→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FINANCIAL

Several New Stock Issues Registered

NEW SECURITY issues are being planned by a number of electronics companies, according to information released by Securities and Exchange Commission.

POTTER INSTRUMENT CO., INC., Plainview, N. Y., has filed for registration of 210,000 shares of common stock of which 190,000 are to be offered for public sale. The stock is to be offered at $10 a share by underwriters headed by Bear, Sterns & Co. Of the net proceeds, $620,000 will be used to retire bank loans. Some $350,000 will be used to finance product development and retooling. Most of the remaining funds will be used to increase accounts receivable and inventory. Potter presently has $750,000 outstanding in eight-percent subordinated convertible debentures due October 1969, purchased by Electronics Capital Corp.

SEALECTRO CORPORATION, Mamaroneck, N. Y., is seeking registration of 231,600 shares of common stock of which 100,000 shares are to be offered for public sale by the issuing company, 110,000 by William Silberstein, Sealectro president, and 21,600 by another stockholder. Offering will be made through Bache & Co., New York. Offering price and underwriting terms have not yet been disclosed.

AEROTEST LABORATORIES, Deer Park, N. Y., has filed for registration of 100,000 shares of common stock of which 40,000 shares are to be offered for public sale by Hayden, Stone & Co. The remaining 60,000 shares are to be offered by present stockholders. The company tests components and systems in electronics, space and aircraft applications. It also makes and sells specialized test equipment.

GENERAL PRECISION EQUIPMENT CORP., Tarrytown, N. Y., is seeking registration of 150,000 shares of common stock for public sale. The underwriters are the First Boston Corp. and Tucker, Anthony & Day. Offering price will be related to the current market price on the New York Stock Exchange at the time of the offering. The Tarrytown company is a holding firm whose subsidiaries develop and produce electronic components and subsystems.

CLAIRTONE SOUND CORP. LTD., Ontario, Canada, has applied to SEC for registration of 200,000 shares of common stock to be offered for public sale through Reiner, Linburn & Co. Offering price and terms have not yet been disclosed. The company manufactures stereo, high-fidelity and radio-phonograph equipment. Of net proceeds from the stock sale, $400,000 will be used for new product research and development and some $200,000 will be used for reduction of accounts payable and receivables. Balance of proceeds will be used for general corporate purposes.

ELECTRONICS ASSOCIATES, Long Branch, N. J., has registered with SEC an issue of 75,000 shares of capital stock to be offered for public sale through underwriters headed by W. C. Langley & Co. The statement includes an additional 50,000 shares purchasable under the company's stock plan open to any associate of the company employed more than six months. The firm makes analog computers and related equipment, electronic plotting equipment and also furnishes computer engineering service. Proceeds of the stock sale will be used to retire a bank debt and to add to the company's working capital.

CTS CORPORATION, Elkhart, Ind., has filed with SEC for registration of 300,000 shares of common stock of which 75,000 shares are to be offered for public sale by the company and the remainder are to be offered by the present holders. Underwriters are headed by Goldman Sachs & Co. The registration statement also includes 15,000 shares to be sold by their present holder. The company makes electronic and electromechanical components. Its primary product is variable resistors. Of net proceeds of the stock sale, $540,000 will be applied to debt retirement. The remainder will go for general plant expansion, new product tooling and other corporate purposes.

MICROWAVE ASSOCIATES, INC., Burlington, Mass., is seeking registration of 130,000 shares of common stock which have been or will be issued on the exercise of present and future options granted company employees and officers under MA's stock option plans.

AUDIO DEVICES, INC., New York City, has filed registration for 117,405 shares of common stock of which 100,000 shares are reserved for issuance upon exercise of stock options granted to certain company employees. The balance of the shares are to be offered from time to time by warrant holders. This stock was acquired by warrant holders at a cost to them of $7.74 per share in March of 1960.

25 MOST ACTIVE STOCKS

WEEK ENDING APRIL 21, 1961

	SHARES (IN 100's)	HIGH	LOW	CLOSE
Sperry Rand	6,054	34⅜	29¼	32¾
Waltham Precision	4,052	4⅜	2⅞	4
Ampex Corp	3,103	27¾	25¼	26⅜
Gen Tel & Elec	1,946	31⅝	29⅛	29⅛
Lockheed Aircraft	1,653	43⅜	39⅛	42¾
Gen Elec Co	1,618	63⅝	62⅛	62⅜
Cohu Elec	1,378	15⅝	12¾	14¾
U.S. Industries	1,216	15⅛	13¾	14¼
Reeves Sndcraft	1,193	8⅞	7¾	8⅜
Universal Controls	1,175	15	13	13½
Dyn Corp of Amer	1,113	15½	13⅝	13⅞
Avco Corp	1,075	19¾	18⅜	18¾
Standard Kollsman	949	47⅞	42⅜	43⅛
Martin Co	940	35	31⅜	34½
Westinghouse Elec	939	42⅞	41½	41½
Ntl Video Corp (A)	889	46½	37⅞	41¾
Transitron	774	35⅞	33⅛	34⅜
Avnet Elec	759	43⅝	39⅜	40⅝
Hycon Mfg	750	5⅝	4⅞	5
Gen Dynamics Corp	739	39⅞	37½	39⅛
CBS	724	42⅜	39½	41⅛
Rheem Mfg	712	19⅜	15¾	19⅜
Clary Corp	633	17¾	14⅛	16¾
Mutter Co.	631	11¼	8	8⅝
Muntz TV Inc	628	6½	5½	6¾

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.

What can you do with sub-fractional h.p. motors with this versatility?

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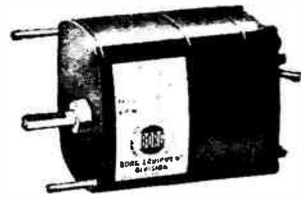


Gear Train

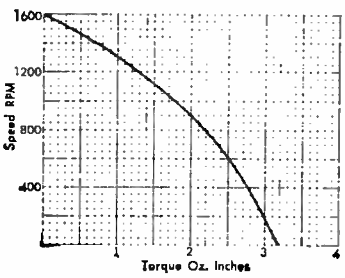
No Gear Train

BORG offers a very broad line of sub-fractional horsepower instrument motors ranging from 1/750th to 1/2000th horsepower. In the beginning these motors were developed to meet specific customer requirements. Once developed, it occurred to us that there were probably other original equipment manufacturers who would be interested in a motor with these or similar characteristics. We were right. Borg Motors are becoming increasingly popular among mechanical and electrical/electronic engineers who are looking for sub-fractional horsepower motors with extreme precision, ruggedness and reliability.

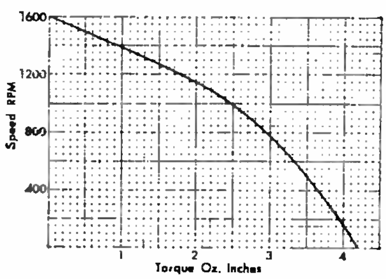
What makes Borg Motors different? Probably the most important single factor is their inherent versatility. They can be operated two-phase, or split-capacitor-connected for single-phase operation from a 115 volt, 60 cycle source. They are available with or without gear trains. If gear trains are desired, Borg offers twenty gear ratios from 6 : 1 to 1800 : 1. They are available with special windings to meet special voltage, frequency, push-pull operation and impedance requirements. And they are reversible.

Another important advantage is the speed/torque ratio. Following are two typical speed/torque curves for the new Low Inertia 1060 Series (curves are for single-phase operation):

Model 1063



Model 1065



Following are further breakdowns between the 1063 and 1065 models. These performance figures are representative (though not necessarily the same) for the entire Borg line:

Model 1063

115 v/60 cps, single phase
12 watts input at stall
No-Load Speed . . . . 1600 RPM
D.C. Resistance . . . 550 ohms each winding
Impedance . . .
2700 ohms each winding at stall
Effective Resistance at Unity Power Factor . . . . 5500 ohms each winding
Rotor Moment of Inertia . . . .10 oz./in.^{2}
Dimensions . . .
(housing) 2-9/16" x 2-9/16" x 2-1/64"

Model 1065

115 v/60 cps, single phase
14 watts input at stall
No-Load Speed . . . . 1600 RPM
D.C. Resistance . . 400 ohms each winding
Impedance . . .
1700 ohms each winding at stall
Effective Resistance at Unity Power Factor . . 2800 ohms each winding at stall
Rotor Moment of Inertia . . . .13 oz./in.^{2}
Dimensions . . 2-9/16" x 2-9/16" x 2-1/64"

We would like to send you engineering data on the complete line of Borg Motors. We think this kind of material should be in the file of every engineer who has or may someday have a need for such an *exceptionally* well-made motor. If you prefer you may get this engineering data from your nearest Borg technical representative or distributor. Ask for catalog sheets BED-A139 and BED-A165.

BORG EQUIPMENT DIVISION

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RCA MEMORY STACKS

256 WORDS BY 8 BITS

10,000 WORDS BY 14 BITS

From miniature stacks to super-size stacks, RCA is ready to custom-build completely wired, ready-to-use memory stacks to meet your most complex system requirements.

Now, RCA memory stacks, in custom and standard designs, are available to help you solve computer assembly problems and meet today's exacting performance specifications. Incorporating RCA ferrite memory cores and planes, with specified wide margins of operation...up to 8 percent...RCA stacks can cope with broad variations in power levels.

RCA magnetic-memory specialists are ready to custom design and deliver virtually any stack you specify. Stacks ranging from 16 words by 5 bits to 16,304 words by 34 bits have been built and are now in operation for coincident-current, word-address, and impulse-switching applications.

Reliability: All RCA ferrite memory stacks are designed and built to meet stringent environmental specifications of shock and vibration. And all are 100 percent dynamically tested to assure the utmost dependability under actual computer operating conditions.

Adaptability: All RCA memory stacks are compactly assembled to assure most efficient space utilization. In addition, they are designed to provide superior rigidity and accessibility. Stacking frames are available in a wide range of materials.

Service: Your local Semiconductor and Materials Division Field Representative is prepared to provide a completely coordinated application service, covering transistors, tunnel diodes and other semiconductor diodes, ferrites and memory systems. Call him today. For further technical information, write RCA Semiconductor and Materials Division. Commercial Engineering, Section E-19-NN-1, Somerville. N. J.

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RCA®

The Most Trusted Name in Electronics
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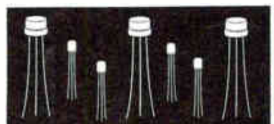
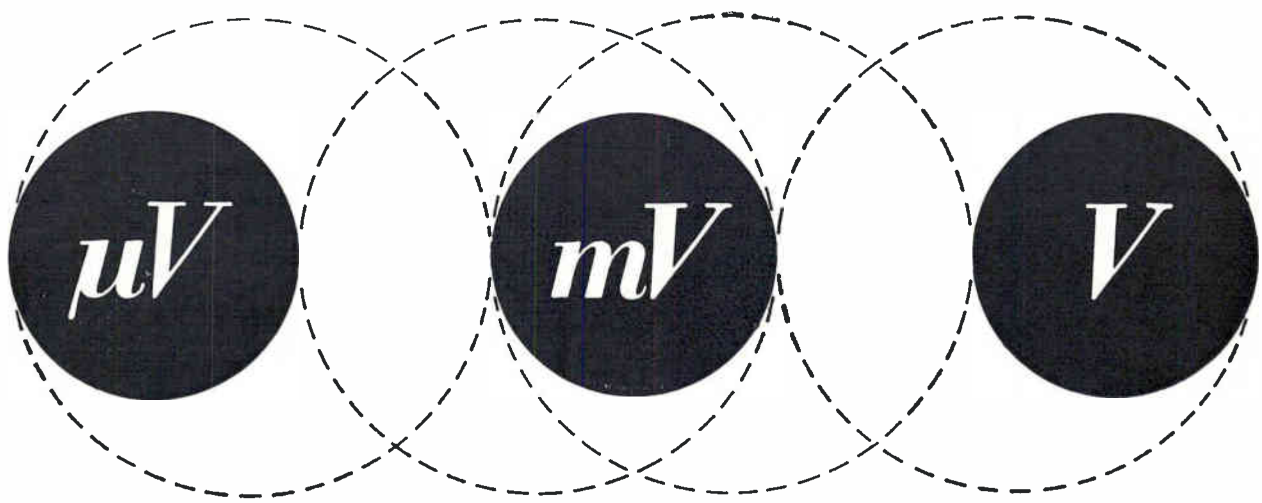


TRANSISTORS

TUNNEL DIODES



electronic millivoltmeters

internal calibration

It should be noted that all Philips electronic voltmeters contain calibration standards which enable the user easily and rapidly to check, and, if necessary, to re-calibrate his voltmeter at any time without the use of additional instruments.

VHF Voltmeter, type GM 6025

Frequency range: 0.1 Mc/s - 800 Mc/s
flat from 1 Mc/s - 300 Mc/s
− 1 dB at 0.1 Mc/s
+ 1 dB at 800 Mc/s

Measuring range: 10 mV (f.s.d.) - 10 V divided into 7 ranges in a 1-3-10 sequence

Overall accuracy: < 5% with respect to full scale

Input resistance: 65 kΩ at 1 Mc/s ; 50 kΩ at 100 Mc/s.; 35 k Ω at 200 Mc/s

Input capacitance: 1 μμF

Replacement of the probe crystal:
the probe crystal can be easily replaced and the instrument rapidly re-calibrated by the user

For measurements on 50 Ω -coaxial lines the T-connector, type GM 6050T, can be ordered

PHILIPS *electronic measuring*

Sold and serviced by Philips Organizations all over the world
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HOW THEY'RE BUYING ELECTRONIC

SINCE THE FIRST of the year there has been a marked trend for electronic purchasing to become more engineering oriented. Indeed, at one large firm, where top purchasing men are known as value analysts, a purchasing man has been described as ⅓ engineer, ⅓ economist and ⅓ diplomat.

Recently ELECTRONICS explored the mechanics of purchasing at three representative firms in the field: one large, one medium sized, one small. Aside from the trend to get more technically trained men into purchasing, other trends noted were an increasing give and take between engineering and purchasing both to reduce costs and to enhance reliability and the discovery that purchasing in the military and nonmilitary sectors of the industry have more resemblances than differences. (See charts.)

RCA's IEP activity is headed by the agent for commercial purchasing. He reports directly to the manager of the production department, who is on a level with the chief engineer and reports directly to the general manager. The purchasing agent is an electrical engineer, value analysts are mechanical and electrical engineers, the manager of electrical buying is an electrical engineer and the manager of cost control and coordination is an industrial engineer. This organization has been operative since January.

Value analysts are available for consultation with engineering during initial design stages and subsequently they frequently can recommend design changes that will result in cost savings.

After firming-up the design, which entails accepting or not accepting recommendations by the value analysts, engineering prepares the bill of materials that is sent to the estimating department (reporting to the controller).

After determining whether items on the bill of materials should be made or bought and performing a price analysis for budgeting, the estimating department sends the bill of materials to the material ordering group, (reporting to the commercial plant manager).

Here it is broken down in essential detail. Purchase requisitions are then printed by the materials ordering group after determining required overages and sent to the cost control group in purchasing.

Here, the purchase requisition is examined to determine what purchase control cards should be attached before being sent to buying managers. These cards record past history on items to be purchased—price, vendors and their past performance, alternative makes, previous delivery lead-times. The cards are continually up-dated and copies sent to estimating department so price-analysis and budgeting can be done more accurately.

One or more buyers are assigned by the buying managers to determine what suppliers, mainly manufacturers rather than distributors, should be contacted to make bids. The selection of bidders is based largely on information worked-up by the value analysts who have studied the technical and business phases of each firm's operations.

Another basis for selection of bidders by buyers are vendor rating reports that are up-dated monthly and indicate delivery performance, product quality and costs. Follow-up personnel in the cost control and coordination section of purchasing maintain these reports.

The purchasing department of Arma is divided into three sections: general procurement, subcontracts and support.

General procurement is responsible for ordering standard components and assemblies, supplies and services. Subcontracts is responsible for all special fabrications, the administration of all subcontracts and all research and development requirements. Support is responsible for estimating and price analysis, typing, filing, mail, reports and follow-up activity.

Operational breakdown is on a commodity basis. This provides for specialization and flexibility to shift strength or emphasis.

On any subcontract procurement project, the purchasing agent heading the purchasing section involved assigns an administrator to partake in prebid discussions with representatives from engineering, manufacturing, and product reliability.

The administrator also prepares the solicitation for quotation, selects the list of bidders, moderates conferences with bidders, participates in evaluation surveys of bidders, prepares abstracts of quotations and bid analyses for review by supervision and price analysts, and administers the contract.

A group external to the purchasing department, which reports to the manager of the purchasing department, is the internal liason staff. This group assists purchasing in the selection and surveillance of subcontractors, and also insures orderly channels of communication between the subcontractors and Arma. Internal liason staff members are permanent representatives from the following departments: controller, contracts, engineering and manufacturing.

By using the services of these people, purchasing exercises a business and technical check on suppliers. Not only is trouble at the supplier-end detected early but the reasons for it are uncovered. A trouble-shooter from purchasing's follow-up group (support section) is constantly in the field to help detect trouble not spotted by periodic visits of the purchasing-internal liason surveillance team.

If real trouble does develop with a supplier, a purchasing man will head up an administrative and technical team that will take up residence at the supplier's plant to monitor corrective actions. The effectiveness of action on projects is kept track of by the follow-up group, which maintains a graphic record of purchasing's performance.

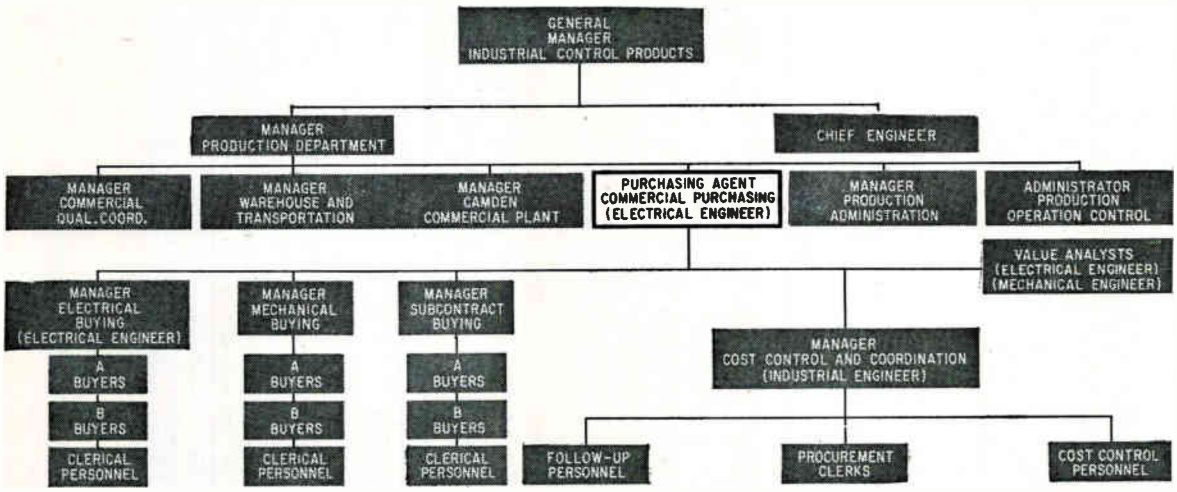
At Huyck Systems, company operations are on a smaller scale than at RCA and Arma.

An engineering design department makes up the bill of material specifications on the basis of engineering design. Using the bill of material, purchasing performs a vendor analysis with the help of vendor rating information provided by the company's quality-control manager. Three vendors for each

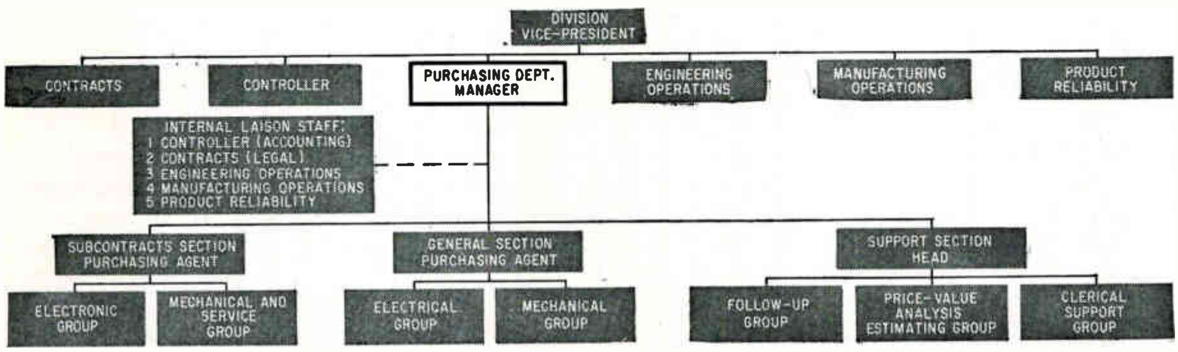
By ROY J. BRUUN, Assistant Editor

order are selected, on the results of the analysis, for negotiation. Two are chosen on the basis of negotiated price and delivery. Orders sufficient to service prototype equipment are given both vendors. If components from both vendors function satisfactorily in the prototypes, negotiation is undertaken with both for production orders, on the basis of price and delivery. The unsuccessful bidder will probably receive at least some business for subsequent production runs.

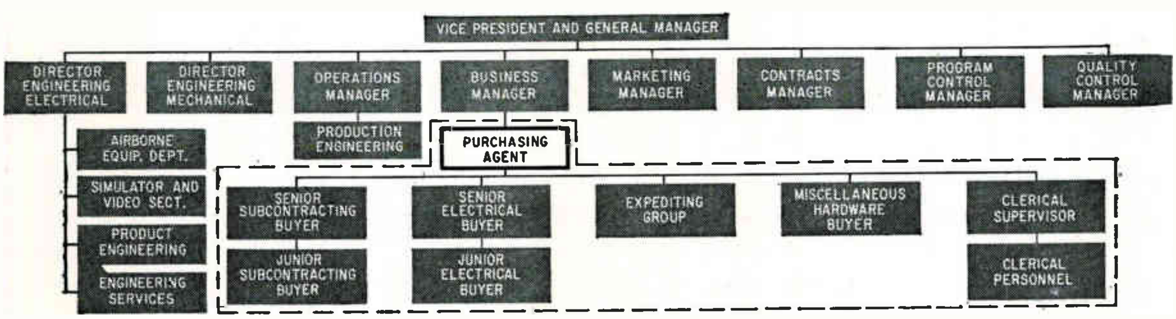
Although engineering may make suggestions as to what suppliers and make of components should be used, the final decision is purchasing's as based on quality, delivery and price in that order. Purchasing will, at the request of product engineering, recommend the use of components not having the designated engineering specifications but which they feel will do the job at lower cost. Engineering can accept or reject the recommendation. On one recent project, savings resulting from purchasing's change recommendations were sufficient to pay for additional system debugging, which would otherwise have resulted in a project loss.



Purchasing department at RCA's Industrial Electronics Products activity



Purchasing department at Arma division of American Bosch Arma



Purchasing department at Huyck Systems Co., a division of Huyck Corp.

CONFERENCE SPOTS COMPUTER TRENDS

Fifty disks store 2 million words in IBM's giant Stretch system. Disks spin at 1,750 rpm; 40 arms at right hold read-write heads

WESTERN Joint Computer Conference meeting in Los Angeles next week (May 9-11) will present a comprehensive technical program highlighting industry progress in developing faster and smaller systems, and devices for communicating with them.

Technical sessions on problem-solving systems, automation theory, pattern recognition and information retrieval will spotlight important trends in systems and logic. Other sessions will deal with molecular electronics, new circuit developments, memory devices, simulators, control systems and analog techniques.

Noteworthy among papers to be presented is increasing emphasis on higher-level information-processing functions, such as in self-organizing systems. Application of computers to areas other than scientific and commercial processing —language translation; problems in social sciences, medicine, psychology—will be discussed.

Thin-film and glass-rod types of memory are arousing advance interest, as are storage devices, communications links, and real-time processing of industrial and other data.

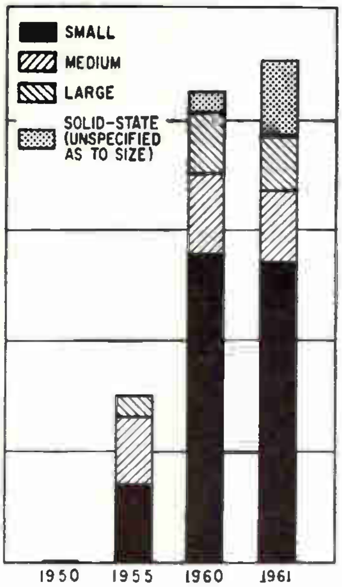
Over $3-million worth of exhibits from 55 firms will illustrate these trends. A thin-film memory will be exhibited by Remington Rand Univac, which will also demonstrate a real-time computer. Another real-time system will be demonstrated by Ramo-Wooldridge. The R-W system is designed to facilitate communications between the computer and the operator, particularly the non-expert.

R-W is also showing a high-speed photographic printer which processes maps or charts in from 10 to 60 seconds, converting them from black-and-white to full color, revising information and updating them as directed. General Dynamics/Electronics will exhibit a microfilm printer capable of recording information on 35-mm film at 15,000 characters per second. This device can be used for automatic drafting, in which engineering drawings can be produced electronically, displayed optically and printed on microfilm.

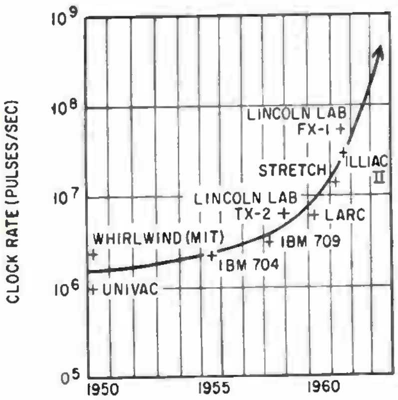
NCR will show its solid-state 390 system for bank bookkeeping. Computer Control Co. will discuss its digital data-processor and data converter; the data processor is a high-speed system for industrial process control and scientific applications; the converters translate bilaterally among the formats of most automatic data-processing systems. Friden will show its punched-tape code converter, which also translates among various machine codes; reading speed is 1,180 digits a minute. Among other exhibits will be the Philco 2000, Royal Precision's RPC 4000, and the Burroughs B5000.

The technological developments spotlighted at the WJCC (also discussed in the special report "Computers Today," p 63, Apr. 28) are being accompanied by a number of shifting patterns in the business of computers. Most marked pattern in the computer business is sheer growth. H. W. Robinson, president of computer service organization C-E-I-R Inc., recently remarked that "within a decade, the electronic computer and control manufacturer will be supplying one fifth of the value of all producers' durable goods installed in the U. S."

The decade just closed saw the



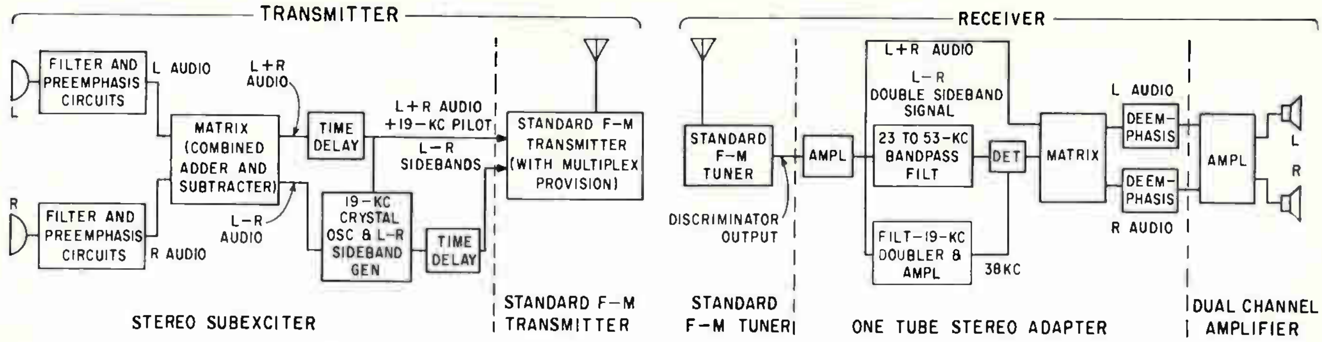
Installations of computers continue rapid growth, with solid-state units now strong



Computer speeds, as represented by effective clock rate, show recent exponential rise

computer business grow rapidly, albeit occasionally in fits and starts. Production capacity has risen steadily. Capabilities have broadened to include most requirements of science and industry. Today at least 100 companies produce computers, systems, subsystems and components.

The 1960s will see computers take a larger and more essential part in the economic and social progress of the industry and the nation. Their role will be larger in the office than in the factory, although industrial control computers are among the hotter developments in the business. The importance of computers in the office is inevitable: the number of office workers in this country has grown 450 percent since 1940, while the number of industrial workers has risen only 85 percent, and office-worker productivity has not kept pace.



Block diagrams of General Electric stereo transmitter (left) and stereo receiver

Stereo Decision Creates New F-M Market

FEDERAL COMMUNICATIONS COMMISSION adoption of standards for stereophonic radio has created a wave of enthusiasm among broadcasters and manufacturers. Both groups see the move as spelling more business and more profits.

Despite the Commission's ruling allowing broadcasters to transmit stereo on or after June 1, it is not likely the consumer public will be tuning in much before late Fall.

Manufacturers are not disclosing details on their plans for transmitter equipment right now. Most are waiting for the National Association of Broadcasters convention starting Sunday.

Zenith and General Electric, whose systems with some modifications have been adopted by FCC, are both planning to produce receivers as fast as they can. ELECTRONICS asked a Zenith official how soon production would start. The answer was, "Almost immediately!" General Electric has made last minute design changes in its production line to match the FCC modifications, and is planning a start making receivers right away. Zenith has no plans to make adapters and will concentrate on stereo receivers. Stereo will probably add from $30 to $50 to set costs.

Despite widespread enthusiasm from other manufacturers, however, general industry attitude shows some degree of caution. No one doubts that the new development will swell the radio receiver market beyond the more than 10 million units produced last year, but manufacturers want to see that the initial public reaction to stereo is a good one.

Motorola, for example, has expressed misgivings to ELECTRONICS on hurrying stereo receivers and adapters to market at the possible risk of jeopardizing quality of reproduction. Philco has gone on record as being sure that stereo will help the market, but cautions that the new gear must be properly merchandised and explained to the public.

Other manufacturers such as Pilot, RCA and Granco indicate they will enter the market by producing adapters initially, moving into receiver production by late Fall.

Cost of the adapters is under heavy discussion. Estimates range from $14 to $25 and some indications are higher. General Electric told ELECTRONICS its entire present line of console radios contains an adapter output.

The company describes its adapter as having only one tube, and fitting in a chassis somewhat larger than a pack of cigarettes. Production cost would be about $8, sales price might be about $15.

Other manufacturers say they have more elaborate plans in mind. Sherwood Electronics, in Chicago, for example, says it has converted the bulk of its production facilities to making a three-tube adapter. The units will be external and cost $39.50. Another model with a self-contained power supply will sell for $49.50. A combination f-m tuner/adapter for stereo phonographs will sell for $110.50. The company says it will have an 18-tube 30-watt dual receiver on the market by September.

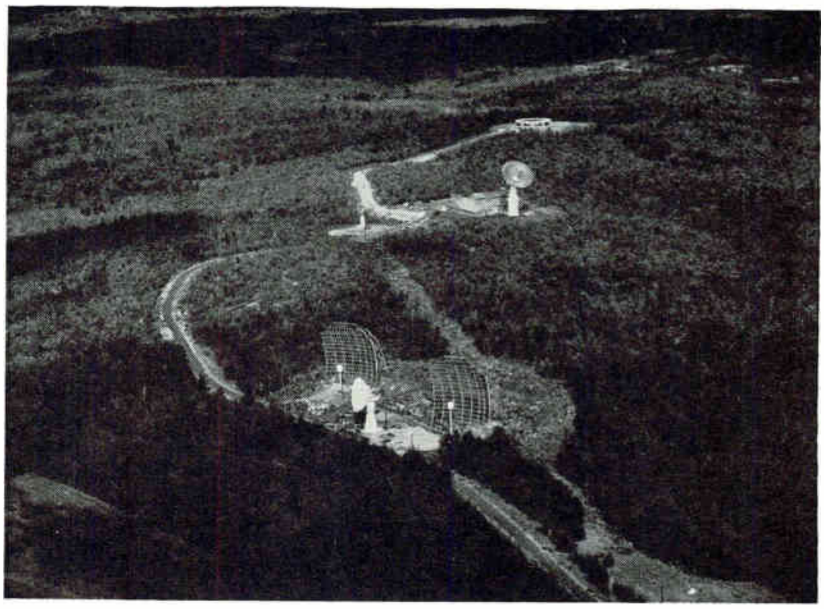
Stereo receiver sales will depend on how many f-m broadcast stations convert to stereo. Broadcasters are frank in their doubts that many will be on the air by June 1, but their general indications of interest are running high. Zenith's noncommercial station WEFM, Chicago, and GE's WGFM, Schenectady, will start airing stereo as soon as possible. Station WKFM, also in Chicago, is already broadcasting plans to be on the air with stereo by June 1.

The guesses are that some half-dozen stations will be stereocasting when the starting gun goes off June 1. This should jump to about 75 by December, with most of the action being in major tv markets. By 1962, expectations are that the majority of f-m stations will be stereocasting.

GE is planning to furnish modification kits for f-m transmitters in the near future. RCA plans to offer an f-m stereo adapter for transmitters.

Gates Radio, which made some of the equipment used in the stereo evaluation tests, says it is ready now to accept orders for stereo transmitters, but would not like to quote delivery dates at this moment. Collins Radio says it will have equipment available later this year and be in full swing by early 1962.

Cost of converting to stereo transmission is up in the air to about the same extent as cost of receivers. NAB's engineering chief, A. Prose Walker says it might range between $2,000 and $4,000. One unofficial estimate on the cost of a new stereo transmitter puts the price at about $9,000.



West Ford-Millstone-Haystack complex in Massachusetts. Rear: base for Haystack Hill antenna-radome in Tyngsboro. Center: 84-ft Millstone Hill research radar in Westford. Foreground: new 60-ft dish for first testing of Project West Ford. Idle 120-ft paraboloids are seen behind new dish

150-Ft-Wide Radome Going Up

THE FREE WORLD'S largest radome—150 ft across at its widest point—will house the world's largest X-band dish, a 120-ft precision Cassegrainian antenna under construction on Haystack Hill in Tyngsboro, Mass., for global communications and propagation research (ELECTRONICS, p 51, Nov. 25, 1960).

Haystack system, located a short distance from MIT Lincoln Laboratory's Millstone Hill radar, will be completed by the end of 1962.

Initial application will be testing of Project West Ford, the orbital scatter communications experiment proposed by Lincoln Laboratory in which tiny metallic fibers will be placed in orbit around the earth to form a belt for reflection of signals at about 8 Gc (ELECTRONICS, p 43, Sept. 30, 1960).

But the $3,800,000 Haystack Hill facility, funded from the Air Force's global communications budget, will be a versatile test-bed for a variety of satellite-relay communications systems, for propagation research, troposphere and ionosphere probing, study of atmospheric noise, diffraction and scattering of superhigh frequency waves.

Although communications will be the principal use for the system, it is known that radar experiments are also being planned, including probes of the surface of the moon and Venus. Among features of Haystack is a "pluggable" electronics package behind the 120-ft dish for unparalleled flexibility of application.

Lincoln Lab designers of the rigid spherical radome describe as "monstrous" the problem of achieving compatibility between the electromagnetic and structural requirements of the 150-ft radome. To avoid grating effects, there will be a minimum of parallel structural beams.

An extensive research effort at Lincoln showed the possibility of using a metal-space frame without excessive interference with the signals.

Because of the support problem, designers were forced to go to metal rather than plastic, but members will be kept to a small cross-section—three inches by five inches—to keep at a minimum the boresight shift in beam. Actually, designers say, the loss will be scattered to sidelobe areas uniformly so there will be no substantial sidelobe effect in one direction.

Distortion of the precision antenna must be kept to 0.075 inch over its quarter-acre surface. At an operating frequency of 10 Gc, Haystack will have a 1/20-degree beamwidth, compared to the 2-degree beamwidth of its predecessor radar on Millstone Hill.

North American Aviation's Columbus division is building the antenna system, and radome contract is held by the H. I. Thompson Fiber Glass Co., Long Beach, Calif.

The radome will be 150 ft across at widest point, 134 ft high, 90 ft across its base. Frame will be of hollow aluminum beams 10-15 ft long. Glass-fiber-reinforced plastic membrane panels on the framework will be $\frac{3}{32}$ in. thick.

Surface of main reflector will consist of 96 panels of $\frac{1}{2}$-in. thick aluminum honeycomb. Panels will be held in place by five concentric rings interconnected by tension rods which will be tuned for precision tension adjustment. Aim of the design is to provide greatest possible rigidity with smallest possible weight.

The Haystack megawatt power supply will be on the ground, housed in the walled-in radome base along with the computer and auxiliary equipment. The "pluggable" transceiver equipment, however, will be mounted on the antenna system, just in back of the big dish, and will move with the dish.

Two-ton electronic package will add to flexibility of the station, allowing operation over a wide range of frequencies from S to X-band and beyond. Electronic package arrangement on the dish will also eliminate transmission path losses, improve receiver sensitivity.

Project West Ford package will be first installation. It will be a 100 kw CW X-band transmitter at about 8 Gc. X-band masers for West Ford are under development at Lincoln Laboratory. Air Force says later equipment packages for Haystack may contain low-noise receivers for radio astronomy, a short-pulse X-band radar, and perhaps higher-power S or C-band transmitters and receivers.

Energy will be beamed from the electronics package through the center of the 120-ft dish toward a secondary reflector mounted close to the focus of the main dish. The energy will bounce back from smaller, 9-ft dish to large antenna.

Geoscience Electronics Group Formed

DALLAS—A move to start a national geoscience electronics society, and discussions on the deficiencies of engineering and science education, were highlights of the 13th annual Southwestern Institute of Radio Engineers Conference and Electronics show here.

Most new technical trends had been previewed earlier at the national IRE show in New York, as had most exhibits on display in Dallas.

A group of 28 geophysicists agreed to start a move for a national geoscience electronics professional group.

Coordinator for it, in the beginning, will be Robert W. Olson, of Texas Instruments. Plans call for establishing four chapters in Houston, Austin-San Antonio, and Dallas, Tex., and in Tulsa, Okla.

SWIRE devoted an entire morning session to a panel discussion on education, in which industry and educational people admitted big voids exist in the field of engineering and science education.

Lloyd V. Berkner, head of IRE and president of a still-to-be-built Graduate Research Center in Dallas, said it is a must that all regions of the country become intellectually advanced. The alternative, he said, is "economic colonialism."

The U. S. currently produces about 9,000 PhD's annually. Of these, about 790 are in engineering and about half of the remainder are in science. This number, he added, is less than the annual attrition due to men changing jobs, retiring, dying, and so forth.

