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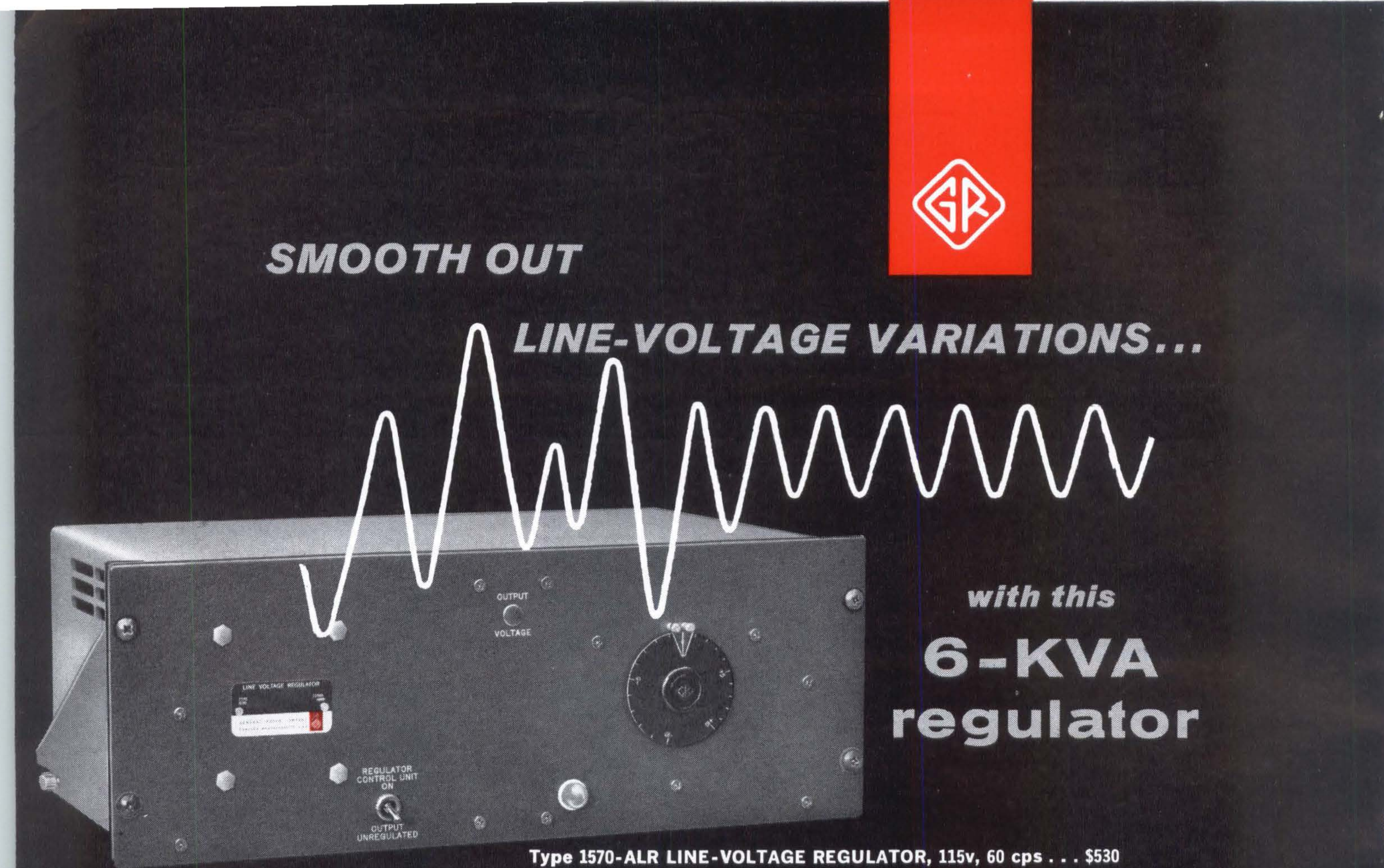

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July 13, 1962

electronics

A McGraw-Hill Publication 75 Cents

W. W. MacDONALD, Editor

Contents continued

electronics

July 13, 1962 Volume 35 No. 28

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DEPARTMENTS

IEEE: Now Let's Get to Work

THE VOTES are in and counted. And by a substantial majority the members of the Institute of Radio Engineers and the American Institute of Electrical Engineers have agreed to merge. So, whether you call the new body the IEEE, the I-triple-E or just IE^3, the Institute of Electrical and Electronic Engineers, more than 160,000 strong, will come into being January 1, 1963.

Some of us had misgivings about the merger. These misgivings were not over the desirability of achieving unity within our profession. They were, rather, over many unanswered questions about the detailed operations of the combined society.

We who voted for the merger in many cases did so in spite of doubts. In effect, we gave the officers of IRE and AIEE and the committee members who put the merger together a blank check on faith because we felt the advantages of the combined society would outweigh its disadvantages. In many cases, members voted affirmatively in spite of uncertainty concerning the constitution and the articles of consolidation and equivocal statements of society officers, not because of them.

Now that the merger is a fact it is up to the officers and members of the IEEE to make the new institute really work. It should combine the best features of both the IRE and AIEE.