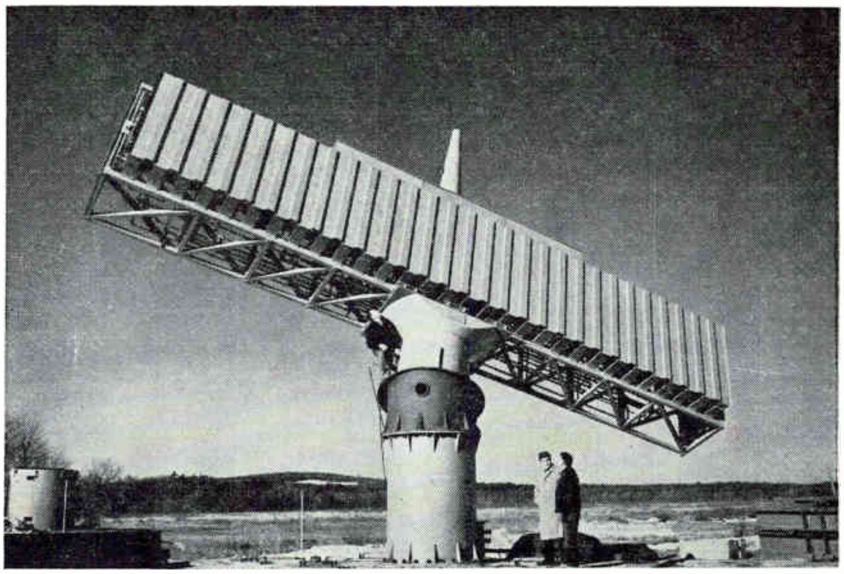
Southwest community leaders and university educators hope, through the Graduate Research Center and other such facilities, to increase the number of doctoral degrees from southwest institutions from the present 400 per year to about 2,000 by 1975, Berkner said. This, he added, will bring the area "more nearly in line" with the north, northeast, and far west.

Rochester Shifts Optics To Engineering Studies

MOTIVATED largely by existing optics-electronics needs, the University of Rochester has made its Institute of Optics the fourth department in the College of Engineering, effective Sept. 1.

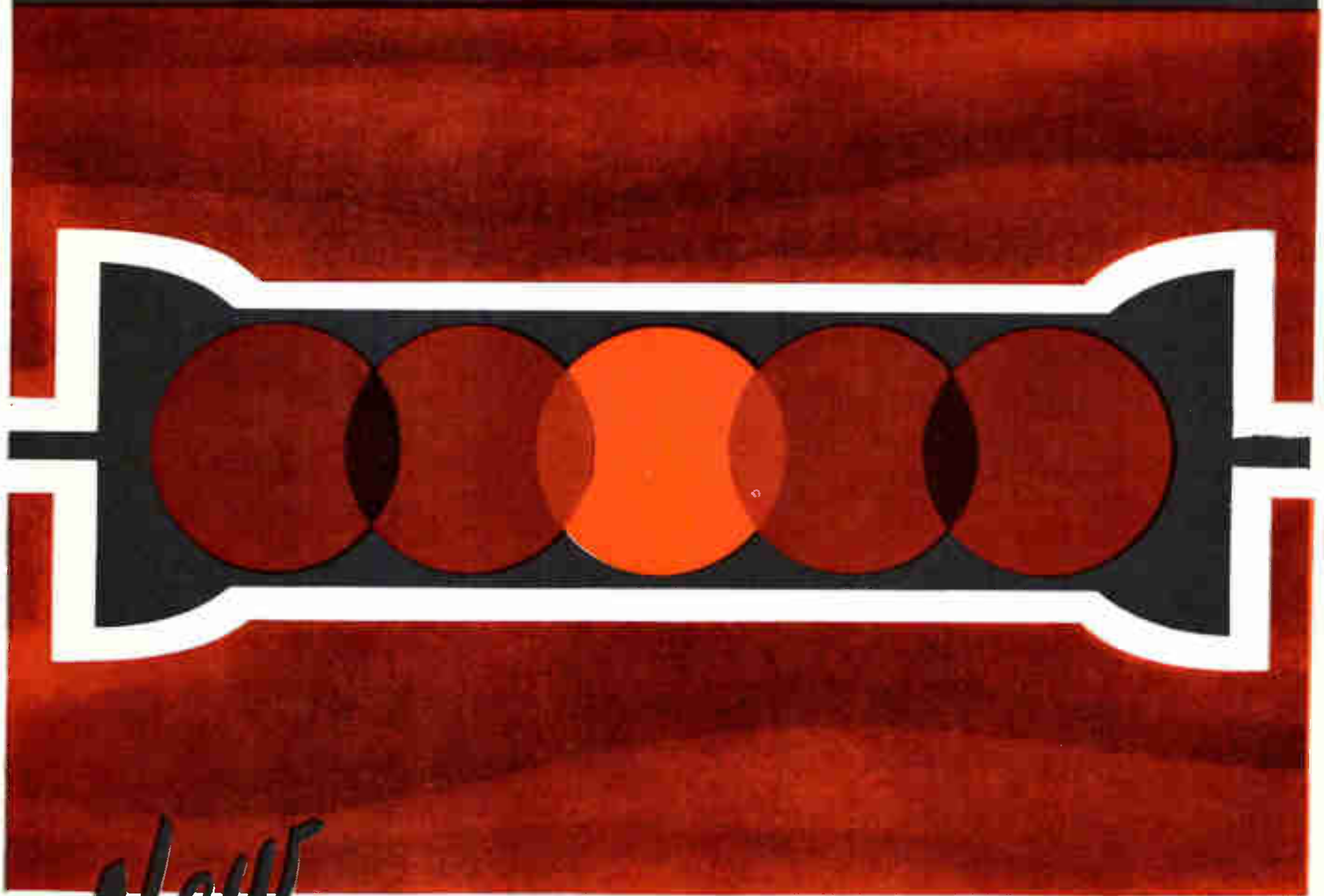
Recently Case Institute of Technology was similarly motivated by industrial interdisciplinary requirements to combine various engineering departments into a single division (ELECTRONICS, p 29, April 21).

Seagoing Radar Undergoes Final Test



Forty-foot aluminum antenna of new Raytheon AN/APS-38 radar developed under $7-million dollar BuShips contract has 150 horns

In POWER RESISTORS if it's news, expect it first from IRC



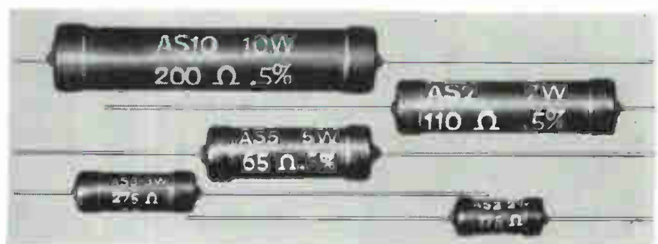
New Thermacoat Miniature Power Resistors

40% more power • 1/3 smaller size

New Thermacoat resistors surpass other types in three ways: 40% more power for the same size . . . ⅓ smaller for the same wattage rating . . . up to 100 degrees higher ambient or hotspot temperatures permissible. These advantages result from the new high-temperature formulation, Thermacoat, which is IRC's exclusive coating for miniature precision power resistors.

Thermacoat is a non-refractory coating cured at low temperature for positive protection of the precision winding. Curing temperature is 800 to 1000°F. lower than that required for refractory coatings. There is no wire shifting during low temperature curing, no "work-hardened" after effect, no chance for arc-over.

Type AS miniature power resistors save space and cost less. Write for data bulletin. International Resistance Co., 401 N. Broad St., Philadelphia 8, Pa.



SPECIFICATIONS

Ratings: 2, 3, 5, 7, 10 watts, at 125° C. ambients! (other types rated as much as 100° lower).

Hotspot: Meet MIL-R-26C, Characteristic V, with allowable hotspot of 350° C. (other types allow only 250-275° C.)

Resistance ranges: 0.1 ohm to 175K ohms.

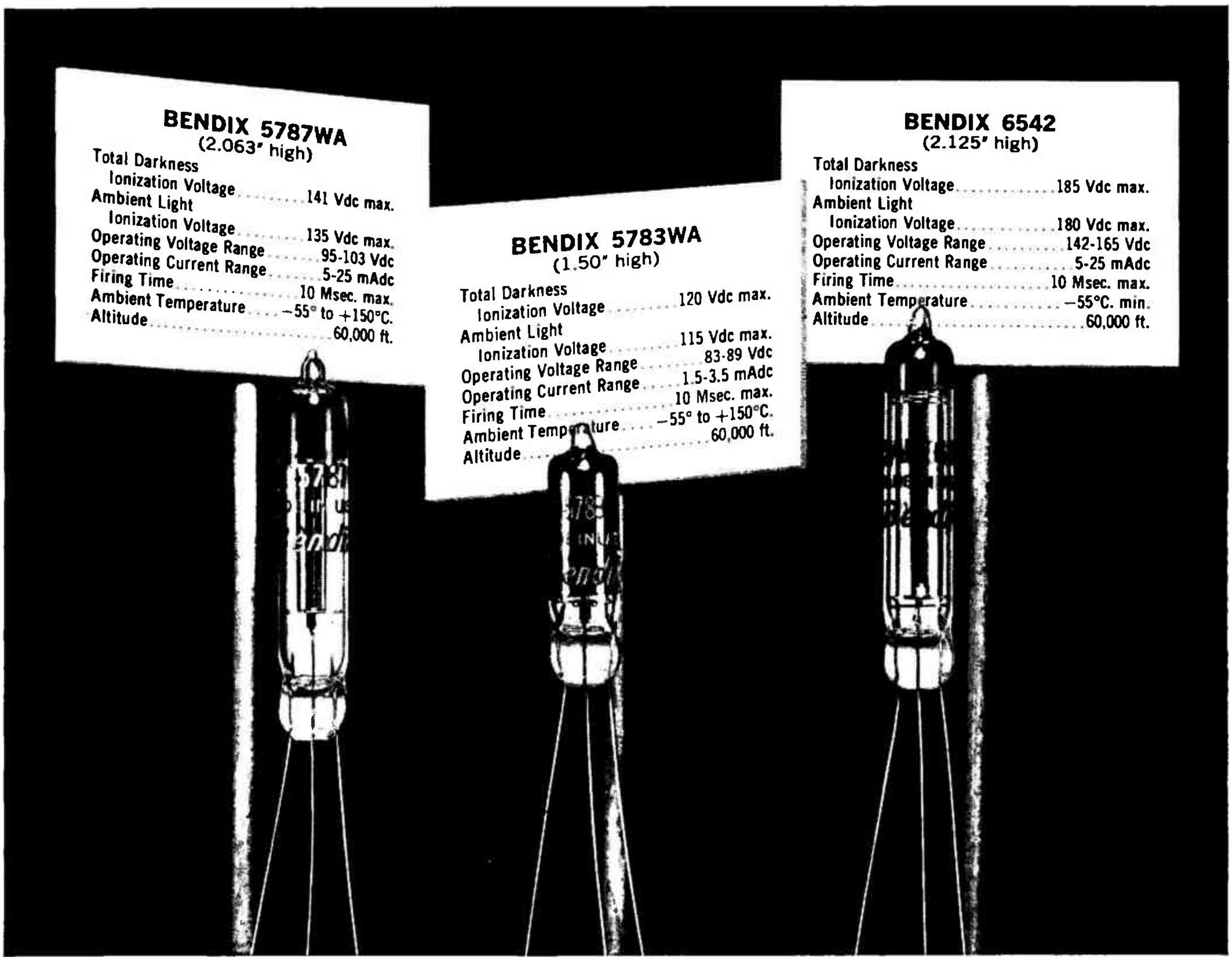
Tolerances: ±1% and ±3% commercial; ±5% MIL. As close as ±0.05% available.

Temperature coefficient: Averages less than 25 ppm/°C.

High frequency applications: Non-inductive windings available.

IRC *Leading supplier to manufacturers of electronic equipment*

Bendix Craftsmanship at work for you



Diodes shown actual size

SUBMINIATURE COLD CATHODE VOLTAGE REGULATOR AND REFERENCE DIODES

provide close, reliable voltage regulation or reference for DC power supply. Bendix® voltage regulator reference tubes are of the gas-filled, cold cathode type. They may be soldered directly into any circuit, and are subminiaturized to save space. They measure only .40" in diameter (heights are shown above). They exhibit very fast start-up times which are independent of ambient light and temperature conditions. They are designed for long life under conditions of severe shock and vibration. Rigid Bendix quality controls, inspection and testing assure utmost reliability. For further information, write . . :

ELECTRON TUBE PRODUCTS

Red Bank Division

EATONTOWN, NEW JERSEY

THE Bendix CORPORATION

Checks, packaged in plastic jackets and identified by coded magnetic tape strips, are sorted into preprogrammed groups. Unit is part of ITT Corp. automated system for processing bank documents

Automated Bank Document Handling

AN AUTOMATIC SYSTEM for processing bank documents, including checks and deposit slips, has just been placed in operation at the Valley National Bank of Phoenix. It uses transparent plastic envelopes identified with strips of coded magnetic tape affixed to each container for identification and computation.

The transistor system, designed and built by International Telephone and Telegraph Corp., accepts documents at an input encoder station that automatically packages each one in its own plastic jacket, at a maximum rate of 800 documents per hour.

A keyboard operator codes the magnetic tape at the top of each envelope.

An edit reader machine then verifies information placed on magnetic tape, as compared to original encoder totals. Personnel monitoring the station can catch errors at this stage.

Photoelectric devices inspect the jackets to make sure every one contains a document at all stages of system operation. A prime sorter reads the magnetic tape information attached to each plastic jacket and separates the documents into 26 preprogrammed groups; sorter can handle 25,000 pieces an hour.

Next a classifier breaks down the bank's own checks by account number and amount. Finally a lister machine removes the documents from their plastic jackets and prints out totals.

Special inks and uniform size documents are not required.

Electronic Laboratory Monitors R-F Surgery

UNIQUE ELECTRONIC LAB troubleshoots brain circuitry damaged by Parkinson's disease, then monitors and controls delicate r-f surgery of lesions deep within flawed tissue—using special instrumentation developed for Northwestern University medical school by consulting electronics engineer Mathew Petrovick.

Sensors for systems are variable reluctance accelerometers — type developed to test aerodynamic surfaces and vibration of guided missiles—taped to patient's extremities.

Accelerometers, sensing tremors too faint to be visibly noticeable, localize position of r-f probes deep within brain through motor response. Tremor track includes spike traces corresponding to light signals when visual network is contacted. Similar outputs signal location of other vital nerve circuits, then monitor r-f treatment of degenerated nerve cell area by tracing microvoltage responses instantaneously proportional to tremor.

MEETINGS AHEAD

May 6-9: Symposium on Circuit Theory, 5th Midwest, PGCT of IRE; Allerton Park & Urbana Campus, Univ. of Ill., Urbana, Ill.

May 7-11: Broadcast Engineering Conf., NAB; Washington, D. C.

May 7-12: Society of Motion Picture and Tv Engineers, Semi-annual; King Edward Hotel, Toronto, Ontario.

May 8-10: Power Instrumentation Symposium, ISA; LaSalle Hotel, Chicago.

May 8-10: Na'tl. Aeronautical Electronics Conf., NAECON, PGANE of IRE; Miami & Dayton-Biltmore Hotels, Dayton, O.

May 9-11: Power Sources Conf., U. S. A. Signal R&D Lab., Fort Monmouth; Shelbourne Hotel, Atlantic City, N. J.

May 9-11: Western Joint Computer Conf., PGEC of IRE, AIEE, ACM; Ambassador Hotel, Los Angeles.

May 15-17: Microwave Theory & Tech., National Sym., PGMTT of IRE; Sheraton Park Hotel, Washington, D.C.

May 17: Reliability & Quality Control, Product Engineering, Joint PGRQC and PE of IRE; Willkie Memorial, N. Y. C.

May 22-24: Communications Symposium, (Globecom V), PGCS of IRE, AIEE; Sherman Hotel, Chicago.

May 22-25: Electronic Parts Distributors Show, Electronic Industry Show Corp; Conrad Hilton Hotel, Chicago.

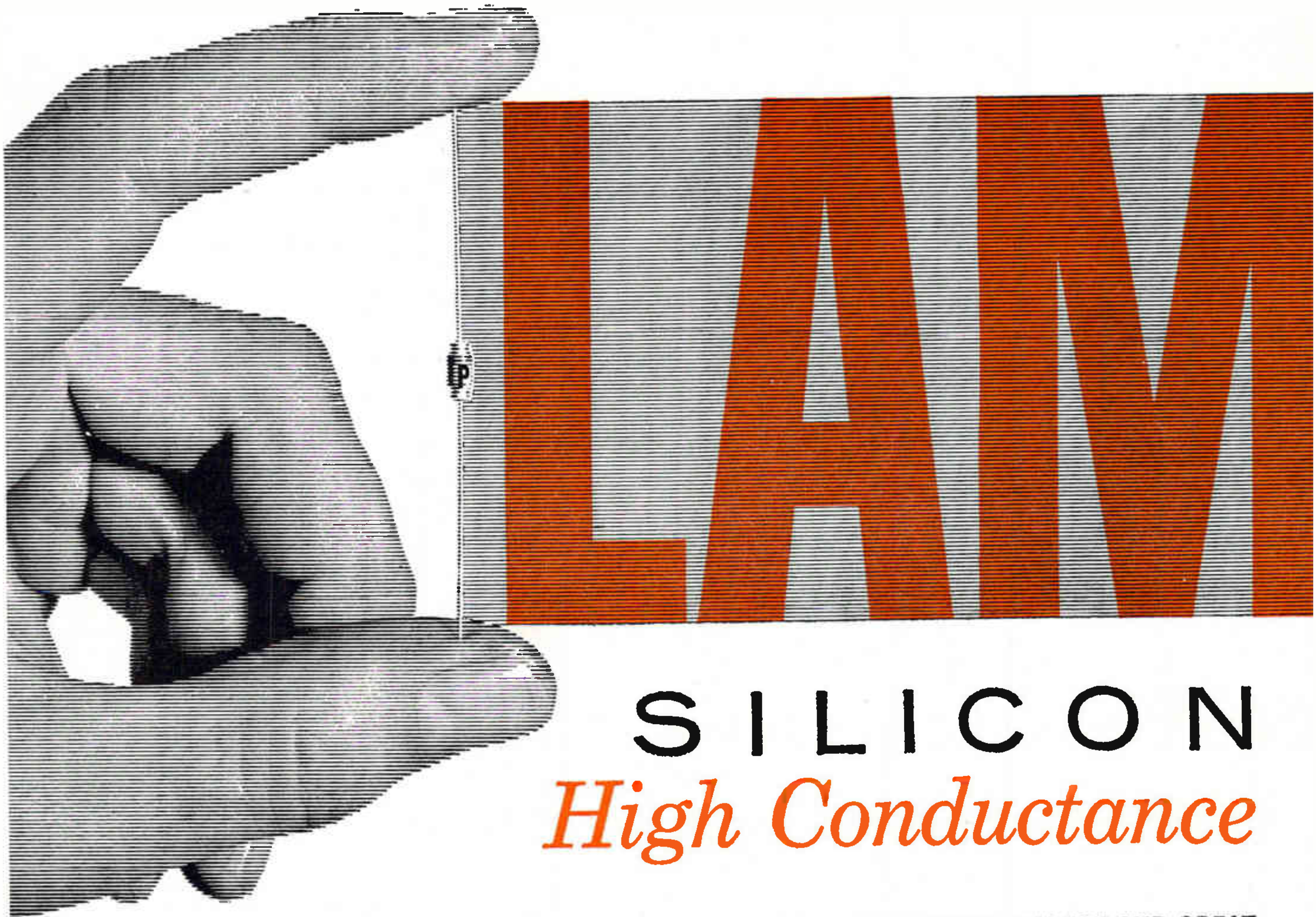
Aug. 22-25: WESCON, L.A. & S. F. Sections of IRE, WCEMA; Cow Palace, San Francisco.

Sept. 11-15: Instrument-Automation Conf. and Exhibit, ISA; Sports Arena, Los Angeles.

Oct. 9-11: National Electronics Conf., IRE, AIEE, EIA, SMPTE; Chicago.

Nov. 14-16: Northeast Research & Engineering Meeting, NEREM; Commonwealth Armory and Somerset Hotel, Boston.

Entirely New Diode Concept...Combinations



SILICON
High Conductance

Pacific Semiconductors, Inc. announces a new approach to the production of silicon diodes to provide performance characteristics never before possible.

The PSI Laminar process makes possible large scale production of diodes having these outstanding features:

- Great Mechanical Stability
- Ultra-Fast Recovery
- Extremely Low Capacitance
- Extremely Low Leakage
- Extremely Low Stored Charge
- High Rectification Efficiency
- *Double* Hermetic Seal
- 200°C. Storage Temperature

HOW IS SUCH PERFORMANCE AND GREAT MECHANICAL STABILITY POSSIBLE?

Briefly, the PSI Laminar Diode with its many layers, permits extremely low series resistance coupled with a very small junction area to provide a structure yielding a combination of speed, conductance and capacitance never before obtainable.

The laminated silicon element is provided with a glass-like surface layer which passivates the silicon and gives the element complete moisture integrity. This thoroughly sealed element is then welded within the standard PSI package... *double hermetic sealing.*

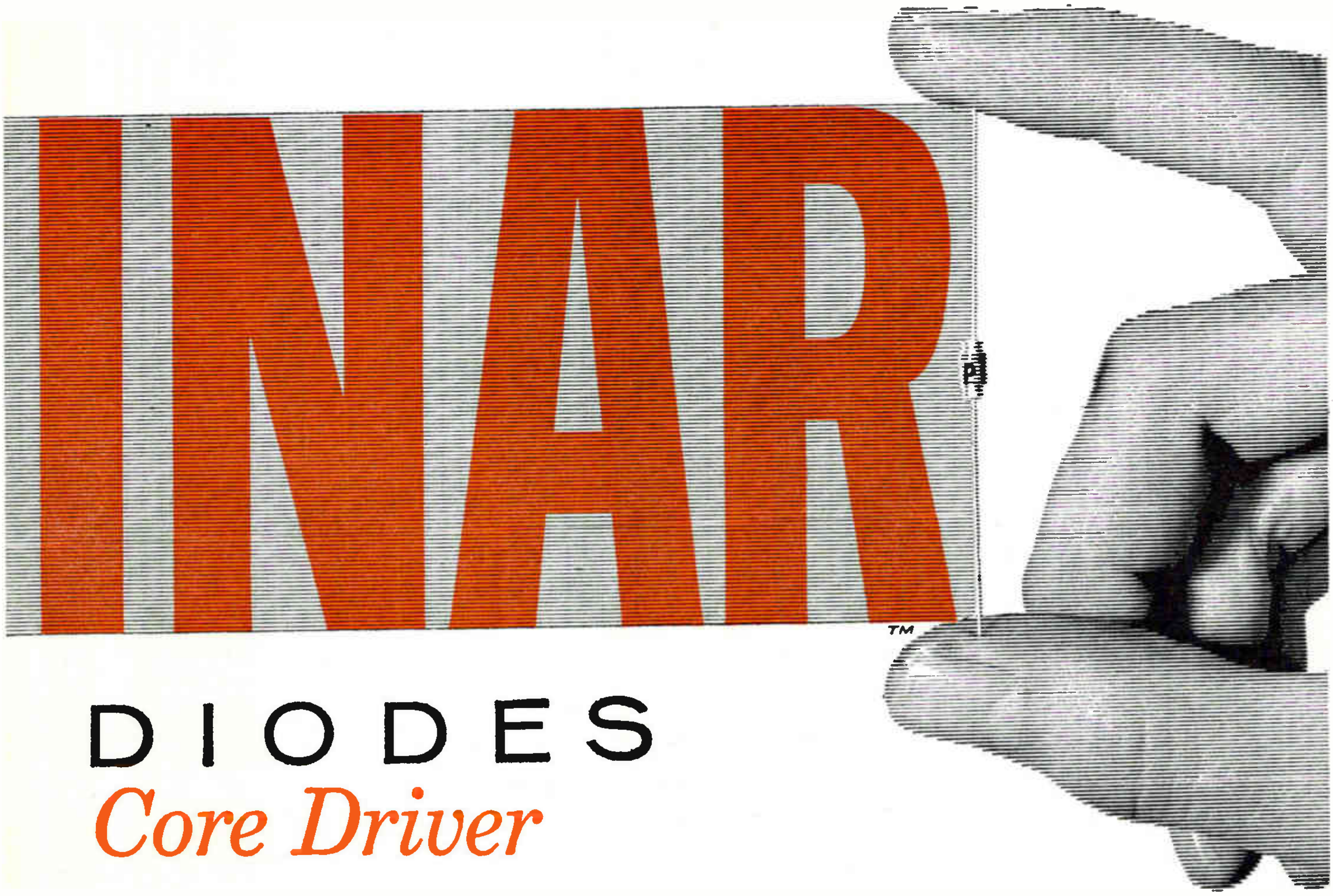
The front contact of the PSI Laminar Diode

PSI ®

Pacific

12955 CHADRON AVENUE,

of specs never before possible!



DIODES
Core Driver

is decisively imbedded in a gold lamination on the crystal giving the device complete and absolute protection against failure due to shock and vibration. *Front contact failure is positively eliminated!*

WHAT DIODE TYPES ARE AVAILABLE?

All diode types now being made from conventional mesa and planar processes. This includes the PS9013 high conductance core driver, with the following specifications:

LAMINAR TYPE PS9013

Forward current @ 0.9V > 500mA
Saturation voltage > 80V @ 25°C
I_{-60} @ 25°C < .20μA, I_{-60} @ 150°C < 50μA
Reverse Recovery* < .2μsec
Capacitance @ 9V reverse < 7 pfd
*Switching 500mA forward to −30V reverse recovery to 10K ohms

The PS9013 will replace the following:
1N690, 1N691, 1N920, 1N921

LAMINAR LOGIC DIODE 1N3257 will replace the following:
1N903 thru 1N908A, 1N914, 1N914A, 1N916, 1N916A, 1N251

LAMINAR MEDIUM CONDUCTANCE DIODE 1N3258 will replace the following:
1N658, 1N662A, 1N663, 1N792, 1N796, 1N800, 1N808, 1N815

All of the above EIA types are also available in Laminar construction.

Semiconductors, Inc.

HAWTHORNE, CALIFORNIA • A SUBSIDIARY OF THOMPSON RAMO WOOLDRIDGE INC.

CIRCLE 43 ON READER SERVICE CARD

LET'S KEEP

Business Help For Our Colleges Going Full Speed Ahead

"Should our company fold up its program of financial help for higher education now that the Kennedy Administration plans to have the federal government provide this kind of help in a big way?" It is clear why, in the light of campaign promises and plans announced since, this question is being raised in many business firms at this juncture.

What seems far clearer, however, is the right answer to the question. It is a resounding NO! **This is no time for the business community to ease up in what have been its notably successful efforts to help our colleges and universities get out of the deep financial hole in which they are operating. On the contrary, this is the time to put more steam than ever behind the drive of business to increase its financial help for higher education.**

Massive Help Needed

It is easy to understand why any individual businessman or firm might have a rather despairing feeling about the prospect of competing with the federal government, with its almost all-embracing tax arm, in providing financial support for higher education or almost anything else for that matter. But this is not a case of competition. It is a case where our colleges and universities must have massive help all along the line if they are to be put squarely back on their feet financially—a goal of crucial and perhaps decisive national importance. **The business community will continue to have both the opportunity and the obligation to keep on increasing its help for higher education as rapidly as possible.**

To underline this proposition take a look at the chart at the top of the next page. It shows how far the salaries of college and university faculty members continue to lag behind those of other occupational groups in the U.S.A. There has been some relative improvement in the average of faculty salaries in recent years. And the salary improvement in some fields, such as those of science and mathematics, has been very pronounced. But the chart makes clear how badly the average salary of college and university faculty members still lags.

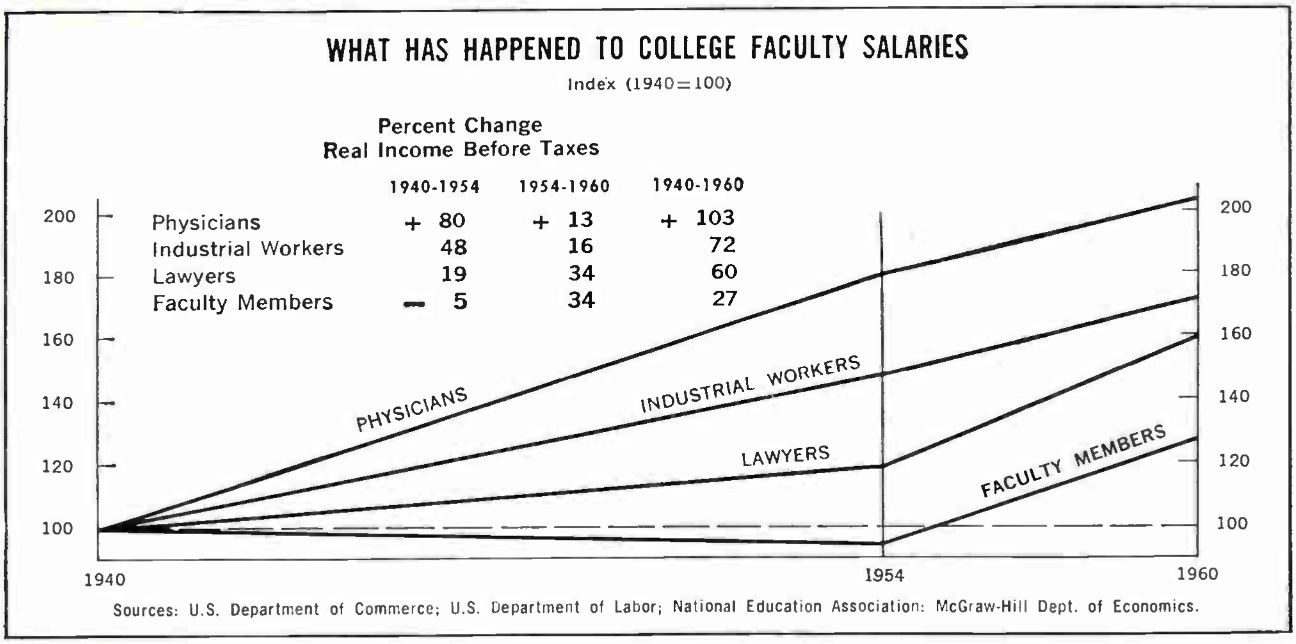
No Federal Funds For Salaries

The plans for increased financial aid for higher education, proposed by President Kennedy, do not contemplate increased expenditure for faculty salaries. This, we believe, is wise whether or not you feel, as many do, that resort to this kind of federal financing would inevitably carry with it federal controls that would ultimately undermine academic independence. The fight over federal appropriations for faculty salaries would be so long and bitter that it would be destructive to the aid program as a whole.

However, what the federal government will not be doing to remedy the deplorable condition of faculty salaries, as reported by the chart, is one indication of the tremendous scope that remains for crucially important help for higher education from business. Manifold other indications are available.

Disaster Escape Route

One of these indications is provided by the careful calculation that the annual income of our colleges and universities must be increased by about $4½ billion (from about $4½ billion to about $9 billion) over the next eight years if the tremendous wave of students



now gathering to descend on these institutions is not to wind up in both a financial and an educational disaster. This wave promises to add more than 2.5 million, or 75%, to college enrollments by 1970.

Thus far, the program for financial help for higher education by business, spearheaded by the Council for Financial Aid to Education, has been a remarkable success in all dimensions. The dollars contributed have increased rapidly—from about $100 million five years ago to about $150 million this year. Contributions of $500 million a year by 1970 are a clear possibility.

One of the inspiring developments increasing this possibility stems out of Cleveland, Ohio. There through their chief executives, an imposing group of business firms have established one per cent of their profits before taxes as their minimum goal for contributions to higher education, to be reached within three years. General acceptance of this goal by business would go most of the way toward getting our colleges and universities firmly on their feet financially.

Mutual Respect Increased

The mutual esteem of the academic community and the business community, an element of enormous importance to a free society, has been increased by the manner in which the program of financial aid has been carried out. In making its contribution, there has been no attempt whatsoever on the part of business to encroach upon the academic freedom of the institutions financially benefited. And the program of financial aid has greatly increased the knowledge, understanding and respect which the colleges and universities and business have for each other.

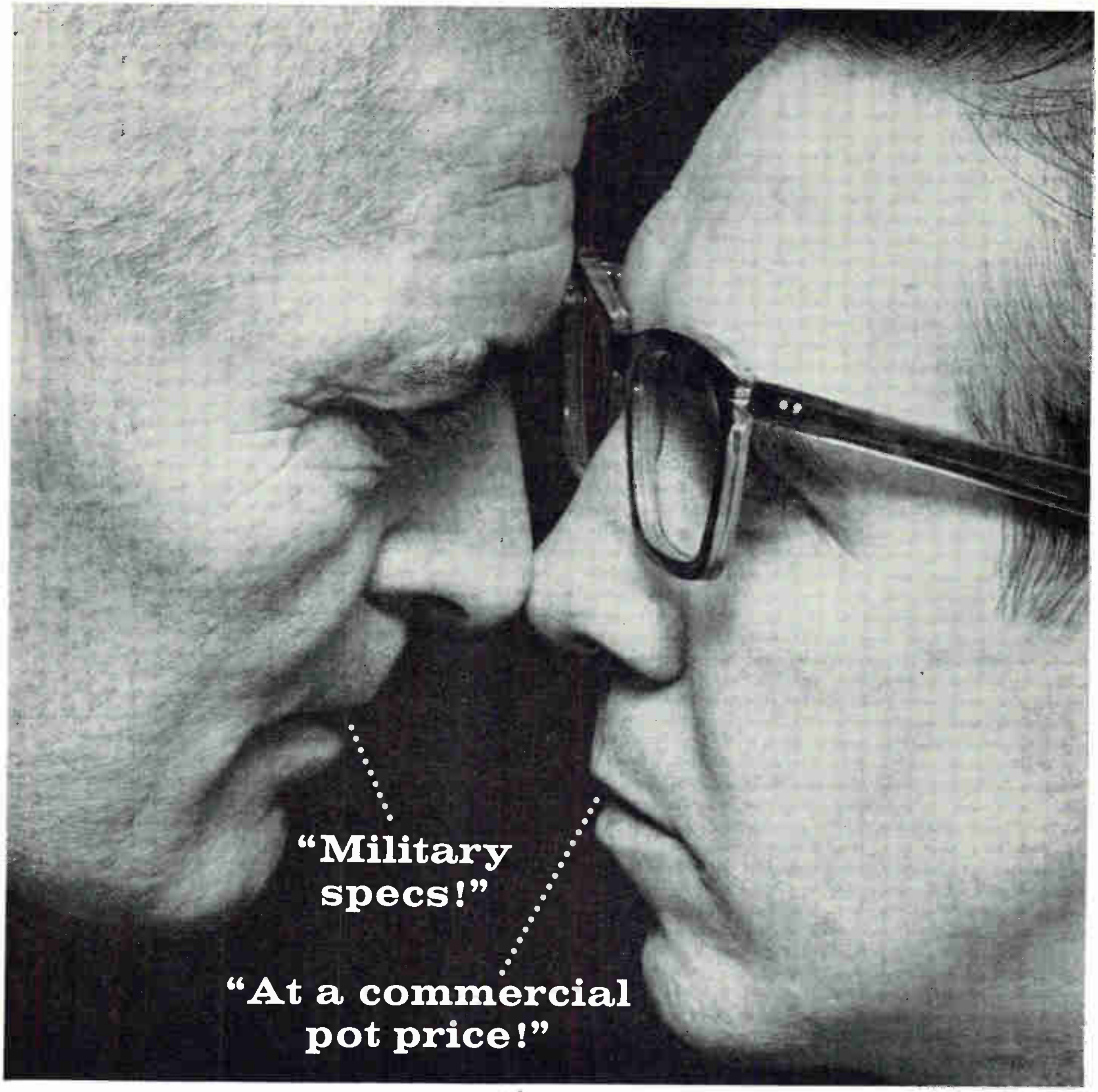
The Kennedy Administration's program to enlarge federal financial support of higher education is certain to arouse strenuous controversy. As proposed by its Task Force, it avoids some of the most controverial areas of principle. However, the very magnitude of the proposed extension of the federal government's already vast program of financing higher education involves fighting issues.

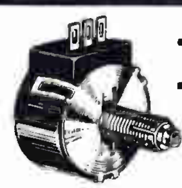
But if the enlargement of federal aid were to be deeply discouraging to the continued expansion of private aid for higher education, it would be a national misfortune of major proportions. There is no good reason why it should be. On the contrary, there is compelling reason for the business community to continue giving higher education all the financial help it possibly can, thus speeding onward a program that has been and continues to be a major constructive force for our colleges and universities, for business and for the nation.

This message was prepared by my staff associates as part of our company-wide effort to report on major new developments in American business and industry. Permission is freely extended to newspapers, groups or individuals to quote or reprint all or part of the text.

PRESIDENT

McGRAW-HILL PUBLISHING COMPANY



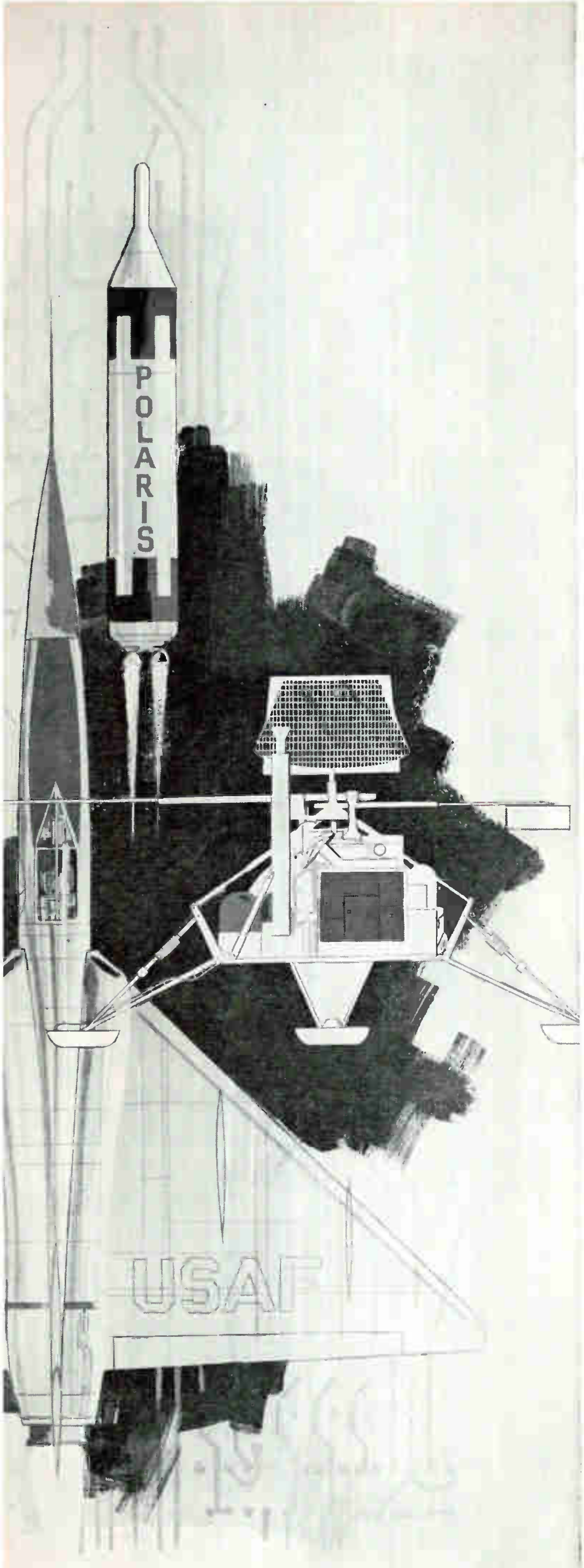
Waters new  PT¾ sealed potentiometer

Dust! Corrosion! Moisture! Vapors! All are foes of potentiometer reliability, yet ordinarily costly to keep out. Now, however, Waters introduces a new ¾" plastic case pot, the PT¾, meeting military sealed pot specs (MIL-R-19A, MIL-R-19/1A), yet priced no higher than many commercial grade pots! "O" ring shaft seal and complete internal sealing virtually eliminate environmental problems. Provides the same protection as encapsulation in less space. Resistance element is a copper mandrel wound with wire alloy which has a temperature coefficient of 20 P.P.M. per degree C. Resistance range 1 to 20,000 ohms. Dissipates 1.5 watts at 40°C. Available with split or plain bushings. Write for Bulletin PT 760.

Waters

WATERS MANUFACTURING, INC. · WAYLAND · MASS.

POTENTIOMETERS • COIL FORMS • POT HOOK® PANEL MOUNTS • TORQUE WATCH® GAUGES • C'TROL® METER/CONTROLLER • INSTRUMENTS



Opportunities for

circuit designers

Requirements of new and continuing projects, such as Surveyor and supersonic interceptor fire control systems have created new openings for circuit designers. The engineers selected for these positions will be assigned to the following design tasks:

1 the development of high power airborne radar transmitters, the design of which involves use of the most advanced components,

2 the design of low noise radar receivers using parametric amplifiers, solid state masers and other advanced microwave components,

3 radar data processing circuit design, including range and speed trackers, crystal filter circuitry and a variety of display circuits,

4 high efficiency power supplies for airborne and space electronic systems,

5 telemetering and command circuits for space vehicles such as Surveyor and the Hughes Communication Satellite,

6 timing, control and display circuits for the Hughes COLIDAR* (Coherent Light Detection and Ranging).

In addition, openings exist for several experienced systems engineers capable of analysis and synthesis of systems involving the type of circuits and components described above.

If you are interested and believe that you can contribute, please airmail your resume to: **Mr. Robert A. Martin,** Supervisor, Scientific Employment, Hughes Aerospace Engineering Division, Culver City 32, California.

*Trademark H. A. C.

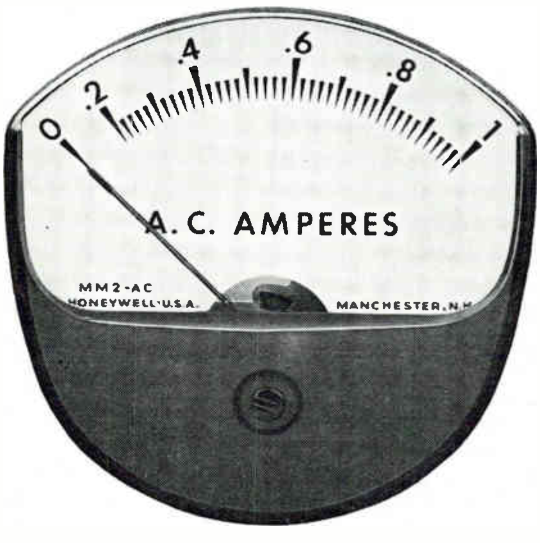
We promise you a reply within one week.

Creating a new world with electronics

HUGHES

HUGHES AIRCRAFT COMPANY
AEROSPACE ENGINEERING DIVISION

IMAGINATION



IMAGINATION . . . AN IMPORTANT COMPONENT IN EVERY HONEYWELL METER

If hard work and technical skill were the only requirements, almost anyone could build superior meters. But in many meter applications, success depends on the disciplined imagination of gifted designers and engineers. This is where Honeywell is outstanding. We can design and assemble panel instruments to solve any specific problems you may have. In fact, there's an excellent chance that we've already done so. ■ To find out more about quality instruments from Honeywell, get in touch with our representative in your area. He's listed in the classified pages of your telephone directory. Or contact us directly:
Precision Meter Division, Minneapolis-Honeywell Regulator Company, Manchester, New Hampshire, U.S.A. In Canada, Honeywell Controls Limited, Toronto 17, Ontario. HONEYWELL INTERNATIONAL Sales and service offices in all principal cities of the world.

Honeywell

H Precision Meters

With RADATAC I, Radiation's portable, low cost data acquisition system

Selecting data from low-level analog pick-offs and putting them into the *right* format for entry into a digital computer is frequently the most costly step in a performance evaluation program. RADATAC I (Radiation's Data Acquisition Cart) permits you to take this step directly and rapidly—eliminating much expensive data processing equipment and appreciably reducing computer time.

RADATAC I combines Radiation's Radicon analog/digital converter, Radiplex low-level electronic commutator, and an Ampex tape recorder (with the necessary logic circuitry and power supplies) into a single mobile unit. The system handles up to 48 analog inputs from resistive or thermocouple sources (as low as ± 5 mv full scale) with a resolution of ± 10 μv. After digital conversion, the information is recorded in computer format on magnetic tape. Data formats are available which are directly compatible with most large and medium scale digital computers.

For more complete data on RADATAC I, write to Dept. EL-5, Radiation Incorporated, Products Division, Melbourne, Florida.

THE ELECTRONICS INDUSTRY ALSO RELIES ON RADIATION FOR...

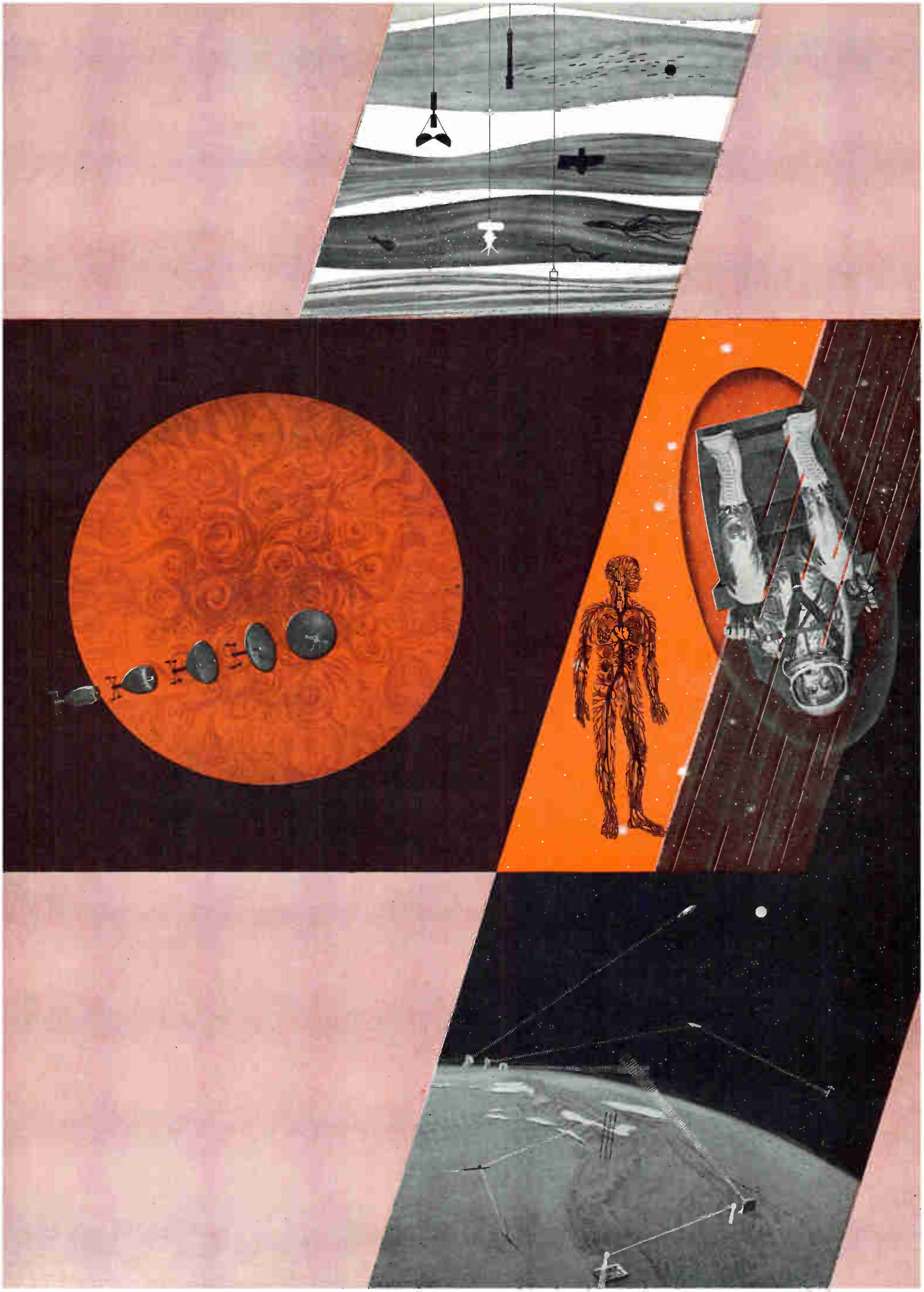
RADIPLEX 89 – a 48-channel low-level multiplexer with broad data processing applications. Features rugged solid-state circuitry, almost unlimited programming flexibility, unique modular construction for compactness and exceptional ease of operation and maintenance.

RADICORDER – Multistylus recorder provides high-speed instantaneous readout for wide range of data acquisition or processing systems. Eliminates necessity of electronically translating complete data, thereby reduces computer work loads.

TDMS – Telegraph Distortion Monitoring System pinpoints type and source of trouble on teletype, data processing and similar communications links without interrupting traffic. Ultra-compact TDMS can replace most test equipment now required for teletype maintenance and monitoring.

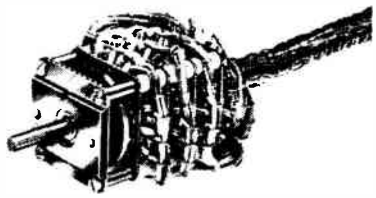
RADIATION INCORPORATED

CIRCLE 53 ON READER SERVICE CARD→



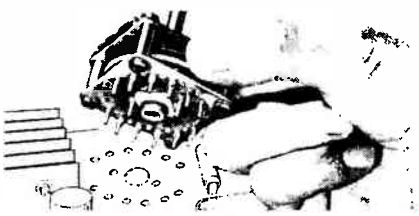
Shallcross precision circuit news

Standard 'Specials' in Shallcross Miniature Switches

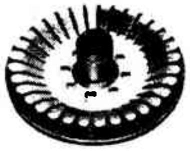


PRE-WIRED & HARNESSED SWITCHES — Decks pre-wired before ganging to reduce your production costs and time.

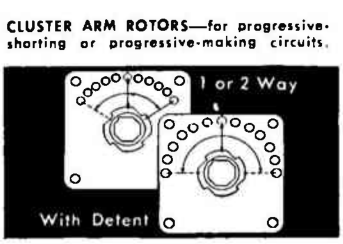
GOLD PLATED CONTACTS & TERMINALS—for the ultimate in maintaining low, stable contact resistance under corrosive conditions.



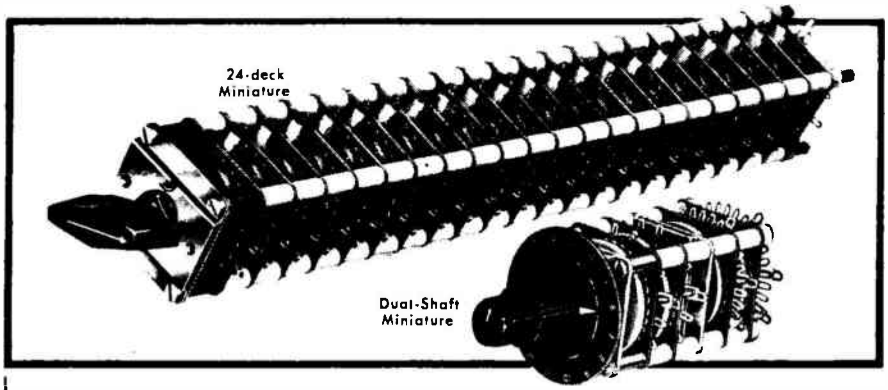
PRINTED CIRCUIT TERMINALS—available on single-deck or last deck of multi-deck switches.



CLUSTER ARM ROTORS—for progressive-shorting or progressive-making circuits.



SPRING RETURN ROTORS—on either or both directions of rotor travel.



MAXIMUM CIRCUIT SWITCHING IN MINIMUM SPACE

Here's a positive approach to miniaturization—a way to handle more circuits per cubic inch! Conservatively estimated, over 650 circuits may be switched in only 38 cubic inches by a Shallcross Miniature Series switch . . . and with the quality and reliability only a button-contact, multi-leaf wiper arm switch can provide. In one recent application, the single 24-deck Shallcross Miniature switch shown above replaced four "subminiature" units.

Equally impressive space advantages are possible with dual concentric shaft versions of the Shallcross Miniature Series. Either shaft may operate up to five of a total of ten decks. The inner shaft may also control a rheostat, variable capacitor, or other device.

If, in addition to size, switch quality is also your concern, the following highlights substantiate why Shallcross Miniature Switch users repeatedly specify these switches, and no others, for critical airborne, missile control, and computer applications.

Low initial contact resistance—less than 0.002 ohm.

Stable contact resistance—0.5 milliohm for 10,000 operations.

Highly immune to vibration damage—exceeds MIL-S-3786 requirements.

Uncompromised material quality—silver button contacts; silver alloy, multi-leaf, self-cleaning wipers; diallyl phthalate rotors; epoxy-laminate decks (filament woven with glass fiber).

Designed to applicable MIL-S-3786 Specifications.

Minimum thermocouple effects—similar materials for all current-carrying parts.

Excellent RF characteristics.

Minimum depth—1" first deck, ⅝" each additional deck.

Maximum Versatility—up to 32 positions, 1 to 4 poles, shorting or non-shorting in the same switch, 1 to 24 decks, ball detents, many special modifications.

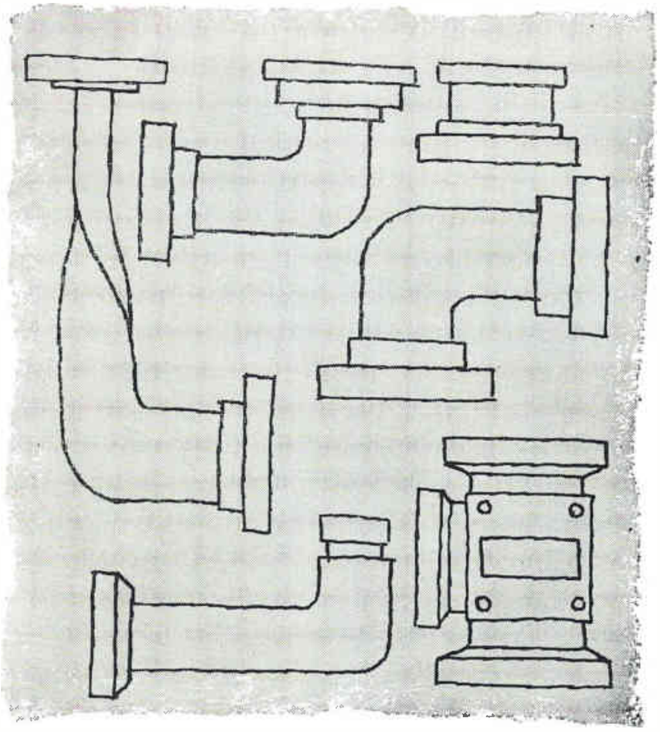
For complete details, write for Shallcross Switch Bulletin

Solenoid-Operated Switches

For indirect switching of complex circuits, or to avoid "over stepping" positions in critical circuits, most Shallcross Miniature Switches can be furnished with solenoid operation. Outline your circuit requirements for a prompt recommendation by Shallcross engineers.

Shallcross Manufacturing Co. Selma, North Carolina

Precision wirewound resistors. Switches. Instruments. Delay lines. Resistance networks. Audio attenuators.



MEMCOR
PRECISION MICROWAVE COMPONENTS

MEMCOR designs and produces waveguide components in standard and special configurations with all types of adapters, flanges, probes, accessories and other hardware which may be specified.

These components and fittings are available in alloys of brass, aluminum or magnesium (which MEMCOR pioneered), to MIL or customer specifications, with approved plating or other applied finishes.

Components for all bands from K/a to and including S bands, are produced; but MEMCOR also designs and manufactures special prototypes for new or experimental frequencies or applications, according to your project requirements.

MEMCOR is backed by 15 years of intensive experience developing and manufacturing microwave components, and offers unduplicated service and facilities in this field.

YOUR INQUIRY CONCERNING MEMCOR'S STANDARD COMPONENTS OR SPECIALIZED DESIGN CAPABILITIES IN THE MICROWAVE FIELD ARE INVITED, AND WILL RECEIVE PROMPT RESPONSE.

SEND FOR DETAILED DATA PAGES

MEMCOR

Model Engineering and Manufacturing, Inc.
50 Frederick Street • Huntington, Indiana

CIRCLE 58 ON READER SERVICE CARD

LASER—MASER
RUBY RODS *fabricated to exacting specifications*

VALPEY CRYSTAL CORPORATION is prepared to supply special chromium doped ruby rods fabricated to your specifications with quick delivery.

We can supply rods fabricated from low strain, annealed ruby boules specifically grown for optical and microwave maser applications at 0° or 90° orientations. We have available for quick delivery 0.05, 0.5, and 1.5 weight percent Cr_2O_3 : Al_2O_3 concentrations. Other chromium dopings also available. Valpey will also fabricate your material.

Depending on orientation we can supply rods from .080" diameter up to .750" diameter and up to 8" in length.

We can supply rods to the following specs:

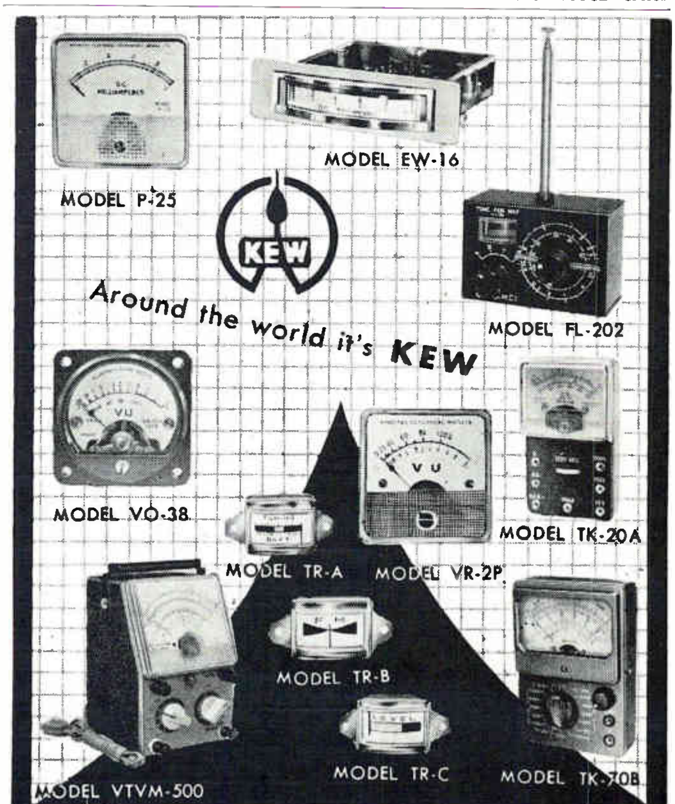
- C axis orientation to within 10 minutes.
- End surfaces optically polished flat to 1/5' wave of sodium light.
- Ends parallel to within .000010".
- Tolerance on length ± .005", diameter ± .001".
- Tolerance on 90° angle between end faces and cylindrical surfaces within 1 minute.

Valpey's precision optical department is also prepared to fabricate other materials to your specifications.

Please submit your specifications for a prompt quotation.

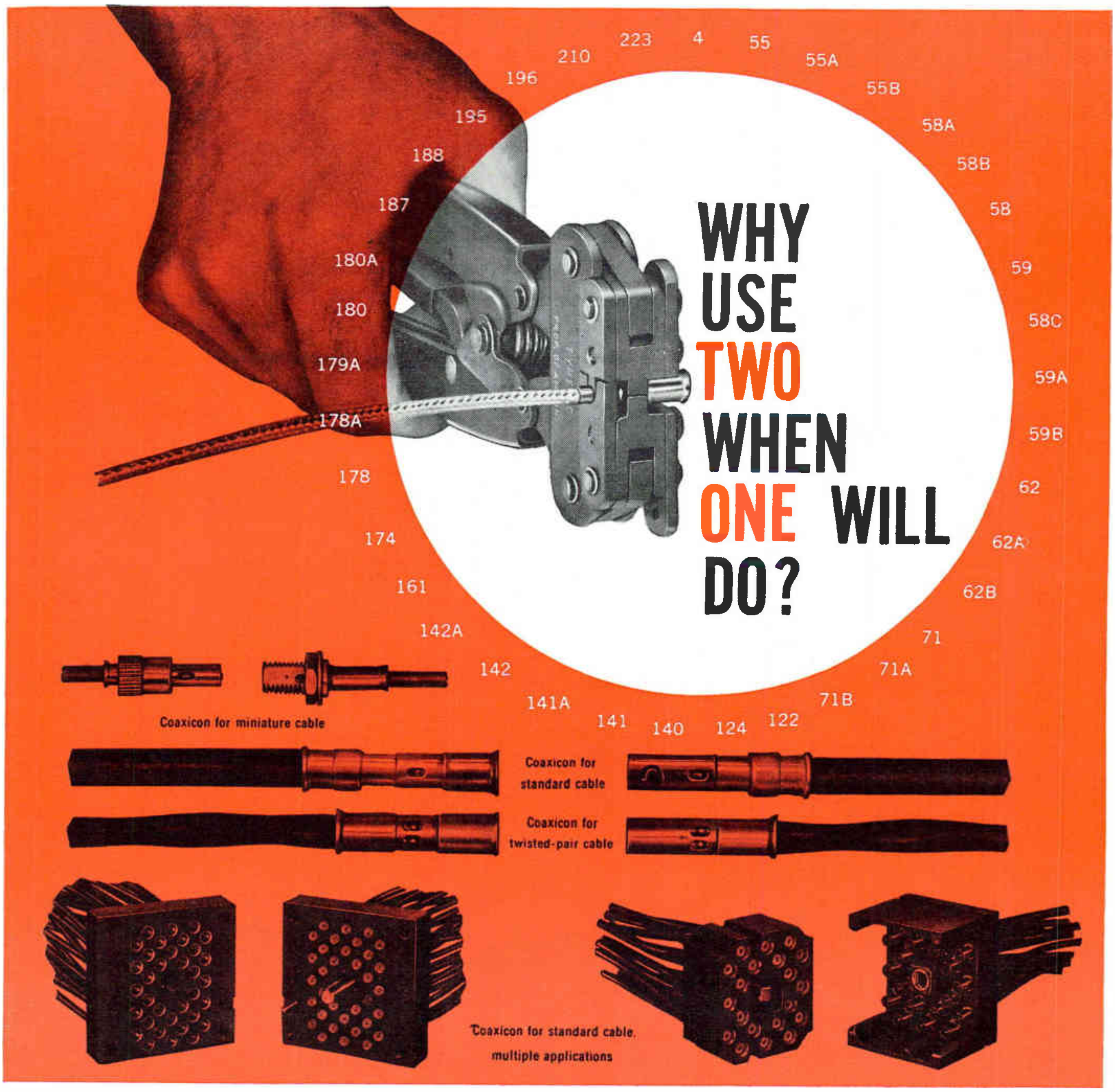
VALPEY CRYSTAL CORPORATION
Holliston, Mass. • Tel. GArden 9-4851, 9-4854

CIRCLE 203 ON READER SERVICE CARD



KYORITSU ELECTRICAL INST. WORKS, LTD.
No. 120, Nakane-cho, Meguro-ku, Tokyo, Japan
Cable Address: "KYORITSUKEIKI TOKYO"
Tel: (717) 0131~5

CIRCLE 204 ON READER SERVICE CARD



When you've got to attach a connector contact to the end of a coaxial wire, a single precise stroke of a crimping tool (one that crimps braid and inner conductor to the contact simultaneously) is the fastest way, the lowest-installed-cost way, the way that cuts human error in half . . . THE AMP WAY.

Our COAXICON® contact is designed on this principle: two strokes here is one too many!

COAXICON is a one-piece contact. It can be attached, simultaneously, with a single crimping tool stroke, to the braid and inner conductor of 37 sizes of RG/U coaxial cable up to ¼" O.D. (see size numbers above). And AMP makes the tools — hand and automatic — that control the crimp.

COAXICON consists of polarized, concentric male and female shells, made from drawn parts. The inner contacts, assembled in the shells, will attach equally to solid or stranded conductors. Where contact density is important, a miniature COAXICON fulfills the requirement.

COAXICON connectors will match cable impedances in the 50-100 ohm range, at frequencies as high as 150 megacycles. Impedance mis-match, incidentally, is only 1.06 to 1.09, even at 500 megacycles.

Write today for complete product information.

AMP INCORPORATED

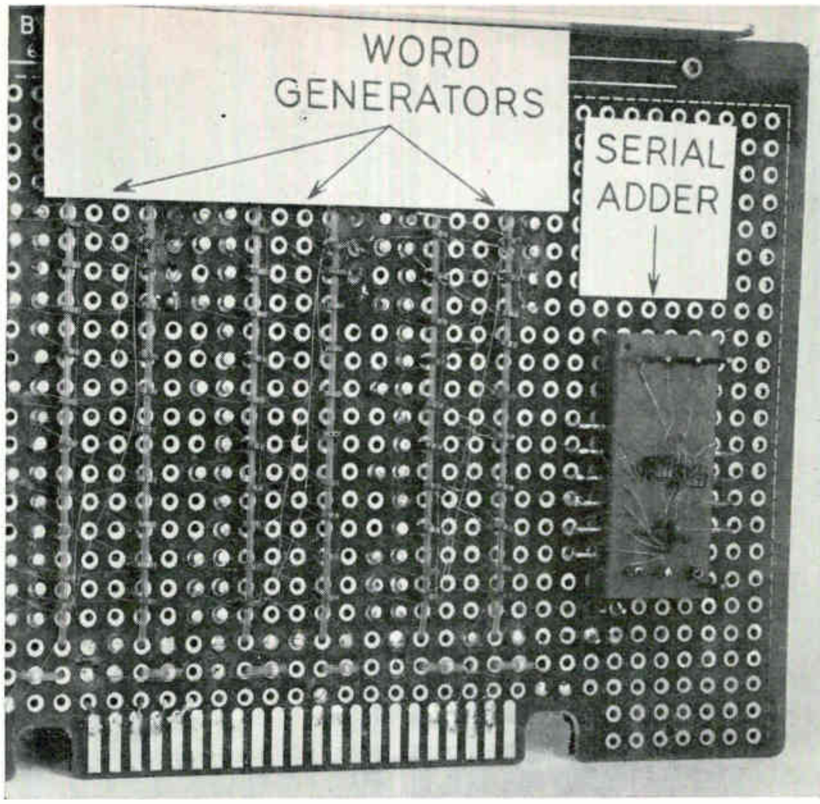
GENERAL OFFICES: HARRISBURG, PENNSYLVANIA

AMP products and engineering assistance are available through subsidiary companies in: Australia • Canada • England • France • Holland • Italy • Japan • Mexico • West Germany

electronics

May 5, 1961

Survey of general problems of magnetic logic and some of the methods of designing magnetic logic circuits



Photograph shows an all-magnetic core circuit built according to Fig. 6

SOLVING

Design Problems in All-Magnetic Logic

By U. F. GIANOLA,
Bell Telephone Laboratories,
Murray Hill, N. J.

ALL-MAGNETIC LOGIC CIRCUITS have been receiving serious attention recently. This article will explore the reasons for this interest and indicate the present state of development. The discussion will be limited to basic ideas and will not include detailed descriptions of the many proposed approaches.

The term all-magnetic is somewhat misleading, since all techniques must use some nonmagnetic components; at the least, nonmagnetic drivers must be used to supply current pulses. The term thus describes circuits composed as far as possible of compatible magnetic devices.

Parametron[1] and ferroresonant circuits[2], based on parametric excitation of nonlinear inductors in resonant circuits, could be included. However, the present discussion will be restricted to devices that use rectangular hysteresis loop materials similar to those developed for digital memory applications.[3, 4, 5]

Success of magnetic memory devices is partly responsible for the effort that has been directed towards using similar components for logic. A number of techniques have been developed using circuits that combine cores with semiconductors, particularly diodes.[6, 7] Although these circuits are satisfactory, a circuit that dispenses with semiconductors may be more reliable and economical, particularly if it is possible to reduce the multiturn windings or large cores needed to achieve electrical compatibility between magnetic and semiconductor components. This then is the practical basis for the interest in all-magnetic techniques.

Consideration will be restricted to synchronous sequential logic circuits, since there are few problems in the design of magnetic devices for combinational logic.[8–11] The problem is to obtain the step-by-step propagation of digital information through a network of bit storage locations, unilaterally and without degradation.

More general circuits can be derived by the straightforward addition of combinational logic components. A binary word stored in a bit location has to be transferred laterally on application of a controlling clock impulse. The bit must first be transferred in an intermediate step into an adjacent temporary storage location so that the primary storage components may be cleared before assuming a changed information state. The transfer connection must be unilateral, and there must be gain and regeneration between stages to compensate for transfer losses.

As in memory applications, the direction of magnetization may represent a binary digit. Remanence provides long-term storage. Unilateral direction of propagation can be achieved by taking advantage of the threshold for switching properties of a rectangular-loop material, and of the effective saturation of its magnetization at remanence. Directionality is mostly a matter of circuit organization.

The necessary gain can be ob-

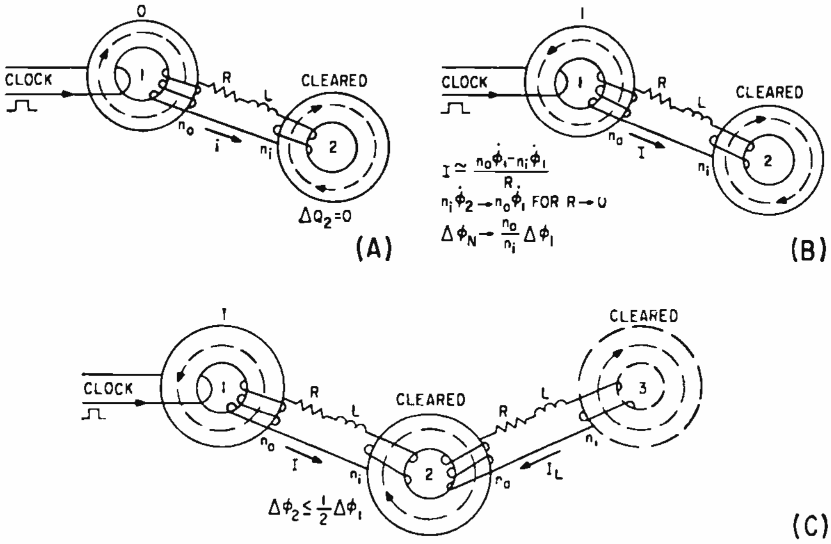


FIG. 1—Core circuits illustrate use of turns ratios to achieve flux gain, (A) and (B); circuit in (C) illustrates loss of gain due to adverse loading

tained either by the turn-ratios in the transfer windings coupling adjacent storage components, or by using materials with reentrant B-H characteristics. The requirements for gain and directionality should always be considered together. However, the proposals that have been made can be classified according to the method used for obtaining gain.

One method achieves gain through turn-ratios in transfer windings.[12-17] Conventional memory cores can be used for both the primary and secondary storage components. Here the transfer interconnections may be coupling windings between adjacent cores. As in the memory application, a binary 1 or 0 may be represented by anticlockwise or clockwise directions of magnetization of the core.

Consider the circuit in Fig. 1A. Cores 1 and 2 are connected by a coupling winding having resistance R and inductance L. There are n_o turns on the first core, n_i turns on the second. Assume that core 2 is magnetized in a clockwise direction, corresponding to both cleared and 0 states, and that core 1 contains the bit that is to be transferred to core 2. The transfer is done by applying a clock current pulse to clear core 1.

If core 1 contains a 0, Fig. 1A, the flux change in it is small and reversible, and the current i induced in the coupling winding may be made smaller than the threshold current for producing a flux reversal in core 2 by a choice of R, L and clock current. The small flux excursion produced by driving core 1 further into saturation is absorbed and dissipated in the inductance and reistance of the coupling winding. Therefore, no change of flux state is produced in core 2; that is, $\Delta\phi_2 = 0$. The result is a transfer of the 0 from core 1 to core 2.

If core 1 contains a 1, Fig. 1B, a full flux reversal is produced by the clock drive, and a large current I is induced in the coupling winding. This current is in a direction to insert a 1 into a core 2.

Considering the electromotive forces in the coupling winding, and neglecting the back emf due to the inductance of the winding, the instantaneous value of the induced current is $I = (n_o\dot{\phi}_1 - n_i\dot{\phi}_2)/R$ where $\dot{\phi}_1$ and $\dot{\phi}_2$ represent the instantaneous rates of change of flux

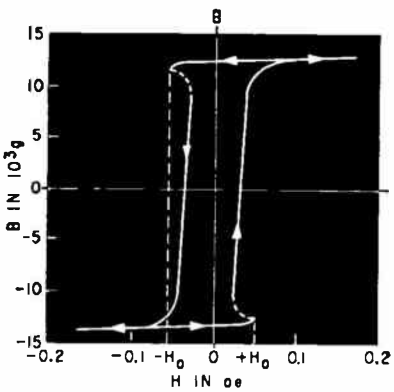


FIG. 2—Example of a reentrant hysteresis loop found in stressed 69-Permalloy

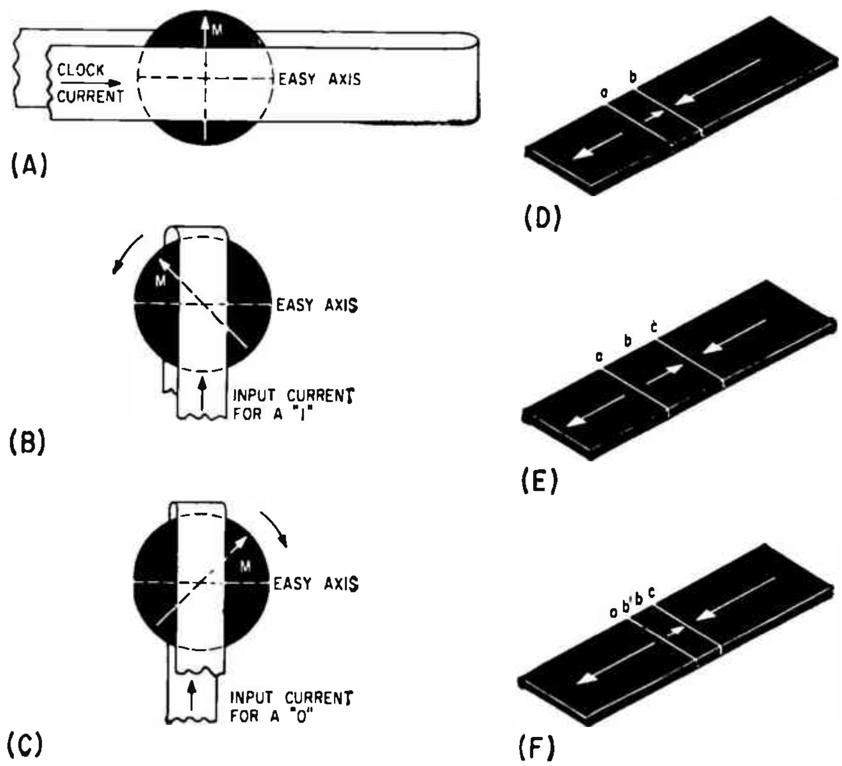
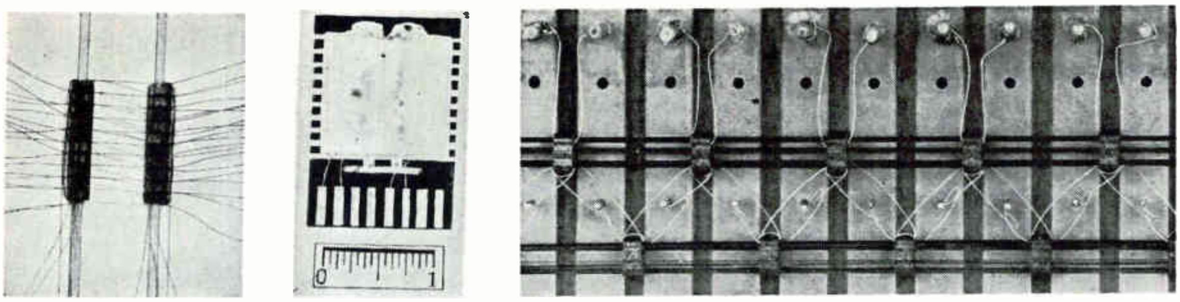


FIG. 3—Diagrams (A), (B) and (C) illustrate use of small input currents to control direction of rotation of magnetization of a thin film spot as it relaxes from the hard to the easy axis of magnetization; (D), (E) and (F) show step-by-step propagation of a domain of reversed magnetization through a thin film magnetized parallel to its easy axis



Photograph at left shows a 10-bit shift register package; same circuit is shown in center, potted and mounted on a printed circuit board. Clock drive connections are at the bottom, parallel output connections are at each side of the board. Size is 2 by 1⅜ inch. At right, a section of an all-magnetic shift register showing diagonal transfer windings, clock drive windings and parallel output windings and terminals

in cores 1 and 2. Integration shows that the quantity of flux reversed in core 2, $\Delta\phi_2$, may exceed that reversed in core 1, $\Delta\phi_1$ for a large choice of the turns ratio n_o/n_i. In particular, $\Delta\phi_2 \doteq (n_o/n_i)\ \Delta\phi_1$ when $R \doteq 0$. Thus the output of core 1 can be used to set any number of identical cores driven in series with core 2, giving the gain required.

However, the receiver core 2 may be loaded by a winding connecting it to a subsequent stage, and furthermore, the requirements of directivity must be taken into consideration.

Consider that core 2 is also coupled to a subsequent core in the circuit, core 3, by an identical winding, Fig. 1C. One way to ensure directivity is to maintain core 3 in the cleared state by an inhibiting clock pulse, during the transfer of information from core 1 to core 2. Therefore, core 3 presents no back emf to limit the loading current I_L induced by the flux reversal in core 2 as a 1 is being transferred from core 1 to core 2. Current I_L is limited by the impedance of the winding only, and, since in a circuit of any size the impedance of all coupling windings must be equal, retards the flux reversal in core 2. In fact $\Delta\phi_2 \leq 1/2\ \Delta\phi_1$ whatever the value chosen for R or n_o/n_i.

No flux gain is possible unless adverse loading of the receiving core is prevented. In core-diode logic circuits this is achieved by incorporating diodes or transistors in the coupling windings to decouple or block adverse current flow. Similar decoupling must be produced by magnetic components in all-magnetic logic.