Let's look at some of the objections and questions raised during merger talks:

- Some AIEE members said the new society would be less democratic than the AIEE. The AIEE has a nominating committee that represents both incumbent national officers and professional and regional interests. In the new society, the nominating committee is the incumbent Board of Directors itself. It could become self-perpetuating. However, if the board is unresponsive to legitimate interests of groups or individuals, or acts in an arbitrary or inequitable fashion, the constitution can be amended to curb the board's powers and change its manner of nomination. Amendment can be proposed by petition of 500 members, and achieved by two-thirds vote among the membership; twenty percent or more of all members must cast ballots.
- The first IEEE Board of Directors will have to make many important decisions. Membership requirements must be spelled out in detail. And here a firm line must be drawn between professional qualifications and society size. Will IEEE membership be meaningful, or will we take everybody with a few dollars in his jeans and a hankering to wear our membership insignia?
- The existing IRE Professional Groups and AIEE Technical Groups must be realigned into IEEE Professional Technical Groups. The ground rules say that groups with conflicting interests must consolidate or redefine their fields of interest. It will take infinite wisdom to accomplish this without alienating many sincere and dedicated individuals.
- Merger papers say that IRE and AIEE sections may delay consolidation where two sections exist in one overlapping area. But how long may they delay? Might we not have, in fact, a single institute that is really a federal union of two institutes if consolidation drags on indefinitely? There has to be some time limit, however generous.
- There has been no decision on what to do about the institute's publications. It is generally believed that the *Proceedings of the IEEE* will be a vehicle for publication of original work of broad significance. The *Transactions* of the various PTGs will provide for publication of important work of narrower interest. What happens to *Electrical Engineering?* Is it needed at all?
- Last, but far from least, there is the matter of engineering standards for definitions, measurements, terminology and symbology. To some engineers this is a key activity of the institute. The merger documents are uniformly silent on this important issue.

The IEEE ballots are in and the word is out. The largest professional engineering society in the world is on its way. But the work for officers and members alike has just begun.

Coming In Our July 20 Issue

MICROWAVE PHOTOTUBE. R. G. E. Hutter of Sylvania describes how these tubes detect microwave modulation and mix modulated with unmodulated laser beams to make possible superhet optical receivers.

COMMENT

Complex-Dielectric Capacitors

On page 66 of the May 11 issue of ELECTRONICS, which contained the story round-up on Modern Electronic Components, there appears a statement by Mr. J. F. Ferrante, Vice President and Research Director of Cornell-Dubilier Electronics that "A forthcoming capacitor development will employ Mylar and polystyrene film that will feature a T-C curve that is virtually horizontal.

We would appreciate it if you would call to the attention of your readers that capacitors employing a complex dielectric consisting of polyethylene terephthalate (Mylar) and polystyrene are not a new development. These capacitors were invented by Dr. Preston Robinson, Director and Consultant to the Sprague Electric Company, and Mr. David B. Peck, now Vice President and Manager, Special Products Division.

Our patent application was filed on October 22, 1952, and U. S. Letters Patent 2,749,490 were granted on June 5, 1956.

Capacitors employing this complex dielectric and having a virtually horizontal T-C curve have been commercially marketed by Sprague under the trademarks Isofarad and Filmite 'F' as plastic-encased and metal-clad capacitors, respectively.

SIDNEY L. CHERTOK
Sprague Electric Company
North Adams, Massachusetts

R & D and Profit

I have been a reader of ELECTRONICS for a considerable number of year. I saw my first copy in the early 1930's and have subscribed over a substantial number of years. I've seen the magazine change from a thin pioneer to a commanding position as a monthly record of the practical and useful, and to its current weekly format. It is in this context that I find myself greatly encouraged by your editorial [on R & D and profit]. The Dangerous Years, in your issue of June 1 (p 122).

There are two sources of encouragement; by your editorial you have taken a step toward establishing ELECTRONICS as a stronger, clearer voice in a growing industry that very desperately needs help and guidance. Your magazine and the industry will profit from a continuing editorial policy that permits further study and discussion of industry problems. Also the actual content of this one editorial has been seeking a voice for some time. Congratulations.

There are several basic problems which you suggest. The progress that is needed to obtain understanding of business by the Government is excellently stated in your editorial. We seem (possibly as a short-sighted expedient policy) to be developing a government philosophy which is forgetting the basics of the American system that has proved so fabulously successful in the past. These basics are simple. By making a contribution, by providing something new and useful, we earn a profit *commensurate* with the contribution, a profit which can then be freely used to take further risks to provide additional new and useful products and services. What we pay in future years for today's expediency may well dwarf the apparent cost of current profits.

I'd like to suggest another industry problem for your consideration. For a number of years, we've been concerned by the qualitative and quantitative inadequacy of our technical talent. Great effort has been made to increase the number of engineering graduates. The fact that business came so easily and failure was relatively hard to achieve, has made us overlook the weakness that fast growth and easy times have developed in our management ranks.

This is such a critical problem that it may be more serious than our shortage of technical talent. For this reason it may well be better for the technical schools to drop some of their technical instruction in favor of instruction in business fundamentals. At least the students might then be self-sufficient to the point of needing less supervision.

F. G. MARBLE
Systron-Donner Corporation
Concord, California

FOR YOUR MICROWAVE APPLICATIONS SPECIFY ARNOLD C-TYPE MAGNETS

Arnold C-type Alnico Magnets are available in a wide selection of gap densities ranging from 1,000 to over 7,500 gausses. There are six different basic configurations with a wide range of stock sizes in each group.

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When used in transverse field isolators, Arnold C Magnets supply the magnetizing field to bias the ferrite into the region of resonance, thus preventing interaction between microwave networks and isolating the receiver from the transmitter. These magnets are also used in differential phase shifters and duplexers, and Arnold is ready to design and supply tubular magnets to provide axial fields in circular wave guides.

A feature of all Arnold C Magnets is the excellent field uniformity along the length of the magnet. Versatility in design may be realized by using multiple lengths of the same size magnet stacked to accomplish the needs of your magnetic structure.

Let us work with you on any requirement for permanent magnets, including high coercive force Alnico VIII for TWT focusing applications. ● For information on Arnold C Magnets, write for Bulletin PM-115. For data on Alnico VIII, ask for Bulletin PM-119. Address *The Arnold Engineering Company, Marengo, Illinois.*

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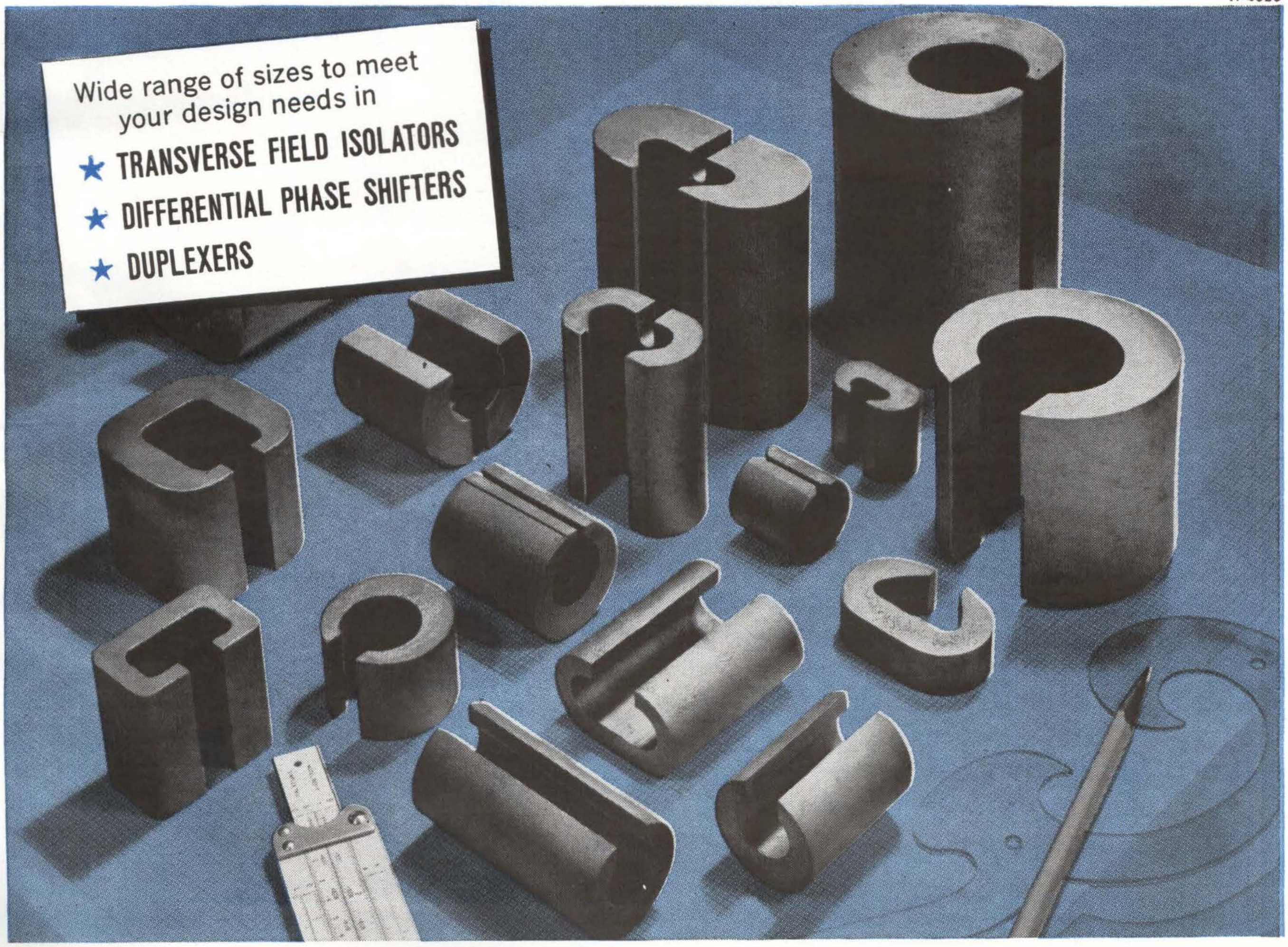

ELECTRONICS NEWSLETTER

NATO Air Defense Market To Be Competitive

ADMINISTRATIVE ORGANIZATION for creating an air defense system for the NATO countries of Europe will be set up in Paris early next month and functioning by mid-September. Initiated by the Defense Department's Office of Research and Engineering, with consulting support by the non-profit Mitre Corp., the NATO group will be called the Systems Engineering Management Organization (SEMO).

Parallel with SEMO will be a team of national experts to assist SEMO in preparing specifications for the equipment to be bought. For this group, Mitre will provide the leadership and about five technical staff members. Industry will lend about ten technical men to Mitre for the duration, probably one year.

How elaborate the air defense system will be, how much gear will be bought from the U. S. and how much from Europe, remains to be seen. At best, competition will be tight.

Where Bulk of NASA's 1963 Money Will Go

WASHINGTON—Largest layout in NASA's 1963 spending will go for Advanced Manned Space Flight—$863,628,000. For the manned 1-day missions—$12.2 million; Gemini—$203.2 million; and Apollo—$617.2 million. All this is over and above the $13.3 million slated for Mercury in 1963.

Lunar and planetary exploration will get $263,560,000—almost $100 million more than was budgeted for this program in 1962. For the lunar flight program alone, Ranger will get $44 million; Surveyor, $97.3 million and Prospector, $400,000. For the planetary and interplanetary flight program: Mariner R, $9.2 million; Mariner B, $73.7 million; and Voyager, $6.8 million.