One approach is to use additional unloaded cores as variable impedance components in series with the resistance of the winding that couples the storage cores. Such a buffer core presents a high impedance to currents in a direction to switch it, but a low impedance to currents in the opposite direction. It may be slowly set to the required state in the interval between transfers, without affecting the setting of the information cores.

Therefore, buffer cores may be used to limit adverse loading currents and provide sufficient decoupling to make flux gain possible. The buffer cores may be used to provide a variable transformer coupling between unloaded storage cores. Transfer with gain between the storage cores is possible, and directionality in the circuit is obtained by slowly setting the buffer cores in between transfers to either a blocking or a transmitting state.

Various mechanisms for internal gain are also possible. A number of rectangular loop materials have a reentrant loop,[18] such as shown in Fig. 2. In these materials, once the static threshold field H_o is exceeded, and flux reversal begun, the threshold field for continued switching decreases. One explanation is that the field necessary to continue a flux reversal by domain wall motion is smaller than that needed to nucleate domains of reversed magnetization[17, 19]. The magnitude of the reduction in the threshold may depend upon the magnitude of the field that is applied to produce the initial partial reversal, as well as upon the degree of flux reversal.

If the storage cores have a reentrant characteristic, then flux gain is possible without depending on turn-ratios in the coupling windings. This can be shown in Fig. 1B. If core 2 has the re-entrant property, then the transfer currents from core 1 need only be sufficient to produce a partial reversal in it, since a bias field that exceeds the reduced threshold, but not H_o, may be applied subsequently to complete the reversal. Transfer current obtained on clearing core 1 need provide only a triggering impulse to initiate switching in core 2.

The circuit of Fig. 1B was selected for convenience. A number of more suitable circuits using the reduction in threshold produced by partial switching in both multiapertured cores and toroidal cores have been developed[14, 20].

Two related methods for obtaining gain have been proposed. The first is based on the restoring action of the anisotropy field in thin magnetic films having uniaxial anisotropy[21].

If a thin-film spot is magnetized normal to its easy axis (cleared state) by a clock drive, see Fig. 3A, then, when the drive is removed, the direction of magnetization will relax either to the left or to the right towards the easy axis. These directions represent a binary 1 and 0. The initial direction of rotation can be controlled by a small input field parallel to the easy axis, Fig. 3B and 3C. The controlling field need be only an impulse, since it is assumed that the magnetization will relax coherently.

The impulse may be generated by the current induced in a coupling winding by clearing a preceding information spot. Unfortunately, loading is produced by currents induced in the winding coupling the receiver spot to the next one. If this is taken into account, calculation shows that the

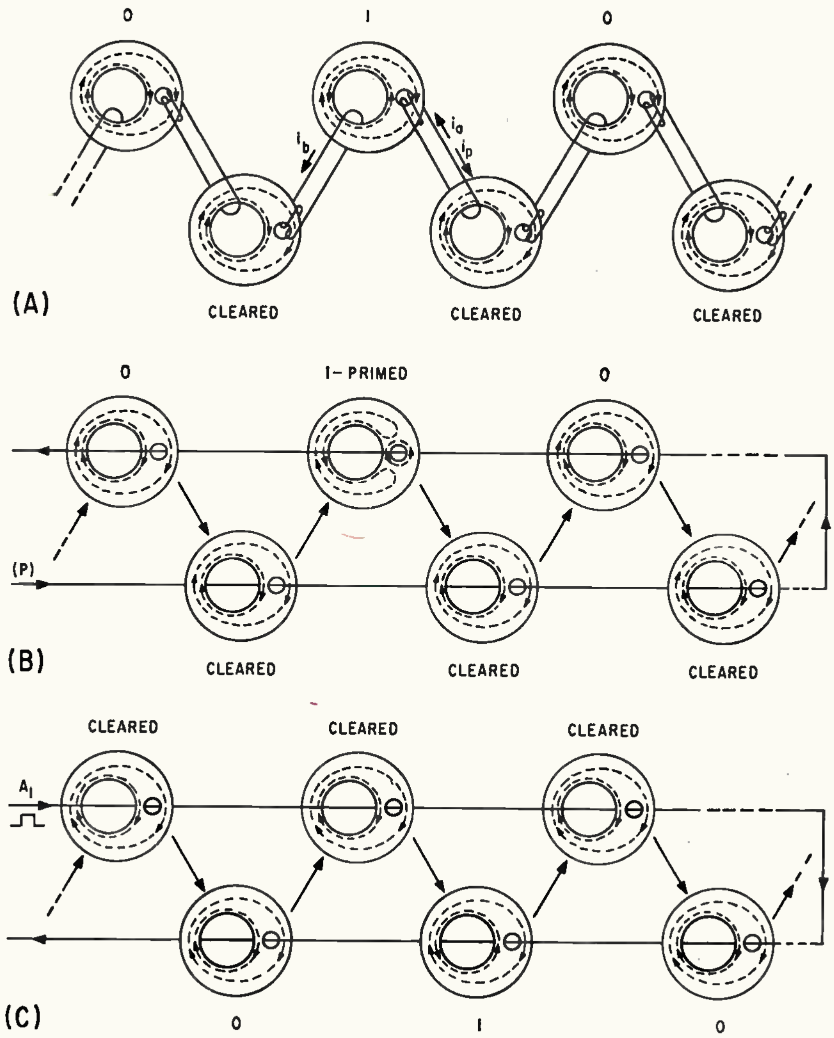


FIG. 4—Transfluxor shift register circuit (A) shows coupling windings and initial flux states; (B), flux states following priming operation; and in (C), following the advance operation

impulse field from the transmitter spot can at best control the direction of rotation for the first 30 deg only, even for unity fan-out, or 14.5 deg for a fan-out of three.

Therefore, this scheme depends upon an ability to make films that have sufficient anisotropy to ensure coherent rotation from large angles without controlling fields.

Furthermore, fields produced by currents induced in the coupling windings during this time, may retard the transition time and form a multiple-domain structure within the spot. The rise and decay times of the drive pulses may also play a large part in determining the operating speed.

The second method is based on differences between the fields needed to establish a domain of reversed magnetization in a thin film having uniaxial anisotropy, and that needed to extend it by wall motion[15, 22-24]. Consider a magnetic tape that has its easy direction parallel to its long axis, and is initially magnetized from left to right.

Now apply a field in a direction to reverse the magnetization in a small segment, Fig. 3D, by a strip solenoid. Flux closures must be completed by air flux. Therefore, the reversed segment is subjected to demagnetizing fields, which increase as the length *ab* is decreased.

If *ab* is too small, the reversed setting will be unstable once the applied field is removed. A stable zone of reversed magnetization can be produced only if *ab* exceeds a critical length. Once a stable segment has been produced it can be extended by wall motion by the field of an adjacent solenoid, even though the latter is itself incapable of establishing a stable segment of reversed magnetization.

A less than critical field can be used to extend the domain wall from *b* to *c*, Fig. 3E. At the same time, or subsequently, a field can be applied to move wall *a* to *b'*, Fig. 3F, such that $ab = b'c$. Thus a binary word, in which 1's are represented by segments of reversed magnetization, can be propagated step by step, unilaterally and without degradation, along the strip, exactly as information is propagated from core to core in the core circuits.

The possibilities for fan-out are limited since the flux gain is unity, although it has been suggested that added flux gain may be achieved by lateral growth of the reversed segments during propagation[24]. Otherwise gain can only be achieved through the use of turn-ratios in interconnecting windings.

The approaches differ mainly in the means used to obtain gain, leading to differences in circuit organization. They have, however, many similarities. One circuit will illustrate the relevant features. The circuit is Fig. 4A; it uses two-apertured transfluxor cores[25]. Each small hole is coupled to the large hole of the adjacent core by a 2-turn to 1-turn winding. This turns ratio gives the gain to compensate for transfer losses. By using a larger turns ratio, additional flux gain can be obtained, permitting fan-out.

Assume that a binary word has been advanced into the upper row of cores. The lower row cores are left in a cleared or 0 state, represented by full clockwise magnetization of the core.

A 1 is inserted by reversing the magnetization of the inner annulus, Fig. 4A. This reversal is not coupled to the output winding. Thus the core is not loaded adversely by the output winding while a 1 is being inserted. Flux gain is possible for the transfer of flux between cores because of the turns ratio.

The next step is to advance the reversed component of flux in the second leg of cores containing a 1 into coupling with the output winding, thus priming the cores for subsequent transfer. This is done by applying the priming current *P*, Fig. 4B, in a direction to produce a flux reversal around the small hole of all cores, that is between the second and third legs. It is limited in amplitude so that it cannot produce a reversal around the large hole and disturb the flux pattern representing at 0. This selective action is due to the large threshold current needed to produce switching around the large hole compared to that for switching around the small hole.

The current i_p, Fig. 4A, induced in the coupling winding is in a direction to leave the lower row cores unaltered, since they already magnetized to saturation in the same direction as the field produced by i_p. So that the switching time of the priming phase be as short as possible, i_p must be small, and since the winding resistance R is the only limiting impedance, R must be large. However, a maximum value of the winding resistance is determined by the requirements of the subsequent transfer phase, and this limits the priming speed. The core sizes can be so chosen that the maximum winding resistance is that of the copper wire used for the coupling winding.

Following priming, an advance current pulse A_1 is applied to clear the upper row cores, Fig. 4C. If an upper row core contains a 0 it will not be disturbed by the pulse; neither will the adjacent lower row core. Thus, the 0's are transferred into the adjacent lower row cores. If an upper row core contains a 1 it will be driven to the cleared state, thus inducing a current i_a (Fig. 4A) in a direction to insert a 1 into the adjacent lower-row core, Fig. 4C. The A_1 pulse is returned through the small hole of the lower-row cores. The purpose is to maintain clockwise magnetization of all output legs, thus inhibiting spurious flux reversals that could be produced by the forward and backward propagation currents i_a and i_b, Fig. 4A.

The bit pattern has now been transferred to the lower-row cores one step to the right, Fig. 4C. A subsequent P phase followed by an A_2 pulse, which clears the lower row of cores, will transfer the bit pattern back to the upper row cores one further step to the right. Thus, by applying clock pulse sequence P, A_1, P, A_2, the bit pattern may be transferred step by step from left to right.

The circuit is a shift register. Fan-out may be achieved by choice of turn ratios. However, the problem remains of introducing additional combinational operations in between, or coincident with, the shifting operation, so as to achieve an all-magnetic logic. Any additional components should be compatible with those already employed. This aim can be achieved in all-magnetic logic circuits in a number of ways[15]. In the circuit just described, combinational logic can be achieved by using more complicated input structures. A small output aperture and a larger isolation aperture achieve sequential transfers, but one or more additional small apertures in the input leg of the core make possible combinational operations by flux steering[8–11].

There are two possibilities: first, outputs from one stage may be used as voltage sources to produce switching of flux in the receiving stage; second, the outputs may be used as current sources to produce inhibition of switching by clock pulses.

Figure 5 illustrates the first type. The core has three additional input

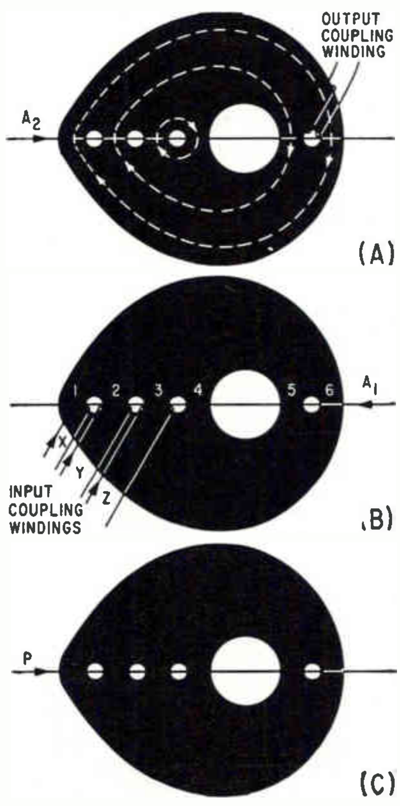


FIG. 5—Example of modified core suitable for introducing added combinational logic into the circuit of Fig. 4

apertures. It is used in place of one of the lower-row cores in Fig. 4. When cleared by an A_2 pulse, its legs are fully magnetized clockwise, Fig. 5A. During the subsequent A_1 phase inputs x, y and z are provided by the outputs of three upper row cores, Fig. 5B. If just one of these inputs is present, e.g. $x = 1$, $y = 0$, $z = 0$, then a flux reversal takes place between the corresponding input leg; leg 3 and leg 4; leg 5 is unaffected. There will be no flux reversal between leg 5 and leg 6 during the following priming P phase, Fig. 5C, and the core yields no output when cleared again by A_2. However, if two or three of the inputs are present, e.g. $x = 1$, $y = 1$, $z = 0$, then there is a flux reversal in leg 5. Therefore, a flux reversal between leg 5 and leg 6 will be produced in the following P phase and there will be an output when the core is subsequently cleared by A_2. An output will be obtained during the A_2 phase if, and only if, the inputs during the preceding A_1 phase had satisfied the Boolean expression $xy + xz + yz = 1$.

Any Boolean function or its negation can be generated by devices of this nature. Circuits more complicated than shift registers have been constructed to test this approach. One is the serial binary adder shown in Fig. 6.

The serial inputs, x_n and y_n, to be summed are provided by the outputs of all-magnetic shift registers. The third input, z_{n-1}, to the carry generator is provided by its own delayed output. The output of the adder $S_{n-1} = x_{n-1}y'_{n-1}z'_{n-2} + x'_{n-1}y'_{n-1}z_{n-2} + x'_{n-1}y_{n-1}z'_{n-2}$ + (plus) : $z'_{n-2} + x_{n-1}x_{n-1}y_{n-1}z_{n-2}$ is transferred into an accumulator register, which is also all-magnetic.

A photograph illustrates the circuit.

Other features that can be obtained include nondestructive (Transfluxor) read-out, and selective steering of the output into different channels through multiple output apertures selected by corresponding priming currents.

The requirements of an all-magnetic synchronous sequential logic circuit can be achieved in a number of ways. Certain of the core circuits are in an advanced state of development, and a number of components, including both toroidal and multiapertured cores, are commercially available.

The thin-film approaches, although feasible and attractive in certain respects, require considerable development, with particular attention to the attainment of suitable and uniform materials characteristics, before components are generally available. They can be regarded as second-generation components. The requirement of materials uniformity must also be emphasized for core circuits that derive gain through internal gain mechanisms.

An appraisal of circuits should take into account speed, power, margins, cost and reliability under different environmental conditions. Speed and power should be considered jointly. In many of the core circuits it has been shown that[15], to a first order approximation, the maximum bit rate is proportional to the ratio of the threshold field for switching H_d to the switching coefficient S_w. Both are properties of the core material alone.

It is difficult to reduce S_w, but there is latitude in the choice of H_d. Therefore, increased speed is, to be looked for in an increased H_d as in core memories. This is accompanied by an increase in the drive field needed to switch the core in a given time, and consequently, by an increase in drive power for a core of given flux capacity.

An equally important point concerns the effect on the core of the power dissipated in it, as the bit rate is increased. The consequent rise in temperature results in a degradation of the magnetic characteristics and therefore lowers the useful bit rate. Similar considerations apply to all approaches. The transition time from hard to easy directions of magnetization in the thin film spots may be reduced by increasing the anisotropy field H_k; but, conversely, an increased drive field is also needed to maintain magnetization in the hard direction. However, note that S_w is smaller for films than for ferrite cores.

Finally, for a given H_d and S_w some increase in speed may be obtained through partial switching. In the Transfluxor circuit, if a partial flux setting is used to represent a binary 1, then, for a fixed (maximum) switching speed during the priming phase, the total switching time is less than if a full setting were used. However, there are limitations to an increase in speed by this means, since the partial setting must be appreciably larger than the shuttle flux excursion accompanying the transfer of 0.

There is little information concerning limitations on speed, but all-magnetic shift registers have been operated at bit rates of the order of 10^5/second[12-17,23] and bit rates as high as 10^6/second may be possible. A representative figure for the average power requirement is 10^{-6} watts/bit times the stepping frequency. A reduction of perhaps an order of magnitude may be possible by reducing the core size and the saturation flux density[26] of the material used, or both.

For the core circuits, the tolerances on drive currents and magnetic characteristics are satisfactory. Current margins may be ±50 per cent or better, and individual selection of commercial cores has been found to be unnecessary even for circuits containing as many as 1,600 cores[27]. The details of the design of the cores are flexible. Closer control may be necessary for second generation components. High reliability is generally conceded for magnetic components; they are also reasonably insensitive to changes in temperature, humidity, nuclear radiation. Costs appear to be competitive. Individual cores can be designed to perform complex logical functions, but the same function can usually be performed by interconnecting a number of simpler components. There is some question concerning the degree of complexity that can be justified in a single logic package.

The author wishes to acknowledge extensive discussions with J. A. Baldwin, T. H. Crowley, and D. H. Looney, that have contributed to this paper.

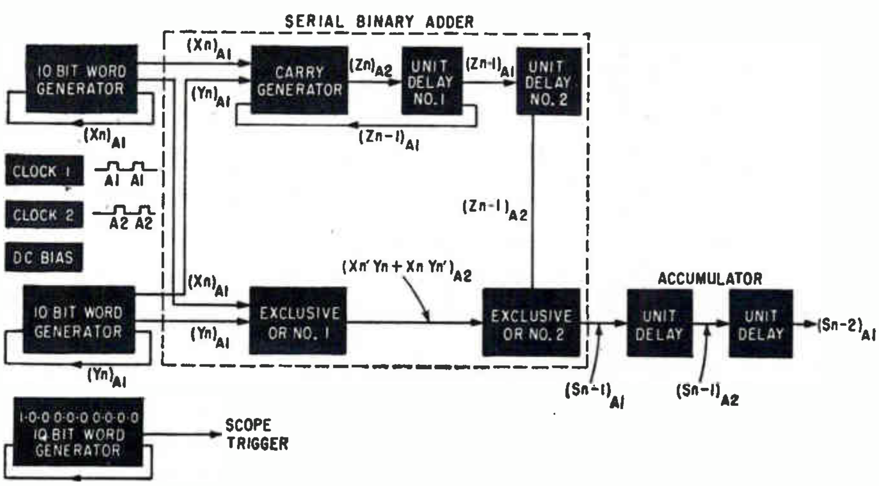


FIG. 6—Block diagram of a serial binary adder circuit

REFERENCES

(1) E. Goto, *Proc. IRE* 47, p 1304, 1959.

(2) W. E. Proebster, *Proc. Nonlinear Magnetics and Magnetic Amplifiers Conf.*, p 434, Aug. 1958.

(3) N. Menyuk and J. S. Goodenough, *J Appl Phys* 26, 8, 1958.

(4) J. A. Rajchman, *Proc Nonlinear Magnetics and Magnetic Amplifiers Conf.*, p 179, Aug. 1958.

(5) D. H. Looney, *Proc Electronic Components Conf*, p 96, May 1960.

(6) M. Karnaugh, *Proc IRE* 43, p 570, 1955.

(7) J. A. Rajchman, *Proc Western Joint Computer Conf.*, p 63, March 1958.

(8) H. W. Abbott and J. J. Suran, *Proc IRE* 45, p 1081, 1957.

(9) N. F. Lockhart, *IRE Nat Conv Rec* 6, Part 4, p 268, 1958.

(10) U. F. Gianola and T. H. Crowley, *Bell Syst Tech J* 38, p 45, 1959.

(11) D. B. Armstrong, T. H. Crowley, U. F. Gianola, E. E. Newhall, *Trans IRE* EC9, p 30, 1960.

(12) L. B. Russell, *IRE Nat Conv Rec* 5, Part 4, p 106, 1957.

(13) N. S. Prywes, *Trans IRE* EC7, p 316, 1958.

(14) D. R. Bennion and H. D. Crane, *Proc Western Joint Computer Conf.*, p 21, March 1959.

(15 U. F. Gianola, *Bell Syst Tech. J* 39, p 295, 1960.

(16) S. B. Yochelson, *IRE Wescon Conv Rec*, Part 4, p 82, Aug. 1960.

(17) D. R. Bennion, *Proc Nonlinear Magnetics and Magnetic Amplifiers Conf.* Oct. 1960.

(18) R. M. Bozorth, "Ferromagnetism," D. Van Nostrand Co. Inc., Princeton, N J p 495, 1956.

(19) R. H. Tancrell and R. E. McMahon, *J Appl Phys* 31, p 762, 1960.

(20) D. C. Engelbart, *Proc Solid State Circuits Conf*, p 68, Feb. 1959.

(21) W. E. Proebster and H. J. Oguey, *Proc Solid State Circuits Conf*, p 22, Feb. 1960.

(22) A. H. Bobeck and R. F. Fischer, *J. Appl Phys* 30, p 435, 1959.

(23) K. D. Broadbent and F. J. McClung, *Proc Solid State Circuits Conf*, p 24, Feb. 1960.

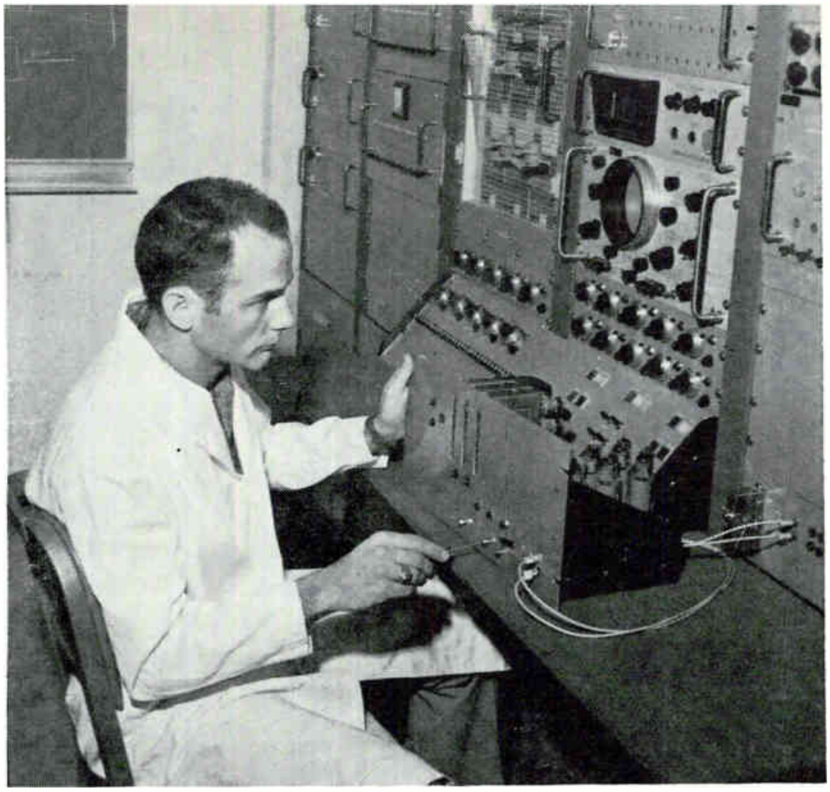
(24) D. W. Moore, *Proc Electronic Components Conf*, p 134, May 1960.

(25) J. A. Rajchman and A. W. Lo, *Proc IRE* 44, p 321, 1956.

(26) W. L. Shevel and H. Chang, *J Appl Phys* 31, p 1255, 1960.

(27) D. L. Hofmockel, Private Communication.

No stepping switches are used in this digital meter, which gates clock pulses into a counter in proportion to the amplitude of the input voltage. The instrument uses inexpensive d-c amplifiers and counters



Technician checks the instrument's calibration against a precison reference

Digital Voltmeter Employs Voltage-To-Time Converter

By BOONE BARKER and MARION McMAHAN
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INPUT VOLTAGES of both positive and negative polarity cause a voltage-to-time converter to deliver output pulses whose width is proportional to the input-voltage amplitude. These output pulses are fed to a gate circuit' where they permit clock pulses to pass into a digital counter; wide pulses due to high voltage pass relatively many clock pulses; narrower, low-voltage-derived pulses pass fewer clock pulses. With calibration, the number of clock pulses counted gives an input voltage reading correct to three digits. See Fig. 1.

The analog-to-digital converter described here produces an output pulse whose width is accurately proportional to an unknown input voltage. The width-controlled output pulse then gates clock pulses into digital counters for voltage readout. The instrument uses inexpensive commercially available plug-in d-c amplifiers and decimal counters.

The circuit element is the switched analog integrator[1, 2] shown in Fig. 2A. At the start of the operating cycle, the rise of the triggering voltage V_t triggers the monostable multivibrator, so that its output V_s rises to +60 v and cuts off switching diodes D_3 and D_4.

The positive input reference voltage E drives the d-c amplifier output voltage into its negative limit, which is determined by the reverse bias on the limiter diode D_2. This reverse bias, for the interval $(0 < t < t_2)$, is −30 volts.

Feedback through the limiter diode D_2 keeps the amplifier summing point at zero voltage. Positive input voltage V now causes D_1 to conduct and charge C to voltage $V/2$, with charging time-constant $RC/2$ small compared to the charging period of, typically, 80 millisec.

When the one-shot next turns D_3 and D_4 ON, feedback through C is reestablished. Amplifier output voltage V_o jumps rapidly to the capacitor voltage $V/2$; then the input voltage drives V_o linearly downward. During this timing period, the output is $V_o = V/2 - E\,(t - t_2)/RC$ for the period $(t_2 < t < t_3)$. When V_o reaches zero volts at time t_3, D_1 switches open the feedback loop through C. The amplifier output V_o falls rapidly to −30 v, and the timing cycle is completed.

The integrator reference voltage E is set so that $5\,(t_3 - t_2)$ in millisec = V in volts.

This is, if V = 100 v, output

pulse will be 20 millisec in duration.

A diagram of the switching multivibrator is given in Fig. 2B. The one-shot multivibrator may be triggered by an external pulse, or by a neon-lamp relaxation oscillator; after triggering, the one-shot switches the integrating circuit through diodes D_3 and D_4 (Fig. 2A). A thyratron V_2 is also triggered by the one-shot, so that a series of decade counters may be reset by the thyratron output pulse at the start of each operating cycle.

Bias for the relaxation oscillator is taken from the one-shot, so that the oscillator may be set to trigger at a fixed time delay from the end of the timing cycle.

The one-shot is a cathode-coupled monostable multivibrator and requires a positive input pulse of 5 volts for triggering; the unloaded output voltage swing at the plate is 140 volts, while a timing capacitor of 0.1 μf gives an 80 millisec period.

The one-shot output is d-c coupled to the switching diodes of the integrating circuit so that the diodes D_3 and D_4 are normally held in the conducting state, but are held firmly off during the charging period.

Charging current for the neon relaxation oscillator is controlled by the one-shot, so that the oscillator's timing period is measured from the beginning of the operation cycle. Display time of the counter thus remains almost constant, even though the input voltage is varied.

Circuit operation is as follows: the neon lamp ionizes at the start of the operating cycle, causing the voltage on the oscillator capacitor to rise to +200 v, at which time the neon bulb is turned off. This rise in voltage triggers the one-shot into its quasistable state. The output of the one-shot, which is taken from the plate of the normally-on tube, rises to approximately +30 v. The oscillator capacitor starts to charge negatively through the 44-megohm resistor (Fig. 2B), while the output of the integrator remains at −30 v. When the one-shot switches again to its stable state, the plate of the one-shot drops to +80 v, while the oscillator capacitor continues to charge negatively through the 44-megohm resistor.

The output V_o of the integrator rises sharply to a maximum of +50 v and starts integrating linearly toward zero volts. When the output of the integrator reaches zero, the output again limits to −30 v. The oscillator capacitor continues to charge negatively until

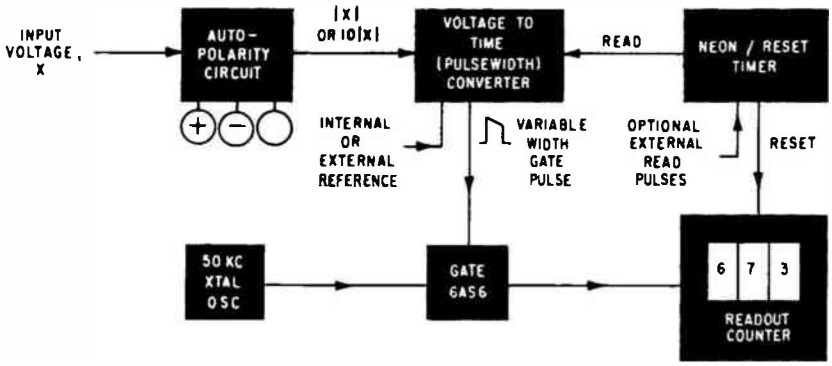


FIG. 1—Number of clock pulses reaching the counter is controlled by the width of the gate pulse, which in turn, is controlled by the magnitude of the input voltage signal

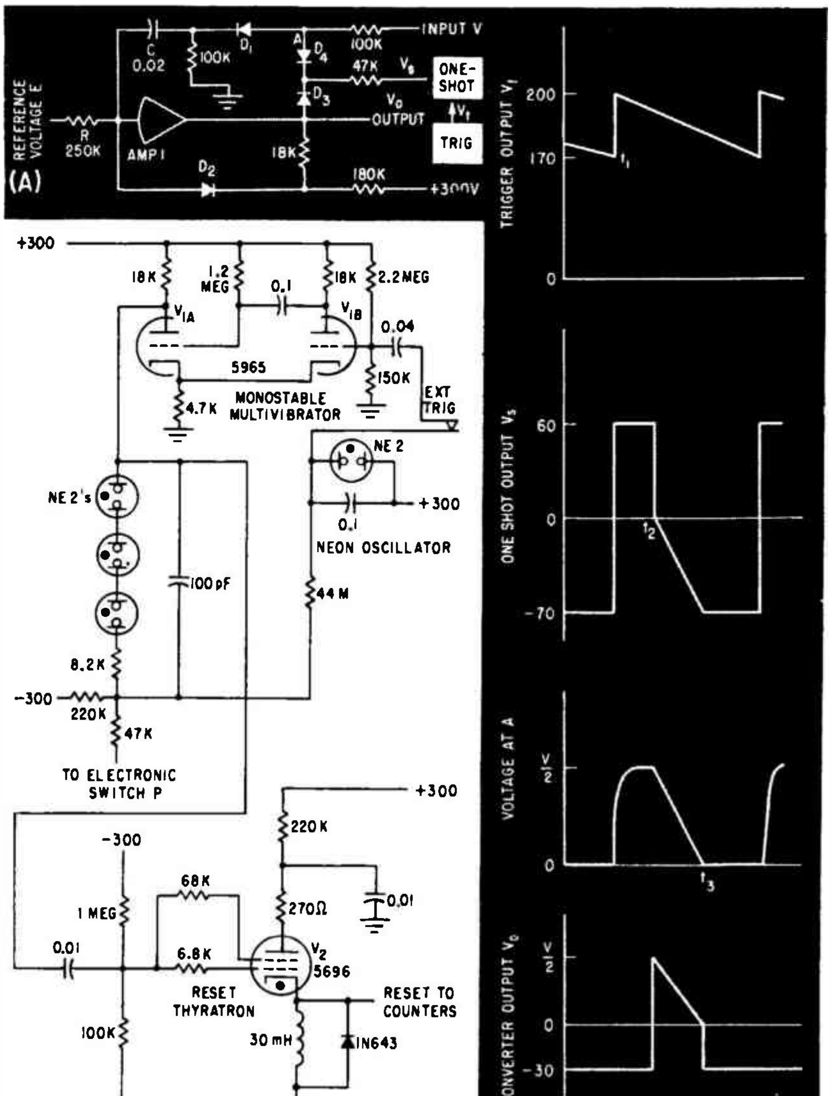


FIG. 2—Conversion of input voltage to an output pulse of predetermined width takes place every time the converter is switched on by the one-shot, with resulting waveforms as shown in (A); in addition to switching the one-shot, the converter triggers the thyratron for resetting the counters (B)

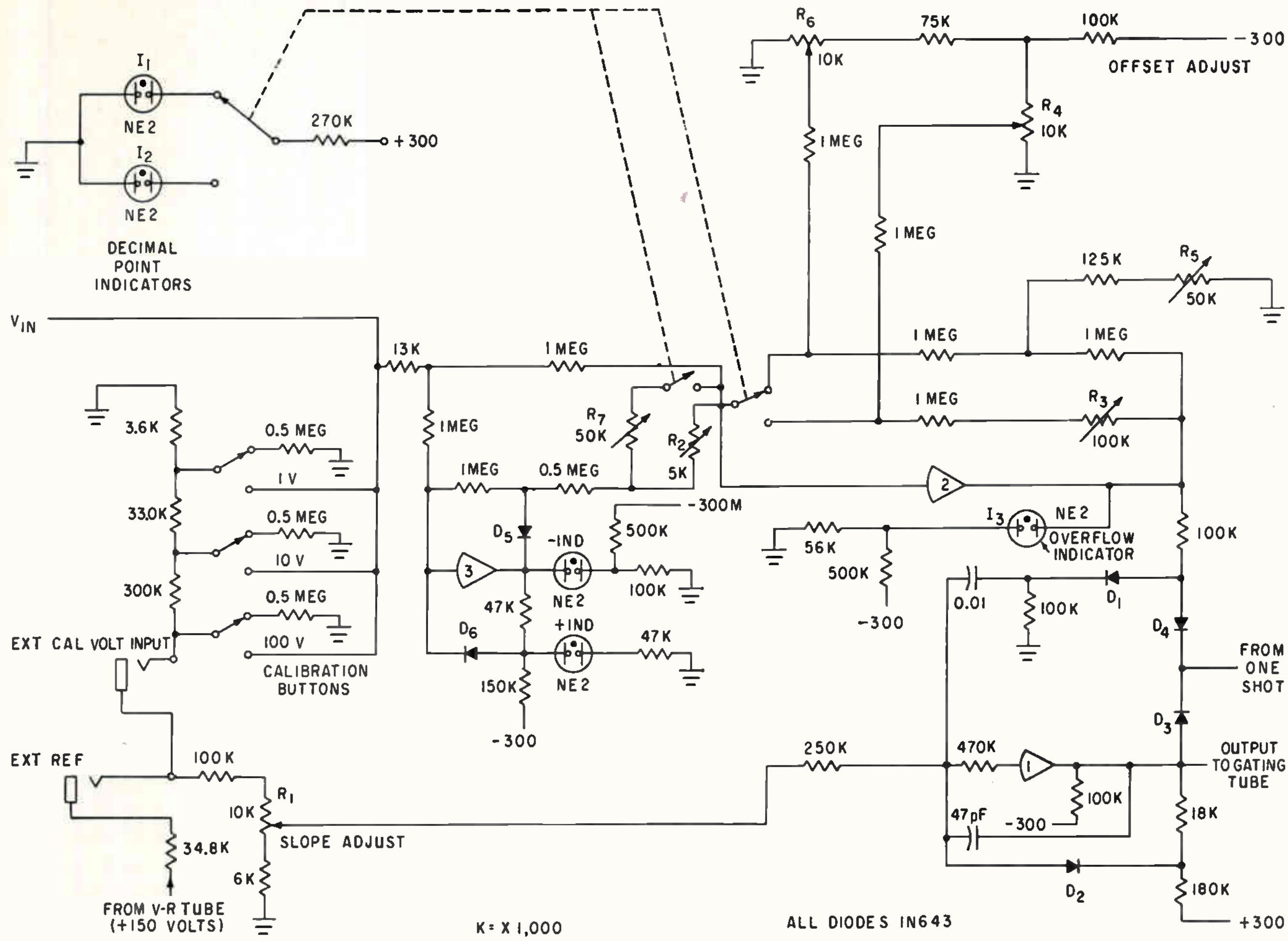


FIG. 3—Twin high-gain amplifiers 2 and 3 permit the meter to accept inputs of both positive and negative polarity, while calibration for all inputs is provided by the switched network

it reaches +170 v, at which time the neon bulb ionizes, and the operating cycle is repeated.

A thyratron circuit with an inductance at the cathode resets the binaries of a series of decade counting units to zero. The thyratron fires at the start of the operating cycle, producing a positive pulse of 100 v of 2 μsec. The cathode of the tube may be connected directly to the grid-return resistors of the even grids of the binaries.

Reference voltage E, which is used to calibrate the instrument, may be derived from an internal V tube reference supply, or from an external reference that may be plugged in (Fig. 3). Calibration voltages of 100 v, 10 v, and 1 v are derived from the reference voltage and can be applied to the voltmeter input by pushbutton switches.

Operational amplifiers 2 and 3 constitute a precision full-wave rectifier for handling both positive and negative inputs (analog-computer absolute-value circuit[3]). When the input voltages V_{in} is positive, D_5 is ON, D_6 is OFF, and the negative output of amplifier 3 overcomes the direct input to amplifier 2 to produce a positive input V for the converter. If V_{in} becomes negative, then D_5 goes OFF decisively and D_6 goes ON as feedback through D_5 is interrupted. Only the direct negative input to amplifier 2 acts and again produces the correct positive converter input voltage V. Biased neons I_1 and I_2 indicate positive and negative polarity, respectively; neon I_3 indicates a voltage in excess of 90 percent of scale (overrun light), to distinguish between counter readings of, say, 001 and 1001. The input impedance of the instrument is 0.5 megohm.

Comparison of voltmeter readings with a commercial four-digit instrument after a one-hour warm-up and calibration indicated three-digit accuracy between 10 and 100 volts on the 100-volt scale, and between 1 volt and 10 volts on the 10 volt scale, indicating the possibility of a digital voltmeter for less than $500.

The operational-amplifier timer and charging circuit of Fig. 2 were conceived by H. Koerner and G. A. Korn at the University of Arizona[2,4]. The writers are also indebted to R. Bell, T. Brubaker, K. Hanson, S. Jurich, R. Maybach and R. Streets for suggestions. Acknowledgment is due to the Electrical Engineering Department of the University of Arizona, and to P. E. Russell for their continuing support of this project.

REFERENCES

(1) H. Huskey and G. A. Korn, "Computer Handbook," McGraw-Hill Book Co., New York, 1961.

(2) H. Koerner and G. A. Korn, Function Generation With Operational Amplifiers, ELECTRONICS, Nov. 6, 1959.

(3) C. D. Morrill and R. V. Baum, Diode Limiters Simulate Mechanical Phenomena, ELECTRONICS, Nov., 1952.

(4) W. F. Caldwell, G. A. Korn, V. R. Latorre, and G. R. Peterson, A Precision Amplitude-distribution Analyzer, *Trans-IRE/PGEC,* June, 1960.

Three-Phase Static Inverters

Solid-state inverters develop three-phase 400-cycle, 115-volt

DESIGN SPECIFICATIONS

Input

Nominal 28 volts — vary from 22 to 29.5 volts

Withstand transient of 41 volts for 100 milliseconds

Allowable ripple into line of 50 millivolts peak to peak

Output

115 volts rsm ± 1%, three phase delta connected

400 cps, ±0.02% from −20 to +160 F ±0.005% from +60 to +125 F

Full load output — 500 watts

Load power factor: not less than 0.8 lagging

Efficiency: 85% from 30% to 100% full load, 70% at 10% full load

Distortion of less than 5%

Phase rotation positive. Rotational sequence: AB, BC, CA

Phase voltage balance of ±0.5 volt

Phase shift between phases: 120 ±2 deg

Unbalanced load of 167 watts on phase AB, and 33 watts on BC and CA

Short-circuit protected

Standard space-vehicle environment

STATIC INVERTERS proposed for reconnaissance satellite programs were designed using silicon controlled rectifiers for power switching. The scr offers capability of working at 125 C, voltage ratings up to 400 v, low control power for switching and low forward voltage drop during conduction comparable to that of germanium transistors.