Scientific satellites will cost $175.1 million, with orbiting observatories getting the larger portion—geophysical, astronomical and solar. The sounding rocket program will expand to a $19 million effort. NASA will buy approximately 160 sounding rocket vehicles.

Slated for tracking and data acquisition—$158.4 million; nuclear systems technology—$122.9 million; advanced Saturn—$335.1 million; Saturn C—$249.2 million; and Nova—$163.5 million.

Infrared Generating Diode Developed at MIT

BEDFORD, MASS.—A gallium arsenide diode has been developed at Lincoln Laboratory that generates modulated ir light with an intensity of 2,500 watts per sq cm.

The diode does not produce coherent radiation, but is said to provide a combination of high power, narrow spectral bandwidth and high speed reaction to input. It may be a candidate for some communications applications proposed for the optical maser.

When operated at liquid nitrogen temperatures, electrical input is converted into ir light in a band only 100 angstroms wide, centered at 8,600 angstroms. In tests a peak ir power of 3 watts has been achieved. Larger diodes are expected to yield peak outputs of 15 Kw.

The diode is fabricated from N-type single-crystal Ga-As diffused with P-type zinc. For optimum efficiency, the diodes are operated at liquid nitrogen temperature. At room temperature, a light spectrum of about 300 angstroms wide, centered at 9,300 Mc is produced.

World's Fastest Computer Is Ordered by AEC

WASHINGTON — An electronic computer of unprecedented speed is to be developed for one of the Atomic Energy Commission's key weapons labs by Control Data Corp., Minneapolis. The $5,574,000 contract calls for a computer system faster than any existing machine to be installed at Lawrence Radiation Laboratory, Livermore, Calif., for testing by Feb. 29, 1964.

The system, known as the 6600, consists of a single central processor with a high-speed arithmetic and logical unit, a central memory of 61,440 words, peripheral memory processors, associated consoles and input-output equipment.

Senate Committee Gives NASA More Than House

WASHINGTON—The Senate Committee on Aeronautical and Space Sciences restored all but $10 million of the $33.3 million the House cut off the National Aeronautics and Space Administration's budget request for research, development and operation for fiscal year 1963. The $10 million reduction had been money slated for the Prospector program, the advanced mobile unmanned vehicle to land on the

Can The Electronic Lock Be Picked?

WASHINGTON—President Kennedy's request to Congress for $23.3 million for the Atomic Energy Commission for production of an electronic lock to reinforce safeguards against accidental or unauthorized firing of nuclear weapons raises a number of questions.

If the device is "an electro-mechanical system controlled by a radio signal to be sent from a command headquarters remote from the actual missile site" (as it was described by the Associated Press), how can efficient radio communications be assured to unlock the weapons should they be needed? What is to prevent jamming, or deliberate, unauthorized unlocking? Will SAC's nuclear bombs be locked? No one was answering these questions when Electronics went to press.

Moon. The Senate authorized $400,000 for continuation of in House studies on the project. Total Senate committee authorization for R&D and operations (which means "salaries and expenses") is $2,958,278,000.

The Senate committee also restored some of the money the House had knocked off NASA's request for construction of facilities. The House had cut off $82.7 million. The Senate committee reduced NASA's request by approximately $60 million. Total now authorized is $791,237,250. NASA also gets new 1962 money: $55 million for land acquisition at Canaveral and $16 million at the Mississippi Test Facility.

Soviets Say Cosmos VI Continues Space Research

MOSCOW—The Soviet Union's sixth Cosmos scientific satellite, launched June 30, is rounding the earth every 90.6 minutes, inclined 49 deg to the equator, according to Soviet news agency Tass.

Apogee is reported at 360 km, perigee at 274 km. Besides its payload for "space research" the satellite is said to carry a multichannel transmitter for telemetry, radio devices for trajectory measurements, and a transmitter operating at 90.0233 Mc.

FAA Symposium Hears Air-Collision Avoidance Plan

WASHINGTON—Air-collision avoidance technique outlined yesterday by National Co. at the FAA-sponsored symposium provides a new way to utilize altitude, minimum range and estimated time to collision—criteria that heretofore have not been considered practical due to the large airborne computer required.

National's approach reduces the demands on the computer, and therefore the computer's size. The technique measures the altitude in each aircraft with an aneroid barometer, periodically transmitting this information to all other planes. The range and range rate are measured by one-way radio transmissions from each plane, transmitted at a time precisely known to all other aircraft. Time of arrival of the signals at each aircraft is then converted to range. Precise timing is achieved by use of precise synchronized clocks.

FAA has given National a nine-month feasibility contract.

FCC Homing In On All Channel Tv Specs

WASHINGTON—Federal Communications Commission chief, Newton Minow, has asked the Electronic Industries Association to propose a deadline for prohibiting interstate shipment for sale or resale to the public of tv sets "not capable adequately of receiving uhf signals." Minow also asked EIA to outline performance capabilities to insure the set is capable of handling uhf.

In compliance with Minow's request, EIA has invited tv set and tube manufacturers to attend a meeting in New York on Aug. 7. Chief engineers are being asked to comment particularly on noise figures and sensitivity, and to base their discussions on the present level of technology rather than on anticipated future performance.

New Gear for Missile Ranges on Land and Ship

SECOND GENERATION missile tracking radar is now operational at the Atlantic Missile Range station at Antigua Island. Designated AN/TPQ-18, the radar is the transportable version of the C-band, monopulse AN/FPQ-6 (ELECTRONICS, p 26, dec. 15, 1961). The system's 29-ft dish is capable of tracking at lunar distances; can give unambiguous range readings of a beacon-carrying spacecraft at 32,000 mi. Two additional FPQ-6 installations will be checked out at AMR this fall. RCA built the new radar as well as the FPS-16, out of which it evolved.

For a new Pacific Missile Range ship, the electronics system will be designed, supplied, installed and checked out for performance by RCA under a slightly-less-than $2 million subcontract with Boland Machine and Manufacturing Co. who is converting the World War II Victory ship. A modified FPS-16 radar will be used.

In Brief...

MYSTERIOUS RESUMPTION of continuous transmission from NASA's Orbiting Solar Observatory after it developed a malfunction due to excessive spin rate on May 22 and transmitted only intermittently thereafter may be due to two things, NASA says: the spin rate was slowed back down due to either bearing friction within the turning wheel or the position of the satellite in respect to the earth's magnetic field.

MOTOROLA will develop and fabricate the ground-to-air uhf voice communications equipment (AN/TRC-87) for the 412L Air Weapons Control System.

NASA will soon open a Northeastern Operations Office in the Boston area to conduct technical and administrative liaison with contractors in the area. In the last ten months, NASA has awarded $15 million worth of contracts in New England.

RCA will build a Mobile Random Access Fieldata Computer System for the Army Electronic Proving Ground, Ft. Huachuca, Ariz. under a $2 million contract.

BURROUGHS CORP. will produce Back Up Interceptor Control—BUIC—systems for USAF under $8 million contract. Main components of the radar course directing gear are electronic computers and display equipment. BUIC is a backup for Sage.

JAPANESE GOVERNMENT has approved a joint venture between Komatsu Works, a leading heavy machinery manufacturer, and Hoffman Electronics of Los Angeles, with capitalization of $½ million to manufacture silicon diodes, solar batteries, and semiconductors that are not being currently produced in Japan.

NIPPON MUSEN of Japan has sold weather radar to Pakistan to be delivered next June. More Southeast Asian countries are expected to follow suit in ordering weather radar from Japan.