An scr is functionally like a thyratron, in that it blocks voltage when reverse biased (its cathode positive with respect to the anode). It will also block forward voltage except when its breakover voltage is exceeded, or a triggering current is applied to the gate. Once an scr has been triggered to the on, or conducting, state, it requires no further gate current to remain in this condition. Voltage drop in an scr is comparable with any other similar silicon rectifier. Turning an scr to the off, or nonconducting, state is done by reverse-biasing the device for a sufficient time, typically 12 μsec, for the rectifier junctions to recover. The inverter design uses gate trigger current method for turning the scr on, and a unique method of scr turn-off. The major problem encountered in the use of scr's in this inverter is turning the device off.

Output voltage regulation is obtained at low power levels with a quasi-square wave developed by precisely controlled pulse-width modulation.

Generation of this wave proved to be difficult.

While most of the requirements for the inverter are accomplished through standard methods, there are some unique features in the inverter design. Outside of reliability considerations, the most important feature is the conversion efficiency over a wide range of load condi-

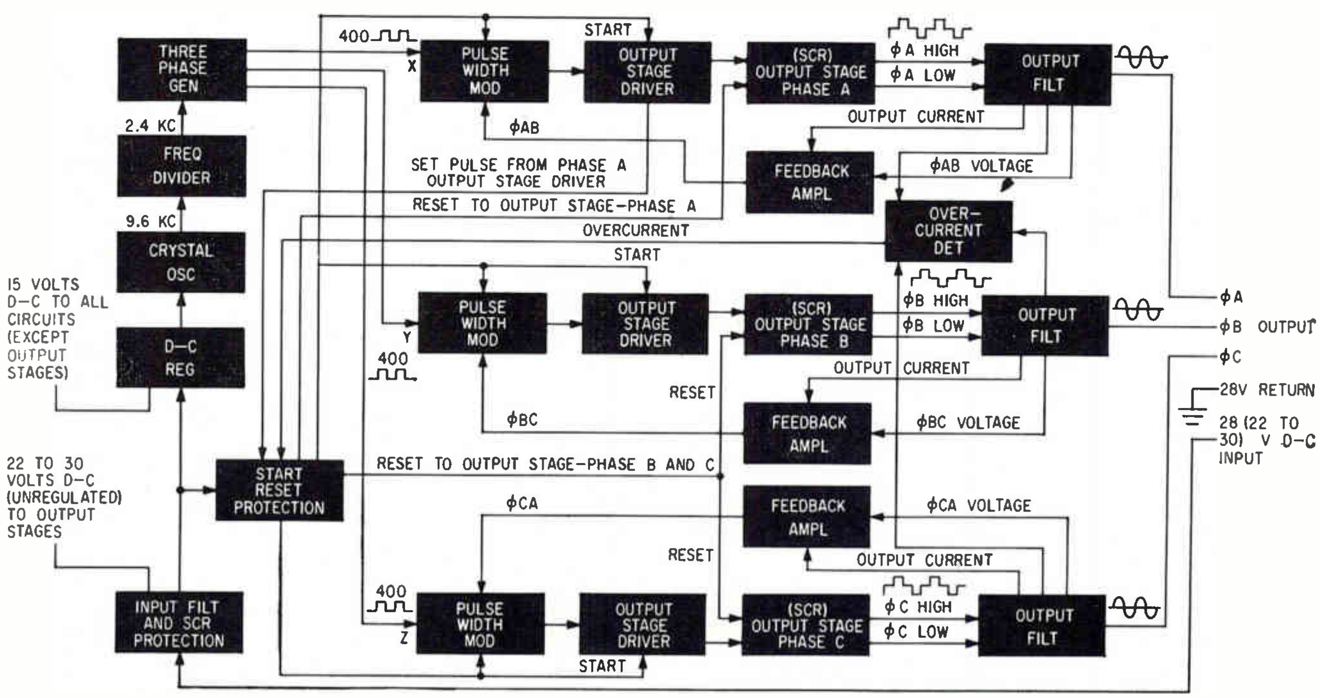


FIG. 1—Block diagram of static inverter shows that all access is through one 5-pin input-output connector

Power Space-Vehicle Equipment

a-c at 500 watts full load, from an input of 22 to 29 volts d-c

By RAYMOND J. KEARNS and JOSEPH J. ROLFE, Lockheed Missiles and Space Division, Palo Alto, Calif.

tions. This conversion efficiency is due to the highly efficient scr output stage of the inverter, and the use of low-loss quality components.

Another important feature is the precise output voltage regulation under varying input voltages and wide load conditions, with these loads both balanced and unbalanced. The regulation is within ±1 percent for any combination of load and input voltage, when the input voltage is between 22 and 29 volts d-c and the load varies from 50 to 500 watts. Part of the reason for the preciseness of the voltage regulation is a stable high-gain d-c amplifier in each of three separate feedback loops, one for each of three phases in the inverter output. Three feedback loops were used to insure regulation of the output voltage under unbalanced loads.

The inverter is fully protected against short-circuiting, overloads, load switching transients, and undervoltage in the input line. The inverter will automatically shut down during a period of adverse operating conditions and restart automatically after the adverse condition has been cleared. It is further protected against any excessive current resulting from a locked-on scr.

Unregulated d-c enters an input filter and scr protection circuit (Fig. 1). This input filter limits the ripple fed back to the d-c source to less than 50 mv p-p for an input source impedance of 0.05 ohm (nominal). Concurrently, the scr protection circuit monitors the scr in the output stages for scr lock-on, which is the failure of an scr to turn off, causing severe overload. Should the protection circuit sense such a condition, it would open the input line until the overload cleared and then automatically allow the inverter to start operation. This momentary opening of the input line is accomplished by a fast-acting high-current contactor, and this open-line condition will prevail long enough for the scr to recover.

The filtered, but still unregulated, 28-volt d-c input is then fed to three other inverter circuits, the power switching output stages, the feedback amplifiers where it is used as a compensation voltage and a series regulator that uses it to develop the supply voltage (15 volts ±1 percent) for the inverter regulation and control circuits. The frequency of the inverter is established by a 19.2-Kc crystal oscillator whose nominal frequency stability is ±0.02 percent for the entire operational temperature range of the inverter. The stability of this oscillator can be increased to ±0.001 percent if the crystal is in a temperature-controlled oven. Slaved to the crystal oscillator is an LC oscillator with a stability ±1 percent, and in case of crystal failure this LC oscillator will determine the frequency of the inverter. The output signal from the LC oscillator is 9.6 Kc, which is counted down to 2.4 Kc by flip-flops in a frequency divider. The 2.4-Kc output from the frequency divider enters a three-phase generator, consisting of three flip-flops in a ring-counter, which uses the signal to develop three 400-cycle squarewave signals that are 120 deg out of phase with each other. The phase and frequency stabilities of the inverter are thus precisely established.

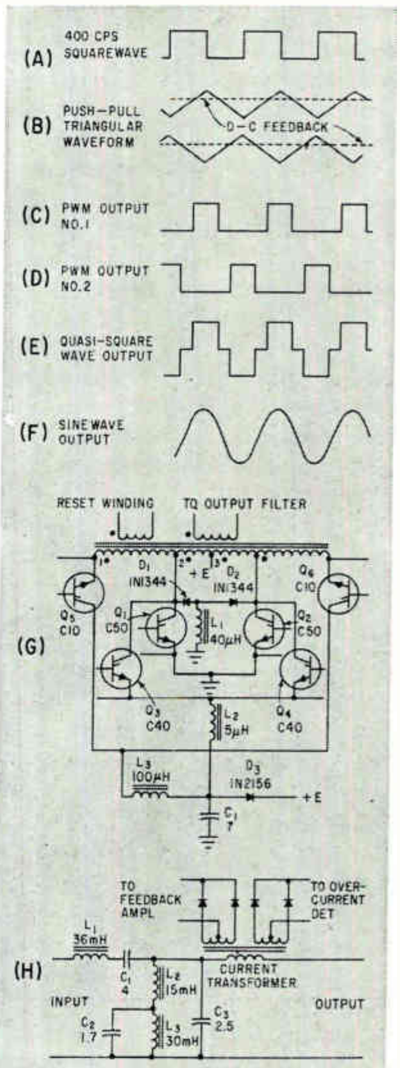


FIG. 2—Static inverter waveforms (A to F); schematic of power-switching output stage (G); and schematic of output filter (H)

The operation of the inverter is on a three-phase basis, but since all three phases are exactly the same, only one phase is described.

The 400-cycle square wave (Fig. 2A) is fed to the pulse width modulator where it is integrated into a triangular waveform. This triangular waveform is compared to a d-c reference signal from the feedback amplifier (Fig. 2B), and the output waveform is a series of pulse-width-modulated squared pulses (Fig. 2C and 2D). The positive and negative-going edges of these squared pulses determine the triggering time of the scr drivers, which are blocking oscillators that convert the low-level squared pulses into short pulses of sufficient amplitude to trigger the output-stage scr.

The scr's in the output stage

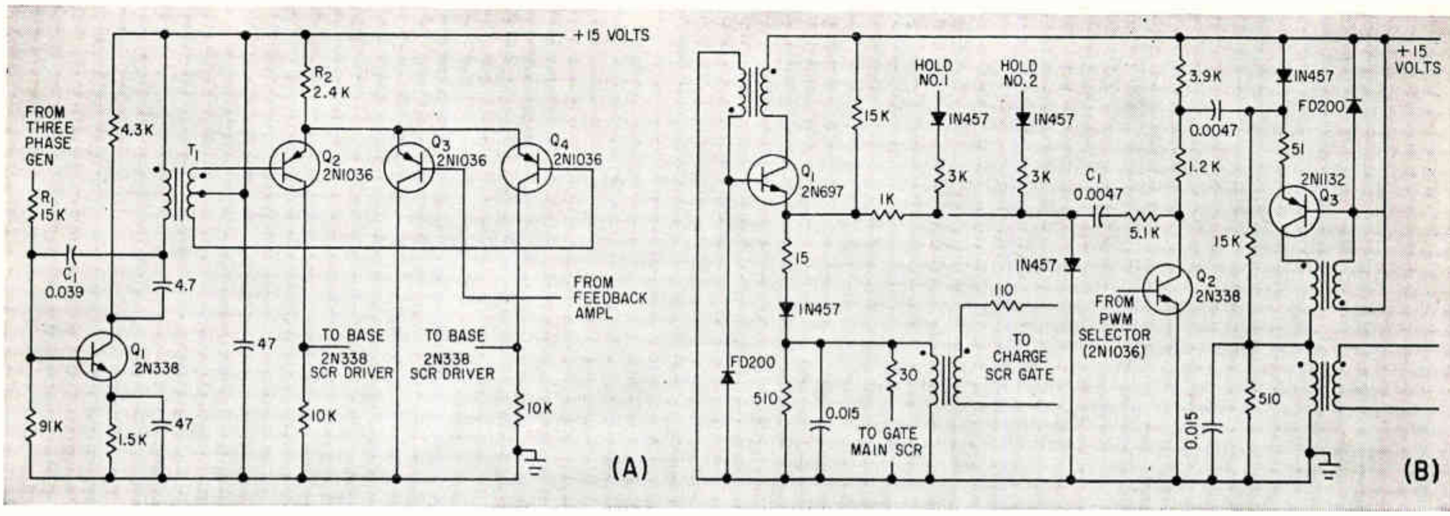


FIG. 3—Schematics of pulse-width modulator (A); output stage driver (B); and feedback amplifier (C). Output from

are triggered in sequence, and this selective composite triggering switches the d-c voltage in the output stage transformer primary to form a quasi-square wave output (Fig. 2E) from the transformer secondary. This quasi-square wave is converted by the output filter to a sinewave signal with less than 5 percent harmonic distortion typically 2 percent (Fig. 2F).

A portion of the inverter output voltage is directed through a feedback amplifier, where it is rectified, filtered and compared to a temperature-compensated breakdown diode, amplified, and returned to the pulse width modulator as the d-c control signal. Regulation of the inverter output voltage is enhanced by feeding output current and input voltage open-loop compensating signals to this d-c amplifier.

The overcurrent detector monitors the output load current in all three phases, and when it detects an overload or short circuit in the output, it causes the start-reset-protection to stop the inverter until the condition has cleared. If an overload or short-circuit is detected, the inverter is shut down for a definite length of time, and after this time-delay has elapsed, the inverter will again be allowed to turn on. If the condition still exists, the inverter will again be shut down for another cycle of the time-delay. This on-off cycling will continue until the overload or short circuit condition no longer exists. The start-reset-protection circuit automatically starts the inverter after any shut down, and also it assures that the output stage drivers start in proper sequence, and that the pulse width modulator output starts at a narrow pulse width. This circuit also sets the residual flux in the output transformers in the proper direction at start, and shuts off the inverter when the input voltage drops below 22 v d-c.

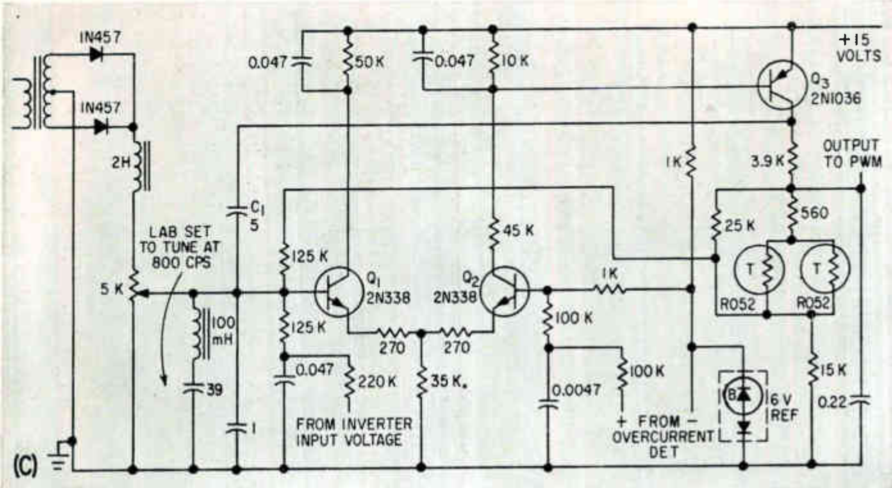
The scr power-switching output stage (Fig. 2G) is the most essential element in the design. At the start of an operating cycle, trigger pulses are applied to the gates of main power rectifier Q_1 and charging rectifier Q_5, turning both of them on. With the voltage drop across Q_1 about 1 volt, voltage E appears across the main part of transformer primary terminals 2 and 3, and because of transformer action a voltage equal to $-E/2$ appears at the charging tap, terminal 1. Inductor L_3 and turn-off capacitor C_1 form a resonant charging network with C_1 being charged to a level greater than E, since there is an initial reverse charge already present on C_1. In any case, C_1 will be fully charged to the required level in about 100 μsec. When the current in the resonant charging network tries to reverse, the charging rectifier Q_5 is turned off. Using a transformer tap insures that C_1 charges to a sufficiently high level, with resonant charging used to permit charging this capacitor with minimum energy loss.

Typically, within 300 to 1,000 μsec after main power Q_1 has turned on, its output pulse is terminated by the triggering of turn-off scr Q_3. The triggering of Q_3 places a back-bias of a level greater than E across main power Q_1, and with C_1 selected to be large enough to hold Q_1 back-biased for the required length of time, turn-off of Q_1 is insured. Any residual energy remaining in C_1 after Q_1 has turned off is not wasted, but is fed into the load through the output filter. Turn-off capacitor C_1 and the output filter form a resonant discharge circuit with a frequency comparable to the resonant charging circuit formed by C_1 and L_3. The ringing of this network is clamped after approximately one-half cycle of oscillation by diode D_3, and the current through Q_3 decays at zero. At this point Q_3 turns off. Inductor L_2 limits the initial reverse current in the main power and turn-off scr's to about 100 amps.

Diodes D_2 and D_1 are a spillover network that returns any excess filter energy to the input supply, with this energy return action occuring when all scr's are in the off state. This network is useful when the inverter load is suddenly removed. Inductor L_1 keeps the spillover network from having any effect on the operation of the output stage during the time of main power Q_1 turn-off.

This description shows how one-half of a full cycle of the quasi-square wave is synthesized, and by repeating the sequence, using Q_2, Q_4, and Q_6, the second, or negative. half-cycle can be produced.

The output stage, or power switching stage, feeds the output filter (Fig. 2H). The output filter consists of two impedances, a series



the feedback amplifier goes to the base of Q_3 in the pulse-width modulator

arm and a shunt arm. The series arm is $z(s) = R_1(s^2 + 1)/s$ where 400 cps has been normalized to $\omega = 1$, and R_1 is a normalizing resistor (150 ohms). The shunt arm $z(s) = R_L\, s(s^2 + 9)/[(s^2 + 1)(s^2 + 10)]$ where R_L is a normalized load impedance and 400 cps is again normalized to $\omega = 1$ ($R_L = 100$ ohms). These impedance functions may be realized by network synthesis resulting in L_1 and C_1 for Z_1, and L_2, L_3, C_2 and C_3 for Z_2.

The series arm has minimum impedance at 400 cps for minimum fundamental attenuation, and inductive impedance increasing with frequency to keep the harmonic energy supplied by the output stage at a low level. The shunt arm is parallel resonant at 400 cps, provides a third-harmonic null at 1,200 cps, and appears capacitive at the fifth and higher harmonics.

The composite characteristics of the output filter are unity power factor input impedance, minimum attenuation at the fundamental frequency, essentially zero transmission at the third harmonic, and excellent attenuation of the fifth harmonic and above.

An overload - current - sensing transformer and a compensation feed-back circuit are included in the output filter circuit.

The pulses that trigger the scr's in the output stage are generated in the output stage drivers, which are transistor blocking oscillators, and the length of the quasi-square waves in the output signal from the output stage is determined by the pulse-width modulator (Fig. 3A). These circuits maintain the required waveform symmetry in the output of the output stage, thus producing an inverter output with only the odd harmonics present.

The square wave input from the three-phase generator enters the pulse-width modulator through an integrator network, transistor Q_1 with resistor R_1 and capacitor C_1. The resulting symmetrical triangular waveform is fed into a push-pull amplitude selector, transformer T_1 with transistors Q_2, Q_3 and Q_4, where it is compared to a d-c feedback control signal that enters the amplitude selector at the base of Q_3. This d-c reference establishes a voltage level across R_2 which in turn establishes the threshold for the two sides of the push-pull amplitude selector, Q_2 and Q_4. Transistors Q_2 and Q_4 are turned on and off during alternating half-cycles when the negative-going portion of the triangular waveform exceeds the voltage across R_2, this voltage being the d-c control signal referred to above and derived from the d-c feedback amplifier. The output from the pulse-width modulator is a series of recurring pulses that are symmetrical about a centerline established by the peak levels in the integrated triangular waveform. Both the negative and the positive-going edges of these precise width-modulated pulses trigger the blocking oscillators in the next stage, the output stage drivers, referred to as scr drivers.

The scr drivers (Fig. 3B) are blocking oscillators of two types: an npn such as Q_1 which generates the scr turn-on and charging pulses; and pnp such as Q_3 which generates the scr turn-off pulses. A typical operating cycle of this output stage driver starts with Q_2 not conducting and its collector at V_{cc} (15 volts) while capacitor C_1 is charged to V_{cc}. The leading edge of the next incoming pulse from the pulse width modulator causes the scr driver to turn on by driving the collector of Q_2 to ground (negative slope). Capacitor C_1 starts to discharge and in so doing draws emitter current in Q_1, which saturates because of the regenerative action of the circuit. Both the transformer voltage and the base-ground voltage of Q_1 are constant. And since the primary voltage of the transformer is constant, the magnetizing current build-up in the circuit is linear, in the absence of magnetic saturation.

When the collector current of Q_1 is approximately equal to the emitter current, Q_1 pulls out of saturation and the circuit turns off, regeneratively terminating the output pulse from the scr driver. The point of turn-off is therefore determined by the common-base current gain. The turn-off scr driver Q_3 is triggered by the trailing edges of the trigger pulses from the pulse width modulator, and is the same circuit as the turn-on scr driver.

In the regulation and feedback amplifier (Fig. 3C), a portion of the inverter output signal is filtered, rectified and compared to a temperature - compensated breakdown diode in a differential amplifier, Q_1 and Q_2. This differential amplifier is also fed signals proportional to the inverter load current and input battery voltage to improve the regulation obtained, with modest loop gains.

The differential amplifier is followed by a complementary second stage, Q_3. The feedback amplifier has a thermistor temperature-compensated feedback loop which stabilizes the amplifier with regard to temperature variations, and capacitor C_1 provides frequency correction of the feedback loop.

The authors acknowledge the contributions of F. McCullough, A. Taleporos, B. V. Golceff, R. D. Stiavetti, C. J. Biggerstaff, J. A. Livingston, W. I. Bendz, and R. J. Stewart.

Tunnel Diode Curve-Tracer Is

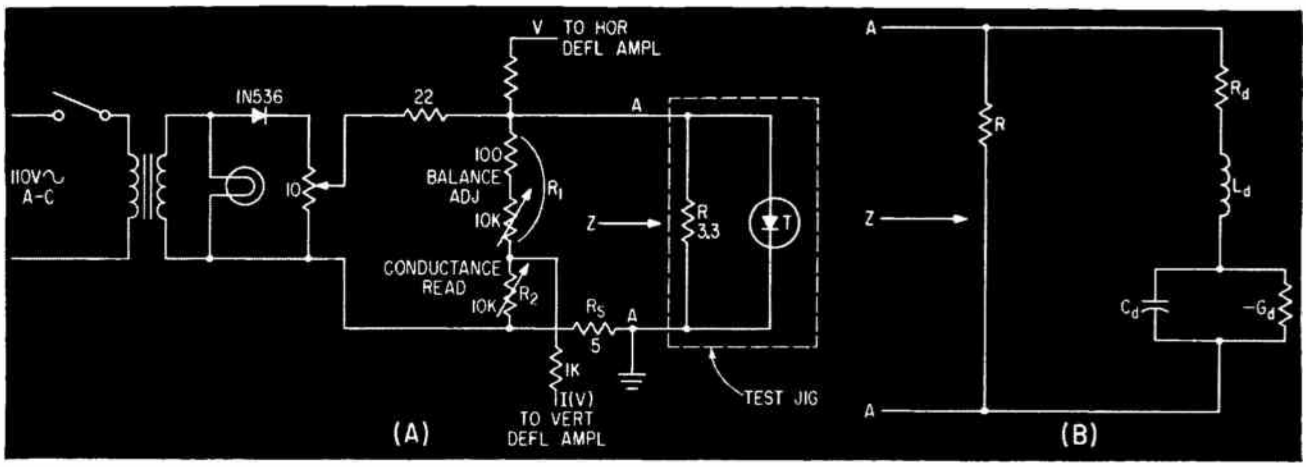


FIG. 1—Schematic (A) of tunnel diode curve-tracer, and equivalent circuit (B) for test jig with tunnel diode inserted

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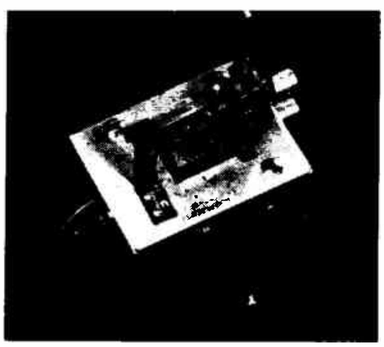
SINCE THE ADVENT of the tunnel diode a large number of curve-tracers have become available. However, because of the difficulty in making tunnel diodes operate stably in the negative-resistance region, none of the curve-tracers have, to the authors' knowledge, been capable of displaying the complete characteristics for units that have a large negative-conductance-to-capacitance ratio (G_d/C_d).

The curve-tracer described here is capable of tracing the characteristics of tunnel diodes having a G_d^2/C_d ratio of up to 10[illegible] mhos² per pf. This was achieved by a bridge tracer and also by a special jig in which the diodes are inserted for testing.

Figure 1A shows the schematic for the tunnel diode curve-tracer. A 60-cycle rectifier circuit applies the positive half of a sinusoidal voltage to the tunnel diode and to the horizontal deflection amplifier of an oscilloscope. Amplitude of this voltage is varied by the 10-ohm potentiometer at the output of the rectifier. The 22-ohm series resistor isolates the tunnel diode from the rectifier circuit. To reduce lead conductance and thereby optimize the stability of the tester in the negative resistance region, stabilizing resistor R is connected directly across the tunnel diode in the test jig. To measure the current through the tunnel diode, the voltage across R_s is coupled through a 1,000-ohm resistor to the vertical deflection amplifier in the oscilloscope. However, since this voltage is proportional to the total current through the test jig rather than the current through the diode itself, the current through R is compensated for by also applying a fraction of the voltage across the diode to the vertical deflection amplifier. Exact compensation is then obtained by adjusting without a diode in the test jig resistor R_1 until the trace on the oscilloscope is horizontal. Under these conditions R_1, R_2, R_s and R form a balanced bridge and satisfy the relationship $R_2/R_1 = R_s/R$. Corresponding sensitivity of the curve tracer is $E_v = -R_s I(v)/(1 + R_s/R)$ where $I(v)$ represents the diode characteristics. With the values shown in Fig. 1A, the vertical sensitivity of the tracer is 2 mv per ma of diode current.



Tunnel diode curve-tracer with low-inductance test jig. The diode body is one electrode; the two common leads are the other electrode

Besides providing a high degree of stability this circuit features also the advantage that the slope or conductance at any point along the tunnel diode characteristic can be determined accurately from R_1, R_2, R_s and R. By adjusting R_1 so that the slope at the desired point on the characteristic appears horizontal on the oscilloscope, it is easily shown that the corresponding conductance is $G = R_2/R_1R_s - 1/R$. This shows that G is linearly related to R_2 and this resistance is therefore more convenient to use than R_1 for determining G. This is particularly true when calibrating a dial for reading G directly.

Figure 1B shows the combined equivalent circuit for the test jig and the tunnel diode. Driving point impedance looking into the terminals A-A is

$Z(s)$ =

Stable in Negative-Resistance Region

$$\frac{s^2 + \left(\frac{R_d}{L_d} - \frac{G_d}{C_d}\right)s + \frac{1 - R_dG_d}{L_dC_d}}{s^2+\left(\frac{R_d+R}{L_d} - \frac{G_d}{C_d}\right)s+\frac{1-(R_d+R)G_d}{L_dC_d}}\, R$$

where s represents the complex frequency operator. So that the curve-tracer displays a continuous and stable trace, this impedance must be short circuit stable, which requires that all its poles must be located in the left half of the s-plane. This in turn imposes the following conditions upon R

$$L_d \frac{G_d}{C_d} < R_d + R < \frac{1}{G_d} \qquad (1)$$

(condition for no oscillations) (condition for no switching)

The upper limit for R corresponds to the requirement of no saddle point in the negative resistance region, that is, the requirment that the load line should not intersect the diode characteristic at more than one point. If this condition is violated, a rapid jump will take place between the two stable operating points surrounding the saddle point as the characteristic is traced, thereby masking out most of the negative resistance region.

Such a case is shown in Fig. 2A. The lower limit on R requires that there should not be an unstable node or focus in the negative resistance region, thus insuring against any oscillations. The trace of a case in which this condition was violated is shown in Fig. 2B. Because of the phase shifts in the scope amplifiers and also because of the erratic nature of the oscillations, the negative resistance region appears spiral-like on the oscilloscope.

From condition 1 note that the upper limit for the stabilizing resistor is inversely proportional to the negative conductance of the diode, while the lower limit is proportional to the product of the conductance to capacitance ratio and the lead inductance. For a fixed lead inductance the range of realizable R therefore becomes narrower and eventually vanishes as G_d and G_d/C_d is increased, the limit being reached when $G_d^2/C_d = 1/L_d$. As diodes are made with higher peak currents and larger conductance to capacitance ratios, the limit is ultimately reached where it becomes impossible to display the negative resistance region without switching or oscillations.

However, there are several ways to extend the range of stability. The obvious way is to reduce lead inductance L_d. This has been the approach used in the tracer. Through the construction of a special jig in which the diode is inserted, the external lead inductance to the diode was reduced to less than a nanohenry. According to the last equation above, this means that the tracer is capable of accommodating diodes having a G_d^2/C_d up to 10^9 mhos^2 per pf. The characteristic of the IBM 25-ma tunnel diode is therefore displayed, as shown in Fig. 2C. Finally, by using a cylindrical or tubular encapsulation for the tunnel diode, this limit could probably be pushed upward another order of magnitude.

To prevent instabilities in the negative resistance region, it is therefore important to reduce lead inductance between the diode and the stabilizing resistor. A low-inductance jig was therefore constructed in which the diode could be inserted (see photo).

The jig consists of two pairs of brass blocks. Two of the blocks are mounted 70 mils apart on a stationary phenolic board and are the two electrodes of the jig. The other two blocks are also insulated from each other and mounted on a hinged phenolic frame that swings down on the two stationary blocks. A springlock presses the blocks firmly against each other when the jig is closed. In two of the four overlapping blocks, semicylindrical slots fitting exactly the contour of the diode body are milled out, so when the diode is inserted and the jig closed, the blocks make firm contacts with the body of the diode and its leads. The upper block that makes contact with the leads is split so that pressure is applied separately to the two diode leads.

Resistor R consists of three 10-ohm Filmohm resistors in parallel, mounted between the two stationary blocks just beneath the slot for the diode. In this way the lead inductance of the jig was reduced to less than a nanohenry.

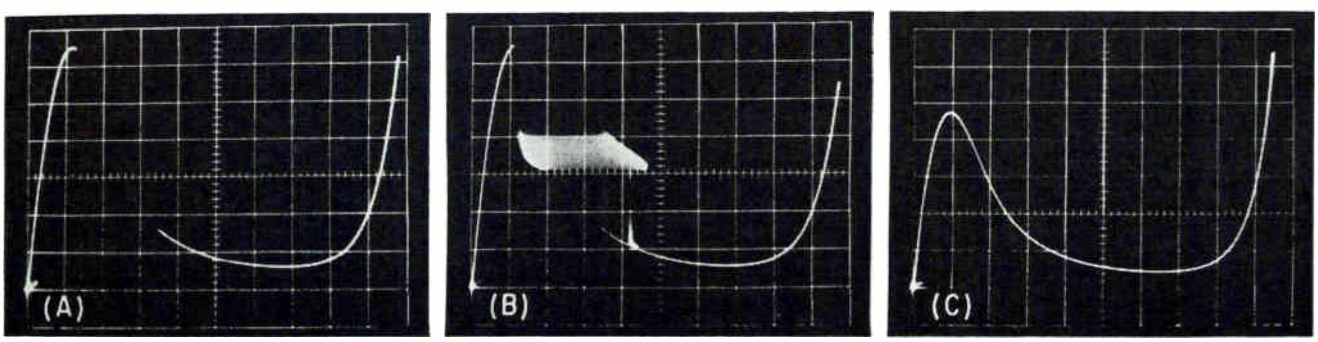


FIG. 2—Tunnel diode waveforms: (A) when switching takes place; (B) when oscillations occur in the negative-resistance region; and (C) when a 25-ma diode is tested in the author's curve-tracer. Horizontal scale is 50 mv per cm for all three. Vertical scale is 4 ma per cm for (A) and (B), and 5 ma per cm for (C)

COOLING TRANSISTORS WITH

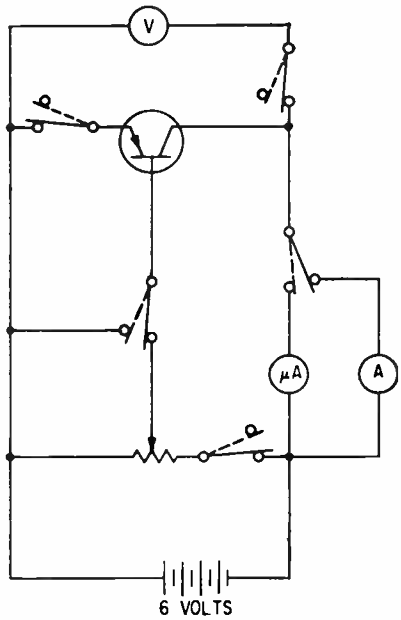


FIG. 1—Circuit used for heat-sink material tests. Current I_{co} is measured when all contacts are in the position shown by dotted lines

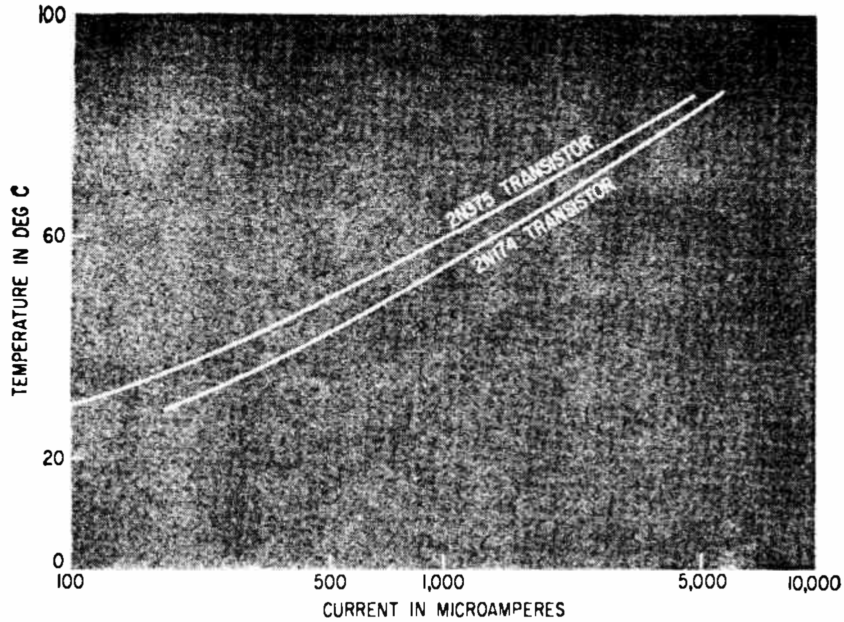


FIG. 2—Plot of I_{co} against temperature for the two transistor types used

TABLE I — RELATIVE THERMAL CONDUCTIVITIES OF MATERIALS

Material	Relative Heat Conductivity
Copper	2
Aluminum	1
Beryllia	1
Steel	0.22
Alumina Ceramic	0.10
Mica	0.004
Teflon	0.001
Epoxies & Phenolics	0.001
Air	0.0001

TABLE II — DIELECTRIC LOSS FACTORS FOR VARIOUS INSULATORS

Material	Dielectric Loss Factor At 1 Mc	L Grade (JAN-I-10)
Phenolic Laminate	0.1	L-1 (Equivalent)
Epoxy Resin	0.08	L-1 (Equivalent)
Electrical Porcelain	0.05	L-2
Steatite	0.01	L-4
Alumina	0.004	L-6
Beryllia	0.0007	L-8 (Equivalent)
Teflon	0.0006	L-8 (Equivalent)

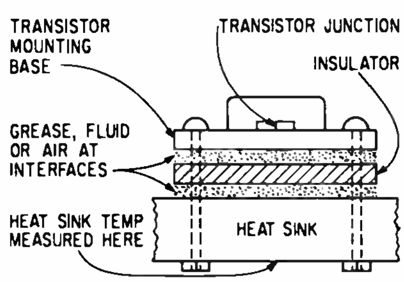


FIG. 3 — Transistor mounting method shows placement of insulator. Grease or fluid may be used to eliminate air at interfaces, thus lowering the temperature gradient

TABLE III — EFFECT OF TRANSISTOR MOUNTING ON TEMPERATURE GRADIENT

Insulator	Grease (DC-4)/ Fluid (LS-15)	Temperature Gradient Deg C/watt Over-All	Across Insulator
None	None	0.50	....
	Grease	0.43	....
	Fluid	0.33	....
Anodized Aluminum 0.022 in. thick	None	0.92	0.42
	Grease	0.54	0.11
	Fluid	0.44	0.11
Mica 0.0015 in. thick	None	1.10	0.60
	Grease	0.59	0.16
	Fluid	0.51	0.18
Beryllia 0.093 in. thick	None	0.87	0.37
	Grease	0.57	0.11
	Fluid	0.48	0.15

BERYLLIA HEAT SINKS

Ceramic has advantages over other heat sink materials. It insulates electrically, conducts thermally

By K. H. McPHEE,
Aircraft Radio Corp., Boonton, N. J.

MATERIALS HAVING LOW ELECTRICAL conductivity and high thermal conductivity have long been sought by scientists and engineers, for use in equipment where higher power levels and more compact designs aggravate the problem of heat dissipation. Transistor users are among those most concerned.

Beryllia (BeO, Beryllium oxide) has a number of properties that combine to make it an excellent transistor heat sink material. This article describes a series of tests run on beryllia heat sinks.

A common approach to heat sinks has been to make the electrical insulator as thin as possible, thus reducing the thermal gradient across its section. Such insulators, however, are fragile and expensive to manufacture. They have lower dielectric strength than their thicker counterparts and provide less protection against flash-over and arcing.

Another solution has been attempted by mixing graphite or metal powder into resins; still another by preparing laminates or sandwiches of materials. These combinations are compromises that fall short of providing the thermal conductivity of one ingredient or the electrical resistivity of the other.

As used in some circuits, the transistor may be mounted directly to an aluminum chassis or other metallic heat sink. Most circuits, however, require that the body of the transistor be electrically isolated from the chassis and other circuit elements.

Effective transistor heat sink devices have been made using thin sheets of mica, or of anodized aluminum. Each of these materials has some of the disadvantages listed above. Mica sheets are 0.001 to 0.002 inch thick with the attendant fragility. The anodized coating on aluminum can be penetrated or scratched by burrs or metal chips, thereby exposing bare aluminum metal.

Table I shows the relative positions of some common materials in the thermal conductivity spectrum. Most of the electrical insulating materials used for this purpose have specific resistivities greater than 10^{10} ohm-cm. This means that only small currents flow in these materials. There is, however, a difference in the amount of energy absorbed, or the dielectric loss, as shown in Table II. A study of these tables and of other data led to the consideration of beryllia as a heat sink for transistors and other semiconductor devices.

Samples of 99 percent beryllia ceramic were obtained from National Beryllia Corp. for the tests. The samples were prepared in the shape of several popular transistor outline (TO) sizes.

Two transistors, type 2N375 and 2N174, were calibrated using the circuit shown in Fig. 1. The following characteristics were made use of: (1) the base to collector current, I_{co}, with the emitter open, increases with temperature; (2) this saturation current is always the same value for a specific temperature; (3) when a transistor has been calibrated in an accurately controlled oven, I_{co} can be used as a measure of temperature.

Each transistor was suspended in the oven by the circuit leads used to conduct the current to the transistor. The temperature was increased in steps of 10 deg from room temperature to 85 C. Each temperature was held until I_{co} stabilized. Current was measured with an ammeter that can be read to one microampere.

The values of junction temperature and I_{co} were then plotted on semilogarithmic paper, as shown in Fig. 2.

The switching circuit in Fig. 1 was used to measure I_{co} instantly on removing power input to the transistor. The value of I_{co} obtained was used to determine the junction temperature.

Each transistor was mounted on a 10 by 10 by ¼ inch aluminum sheet, as shown in Fig. 3.

Table III is a compilation of some of the experimental results. The temperature drop across the mounted assembly, as a function of power input, is shown in Fig. 4 and 5 for all the cases including: no insulator, beryllia, mica, and anodized aluminum.

The importance of closely controlling all variables became apparent early in the program. For example, the current flowing from collector to base is sensitive to temperature. A change of one degree C in junction temperature can change the current by as much as 200 microamperes. The junction temperature must therefore be stabilized and measured accurately.

The torque used in mounting the transistor base to the test fixture has a pronounced effect on the heat transfer of the assembly. For example, the temperature drop across a 0.093-inch beryllia insulator, with all other conditions held constant, was measured as 11.5 C when tightened to one inch-pound, and as 7.5 C when tightened to 3 inch-pounds. Higher torques would undoubtedly produce even smaller temperature drops.

A 0.093 beryllia piece withstood 12 inch-pounds without fracture. The manufacturers of mica insulators recommend a tightening torque of 12 inch-pounds.

The temperature difference between heat sink and transistor junction was independent of heat sink temperature when other conditions were held constant. A number of reruns were made with only the heat sink temperature changed. The junction temperature minus the sink temperature remained constant. This is no doubt due to the unchanging coefficients of thermal conductivity of the materials in the temperature range used.

Grease or fluid between transistor base, insulator, and heat sink greatly improved the heat transfer of the system. These materials replace the air film which is present between adjacent surfaces which are not perfectly flat. Silicone-based compounds are commonly used for this purpose since their thermal conductivities are substantially higher than air or other possible insulating compounds. The conductivity does not, however, approach that of beryllia, and therefore the thinnest film which will provide intimate contact should be used. The silicone greases contain finely divided silica with relatively low thermal conductivity. The graphs included in this paper show that unfilled fluid (LS45) has a higher conductivity than the filled material (DC-4).

Consideration should be given to preparing a silicone fluid filled with beryllia powder. The mixture should have a higher conductivity than present silicone greases and would therefore be more attractive to transistor users.

The temperature drop across the beryllia insulator was approximately the same as the drop across the anodized aluminum washer. This appears to be in agreement with other known data: (a) The conductivity of beryllia and aluminum are equal, and (b) The conductivity of the anodizing is lower than either. It is apparent, then, that the anodized coat counterbalanced the effect of the thickness ratio (4:1) of the beryllia and aluminum pieces.

The mica piece, however, performed much better than had been expected from other known data: (a) The ratio of conductivity of beryllia and mica is approximately 250:1. (b) The ratio of thicknesses used was 62:1 (beryllia:mica). From these figures the mica would be expected to show 250/62 = approximately 4 times the temperature gradient. The test results show that the mica performed equally with the beryllia. This may be due in part to the greater flexibility of the mica which allowed it to conform to irregularities in the transistor base and in the heat sink. This would reduce the film thickness of grease or fluid and thereby reduce the interface temperature drops.

Beryllia has properties that make it an excellent transistor heat sink material:

(1) It has thermal conductivity equal to that of aluminum metal.
(2) Dielectric loss is lowest of any commercially available ceramic. It is dielectrically stable to 400 C and 10,000 Mc.
(3) Has high strength and shock resistance.
(4) Has dimensional stability. Melting point is 4,650 F.
(5) Moisture absorption is extremely low.
(6) It cannot be caused to malfunction by scratches or other abrasions.
(7) Material has complete resistance to all chemicals used in processing or operating electronic equipment.

The author acknowledges the advice and assistance of the technical staff of National Beryllia Corp. and the following engineers: D. P. Kutrz and M. J. Lacharite, of Aircraft Radio Corp.

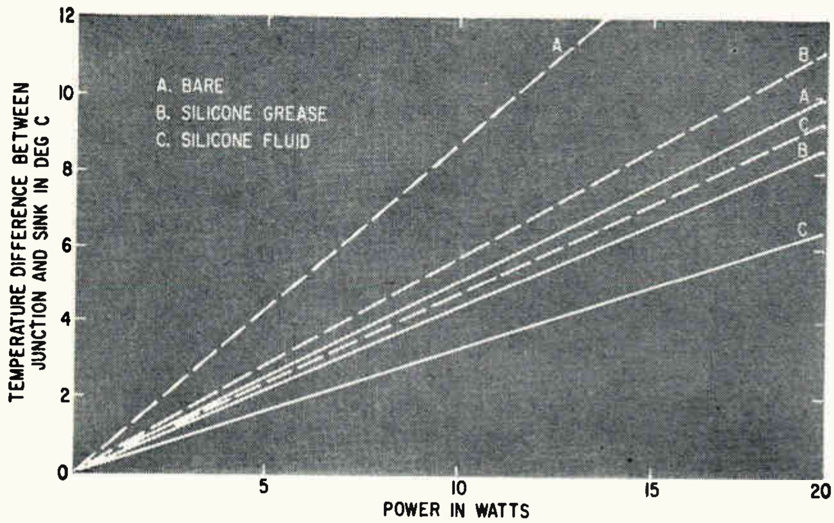


FIG. 4—Plot shows temperature drop against power input for a 2N375 transistor, with a 10 by 10 by 0.125-inch aluminum heat sink. Solid lines were plotted without an insulator; dotted lines with an 0.093-inch beryllia spacer. Torque was 3 inch-pounds

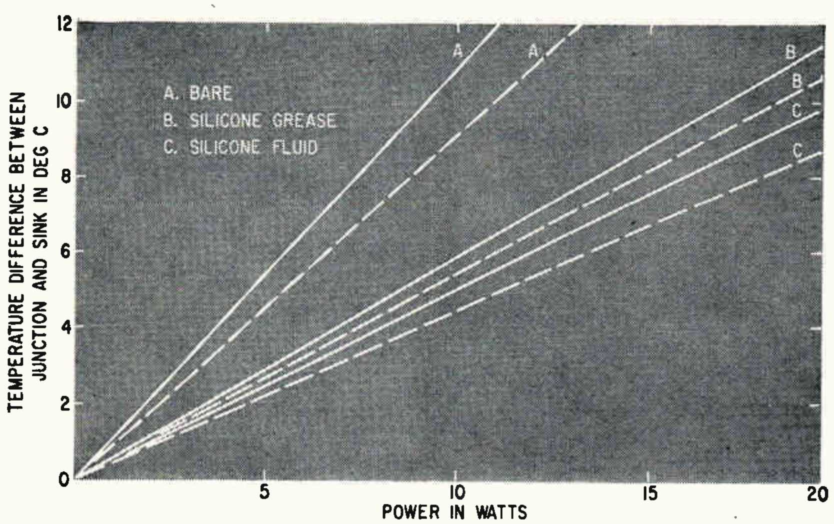


FIG. 5—Temperature drop against power input for 2N375 transistor is plotted using aluminum heat sink as in Fig. 4, with a mica spacer 0.0015 inch thick (solid lines) and with an anodized aluminum spacer 0.022 inch thick (dotted lines), torque of 3 inch-pounds

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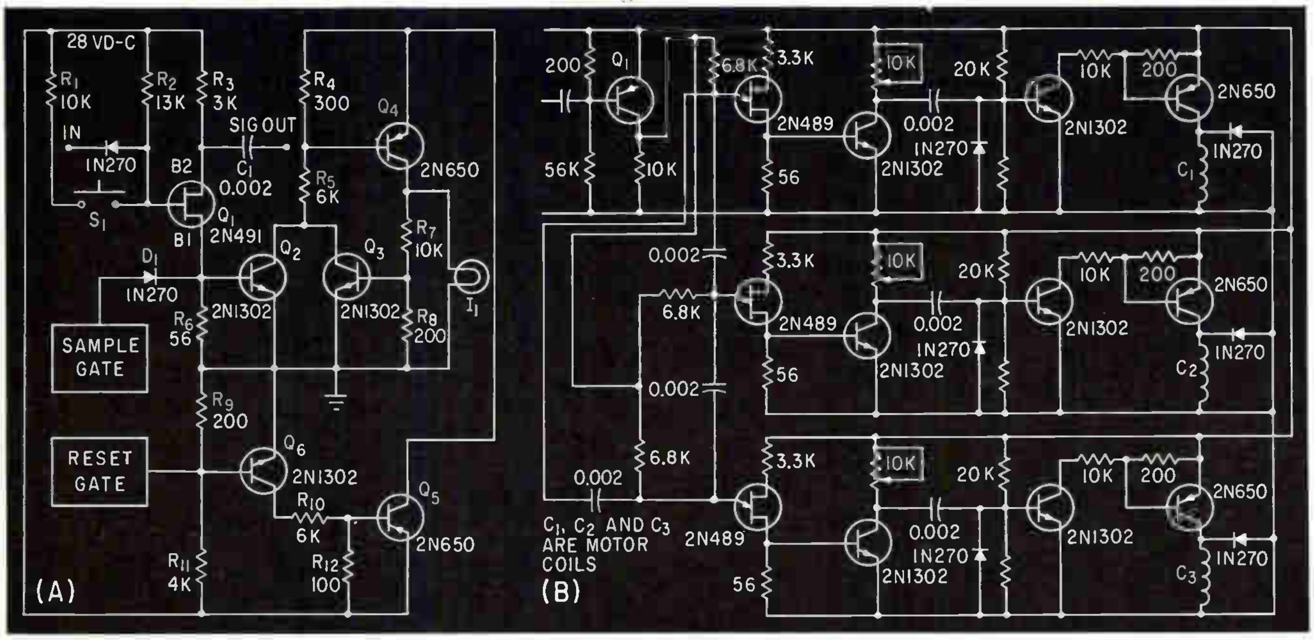

FIG. 1—Unijunction ring counter with readout and resetting circuits (A). Unijunction transistor control circuit used as a motor pulse generator (B)

Digital Control Uses Unijunction Transistors

Unijunction transistors can replace many components in transistor switching circuits. Readout and control circuits are discussed

By FRED W. KEAR,
Supervisor, R&D Lab., Lytle Corp.,
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THE BISTABLE characteristic of the unijunction transistor makes it a useful control device for digital circuits, replacing many components used in conventional transistor switching circuits, reducing package size and lessening maintenance problems. Two common applications of unijunction transistors are in readout and control circuits.

Effective readout and data display of airborne digital instrumentation is one example of a frequently encountered problem in which unijunction ring counters are useful. Simplicity of fabrication and conservation of space are the primary characteristics of this counter. Often the use of unijunction transistors for counting and controlled silicon rectifiers for readout or recording has proven to be a valuable combination of circuit devices.

Figure 1A shows the ring counter with readout and resetting circuits.

Each counter stage consists of a unijunction transistor with its circuit, plus three silicon junction transistors for data sampling. The bistable characteristics of the unijunction transistor are used to sense the pulse input to its emitter. Operation of the counter requires a negative pulse train input to the unijunction emitters for them to enter their secondary stable (conducting) state. A negative input pulse will quench the counter stage that is firing, returning the B_1 voltage of this stage to the primary stable value. The resulting voltage rise is sufficient to cause the next stage to fire into its secondary stable state as the coupling capacitor is charged. The emitter voltage of this freshly triggered stage will maintain it in its conducting state until another quenching pulse is fed into the counter emitter circuit. Duration of the negative quenching pulse must be substantially less than the RC time constant of the emitter to B_2 resistance plus R_3 and C_1; otherwise the input pulse would blank the firing voltage to this stage.

The correct values must be selected for the components in this circuit. The value of R_2 must be selected to provide adequate bias voltage to maintain the unijunction in its secondary stable state. The value of R_3 will affect the value of R_2, however, since it determines the B_2 voltage; R_2 is selected to provide the I_e for bistable operation. It is then possible to determine the value for R_3. Since the supply voltage must also be taken into consideration it is often necessary to determine the optimum component value through substitution.

The sampling gate consists of a time base oscillator that is controlled to some frequency considerably below the minimum expected counting frequency. The sampling gate for the circuit would be a positive pulse. When ground is removed from the cathode of D_1 during the time that Q_1 is firing the base voltage of Q_2 will be raised enough to cause Q_2 to saturate. This will lower the base voltage of Q_4 causing it to saturate and light the indicator lamp I_1. When the collector of Q_4 is at saturation potential the resistor network R_7 and R_8 will bias Q_3 into saturation causing the data sampling circuit to be clamped into its energized condition. Diode clamping may be used instead of transistor clamping.

The data sampling circuit maintains the digital display until the reset gate pulse is present at the base of Q_6. The reset gate may be controlled by the sampling gate oscillator. To kill power to the sampling circuits the reset gate circuit must provide a negative pulse of sufficient amplitude to quench Q_6, thereby allowing the base voltage of Q_5 to rise to approximately 28 v d-c. This removes power from the sampling circuits on all counter stages and when power is restored clamping will no longer be maintained, leaving the readout circuit ready to accept the next sampling gate pulse.

Operation of the sampling and reset circuits suggests that one method of furnishing the proper pulse shapes for the input gates of these circuits would be to use a square wave and feed the same signal into both inputs. The negative portion of the square wave would be clamped to ground potential and its duration would be long compared to the positive portion of the pulse. Such pulse duration times would be set according to the anticipated count rate to give a good visible display.

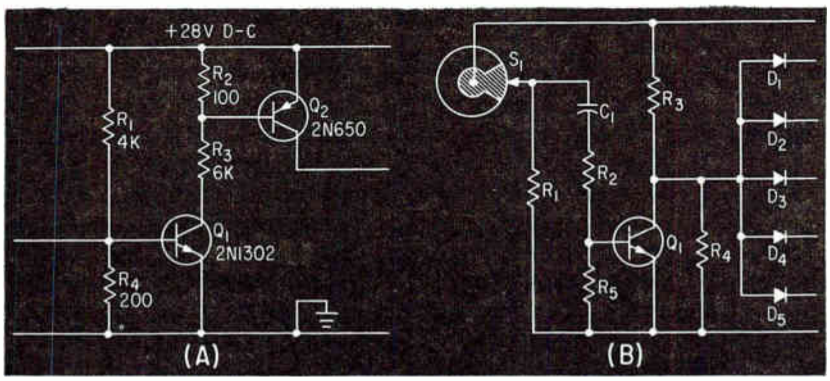

FIG. 2—Buffer circuit (A) used with the ring counter of Fig. 1A; and pulse shaping circuit (B)

In this circuit, S_1 is shown as a conventional switch for firing the zero digit counting stage. This switch can be incorporated in the power switch that energizes the equipment. Closure of S_1 is required but once each time the equipment is energized. Its closure enables the ring counter to start its counting cycle by causing the zero digit counting stage to go into its secondary stable state.

Output of the final stage of the ring counter is returned to the emitter of the first stage, completing the ring of counting. If the readout number consists of several digits the final digit of each ring will fire the next counter using the buffer circuit of Fig. 2A. The same charging voltage that refires the zero digit counting stage of the first ring counter operates this circuit. The positive pulse produced in the ring counter becomes the input signal to the base of Q_1. This pulse is of sufficient amplitude to saturate Q_1 which, in turn, saturates Q_2. The output pulse of Q_2 contains sufficient energy to fire the second ring counter. To control the time constant of the signal to the second ring, and thus prevent blanking of the counter pulses, it is necessary to apply the output pulse of the circuit in Fig. 2A to a pulse shaping circuit similar to that used in the input to the counter (Fig. 2B). A commutator is shown in Fig. 2B, but the commutated signal will be supplied electronically by each ring counter to the succeeding ring counter.

The ring counter stage can be fabricated on printed cards for plug-in or wafer construction so that units can be identical, thus facilitating troubleshooting and making all modules interchangeable. Indicating lamps can be located on these cards so they are visible with modules in equipment.

In most applications of the unijunction transistor in digital control, the transistor acts as a bistable device as in the readout circuit.

A typical unijunction transistor control circuit, Fig. 1B, is a motor pulse generator. This circuit uses a unijunction ring counter for sequentially energizing the windings of a stepper motor. Operation is similar to the readout application. A single pulse of a train is applied to the base of Q_1 causing it to saturate. This produces a negative quenching pulse at its collector. The pulse is applied to the emitter circuits of the three-stage ring counter. As each stage is quenched a positive pulse is produced at its B_1 terminal that fires the next transistor. An output pulse is taken from the unijunction transistor to be amplified and shaped to become a constant width negative pulse operating the motor drive transistors. Each winding of the motor will thus be energized successively until the next excitation pulse is applied to the base circuits of Q_1.

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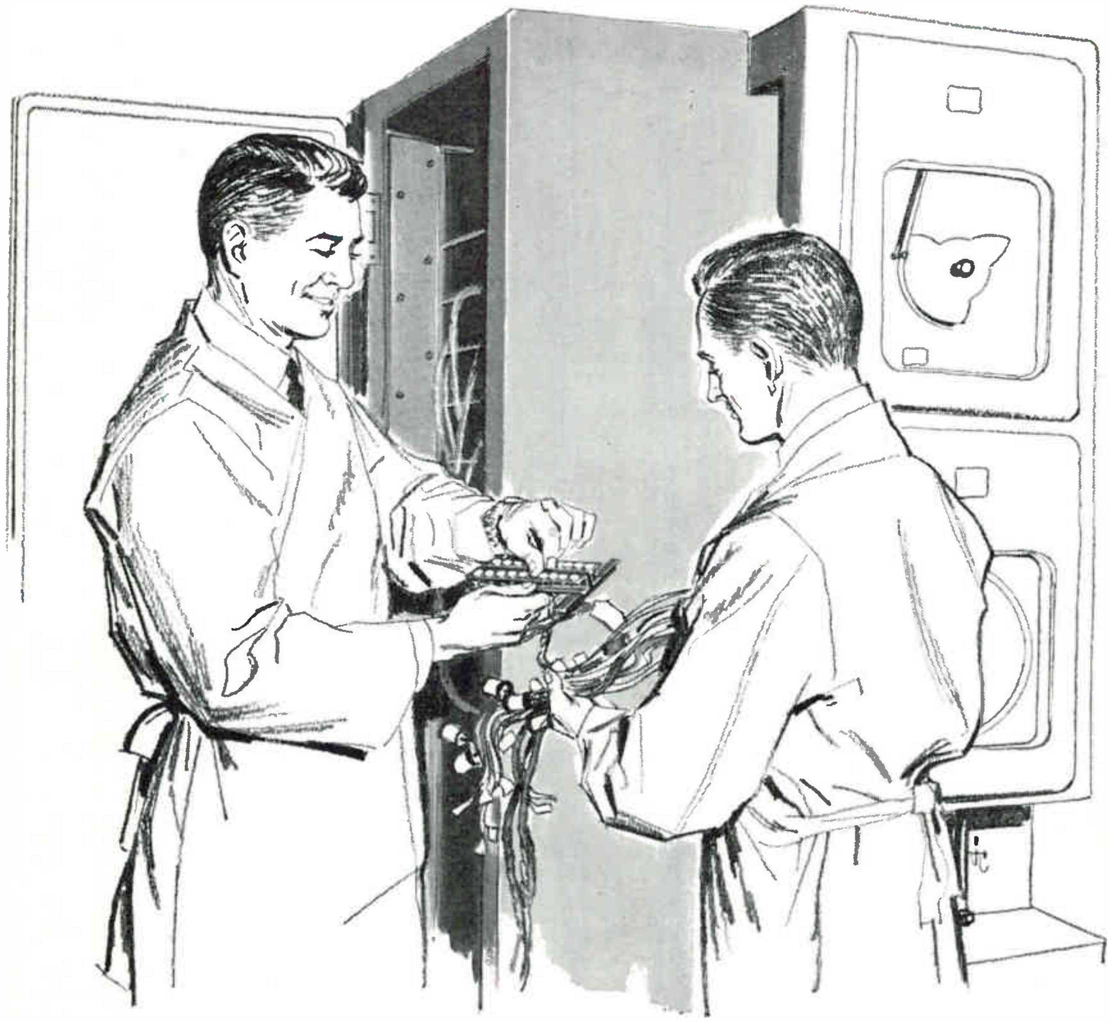

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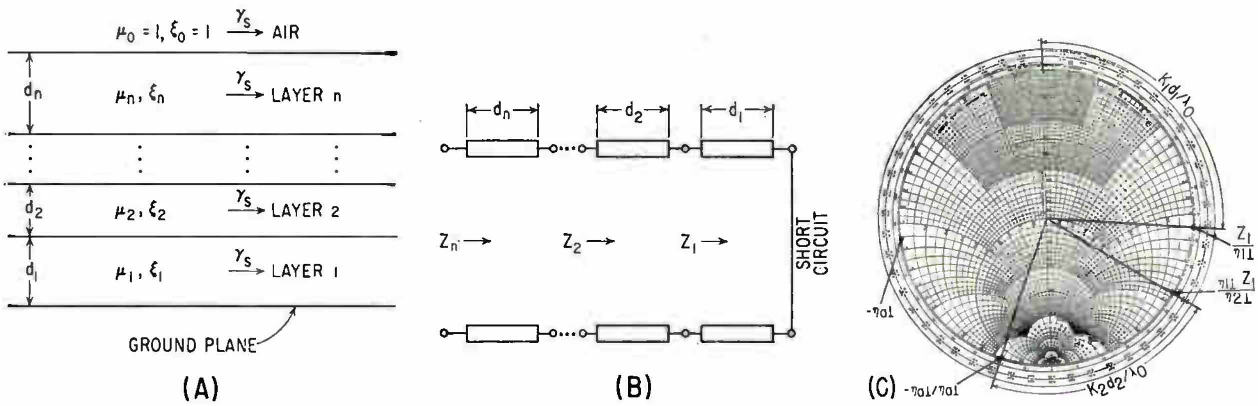

Dielectric sandwich with n layers shown at (A), and the equivalent circuit for surface wave propagation (B). Graphical solution of the problem presented in the text (C)

How Surface Waves Propagate Along a Dielectric Sandwich

By H. F. MATHIS,
The Ohio State University
Columbus, Ohio

TRANSMISSION-LINE analogy for wave propagation can be applied to the propagation of surface waves along a dielectric sandwich lying on a ground plane. The transmission-line analogy for waves propagating through a sandwich has been discussed in a previous ELECTRONICS Reference Sheet.[1]

The complex propagation constant for a surface wave propagating along the sandwich structure, shown at (A) in the figure, is denoted by $\gamma_s = \alpha_s + j\beta_s$. Units for α_s and β_s are nepers and radians per unit length, respectively. The equations in the previous Reference Sheet are modified by replacing sin θ_0 by $\gamma_s/j\beta_0$, where $\beta_0 = 2\pi/\lambda_0$. Since $\beta_s > \beta_0$, θ_0 is complex. This means that the fields in the air are reactive.

If the surface wave is launched so that the electric field is perpendicular to the ground plane, the polarization is parallel in the usual sense, and conversely. It is important that this confusing use of terms be understood. Here the subscripts $\perp$ and $\parallel$ indicate that the electric field is perpendicular or parallel, respectively, to the ground plane.

The sandwich shown at (A) in the figure can be represented by the equivalent circuit of (B). Propagation constant γ and characteristic impedance η of the section of transmission line representing the ith layer are $\gamma_i = j\beta_0 K_i$, $\eta_{i\perp} = K_i/\epsilon_i$, and $\eta_{i\parallel} = \mu_i/K_i$, where $K_i^2 = \mu_i\epsilon_i + (\gamma_s/\beta_0)^2$.

To have continuity at the interface between the air and the sandwich, $Z_n = -\eta_a$, where

$$\eta_{a\perp} = 1/\eta_{a\parallel} = \sqrt{1 + (\gamma_s/\beta_0)^2}.$$

It is generally difficult to solve surface-wave propagation problems if losses are considered. If losses are neglected, transmission line techniques can be used to find answers quickly. For a single lossless layer, with $\mu = 1$, the above equations yield, when the electric field is normal to the ground plane,

$$\epsilon\sqrt{n^2-1} = \sqrt{\epsilon - n^2}\tan\left(\beta_0 d\sqrt{\epsilon - n^2}\right)$$

and

$$\sqrt{\epsilon - n^2} = -\sqrt{n^2-1}\tan\left(\beta_0 d\sqrt{\epsilon - n^2}\right)$$

when the electric field is parallel to the ground plane, where $n = \beta_s/\beta_0 = c/$(velocity of surface wave).

Example: A lossless 2-layer sandwich, with $\epsilon_1 = 4$, $\epsilon_2 = 2.5$, $\mu_1 = \mu_2 = 1$, $d_1 = 0.1\,\lambda_0$, is to be designed so that $\gamma_s = j1.5\beta_0$ or $n = 1.5$ when the electric field is perpendicular to the ground plane. The required parameter is d_2. The problem is solved by using a circular transmission-line chart, as shown at (C) in the figure. The following are computed: $\eta_a = j1.118$, $\eta_1 = 0.331$, $\eta_2 = 0.200$, $K_1 = 1.323$, $K_2 = 0.500$, $K_1 d_1/\lambda_0 = 0.1323$. The points shown are plotted. The arc $K_2 d_2/\lambda_0 = 0.108$ is measured, and $d_2 = 0.216\lambda_0$.

REFERENCE

(1) H. F. Mathis, Transmission Line Analogy for Sandwich Propagation, ELECTRONICS, p 100, May 20, 1960.

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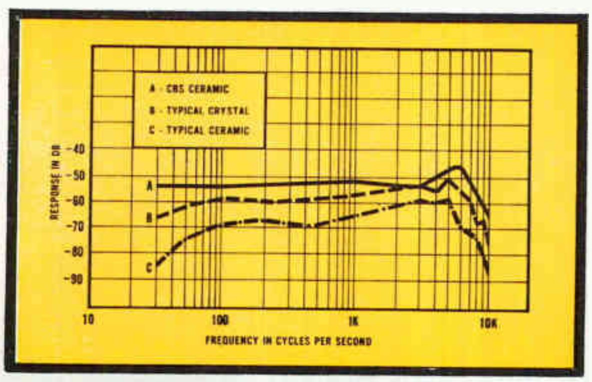
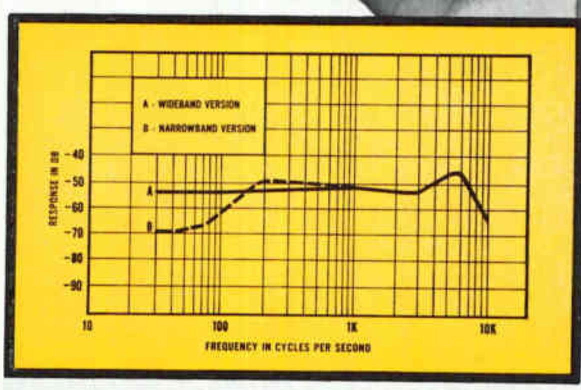


CBS Ceramic microphone compared with crystal and conventional ceramic microphones.



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Distances Are Measured With Modulated Light

VIENNA—Modulated light waves are used to measure distances up to 250 meters in a prototype distance meter. Refinements are expected to increase range of the instrument to 2-3 kilometers with measurement accuracy of a few centimeters. The system was reported by McGraw-Hill World News based on a description by its Czechoslovakian developers.

Light for the distance meter is provided by a 30-watt, point-type tungsten lamp that emits an isotropic light wave. The light is directed through a condenser into the center of the annulus formed by the electrodes of a quartz light modulator.

The modulator in conjunction with two polaroid lenses, one acting as a polarizer and one as an analyzer, produce amplitude-modulated light waves. The modulated beam of light is directed by an objective lens system to a mirror at the spot to which distance is to be measured.

The light is reflected back to the receiver objective lens system at the point of origin and directed at the photocathode of a multiplier phototube. Distance is determined from wavelength of the modulating frequency, the number of whole-cycle wavelengths in the round-trip distance and the distance analogous to the remaining part of a cycle. However, a conversion technique is used so that the portion of a cycle can be determined as a phase angle at a lower frequency.

The conversion requires a main oscillator to provide a 5-Mc signal and an auxiliary oscillator with an output frequency that differs from that of the main oscillator by 10 Kc. Auxiliary oscillator output is mixed with the main oscillator signal and also with the received signal at the last emitting electrode (dynode) of the multiplier phototube. Thus two signals of the same frequency are produced that have the same phase relationship to each other as the two higher frequency signals. These signals are fed to a synchronous detector to which a galvanometer has been connected.

The relationship from which distance is determined is $2D = N\lambda + A$, where D is distance to mirror, N is number of whole-cycle wavelengths in round-trip distance, λ is wavelength of modulating frequency and A is an admeasure algebraically added for the distance represented by a part cycle. The admeasure is related to phase angle so that $A = (\psi/2\pi)\ \lambda$, where ψ is phase angle. Repeating the measurement at a second modulating frequency permits determination of N because the change in phase angle at the new frequency is proportional to the change in wavelength.

The galvanometer indicates phase angle and is reset to zero by shifting phase of the signal from the main oscillator and the mixer in relation to the multiplier phototube signal. A phase-adjusting unit provided for this purpose has a coarse phase-adjusting control connected between the main oscillator and the mixer and a fine phase-adjusting control connected between the mixer and the synchronous detector.

The coarse control can shift phase in increments of 18 degrees throughout 180 degrees; the fine control operates over a range of 20 degrees, which provides some overlap. Dials of the controls are calibrated to indicate magnitude of the admeasure. Graduations on the fine control dial are such that admeasure can be read within an accuracy of about ±1.5 cm.

If ambient light is limited (twilight or night), a 5-cm change in distance is said to be indicated reliably. This error is caused by the phasing device and is constant. An additional error that varies with distance is dependent on frequency stability. In the prototype used to test the concept, frequency stability is 5×10^{-5}. Errors can be reduced by closer dimensional tolerances on the bracket for the modulator crystal and improvements in the electronic circuits.

Range of the instrument is expected to be increased by replacing the temporary lens system with one especially designed for the distance meter. The measuring portion of the meter weighs about 5 kilograms and can be mounted on a tri-

Neutrons Destroy Cancerous Brain Cells

Final check of patient is made by Dr. W. H. Sweet, neurosurgeon at Massachusetts General Hospital, before irradiation (see ELECTRONICS, *p 55, Feb. 24). Neutron source at MIT nuclear reactor is above ceiling. Electronic gear allows radiation-safe remote monitoring of body functions*

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1. **ELECTRICAL LIFE**
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   - no end point failures
2. **85°C STORAGE LIFE**
   - no catastrophic failures
   - no end point failures
3. **100°C STORAGE LIFE**
   - no catastrophic failures
   - no end point failures
4. **HUMID LIFE**
   - no catastrophic failure
   - 1 end point failure

	MAXIMUM RATINGS					ELECTRICAL CHARACTERISTICS				
TYPE	Pc mW	Vcb V	Vce V	Ic mA	Tj °C	MAX. Icbo μA	CONDITION	TYPICAL hFE	CONDITION	TYPICAL fαe (Mc)
MILITARY										
2N526	225	45	—	500	100	10	VCB=-30V	73	Ic=20mA VCE=-1V	3
INOUSTRIAL										
2N381	200	50	25	400	100	10	VCB=-25V	50	Ic=20mA VCE=-1.0V	3
2N382	200	50	25	400	100	10	VCB=-25V	80	Ic=20mA VCE=-1.0V	4
2N383	200	50	25	400	100	10	VCB=-25V	100	Ic=20mA VCE=-1.0V	5
2N480	200	45	—	400	100	15	VCB=-45V	25	IE=1 mA VCB=-6.0V	1.2
2N461	200	45	—	400	100	15	VCB=-45V	50	IE=1 mA VCB=-6.0V	4
2N1705	200	18	—	400	100	10	VCB= -10V	110 hfe)	Ic=1 mA VCE=-6V f = 1 KC	4
2N1708	200	25	—	400	100	10	VCB=-25V	90	Ic=20mA VCE=-1V	3
2N1707	200	30	—	400	100	15	VCB=-25V	90	Ic=20mA VCE=-1V	3

TECHNICAL ASSISTANCE IS AVAILABLE THROUGH THE FOLLOWING SALES OFFICES: ATLANTA, GA.; COLUMBUS, OHIO: CULVER CITY, CALIF.; DALLAS, TEX.; DENVER, COLO.; DETROIT, MICH.; IRVINGTON, N. J.; MELROSE PARK, ILL.; NEWARK, N. J.; PHILADELPHIA, PA.; SEATTLE, WASH. IN CANADA: ABBEY ELECTRONICS, TORONTO, ONT.

TUNG-SOL®

pod. The power supply weighs about the same but is smaller.

Image Amplifier Speeds Gamma Ray Inspection

GAMMA RAY image intensifier eliminates photographic processes from inspection procedures of dense materials. It also permits continuous production-line inspection of materials that could not be inspected nondestructively with gamma rays.

The image intensifier was announced by the Rouland Corp., a subsidiary of Zenith Radio, and Picker X-Ray. It will be used in conjunction with the Picker orthicon camera and cobalt 60 unit.

Gamma rays produced by a piece of cobalt 60 about the size of a dime can penetrate dense materials better than x-ray machines. Energy of these particles is so great that conventional fluoroscopes can not produce a satisfactory image. Nondestructive gamma ray inspection therefore resorted to photography, which is too slow and costly for production-line testing.

Operation of the image intensifier involves directing gamma rays through the material being tested to a thin metal plate in the intensifier tube. Some energy is transferred to electrons of low enough intensity to produce a fluoroscopic image. The intensifier increases brightness of this image about 1,000 times. It can be viewed directly through an optical system or picked up by the orthicon camera for a remote tv monitor.

The system suggests a number of potential uses. For example, solid fuel for rockets must be properly packed to ensure uniform burning. Present inspections of finished rockets are made by gamma rays and photographic film. Experimental studies are scheduled to determine the advantages and economies that might result with visual inspection with the intensifier system.

In rolling mills, steel billets are formed into slabs four inches thick, four feet wide and ten feet long. Ends of the hot slabs are visually inspected for gas bubbles or pieces of slag. When the flaws are found, about six inches are sheared from the slab, which is scrapped and re-inspected. This procedure is repeated until no defects are seen, which inevitably wastes time and good steel.

With the gamma ray image intensifier, an operator in a control room could watch the slabs on a tv screen as they move along a conveyor, determine the exact location of each defect and shear off only the flawed section. Studies have indicated such inspection can effect substantial economies. Development work on a system for this type inspection is in progress.

Other potential applications are in nuclear reactors. The passage of molten metals could be observed through pumps and pipes, and inspections of castings and other metal objects too dense for x-ray study could be made.

Broadcast Unit Offsets Loudspeaker Limits

DEVELOPMENT of a control system should improve fidelity of a-m radio broadcasts as heard on home receivers. The system, called a Dynamic Equalizer, was developed over the past two years by the American Broadcasting Co. It will soon be put into operation by WABC Radio.

Loudspeakers usually used in home radios have relatively limited frequency response. They often cannot reproduce fully the low and high frequencies of the audio spectrum. The equalizer automatically compensates this limitation at the broadcast studio.

The system divides the audio signal into low-, medium- and high-frequency channels. The low- and high-frequency channels are each equipped with automatic amplitude control circuits. Amplification in these two channels is controlled separately and automatically.

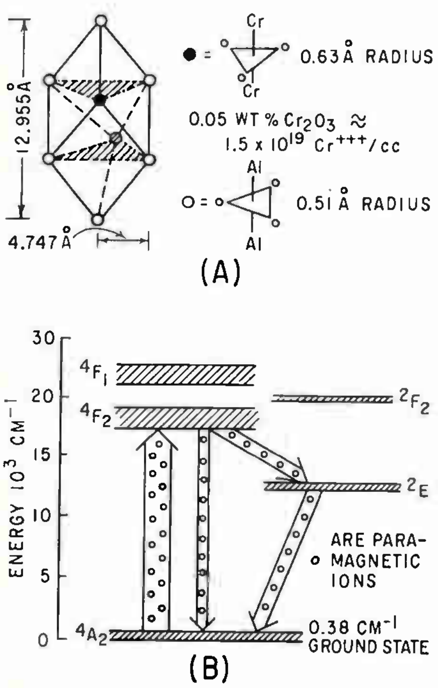
The amount of equalization in either of the controlled channels is a function of program material. For example, if program material has insufficient high frequencies, the equalizer boosts output at the higher audio frequencies independently of the remainder of the audio spectrum.

The audio signal is recombined after passing through the three channels and broadcast as usual.

Crystals for Microwave and Optical Masers

By ROBERT D. OLT,
Linde Co., Div. of Union Carbide Corp., E. Chicago, Ind.

SYNTHETIC RUBY, which is single crystal aluminum oxide doped with chromium oxide, is being used in the majority of masers (microwave amplification by stimulated emission of radiation) that operate in the microwave and the optical spectrum. Wherein the microwave maser, as an ultrasensitive first amplifier in radio astronomy, has opened up many new areas of the galaxy, the optical maser opens up literally millions of communication channels, for propagation characteristics of the emitted light are like those of radio waves. The goal of research with optical masers is to achieve true light amplification and to develop a continuous wave oscillator that can be modulated for communications.[1] At the present time, the output from an optical ruby maser is in the form of a series of pulses, with the length of the pulse train determined by the duration of the pulse (generally about ½ millisecond). Many uses for the optical maser are being uncovered; as a catalyst in chemical reactions; a transmitter in an optical radar[2]; a highly monochromatic source for optical measurements; and as a source for an optical communication system.[3]



Ruby unit cell (A) and energy levels in ruby for optical maser at 6953 Angstroms (B)

Following the introduction of the maser theory[4]. Several investigators[5-8] utilized the paramagnetic properties of ruby in microwave molecular amplification because of its physical and chemical stability, high thermal conductivity, and low dielectric losses. These molecular amplification concepts were later proposed for the light spectrum.[9] Practically all development has been with annealed ruby at tunable microwave frequencies of about 1,250 Mc., 1,500 Mc, 1,950 Mc, and 2,300 Mc. Ruby has further been stimulated at 6943 Å, 7009 Å and at 7041 Å, in the optical spectrum.

Ruby has been used for microwave masers under some of the following conditions:

At temperatures as high as 195-deg. Kelvin[10].

X-band operation having a 14 Mc gain band width at 77-deg. Kelvin.

Gain-bandwidth of 100 Mc. at 1.4-deg. Kelvin and 35 Mc. at 4.2-deg. Kelvin (in a field of 4000 gauss pumped with about a milliwatt of power at 23.1 Gc, signal at 9.14 Gc, 30-deg. K noise figure).[11]

Traveling wave maser using a 3.5-in. long annealed ruby slab operating at L-band having a gain of 6.5 db at 1,250 Mc (±10% turning range), liquid helium temperature.[12]

One investigator has compiled a comprehensive survey of masers, as well as Siegman's design matrix and energy levels.[13]

In late 1959, the narrowed (1 Å) ruby fluorescent band was observed in a 0.05% $Cr_2O_3:Al_2O_3$ final whole annealed pink ruby cube.[14-16] This band, observed at 6943 Å (the red end of the optical spectrum), had a peak power of about 10 kw, and a total energy of over 1 joule. The emitted radiation is confined to a very narrow beam of about one-third of a degree divergence, which can then be optically focused to 3 minutes.

This beam has an optical intensity 10^{10} deg K equivalent.