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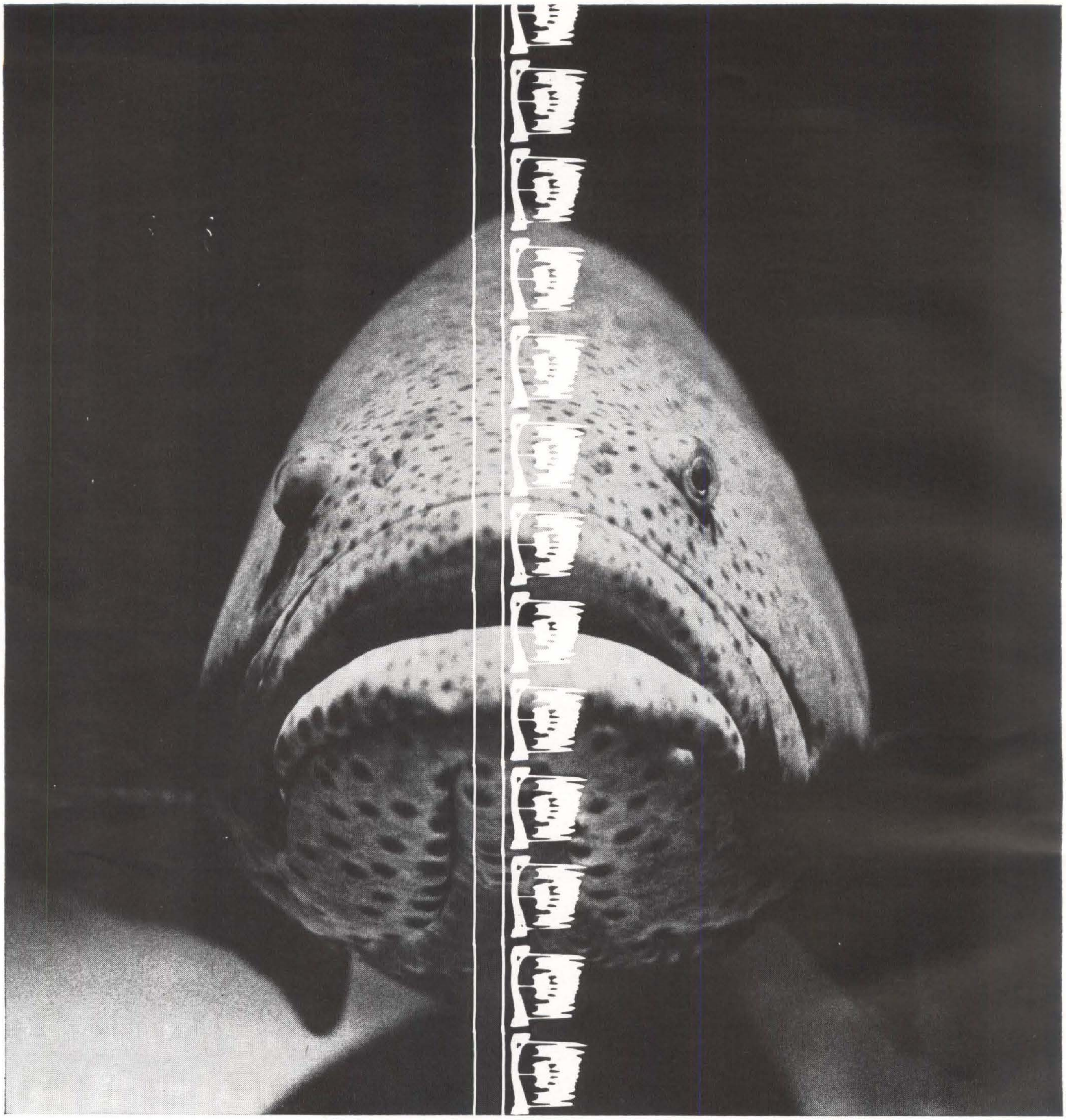
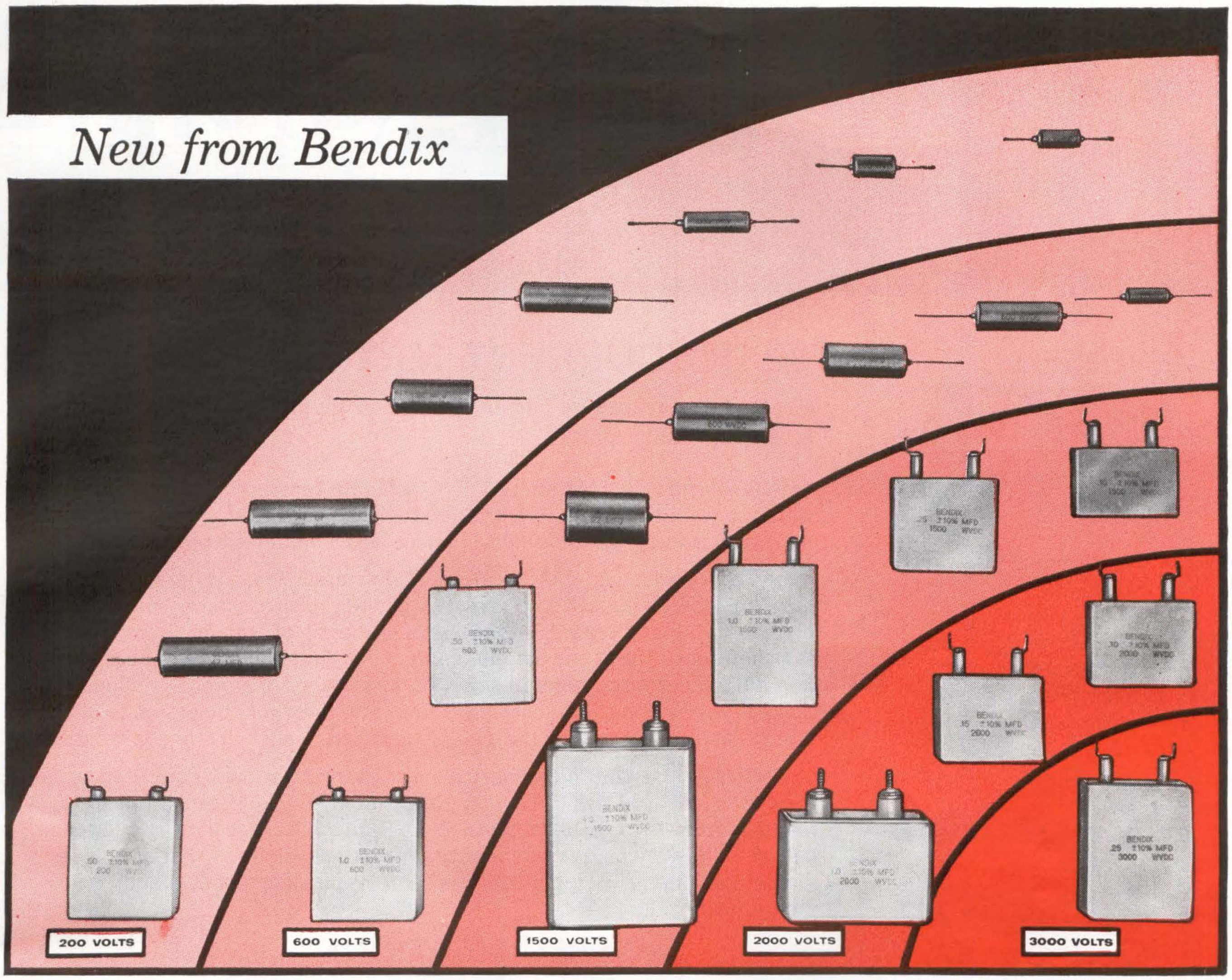


What data recorder can take pictures under the sea? **AMPEX AR-300.**

So small it can fit into the hatch of a submarine. So advanced it can capture visual images, digital data, analog data, sound waves—all at the same time. That's the Ampex AR-300. It records from 10 cycles to 4 megacycles—a wideband performance matched by no other recorder. It goes down to the sea or up into the sky. (Needs only 3½ cubic feet of space.) Together with the FR-700 laboratory recorder/reproducer, the AR-300 provides a remarkable recording system for many uses: laboratory experimentation, predetection, radar tracking, oceanography, any wideband application of today—and tomorrow. For more information on the FR-700/AR-300 write the only company providing recorders and tape for every application: Ampex Corporation, 934 Charter Street, Redwood City, California. Sales and service engineers in major cities throughout the world.



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Operable to +200°C.