The Bell Telephone Laboratory group[17] confirmed the coherence and directionality of the stimulated light emission, using a 0-deg. annealed dilute ruby rod 0.5 cm in dia. by 4 cm long, ends polished flat to $\frac{1}{10}$ sodium band and parallel to 12 minutes, silvered to transmit 1 to 5%. The xenon flash lamp operated above 4,000-deg Kelvin through a capacitor discharge of 400 microfarads at 4 Kv. A one thousandfold light intensity increase was observed at a threshold of about 2,000 joules, having an effective temperature of 10^{10} deg. K through an angle of 0.3 deg, at 14,400 cm^{-1}. Secondary emission was observed at 14,430 cm^{-1}. More recently, pulsed optical maser activity has been observed in 0.5% final annealed standard ruby rod at 7009 Å and 7041 Å at 77 deg K; and 7041 Å at 4.2 deg. K.[18]

Other materials have been considered beside ruby. Measurements have been made at 57 Gc on Cr^{+++} doped rutile, (TiO_2), and on emerald. A chromium doped rutile was used in a 9 Gc maser, pumped at 34 Gc, having a gain-band width of 25 Mc at 4.2 deg. K.[19] An iron doped sapphire has been used in a zero field device.[20] Sm^{++} doped CaF_2 has operated at 7082 Å, and a U^{+++} doped CaF_2 crystal at 2.5 microns, and more recently a continuous wave helium-neon gas maser has operated at 1.15 microns.

Coloring in ruby is associated with a trivalent chromium ion, which is introduced into the crystal lattice during growth. Ruby has an optical absorption band at 5600 Å (green) and 4150 Å (violet), and to a lesser extent, but more sensitive to concentration, an absorption at 4750 Å. Refraction

. nd absorption of synthetic ruby has been measured and reported.[21] In dilute or pink ruby, used in cooled maser applications, the chromium is present in about 0.05-0.06 wt-% Cr_2O_3:Al_2O_3. The introduction of about 1.6×10^{19} Cr^{+++}/cc, as in dilute ruby, results in lattice strain because Cr^{+++} has an ionic radius somewhat larger than that of the aluminum ion. At higher chromium ion concentration, it becomes increasingly difficult to produce ruby boules by the Verneuil technique with a low level of internal discontinuity. Since the Verneuil process requires melting the aluminum oxide at 2050 deg C, thermal stresses present a problem. Linde has developed several modified growth techniques which yield optical quality ruby with decreased thermal stresses. Linage in some optical quality crystals has varied less than a degree about the optical axis. Growth is followed by a long cycle annealing operation in which the crystal is brought to a temperature approaching the melting point. Any slight misorientation, called lineage, in the ruby crystal structure is plainly exhibited between crossed polaroids by differing light refraction through the crystal. Linde conventional dilute ruby has a line width of about 0.3 wave numbers; some boules with strain as low as 0.12 wave numbers[18] have been produced recently.

These improvements in internal optical homogeneity have allowed continued reduction in threshold power required for maser activity.

In the United States, Linde[22] has been producing synthetic ruby, synthetic sapphire, and other crystals since 1942, and has had wide experience in furnishing maser quality crystals for electronics. Linde is now producing three host crystals: sapphire (Al_2O_3); rutile (TiO_2); and spinel ($MgO.315\ Al_2O_3$). Chromia, iron, chromia-iron, nickel, and vanadium doped sapphire have exhibited paramagnetic properties, of the 75 or so different elements put into sapphire. Chromia, iron and chromia-iron doped rutile have exhibited paramagnetism in the 15 or so elements substituted. Linde has grown several compounds in the carbide series: (TiC and CbC); silicide series ($MoSi^2$); boride series (TiB_2); oxide series (TiO, Ti_2O_3), and undoped and low alumina doped Cr_2O_3. All are research materials and are generally available in limited quantities for accredited research studies. Linde stocks chromium doped sapphire boules in 0.05 pink, 0.5 and 0.7 standard and 1.5 extra dark, all approximate final weight percent Cr_2O_3 concentrations. These are of random (generally about 57 deg.) orientation, are carrot shaped, and can be as large as ⅝ in. diameter at the widest point, up to 4 in. long. Optical quality zero oriented 0.05 and 0.5 ruby costs more than microwave maser ruby, and is also stocked. Larger size, specially oriented, and other doped boules are available at premium cost.

REFERENCES ON MASERS

(1) R. Bradbury, M. Stickley. Communications Sciences Laboratory. Air Force Cambridge Research Laboratories. Hanscom Field, Bedford, Mass.

(2) J. W. Meyer, Systems Applications of Solid State Masers, ELECTRONICS, p 58, 4 Nov., 1960.

(3) M. L. Stitch, E. J. Woodbury and J. H. Morse, Optical Ranging System Using Laser Transmitter, Hughes Aircraft Co., ELECTRONICS, p 51, 21 Apr., 1961.

(4) N. Bloembergen, Proposal For a New Type Solid State Maser, Phys. Rev., 104, p 325, Oct., 1956.

(5) J. E. Geusic; Physical Review 102, p 1252, 1956.

(6) C. Kikuchi, J. Lambe, G. Makhov, R. W. Terhune, Ruby as a Maser Material, J. Appl. Phys. 30, p 1061, Jul., 1959.

(7) H. E. D. Scovil, G. Feher, H. Seidel; Physical Review 105, p 762, 1957.

(8) C. H. Townes, Alsop, Giordmoine, Mayer; Astron. Jour., 63, p 301, 1958.

(9) A. L. Schawlow, C. H. Townes; Phys. Rev. 112, p 1940, 1958.

(10) T. H. Maiman, Maser Behavior, Temperature and Concentration Effects. J. Appl. Phys. 31, Jan. 1960.

(11) T. H. Maiman, Solid State Masers-Design and Performance. Proceedings of NSIA-ARD Conf. on Molecular Electronics, Wash., D. C., Nov., 1958.

(12) S. Okwit, F. R. Arams. Tunable L-Band Masers, Proc. IRE, 47, May, 1959.

(13) J. Weber, Masers—Comprehensive Maser Summary, Review of Mod. Phys. 31, p 681-710, July, 1959.

(14) T. H. Maiman, Optical Maser Action in Ruby, British Comm. and Elect., 7, p 674, 1960; and Nature, 187, p 493, 1960.

(15) T. H. Maiman, Optical and Microwave-Optical Experiments in Ruby. Phys. Rev. Letters, Jun., 1960.

(16) I. Wieder, Solid State, High Intensity Monochromatic Light Source, Rev. of Sci. Instr. 30, p 11, Nov., 1959.

(17) R. J. Collins, D. F. Nelson, A. L. Schawlow, W. L. Bond, C. G. B. Garrett. Coherence, Narrowing, Directionality and Relaxation Oscillations in the Light Emission from Ruby, Phys. Rev. Letters, 5, p 7, Oct. 1960.

(18) A. L. Schawlow, Paper presented at OSA Meeting, Pittsburgh, 2 Mar., 1961 (to be published).

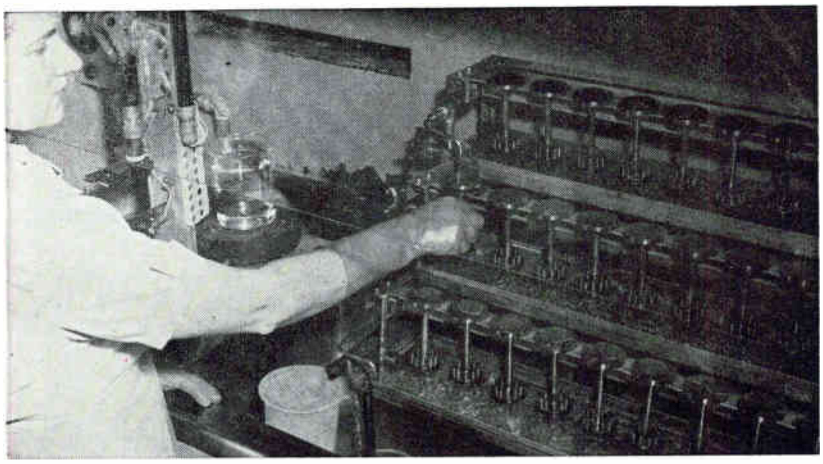
(19) H. J. Gerritsen, S. E. Harrison, H. R. Lewis, Chromium-Doped Titania as a Maser Material, Including Energy Levels, Journ. Appl. Phys., 31, 9 Sept., 1960.

(20) R. W. Terhune, I. E. King, Information Note 2, Project Michigan, Univ. of Michigan, 1959.

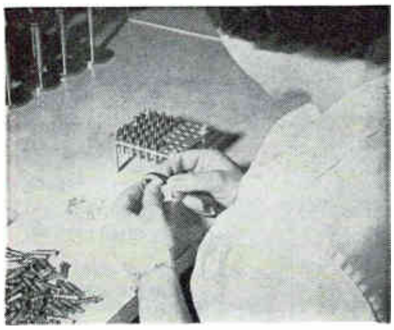
(21) J. A. Mandarinao, Refraction, Absorption and Biabsorption in Synthetic Ruby, American Mineralogist, 44, p 961-73, Sept.-Oct., 1959.

(22) Linde Company, A Division of Union Carbide Corp., 4120 Kennedy Ave., East Chicago, Ind.

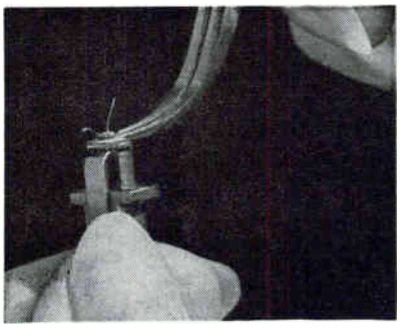
One Fixture Handles Etching, Rinsing, Soldering



Fixtures are hung in turbulent flow rinse baths after etching



Elements are loaded into individual holders



Closeup of holder loading. Tweezers are used

COMPACT FIXTURES, each holding 10 elements, carry alloy junction transistor elements through etching, cleaning and resistance soldering operations at the Lansdale Division of Philco Corp., Lansdale, Pa.

The fixtures carry the elements in individual holders, into which the elements are mounted after furnace alloying and whisker-stud bonding. Spring jaws in the holders grip the collector stud, providing a positive electrical connection for etching. The fixtures have a metal disc on top and a larger metal disk on the bottom. Holders are held behind a rubber belt stretched around the circumference of the bottom disc.

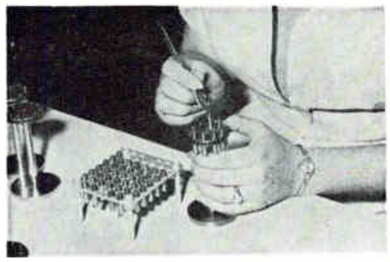
Elements are etched by hanging the fixture from a post which lowers it into etching bath. The same fixture is then used to place the elements in a hot, deionized water rinse.

The water baths and the fixture mounts are arranged in stair fashion. Philco uses a single-tank, turbulent flow rinse rather than a cascade. Water is continually flowed into the front of a shallow tank through a perforated tube. It flows across the transistors, over a baffle and into a drain trough. A tank holds about three pints of water, changed every four or five seconds. The transistors remain in the tank about 15 minutes, ensuring thorough washing.

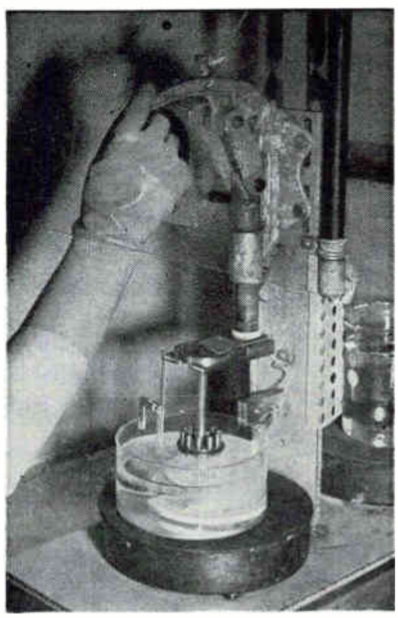
Next, the same fixture is placed on a rotating mount in a spray booth. Two spray guns, set at different angles to give complete coverage, wash the transistors with alcohol. The alcohol also helps remove the rinse water. The transistors are completely dried in a vacuum oven.

Individual holders are then removed from the etching fixture and inserted in a test fixture. The test fixture positions the emitter and base leads against spring strip contacts. A test of I_{CO} and I_{EO} is made. If the test indicates that more etching is required, the holders go back into the etching fixtures and the process is repeated.

Transistors passing the preliminary tests are mounted on stems, baked out, tested and sealed by cold-welding the caps. The vacuum bakeout oven is double-ended; the exit door opens directly into the dry boxes used for testing and sealing. After sealing, transistors are placed in a pressure vessel for leak testing. If the case leaks, the presence of fluid in the case is detected by electrical tests. An ethylene glycol solution is used since it is not corrosive and flows well. Bakeout, plating, painting and final tests



Holders are loaded into etching fixtures



Operator dips loaded fixture into etchant

SIMPLIFY DATA HANDLING

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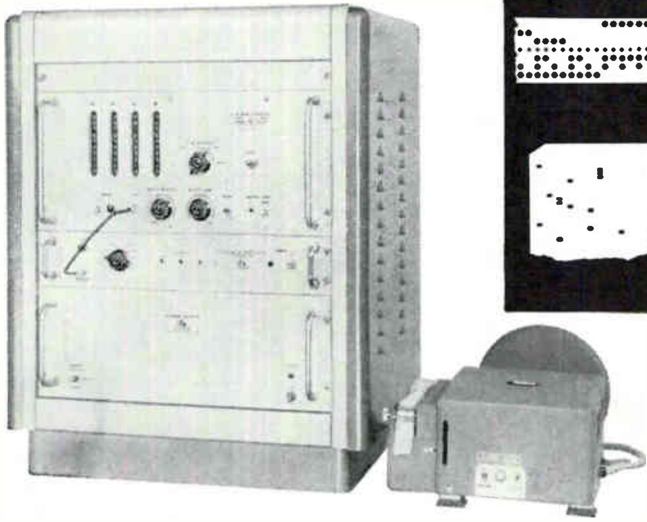

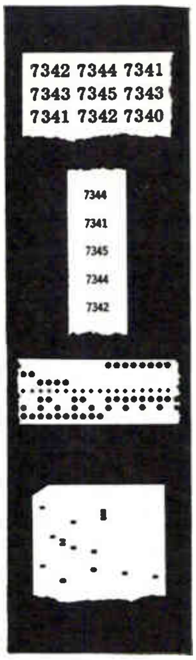

Dymec Model DY-5552 Data Processing System is a remarkably versatile tool for quickly accumulating data on a wide variety of physical, mechanical and electronic processes. Any phenomenon of nature or science that can be converted to a usable voltage or frequency can be measured and recorded through the DY-5552. Digital output can be in any form or combination of forms needed for further machine processing, visual analysis or transmission over any standard communication system. Applications are limited only by the imagination.

The moderately priced Dymec system consists of a voltage-to-frequency converter and electronic counter to convert input information to digital form, plus a scanner/coupler, which transfers this digital data and is capable of providing output for electric typewriter, Flexowriter, serial-entry adding machine and serial entry card punch or tape punch. In many cases two of these recording devices can be operated simultaneously. In addition, the system can drive a digital printer, such as the Hewlett-Packard 560A.

This is one of many Dymec Data Processing Systems which can be assembled from basic "building block" instruments. Versatile, flexible input scanners, counters, digital voltmeters, output couplers/translators meet a wide range of needs for speed, multiple input application, programming.

BRIEF SPECIFICATIONS	
Input Ranges:	0 to 1 v dc, 0 to 10 v dc, 0 to 100 v dc, 0 to 1,000 v dc (30% overrange permissible except on 1,000 v range; either polarity measured without switching). Frequency inputs, 1 cps to 120 KC. Gate times, 0.1 sec., 1 sec.
Accuracy:	DC inputs, .06%, ± 1 count Frequency inputs, .01%, ± 1 count
Operating Speed:	Controlled by Display Time Setting (variable from .1 to 15 sec. or indefinitely), maximum operating speed of 5 full scale readings per second.
Approximate price:	$3,600.00 (as pictured, including tape punch).

Data subject to change without notice. Prices f.o.b. Palo Alto

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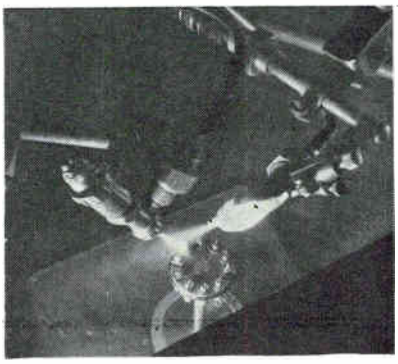
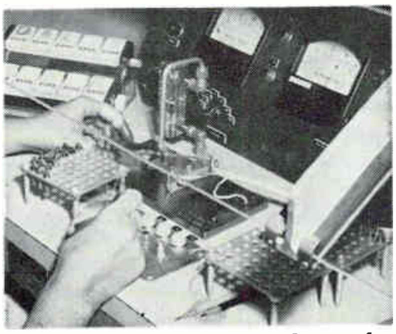
Dept. E-5, 395 Page Mill Road, Palo Alto, Calif. • Phone DAvenport 6-1755 (Area Code 415) TWX-117-U follow leak testing.

In the production of miniature hearing aid and audio types of transistors, a similar fixture solders emitter and collector leads stem directly to the alloy pellets. Only the pellets and base tabs are attached to the dice during furnace alloying.

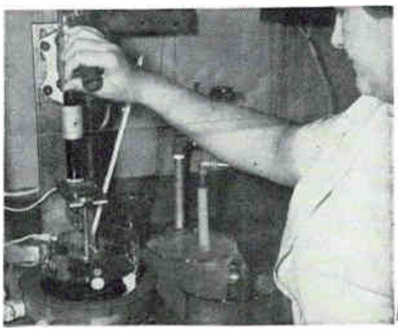
The alloyed assembly is mounted on the stem by the base tab. The stem is provided with leads which



View through window of alcohol spray booth



Preliminary tests are made on elements in holders



Miniature transistor leads are soldered in heated flux

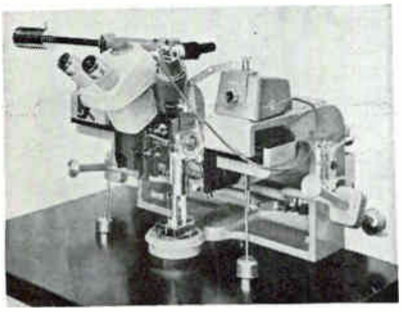
press against the emitter and collector pellets. The assembly is mounted in the fixture with the stem leads behind the rubber belt. The fixture is placed so the transistors are suspended in glycerol flux, which is resistance-heated until the leads penetrate the softened alloy pellets.

The same fixture is then used for etching and rinsing.

Thermocompression Bonder Uses Joystick Positioners

CHESSMAN JOYSTICK manipulators —mechanically deamplifying the movement of a weight sliding on a smooth plane—are used to position wire and its bonding tool in a new thermocompression bonder. The equipment was designed for mesa transistor production and can also be used for making connections to mesa diodes, epitaxial devices and other microminiature and molecular devices.

Kulicke and Soffa Manufacturing Co., Inc., reports that the finger-operated controls give a positioning precision of 10 to 15 millionths



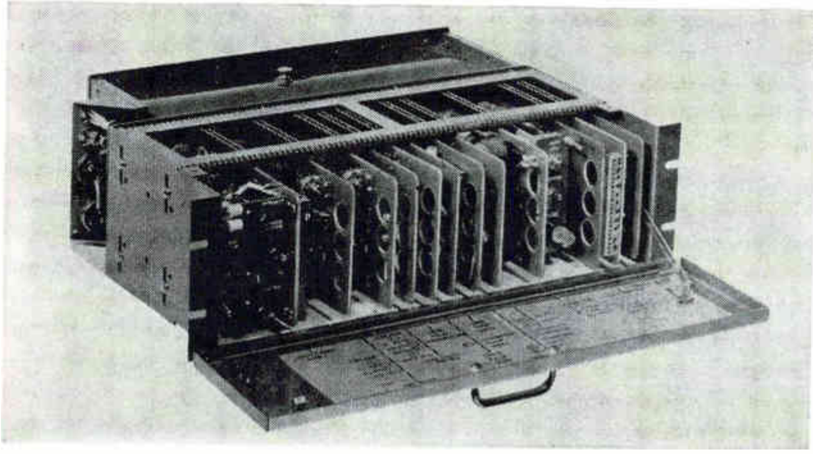
Wire and tool position is adjusted by movement of weights on smooth surface

of an inch. Wire as fine as 0.0002 inch in diameter can be bonded to stripes 0.001 inch wide.

The right and left-hand chessmen control horizontal movement of the wire and bonding tool, respectively, while left and right-hand levers control their vertical movement. Wire, fed from a spool, is extended or retracted by a motorized feed which the operator can use without removing her hand from the positioning lever. This arrangement allows the operator to use both hands to position the wire on the stripe, position the bonding tool and make the bonds to stripes and terminals.

The bonding tool is a dual force needle or hammer. One weight is actuated for bonding wire to the stripes and two weights bond the wire to terminals and cut the wire. Headers are held in a thermostatically-controlled heat column, with inert gas flowing over the bonding area. The columns rotate to bring each pair of strips and terminals within bonding position. The binocular microscope mount moves with the tool.

New On The Market



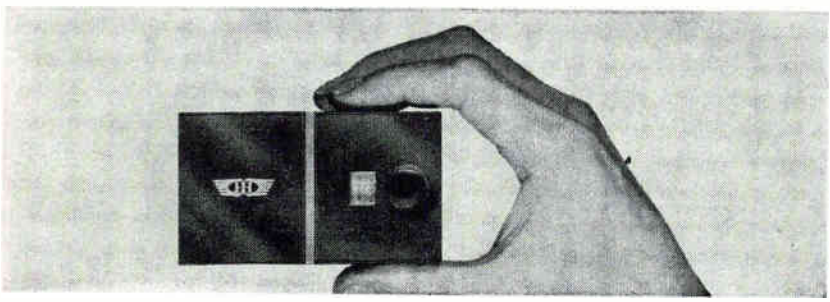
Character Generator
DIGITAL TO ALPHANUMERIC

CHARACTER GENERATOR converts digitally coded machine language into alphanumeric symbols at speeds to 20,000 characters per second.

Electronic decoder, Videograph model 980, is an off the shelf unit for 19 inch racks; it occupies one cubic foot. Output signals can be displayed on a crt, or printed out with an electrostatic printing tube.

Character rate in excess of 30,000 per second is available on special order. Price is about $6,700, from A. B. Dick Co., 5700 W. Touhy Ave., Chicago 48, Ill.

CIRCLE 301 ON READER SERVICE CARD



Calibration Tester
SIMULATES MV SOURCES

CALIBRATION TESTER BH 153 is a direct reading adjustable voltage source, simulating the d-c output of transducers, with a setting accuracy of 0.05 percent. It is for field or laboratory testing of recording or indicating instruments responding to mv or μv.

The scale, 12 feet long, can be specially graduated for the instruments to be calibrated. Device requires 115 v, 60 or 400 cps; size is $4 \times 2\frac{3}{4} \times 2\frac{1}{4}$ in.; weight is about 8 ounces. Manufacturer is Howell Instruments, Inc., 3479 West Vickery Blvd., Fort Worth 7, Texas.

CIRCLE 302 ON READER SERVICE CARD

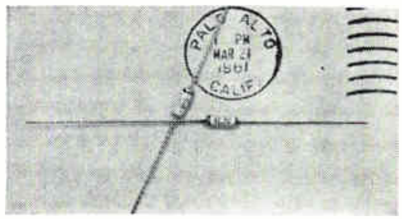
Gadolinium Selenide
THERMOELECTRIC USES

GADOLINIUM SELENIDE is a thermoelectric material with a high Z factor. Although the Z factor of the material being produced has not been determined, the material is being marketed to laboratories doing work on thermoelectric research.

Seebeck outputs as high as 500 microvolts per degree have been obtained, but this and the resistivities vary with the type of doping.

The material being produced is available in a powdered granular form for further processing by the customer into rods. Undoped as well as *n*-type and *p*-type material is available. In research quantities of 100 grams, prices are $5.50 per gram; quantity prices much lower. Producer is Semi-Elements, Inc., Saxonburg Blvd., Saxonburg, Pa.

CIRCLE 303 ON READER SERVICE CARD

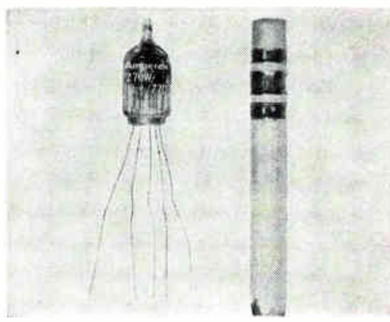


Miniature 4-Layer Diode
10-AMP PULSES

TYPE E diode can handle 10 ampere pulses or 150 ma continuous. The Shockley diode is essentially a very fast, *pnpn*, two terminal, silicon switch, is self-actuated by applying switching voltage across its terminals. The diode is turned off by reducing the current below the holding current. Typical turn-on time is less than 0.1 microsecond.

The diodes are available in two types, commercial, and Mil-Line, in ratings from 20 to 200 volts, from Shockley Transistor, Stanford Industrial Park, Palo Alto, Calif.

CIRCLE 304 ON READER SERVICE CARD



2-Starter Trigger Tube
BIDIRECTIONAL COUNTS

TYPE 7709/Z70W is a subminiature, gas filled cold cathode trigger

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Now available on a tool-of-the-month basis is a new series of Utica pliers. These pliers, never before offered on an industry-wide basis, were developed especially for difficult and all-purpose jobs in electronic wiring, assembly and sub-assembly.

Tools are finely finished, produced to the highest standards of Utica quality, thoroughly market tested and backed by Utica's famous full guarantee. Your Utica Distributor will be calling on you soon to discuss the new program.

UTICA 265-5 TOOL FOR MONTHS MAY AND JUNE.

Electronic Wiring Plier with cutter designed to snap-cut, loop or twist solid or stranded wire. Ideal for printed circuit or subassembly work. Like all Utica electronic pliers, edges will not cut or mark wire and are electronically induction hardened for greater wear. Handles are prime coated and dipped in heavy plastisol for contour fit—maximum comfort—minimum fatigue.

UTICA DROP FORGE & TOOL DIVISION • KELSEY-HAYES COMPANY, UTICA 4, NEW YORK

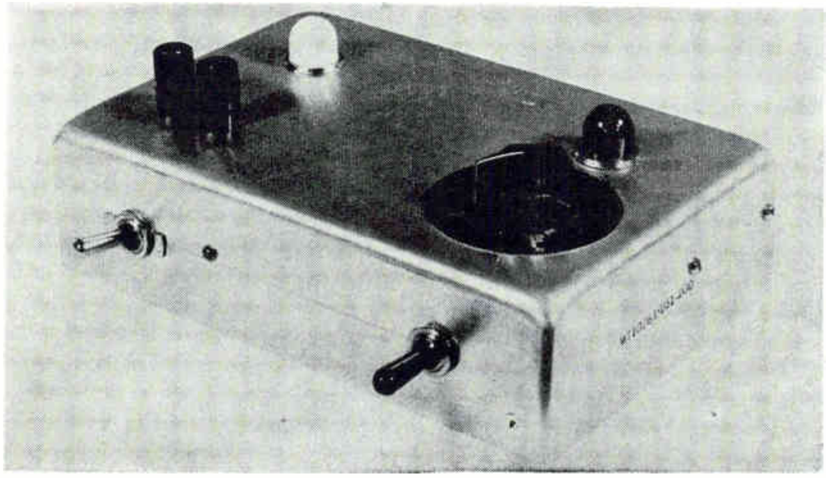
UTICA

tube for counting, timing, selecting, automation and read-out applications.

The tube has two starters, thus can be used in forward-backward counters, gates and reset applications. When used for reset, no additional tube is required. The tube can be used in counters with a frequency up to 5 Kc. Starter current of 30 μa insures discharge.

The cold cathode tube is designed for over 30,000 hours of operation, is manufactured by Amperex Electronic Corp., Semiconductor and Special Purpose Tube Div., 230 Duffy Ave., Hicksville, L. I., N. Y.

CIRCLE 305 ON READER SERVICE CARD



Milliamp Circuit Breaker
OPENS CIRCUIT IN 10 μSEC

SEMICONDUCTOR components generally require an overload of at least forty-microsecond duration before they are damaged or destroyed. Model 150 milliampere circuit breaker responds to one-microsecond transients, opens a circuit within ten microseconds.

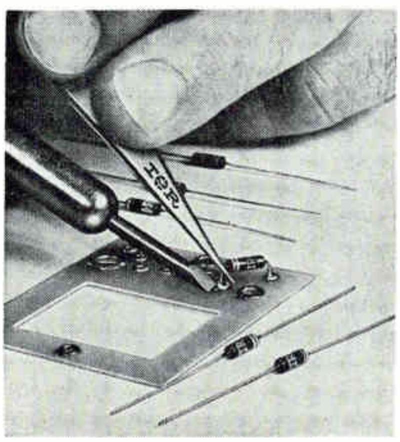
Trip current can be adjusted to any value between 15 and 150 ma. Reset, with button, is prevented if an overload still exists. Accuracy is ± 10 percent, which is within usual limits required. Insertion loss is 4 milliohms to 4 ohms per ma. When open, nominal resistance is 10 megohms. Price is $160, from Orbitec Corp., 512 30th Street, Newport Beach, Calif.

CIRCLE 306 ON READER SERVICE CARD

28 Miniature Zeners
3.3 TO 30 VOLTS

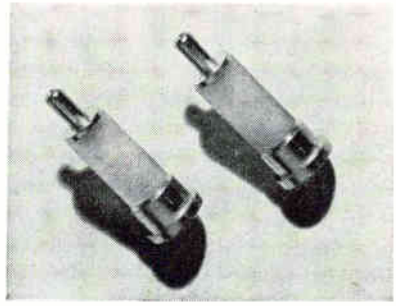
FOR PRINTED circuit boards, miniaturized circuits and other applications, subminiature glass zener diodes rated from 3.3 to 30 volts and 250 mw are available from International Rectifier Corp, 1521 E. Grand Ave., El Segundo, Calif. High stability and excellent voltage regulation is provided from −55 to +150 C.

Types QZ3.3T10 through QZ30T5 are available in 5 or 10 percent voltage tolerance, have a max zener impedance range from 5 to 70 ohms. The devices are process-selected to provide sharp zener characteristics. All units feature glass-to-metal her-



metic sealing, are 0.265 by 0.110 in. in diameter, not counting leads.

CIRCLE 307 ON READER SERVICE CARD



Bolometers For Microwaves
GOLD-PLATED CONTACTS

LINE of bolometers for absolute and relative microwave power measurements incorporates 1N23 crystal diode cartridge design. Bolometer elements are mounted between gold plated contacts within low loss dielectric housings, achieving near theoretical maximum efficiency. The gold plated contacts are non-tarnishing and corrosion resistant; units are hermetically sealed. The bolometers are rated at 200 ohms or 100 ohms at 8.75 or 4.5 ma and are capable of measurements at frequencies up to 18 Gc. Square law response errors are less than 1 percent up to 0.2 mw. Price is $10, delivery from stock, from Microwave Semiconductor & Instruments Inc., 116-06 Myrtle Ave., Richmond Hill 18, N. Y.

CIRCLE 308 ON READER SERVICE CARD

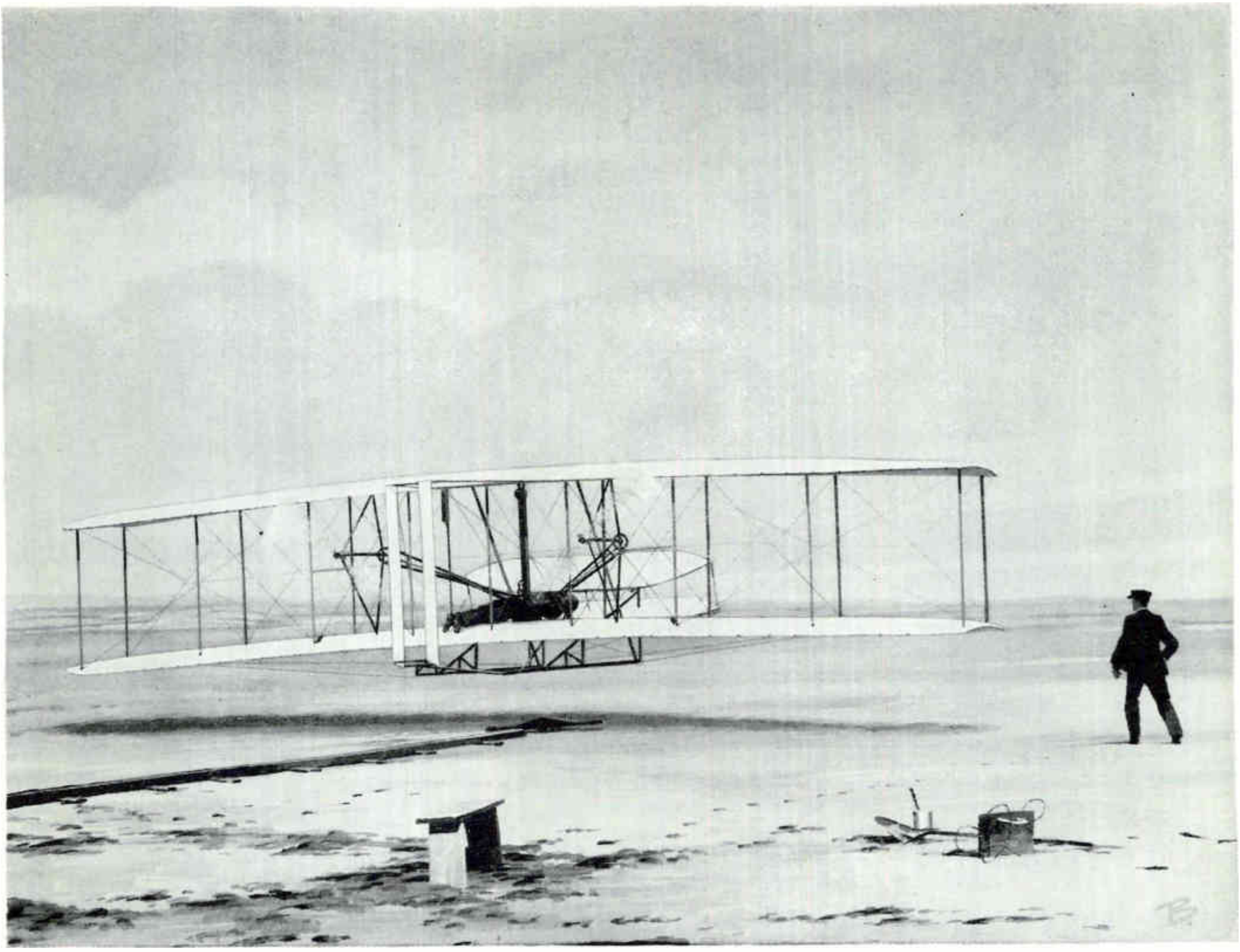
Epoxy Rod
72 INCHES LONG

RAD ELECTRONIC PLASTICS, INC., 1466 Herkimer St., Brooklyn 33, N.Y., announces epoxy in rod form, 72 inches long, to meet all MIL Spec performances. Four standard types of formulations available: No. 31 (260 F, HDT); No. 32 (310 F, HDT); No. 33 (345 F, HDT); No. 34 (410 F, HDT); all diameters within ± 0.001 in., tolerances over the entire 72-in. length.

CIRCLE 309 ON READER SERVICE CARD

H-F Transistor
MILITARY TYPE

MOTOROLA SEMICONDUCTOR PRODUCTS INC., 5005 E. McDowell Road, Phoenix 10, Ariz. Type 2N700A (SIG. C) is capable of an oscillating frequency in excess of 1,000 Mc. It is supplied to military specification MIL-S-19500/123 and is a 25-v

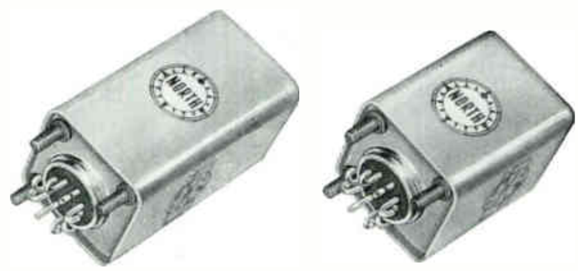


Milestones in Engineering

When Orville and Wilbur Wright gave man wings in one dramatic moment in 1903, a new era was born.

Since that climactic flight, nearly sixty years ago, the efforts to enable man to fly higher, faster, more safely and with greater payloads have made airborne equipment more and more complex and increasingly dependent upon size and weight factors in component application.

Today's engineering accomplishments resulting in smaller, lighter, more efficient airborne components will eventually pave the way for man's total exploration of space.



The NEW North Electric 1500 Series Relays embody ultra sensitivity in hermetically sealed miniature and subminiature sizes. Ideally suited for critical electronic and control operations in stringent airborne and missile, as well as ground control applications, these relays utilize permissive contacts, guarantee withstanding 2000 CPS at 15 Gs and shock tests of 65 Gs and meet or exceed, Mil Spec MIL R 5757D. Their unique design affords freedom in adjustment, permitting make before break, an exceptional offering in a sealed relay. The 1520 miniature is a tiny .970" square x 1.75" with a 20 mw sensitivity with 2 Form C (6 mw with 2 Form A), the 1540 subminiature affords you 40 mw sensitivity in a .970" square x 1.25" package.

For detailed information on 1500 Series Relays, write:

Visit the famous
Wright Brothers National Memorial,
Kitty Hawk, N. C.

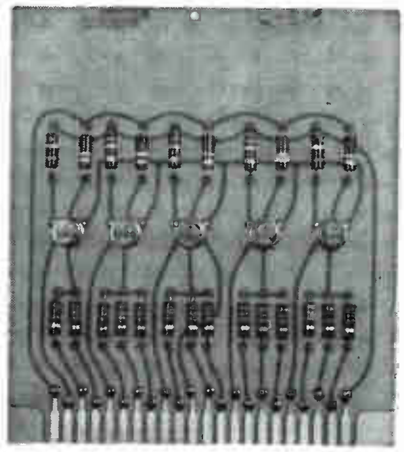
ELECTRONETICS DIVISION

NORTH ELECTRIC COMPANY NORTH

145 S. MARKET ST., GALION, OHIO

(V_{CE}), 75-mw (free air), germanium *pnp*, diffused-base mesa transistor.

CIRCLE 310 ON READER SERVICE CARD



NOR Logic
PLUG-IN CIRCUIT

RANSOM RESEARCH, INC., 374 W. 8th St., San Pedro, Calif., introduces a 250-Kc and a 50-Kc NOR logic circuit packaged as a plug-in circuit card. Resistors instead of diodes are used for the basic logic element, permitting greater simplicity and lower cost. By using a reliable and stable transistor circuit, a single logical element may be used in combinations to solve all logical equations with the exception of time delays.

CIRCLE 311 ON READER SERVICE CARD

Heat Dissipators

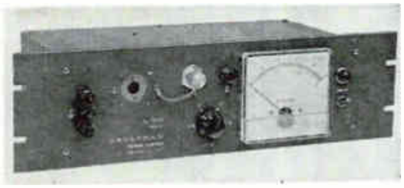
AUGAT BROS. INC., 33 Perry Ave., Attleboro, Mass. Power transistor heat dissipators are designed to utilize a minimum of space while maintaining low thermal resistance with natural draft.

CIRCLE 312 ON READER SERVICE CARD

Frequency Converter
TWO-IN-ONE

UNITRON INC., 1807 Stratford Dr., Garland, Texas, has developed an all solid state dual frequency converter. Unit provides two completely independent power conversions—400 cps three phase to 60 cps single phase at 2,500 v-a and 60 cps single phase to 400 cps single phase at 300 v-a. Low weight is achieved through the use of a transformerless output in the 400 cps to 60 cps unit and a transformerless input on the 60 cps to 400 cps unit. Both units are short circuit protected.

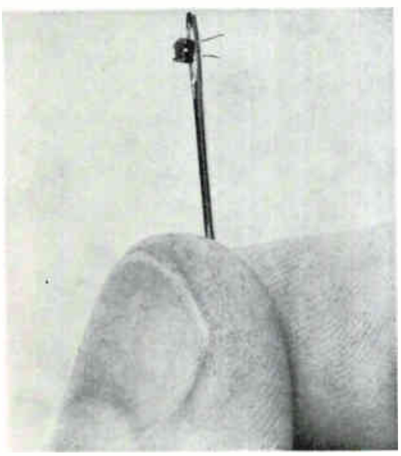
CIRCLE 313 ON READER SERVICE CARD



Test Set
FOR SEMICONDUCTORS

DYNATRAN ELECTRONICS CORP., 178 Herricks Road, Mineola, N. Y. Model $1827C_{ob}$ test set provides direct meter readings of the collector capacitance of transistors with ranges of 0-3, 0-10, 0-30 and 0-100 $\mu\mu$f full scale. It has an accuracy of 5 percent and can also be used to measure the capacitance of diodes when reversed biased. Price is $425.

CIRCLE 314 ON READER SERVICE CARD



Tiny Resistor
WIRE-WOUND TYPE

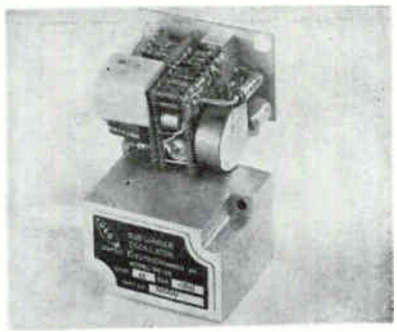
REON RESISTOR CORP., 155 Saw Mill River Road, Yonkers, N. Y. Military-type wire-wound resistor measures only 1/16 by 1/16 in. It is available in resistive values from 1 ohm to 50,000 ohms. Units can be manufactured with power ratings 0.02 w. Extremely fine resistance wire (as small as 0.00045 in. diameter) is wound on a spindle until the correct number of turns have been completed for the desired resistance value.

CIRCLE 315 ON READER SERVICE CARD

Switching & Power Units

MARCONI'S WIRELESS TELEGRAPH CO. LIMITED, Christopher Martin Rd., Basildon, Essex, England. Designed for the AD 7092 range of airborne automatic direction finders, a transistorized switching unit replaces original vibrator units, and an a-c power unit replaces the rotary transformer.

CIRCLE 316 ON READER SERVICE CARD



Subcarrier Oscillator
VOLTAGE CONTROLLED

UNITED ELECTRODYNAMICS, INC., 200 Allendale Road, Pasadena, Calif. Model VC-32 subcarrier oscillator has a volume of only 2 cu in. including internal regulator for operation from raw 28 v supplies. Unit will operate from signal sources of as low as ± 10 mv full scale with overall accuracy of 1 percent or better under external environmental conditions. Input is completely isolated, and common mode rejection is better than 80 db.

CIRCLE 317 ON READER SERVICE CARD

Preset Timer
SOLID STATE

ELDORADO ELECTRONICS, 2821 Tenth St., Berkeley 10, Calif. Solid state preset timer is designed for use with any transistorized scaler. Model 855-6 features two interchangeable time bases—10 Kc crystal controlled oscillator and 60 cps line. Time bases are easily changed by inserting plug-in cards. A 5-digit neon readout expresses elapsed time in multiples of tenths of a sec for the 60 cps time base and multiples of a hundred thousandth of a minute for the 10 Kc time base.

CIRCLE 318 ON READER SERVICE CARD

Ferrite Modulator

FXR, INC., 25-26 50th St., Woodside 77, N.Y. An absorption type ferrite modulator covers the full X band of 8.2 to 12.4 Gc.

CIRCLE 319 ON READER SERVICE CARD

Pulse Height Analyzer
400-CHANNEL

TECHNICAL MEASUREMENT CORP., 441 Washington Ave., North Haven, Conn. Transistorized, portable 400-channel pulse height analyzer occupies 1 cu ft and weighs about 30 lb. Model 404 uses a magnetic core memory system with data being stored in parallel binary-coded-decimal form. Data can be read out directly from the memory into a printed device without auxiliary equipment.

CIRCLE 320 ON READER SERVICE CARD

D-C Torque Motor
SMALL SIZE

CURVIN DEVELOPMENT CO., 13735 Saticoy St., Van Nuys, Calif., offers a pancake type d-c torque motor. The armature is completely encapsulated in a Fibreglas reinforced high temperature epoxy to provide the maximum in reliability. Model 112 is 2.812 diameter by 0.625 long and produces in excess of 35 oz-in. of torque when supplied with 26 v d-c.

CIRCLE 321 ON READER SERVICE CARD

Delay Line
MAGNETOSTRICTIVE

DELTIME INC., 139 Hoyt St., Mamaroneck, N.Y. Model 165 high resolution magnetostrictive delay line features a fixed delay time of 5,000 to 6,000 μsec. It is hermetically sealed and measures 12 by 13 by 13/32 in. Maximum pulse repetition rate is 1 Mc; input pulse width 0.5 μsec. Operable at temperatures of —55 C to + 80 C.

CIRCLE 322 ON READER SERVICE CARD

Grid Board Kits

CORNING ELECTRONIC COMPONENTS, Bradford, Pa. Fotoceram grid board kits enable designers to make prototype printed circuitry in 15 minutes.

CIRCLE 323 ON READER SERVICE CARD

Silicon Computer Diodes
ALL-GLASS CONSTRUCTION

MICROWAVE ASSOCIATES, INC., Burlington, Mass. Six high speed diffused silicon mesa computer diodes (MA-4303 through MA-4308) with all-glass microminiature packaging are available. All meet the environmental specifications of MIL-S-

CIRCLE 103 ON READER SERVICE CARD→

19500B. Direct fusion of hard glass to junction provides significant electrical and mechanical improvements.

CIRCLE 324 ON READER SERVICE CARD

Surge Test Unit

SELF-CONTAINED

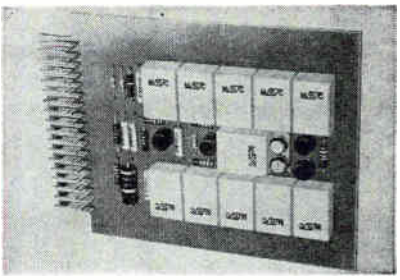
WALLSON ASSOCATES, INC., 912 Westfield Ave., Elizabeth, N. J. Model 220 surge current generator permits surge testing of silicon rectifiers with currents continually adjustable from 25 to 630 amperes peak. It features single half-wave sinusoidal pulse output; sync and calibrated output monitor for oscilloscope display; and provision for sequential testing.

CIRCLE 325 ON READER SERVICE CARD

Accelerometer

ENDEVCO CORP., 161 East California Blvd., Pasadena, Calif. Accelerometer model 2219 features a high output of 250 pk-mv/pk-g.

CIRCLE 326 ON READER SERVICE CARD



Shift Register

MULTIDIRECTIONAL

MAGNETICS RESEARCH CO., INC., 179 Westmoreland Ave., White Plains, N.Y. Magnetic shift register is capable of steering information under control of a single flip-flop mounted on the p-c card. Information is taken in and out of the 10 bit register in series or in parallel. Direction of information transfer can be changed in between shift pulses.

CIRCLE 327 ON READER SERVICE CARD

Literature of the Week

RESINS Isochem Resins Co., 221 Oak St., Providence 9, R. I., "Epoxy Casting and Adhesive Resins of Adjustable Flexibility" is a data sheet describing hardeners based on improved versions of Versamide, Thiokol, and a modified flexible amine.

CIRCLE 328 ON READER SERVICE CARD

PRODUCT BULLETIN Electro-Mech Corp., Reliance Instrument Div., Norwood, N. J. A 20-page bulletin reviews all equipment necessary to a complete combustion control system for industrial and commercial installations.

CIRCLE 329 ON READER SERVICE CARD

POWER SUPPLIES Harrison Laboratories, Inc., 45 Industrial Rd., Berkeley Heights, N. J. Short form catalog covers 22 regulated transistorized power supplies.

CIRCLE 330 ON READER SERVICE CARD

ANTENNA DESIGN Blaine Electronics, Inc., 14757 Keswick St., Van Nuys, Calif. Reference data card contains graphs and charts showing sizes, distances, and values of most required set-up data for recording antenna radiation patterns.

CIRCLE 331 ON READER SERVICE CARD

FOIL CAPACITORS General Electric Co., Schenectady 5, N. Y. Four page bulletin covers the Tantalytic foil electrolytic capacitors for high-reliability applications.

CIRCLE 332 ON READER SERVICE CARD

HEAT RADIATORS The Birtcher Corp., 745 S. Monterey Pass Rd., Monterey Park, Calif. Sixteen-page catalog describes transistor-diode heat radiators. Drawings of more than 72 semiconductor radiators are included.

CIRCLE 333 ON READER SERVICE CARD

ULTRASONIC CLEANING Branson Instruments, Inc., 40 Brown House Rd., Stamford, Conn. "Chemicals for Ultrasonic Cleaning", a 14-page booklet, discusses the physical properties, applications and working temperatures of cleaning chemicals.

CIRCLE 334 ON READER SERVICE CARD

PULSE TRANSFORMERS Hamilton Watch Co., Electronics Div., Lancaster, Pa. Pulse transformer kit to assist in the design of new circuits where the exact transformer need is not known is described in a single data sheet.

CIRCLE 335 ON READER SERVICE CARD

RECORDER PENS Write Right Co., P. O. Box 1081, Houston 1, Tex. A 4-page bulletin describes two automatic ink-feed systems and a universal nib.

CIRCLE 336 ON READER SERVICE CARD

TEMPERATURE SENSORS Trans-Sonics, Inc., P. O. Box 328, Lexington 73, Mass. Product note covers high precision temperature sensors for use with the company's electronic thermometer.

CIRCLE 337 ON READER SERVICE CARD

RESISTOR NOISE Quan-Tech Laboratories, Boonton, N. J., has issued a brochure discussing problems in the accurate measurement of resistor noise and describing a noise test set.

CIRCLE 338 ON READER SERVICE CARD

CERAMIC CAPACITORS Mucon Corp., 9 St. Francis St., Newark 5, N. J. Six-page bulletin gives properties of subminiature capacitors made from one of thirteen ceramics and shows range of capacitance values.

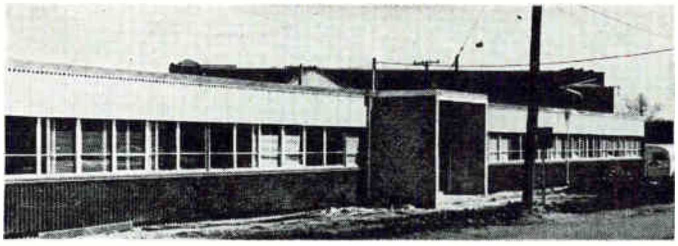
CIRCLE 339 ON READER SERVICE CARD

AUTOMATION & CONTROL Telechrome Mfg. Corp., Hammarlund Automation Div., Amityville, L. I., N. Y. Brochure covers telemetering, remote control, data processing and data transmitting systems.

CIRCLE 340 ON READER SERVICE CARD

SYNCHROS Vernitron Corp., 125 Old Country Road, Carle Place, L. I., N. Y. Detailed specifications to aid in rapid selection of size 23, 60 cycle Thru-Bore synchros for servo applications are given in data sheet CS/TS-6-23-1.

CIRCLE 341 ON READER SERVICE CARD



Gulton Battery Division Moves

GULTON INDUSTRIES' Alkaline Battery division, a producer of nickel-cadmium batteries, has moved from Lodi, N. J., to new consolidated headquarters at Metuchen, it has been announced by Bernard Mayer, manager of the division.

The division has moved from two separate plants in Lodi, each occupying a space of 10,000 sq ft, to expanded facilities aggregating 40,000 sq ft.

Mayer said the move was made necessary by expansion of Gulton's battery business, the need for new research and development laboratories and the growth of Gulton's engineering and test facilities.

In recent months the company has received research contracts for development of nickel-cadmium and silver-cadmium batteries. In addition, new research into fuel cells and other power sources and energy conversion systems has been initiated by the division.

Gulton's nickel-cadmium batteries are used as power sources in missiles and rockets, as stand-by equipment for utilities and industrial plants, as well as for aircraft starting and many related applications.

A major breakthrough in the division's research and development laboratories occurred in late 1960 when a truly hermetically sealed nickel-cadmium battery was produced for use in space vehicles.

Gulton Industries comprises twelve domestic divisions and three recently-announced foreign subsidiaries in Great Britain, France and Israel. The company produces electronic components, instruments, equipment and systems for industrial, military, space and consumer markets.

Kuhlman Accepts Key Resistor Post

ORA F. KUHLMAN has been appointed director of engineering for Key Resistor Corp., Gardena, Calif. Prior to joining the company, he owned and operated Kuhlman Engineering Co.

NAB Promotes G. W. Bartlett

GEORGE W. BARTLETT, former station chief engineer and longtime staff member of the National Association of Broadcasters, has moved up from assistant manager to acting manager of NAB's engineering department. He succeeds A. Prose Walker who has resigned as manager, effective May 16, to join the Collins Radio Corp., Cedar Rapids, Iowa.

Sprague Consolidates Resistor Activities

THE SPRAGUE ELECTRIC CO., North Adams, Mass., is consolidating all resistor manufacturing, engineering, and marketing activities in a new resistor division with headquarters at the company's Nashua, N. H., plant.

Division manager will be Richard K. Morse, with Leonard H. Wurzel as marketing manager.

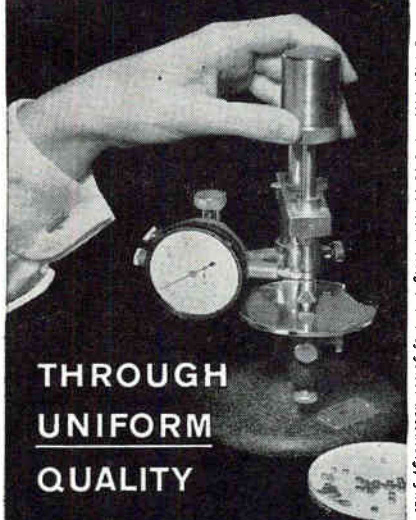
Other key appointments include Stanley Dorst as chief engineer; Fred Powers as production manager; Raymond Calvi, manager of quality assurance and reliability; and Warren K. Heinzelmann, manager of process engineering.

PRD Electronics Advances Castriota

L. J. CASTRIOTA has been promoted to the position of manager of engineering at PRD Electronics, Inc., Brooklyn, N. Y. The company, manufacturer of microwave and electronic test instrumentation, is a subsidiary of Harris-Intertype Corp., Cleveland, O.

Electronic Specialty Fills New Position

APPOINTMENT of Donald W. Moore to the newly created post of director of engineering for the ESCO facility of Electronic Specialty Co.,



Los Angeles, Calif., is announced.

Moore's experience includes three years with the Canadian General Electric Co., a year with Pacific Semiconductors, Inc., and over three years with Electrosolids Corp.

Melpar Picks Fuschillo To Direct Section

NICHOLAS FUSCHILLO has been appointed head of the solid state physics section of Melpar, Inc., Falls Church, Va.

Fuschillo formerly served as manager of the solid state physics department at CBS Laboratories, chief of the Magnetics and Semiconductor Branch at the Franklin Institute of Philadelphia, and as an assistant professor of physics at Pennsylvania State University.

Andersen Laboratories Hires Zilberstein

R. MICHEL ZILBERSTEIN recently joined Andersen Laboratories, Inc., as senior project engineer. He comes from Richard D. Brew & Co. where he designed and developed electromagnetic delay lines.

MB Electronics Fills Newly Created Post

APPOINTMENT of John R. Baker to the newly created position of direc-

tor of planning for MB Electronics, New Haven, Conn., is announced. MB manufactures products to excite, measure and control vibration.

Baker comes to MB from General Electric where he was most recently manager-countermeasure products sales, Light Military Electronics Department.

Appoint Beauregard Senior Engineer

WILFRED G. BEAUREGARD has been named senior engineer of the R&D staff of Dielectric Products Engineering Co., Inc., Raymond, Maine. Prior to this appointment he had been associated with Raytheon Mfg. Co. in its surface radar microwave group.

Sylvania Gets New President

GENE K. BEARE has been named president of Sylvania Electric Products Inc., New York, N. Y., a subsidiary of General Telephone & Electronics Corp. He succeeds Robert E. Lewis who has resigned to become president of Perkin-Elmer Corp., Norwalk, Conn.

Beare previously had been president of General Telephone & Electronics International Inc., with over-all responsibility for all GT&E manufacturing, marketing, and engineering operations outside the United States. Concurrently, he also served as president of Automatic Electric International Inc.

MicroSemiconductor Hires Plant Manager

MICROSEMICONDUCTOR CORP., Culver City, Calif., has appointed Maurice Stillwell as manager, equipment plant.

Prior to this appointment, Stillwell was the reliability equipment manager for Pacific Semiconductor's Minuteman Program.

Wehrlin Becomes Daystrom V-P

RICHARD F. WEHRLIN has been named vice president for European development of Daystrom, Inc., Murray Hill, N. J. He is former director general of international operations of The Martin Co. and former president of the Avion Instrument division of ACF Industries.

In his new post, Wehrlin will be headquartered in Geneva.

Electron Technology Appoints LeVine

ELECTRON TECHNOLOGY, INC., Kearney, N. J., designer and manufacturer of power and special purpose tubes for the electronics industry, has appointed Harris D. LeVine to the position of assistant to the president.

LeVine has had 20 years' experience in the field of power and special purpose tubes. He was formerly director of the Instrumentation Division of Health and Safety Laboratories for the Atomic Energy Commission for 13 years.

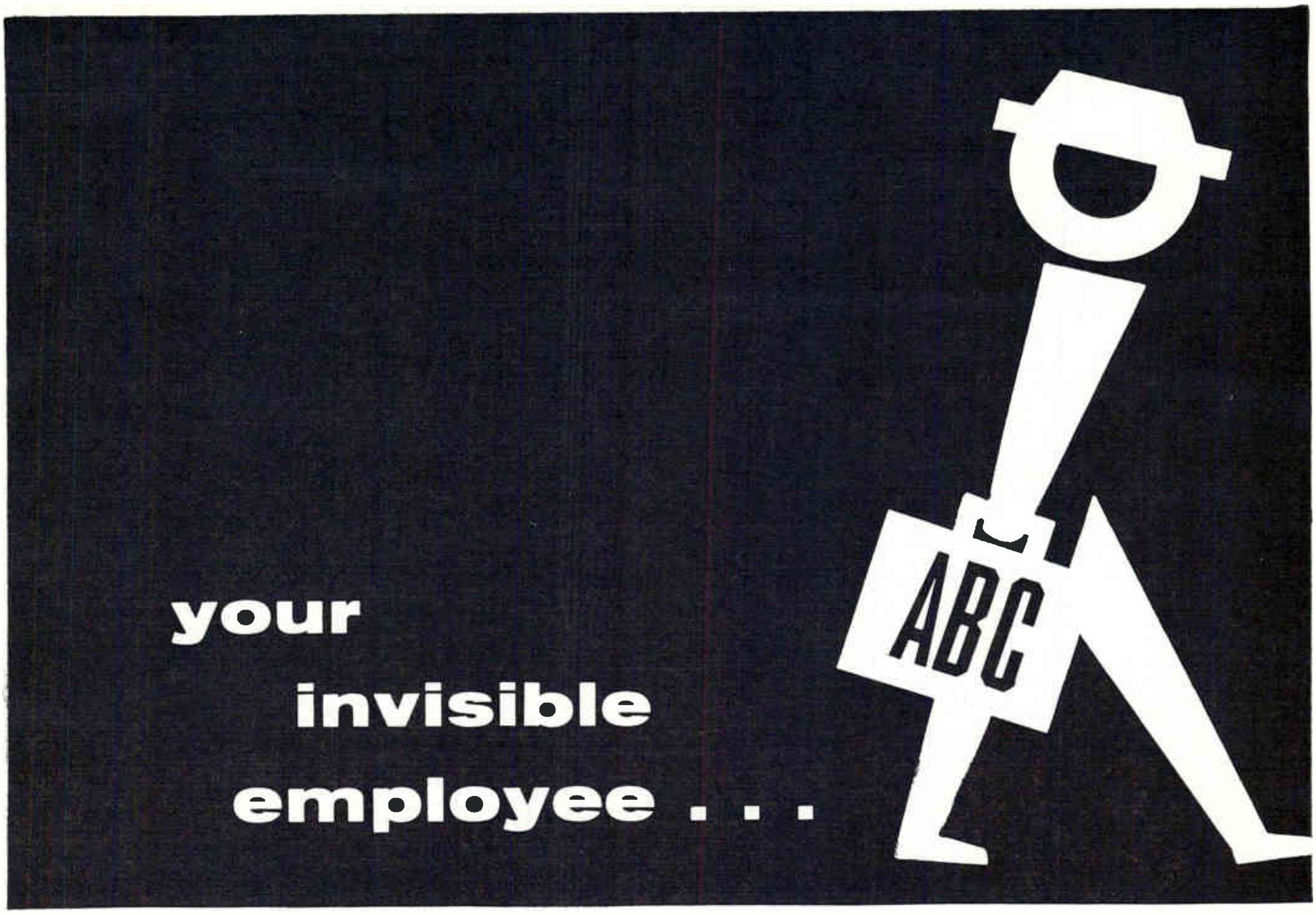
Elect Roberts to Head Core-Tronics, Inc.

JOHN A. ROBERTS has been elected president of Core-Tronics, Inc., Newark, N. J., recently formed company specializing in the manufacture of electronic powder iron cores.

Roberts, until this new appointment, was employed by General Aniline & Film Corp., New York, N. Y., for 23 years.

PEOPLE IN BRIEF

Walter E. Landauer leaves Airborne Instruments Lab to join the G. C. Dewey Corp. as senior associate in charge of the company's electronics lab. **A. V. Gangnes** of Interstate Electronics advances to the post of general manager. **Stephen W. Leibholz** promoted to project engineer at Auerbach Electronics Corp. **Joel M. Cohen**, formerly with Edgerton, Germeshausen & Grier, appointed application engineer in charge of the field-effect transistor by Crystalonics, Inc. **Ronald V. Johnson** transfers from Hughes Aircraft to the Bendix Computer Division as engineer. **John Cammarata** advances at American Bosch Arma Corp. to manager of product reliability for Arma Div. **Claire Bell**, previously with Howell Instruments Inc., named manager of instrument product engineering at Varian Associates. **J. M. Bridgman** promoted to vice president and general manager of Litton Systems (Canada) Ltd. **Howard W. Edminster**, ex-High Voltage Engineering Corp., appointed to the semiconductor sales engineering staff of Philco's Lansdale Div. **William J. Henderson** of FXR Inc. advances to general sales manager.



He's not on your payroll . . . he takes up no desk space in your office . . . and he doesn't hang around the water-cooler talking to your secretaries. But this man works for you — and for every other advertiser.

What does he do? He helps to safeguard your advertising investments in print media — by providing audited circulation facts and figures on 2,900 publication members of the Audit Bureau of Circulations*. Assuring an accurate accounting, he tells you how many people purchased the publication . . . where they live . . . how much they paid . . . and the answers to many other questions about the publications and your markets.

He gives you factual marketing information as the basis for your advertising investments. He walks into every ABC-member publication's office and audits its circulation — just as carefully and as objectively as a financial auditor might check your books.

When he is finished, the guesswork is gone! He gives you facts — no opinions, pleasant statistics, *maybe* projections, or fancy figures — just plain old fashioned circulation facts.

Who is he?

He is the ABC auditor — and he works for *you!*

electronics

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electronics

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1. Review the positions in the advertisements.
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3. Notice the key numbers.
4. Circle the corresponding key number below the Qualification Form.
5. Fill out the form completely. *Please print clearly.*
6. Mail to: D. Hawksby, Classified Advertising Div., ELECTRONICS, Box 12, New York 36, N. Y. (No charge, of course).

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APPLIED PHYSICS LABORATORY The Johns Hopkins University Silver Spring, Maryland	145, 166*	1
BAUSCH & LOMB INC. Rochester, New York	180*	2
BRENTEN EMPLOYMENT AGENCY Newark, New Jersey	180*	3
ERIE ELECTRONICS DIV. Erie Resistor Corp. Erie, Pa.	120	5
GENERAL ELECTRIC Defense Systems Dept. Syracuse, New York	178*	6
GENERAL ELECTRIC Heavy Military Electronics Dept. Syracuse, New York	181*	7
HORIZONS INC. Cleveland, Ohio	120	8
HOUSTON INSTRUMENT CORP. Houston, Texas	178*	9
HUGHES AEROSPACE ENGINEERING DIV. Hughes Aircraft Company Culver City, California	49	10
IBM CORP. New York, New York	179*	11
LOCKHEED MISSILES & SPACE DIV. Sunnyvale, California	54, 55	12
McGRAW-HILL PUBLISHING CO., INC. New York, New York	122	13

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electronics WEEKLY QUALIFICATION FORM FOR POSITIONS AVAILABLE

Personal Background

NAME ....

HOME ADDRESS..

CITY......................... ZONE...... STATE...........

HOME TELEPHONE...

Education

PROFESSIONAL DEGREE(S)....................................

MAJOR(S) ....

UNIVERSITY ....

DATE(S) ....

FIELDS OF EXPERIENCE (Please Check)

551

☐ Aerospace	☐ Fire Control	☐ Radar
☐ Antennas	☐ Human Factors	☐ Radio—TV
☐ ASW	☐ Infrared	☐ Simulators
☐ Circuits	☐ Instrumentation	☐ Solid State
☐ Communications	☐ Medicine	☐ Telemetry
☐ Components	☐ Microwave	☐ Transformers
☐ Computers	☐ Navigation	☐ Other ....
☐ ECM	☐ Operations Research	☐ ....
☐ Electron Tubes	☐ Optics	☐ ....
☐ Engineering Writing	☐ Packaging	☐ ....

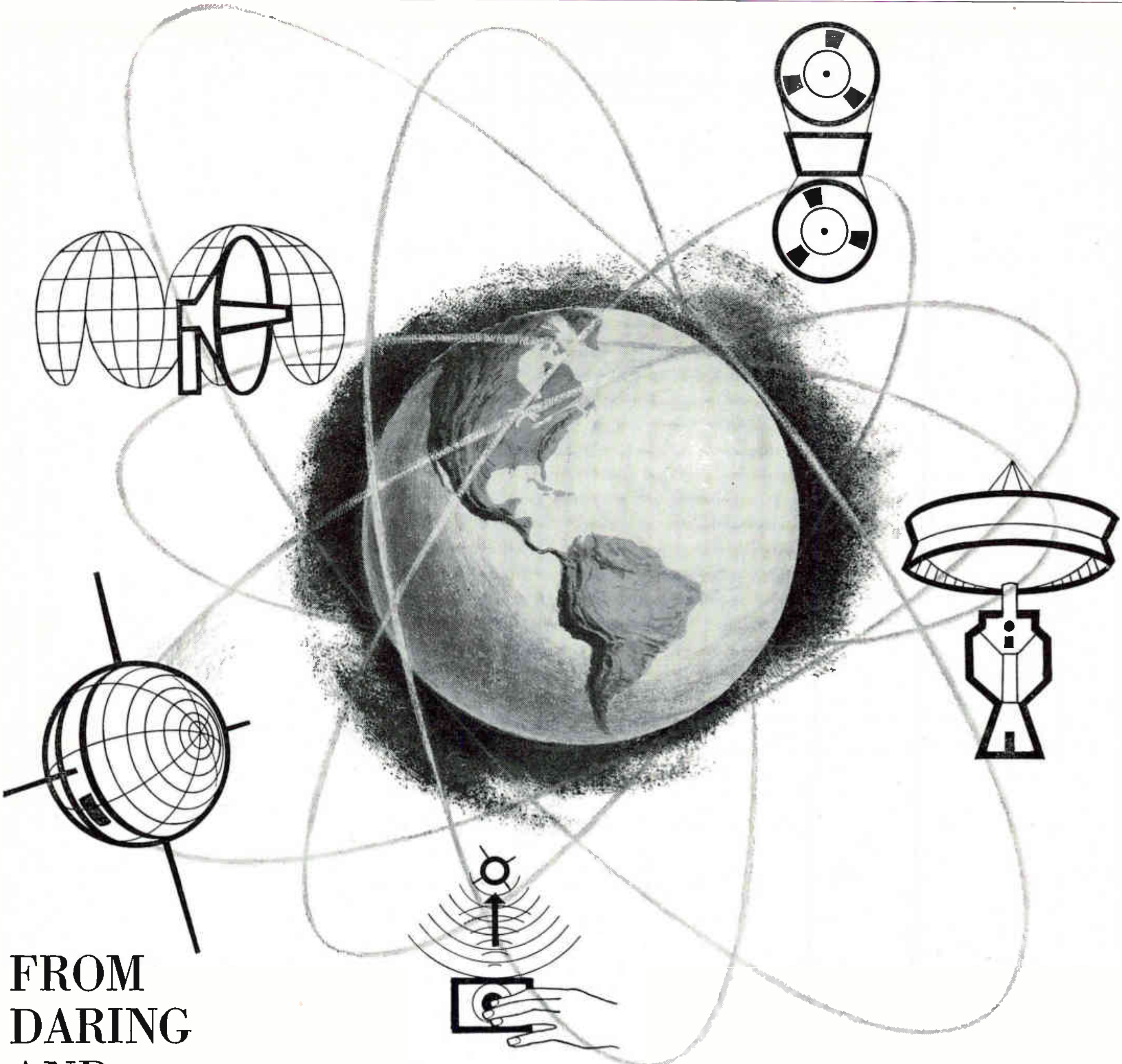
CATEGORY OF SPECIALIZATION

Please indicate number of months experience on proper lines.

	Technical Experience (Months)	Supervisory Experience (Months)
RESEARCH (pure, fundamental, basic)	......	......
RESEARCH (Applied)	......	......
SYSTEMS (New Concepts)	......	......
DEVELOPMENT (Model)	......	......
DESIGN (Product)	......	......
MANUFACTURING (Product)	......	......
FIELD (Service)	......	......
SALES (Proposals & Products)	......	......

CIRCLE KEY NUMBERS OF ABOVE COMPANIES' POSITIONS THAT INTEREST YOU

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25



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Experienced graduate EE's with 3 to 5 years in logic design and transistorized circuit design of digital equipment. Assignments will entail logic and circuit design of buffer storage units and digital peripheral equipment.

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Expanding commercial program offers excellent opportunity to apply advanced techniques in miniaturization. Applicant should have ME degree and substantial experience in packaging techniques for core-type memories and complex digital systems.

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An important position entailing investigation of semiconductor devices for purpose of establishing mathematical models and design parameters used in circuit design. Requires minimum of 3 years' experience and some background in computer circuitry, transistors, diodes, resistors, and transient phenomena.

Senior Product Engineers

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Senior and Intermediate

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ELECTRONICS DIVISION
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PL 7-1811

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BURLINGTON, MASS. — on famous "Electronics Row" in suburban Boston. Advanced Systems Laboratories opened in November 1960

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NASHUA, NEW HAMPSHIRE

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electronics

WEEKLY QUALIFICATIONS FORM FOR POSITIONS AVAILABLE

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PHILCO WESTERN DEVELOPMENT LABS. Palo Alto, California	118	15
REMINGTON RAND UNIVAC Div. of Sperry Rand Corp. St. Paul, Minnesota	175*	16
REPUBLIC AVIATION Farmingdale, L. I., New York	122	17
SANDERS ASSOCIATES, INC. Nashua, New Hampshire	120	18
SIKORSKY AIRCRAFT Div. of United Aircraft Corp. Stratford, Connecticut	121	19
P-6542	122	20

*These advertisements appeared in the 4/28/61 issue.

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To satisfy the demands of more sophisticated electronic systems, Sikorsky now has openings for competent electronic engineers with particular skills in design, instrumentation, test, development, air-borne systems, production and service support equipment, trainers and simulators.

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pioneer and leading manufacturer of rotary wing aircraft

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ELECTRONIC SYSTEMS ENGINEERS...

create the optimum neuro-pattern linking the electronic "brains" of Republic's F-105D

Shown here: some of the electronic devices enabling the F-105D pilot to be fighter-pilot, bombardier, navigator, gunner, and radar operator in one.

This revolutionary aircraft, the most fully automatic one-man fighter-bomber yet conceived, incorporates the most complete and sophisticated array of electronic systems ever assembled in one aircraft.

Integrating the black boxes that comprise the electronic "brains" of the F-105D requires an overall systems network of complete compatibility... a "neuro-pattern" comparable in organization and self-regulation to that of a high order of living organism. It's a tough assignment, but if you like to tackle advanced systems integration, you'll enjoy the challenging problems involved in the following areas:

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High speed tape recorders
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Communications
Servomechanisms

If you have an EE or Physics degree and 5 or more years experience in one of the above areas, we invite you to write in confidence to:
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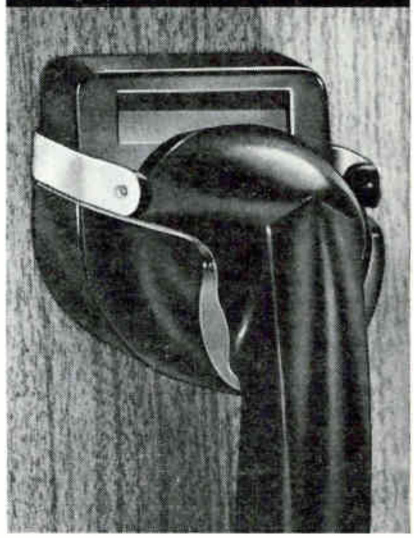

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THE ONLY DIFFERENTIAL DIGITAL VOLTMETER. Completely isolated, guarded inputs eliminate ground loop problems, reject common-mode hum and noise, allow stable, accurate AC or DC measurement at differing ground potentials—regardless of whether printer or other output equipment is grounded or floating.

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DC RANGE:
±0.001 to ±999.9 volts in 3 automatic or manual ranges, automatic polarity.

AC RANGE:
0.001 to 999.9 volts, in 3 automatic or manual ranges, 60 to 1000 cps.

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INPUT IMPEDANCE:
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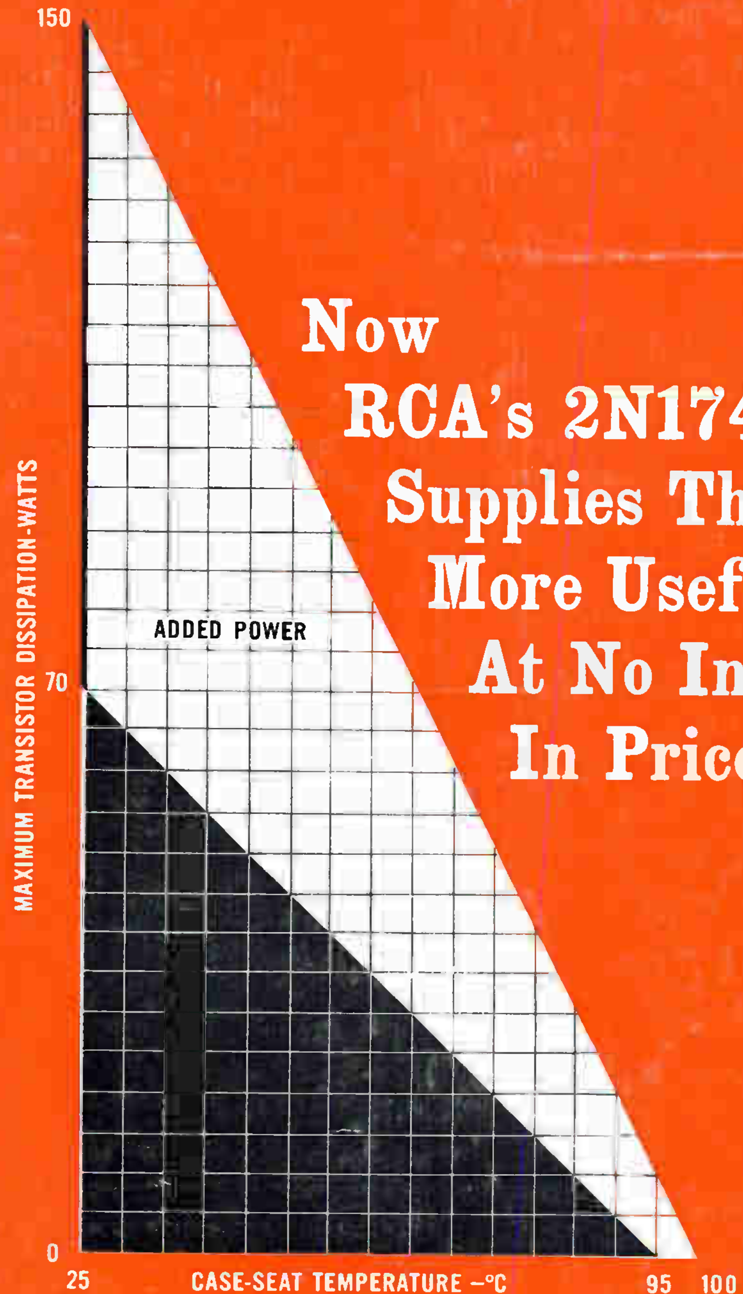

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MAXIMUM RATINGS, Absolute-Maximum Values:

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COLLECTOR-TO-BASE VOLTAGE: With emitter-to-base reverse bias of —1.5 volts (Ic = 4 ma)	—40	—50	—60	—80	—80	—100	—100	volts
EMITTER-TO-BASE VOLTAGE (Ic = 4 ma)	—20	—30	—40	—60	—40	—60	—80	volts
COLLECTOR CURRENT	—15	—15	—15	—15	—15	—15	—15	amp
EMITTER CURRENT	15	15	15	15	15	15	15	amp
BASE CURRENT	—4	—4	—4	—4	—4	—4	—4	amp
TRANSISTOR DISSIPATION: At case-seat temperature of 25°C and for operation with heat sink	150 ~~70~~	150 ~~70~~	150 ~~70~~	150 ~~87.5~~	150 ~~87.5~~	150 ~~87.5~~	150 ~~87.5~~	watt ~~watts~~
MAX. THERMAL RESISTANCE: (junction to case)	.5 X	.5 X	.5 X	.5 X	.5 X	.5 X	.5 X	°C/watt ~~°C/watt~~

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