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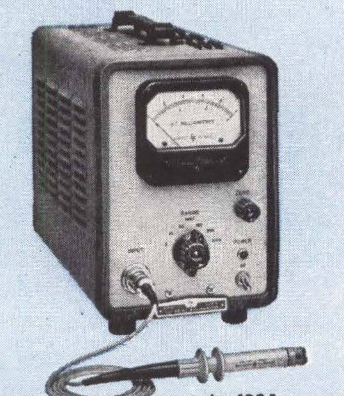

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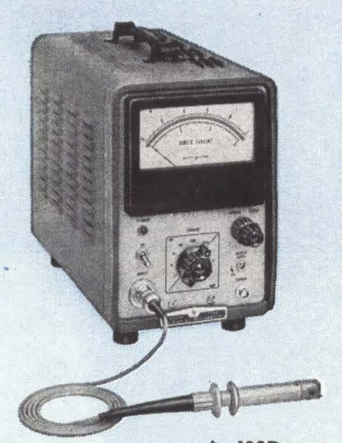

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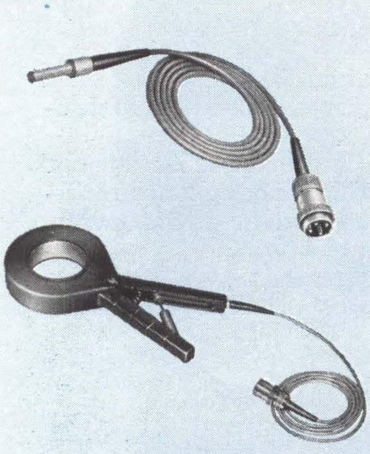


ⓗⓟ DC CURRENT METERS

Measure and record dc current, 0.1 ma to 10 amps without breaking leads or loading circuit

ⓗⓟ 428A/B current meters make fast, accurate measurements in circuits where conventional current-measuring devices would alter conditions to such an extent that the desired measurement would no longer be accurate!

In any application, ⓗⓟ 428A/B current meters are without equal for ease and speed of operation. Just clip the jaws of the probe around a bare or insulated wire and read dc—even in the presence of equally strong ac on the same wire. These current meters are also valuable for measuring sums and differences of currents in separate wires. When the probe is clipped around two wires carrying current in the same direction, their sum is indicated on the meter; when one of the wires is reversed, their difference is measured.

Models 428A and 428B are almost identical except for their current measurement range. ⓗⓟ 428B has three more ranges than ⓗⓟ 428A to give it full scale readings from 1 ma to 10 amperes. ⓗⓟ 428B also has a recorder/oscilloscope output, dc to 400 cps, to make it easy to record dc levels as well as analyze ground bus, hum and ripple currents on an oscilloscope—all without circuit loading.

SPECIFICATIONS

Current range:	ⓗⓟ 428A, 3 ma to 1 amp full scale in 6 ranges ⓗⓟ 428B, 1 ma to 10 amp full scale in 9 ranges
Accuracy:	$\pm 3\%$, ± 0.1 ma
Probe inductance:	Less than 0.5 μh introduced into measured circuit
Probe induced voltage:	Less than 15 mv into measured circuit
AC rejection:	AC with peak value less than full scale affects meter accuracy less than 2% at frequencies above 5 cps and different from the carrier (40 KC) and its harmonics. (On 428B 10 amperes range, ac is limited to 4 amperes peak.)
Output:	ⓗⓟ 428B approximately 1.5 volts and 1 ma max. for full scale
Probe insulation:	300 v maximum
Probe tip:	½" x 9/32". Aperture diam. 3/16"
Size:	Cabinet, 7½"x11½"x14¼"; rack mount, 19"x7"x13" behind panel
Weight:	Cabinet, 19 lbs.; rack mount, 24 lbs.
Price:	ⓗⓟ 428A, $500.00 (cabinet); ⓗⓟ 428AR, $505.00 (rack mount) ⓗⓟ 428B, $600.00 (cabinet); ⓗⓟ 428BR, $605.00 (rack mount)

Accessory Probes for the ⓗⓟ 428A/B DC Current Meters

New ⓗⓟ 3529A Magnetometer Probe—Useful anywhere magnetism is found and an accurate measurement of the magnetic field strength is desired: i.e. orientation of components for minimum magnetic interaction. Features direct conversion of milligauss to milliamps, so that ⓗⓟ 428 meters read magnetic field directly. Accuracy 3% $\pm$0.1 milligauss. Accuracy also depends on calibrating the probe with the specific 428 meter being used. $75.00.

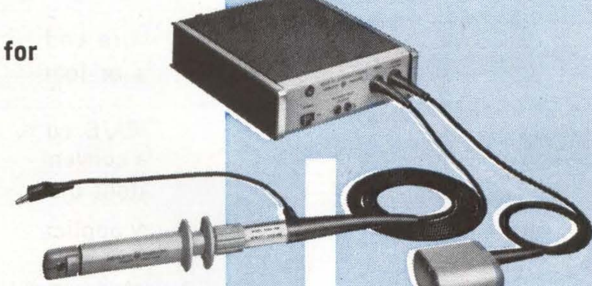
New ⓗⓟ 3528A Clip-On DC Current Probe—2⅝" aperture for large conductors: wires, pipes, multi-conductor cables (including lead-sheathed), ground straps, waveguide testing, waveguide circulating dc current testing. Accuracy obtainable equal to that of ⓗⓟ 428 meters. $350.00.

7755R

CURRENT
Without Loading Circuit

AC

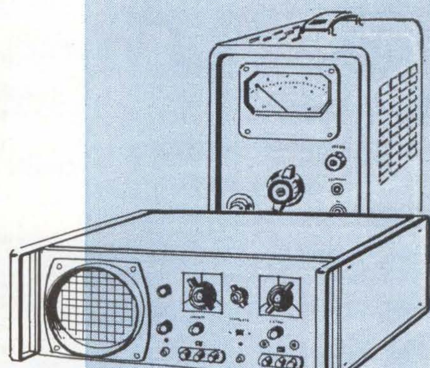
ⓗⓟ 456A AC CURRENT PROBE



Converts ac current to ac voltage directly! 1 amp = 1 volt for reading on your scope or voltmeter

Measure ac current with an ac voltmeter with the ⓗⓟ 456A AC Current Probe. Useful in observing current waveforms with an oscilloscope or measuring signal current in vacuum tubes or transistors. May also be used with electronic counters to measure frequency.

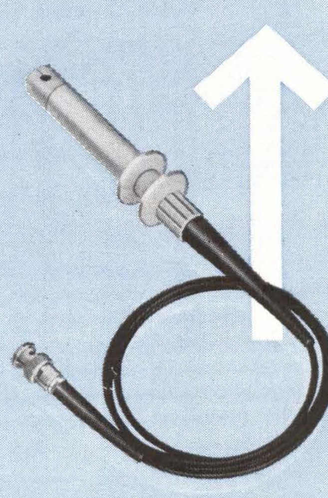
Just clamp the ⓗⓟ 456A probe around the wire under test and view or read ac current directly on your scope or voltmeter. Model 456A's 1 ma to 1 mv unity conversion permits direct readings up to 1 ampere rms. No direct circuit connection is required; there is no loading, no appreciable impedance change in the circuit under test, and the impedance of the test circuit is immaterial.



SPECIFICATIONS

Sensitivity:	1 mv/ma ±1% at 1 KC
Frequency response:	±2%, 100 cps to 3 MC ±5%, 60 cps to 4 MC —3 db at 25 cps and greater than 20 MC
Maximum input:	1 amp rms; 1.5 amp peak. 100 ma above 5 MC
Maximum dc current:	DC up to 0.5 amp has no appreciable effect
Input impedance:	Probe adds to test circuit only approx. 0.05 ohms in series with 0.05 μh
Power:	Two Mallory Battery Co. TR 233R and one TR 234 batteries. Life approximately 400 hours. AC power supply optional at extra cost
Size:	5″ wide, 6″ deep, 1½″ high
Price:	ⓗⓟ 456A with batteries, $190.00; with ac supply installed, $210.00; ac supply for field installation, $40.00

ⓗⓟ AC-21F CURRENT PROBE



ⓗⓟ AC-21F probe with 100-ohm terminations permits measurement and observation of ac currents on your scope or voltmeter without breaking circuit or inserting a resistor. The probe clamps around the wire and forms a transformer with a single-turn primary. Output is 1 mv per ma. Maximum current is 10 amps above 20 KC. Below 20 KC current capacity is reduced proportional to frequency and is 1 amp at 2 KC. DC current up to 0.5 amp has no appreciable effect on probe's operation. $100.00.

Two 100-ohm terminations are available for use with ⓗⓟ AC-21F Current Probe: ⓗⓟ AC-67B Feed-Through Termination, 2,500 cps to 30 MC bandpass, $17.50; ⓗⓟ AC-67C Compensated Termination, 1,400 cps to 30 MC bandpass, $30.00.

Data subject to change. Prices f.o.b. factory.

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WASHINGTON OUTLOOK

FCC SAYS PROMOTE ALL-CHANNEL TV NOW

MANUFACTURERS OF TV SETS and the technical staff at the Federal Communications Commission have begun working out procedures for the swing to all-channel receivers. FCC officials hope major manufacturers will go still further and initiate broad-scale promotion of 82-channel sets before they are legally required to do so.

FCC Commissioner Robert E. Lee, one of the Commission's staunchest promoters of full use of the 70 uhf and 12 vhf channels, told ELECTRONICS that it will probably be two years before manufacturers are required to market all-channel sets.

Based on a turnover rate in sets of 15 percent or 20 percent per year, it will take five to six years for substantial saturation of all-channel sets. Saturation will come sooner, Lee pointed out, if manufacturers move to promote all channel sets without waiting for the FCC's rules. Major manufacturers, he said, will be safe in moving ahead now, for they are already making sets that are certain to meet the specifications FCC sets for "adequately" receiving uhf signals.

TFX AWARD DELAYED UNTIL FALL

AWARD TO DEVELOP and produce a joint Air Force-Navy tactical fighter plane, TFX (USAF calls it the F-111A) has been delayed until Fall.

The two competitors for the contract, Boeing Co. and General Dynamics Corp. (teamed up with Grumman Aircraft Engineering Corp.) have been given 60 days to refine their proposals in a way that irons out differences in Air Force and Navy design requirements and that will establish definitive cost estimates.

Unit costs estimated by Boeing, General Dynamics and the DOD vary anywhere from $5 million to $10 million. To draw up a fixed price contract, DOD needs firmer figures than these.

TRADE BILL GAINING BI-PARTISAN SUPPORT

SENATE FINANCE COMMITTEE HEARINGS on the President's trade bill, already passed by a sweeping majority in the House, will not begin until sometime next week. Until then, industry spokesmen will have time to voice their opinions.

The bill does two major things: It gives the President power to cut tariffs—over a minimum of five years—a small amount or 100 percent (20 percent each of the five years). He can also raise tariffs up to 700 percent in some cases and work out import quota arrangements.

Second, it attempts to balance these new negotiating powers with a list of checks, restrictions, and new Presidential and other governmental responsibilities. A new trade negotiator post has been created that could turn out to be one of the country's top cabinet-level jobs.

Congress will get to send four representatives to each tariff negotiation plus a simple majority veto right over a negative decision by the President on any tariff commission ruling that recommends higher tariffs or other trade adjustment assistance.

The bill, soon to go before the Senate, is different from the one proposed by the administration. The bill now has more of a balance between an industry's right to appeal for higher tariffs and its right to be given adjustment assistance in the form of loans, technical help or tax rebates. The tariff commission will have more of a role as arbitrator than was originally envisioned by the administration.

These modifications seem to be stimulating bi-partisan support for the bill in the Senate.

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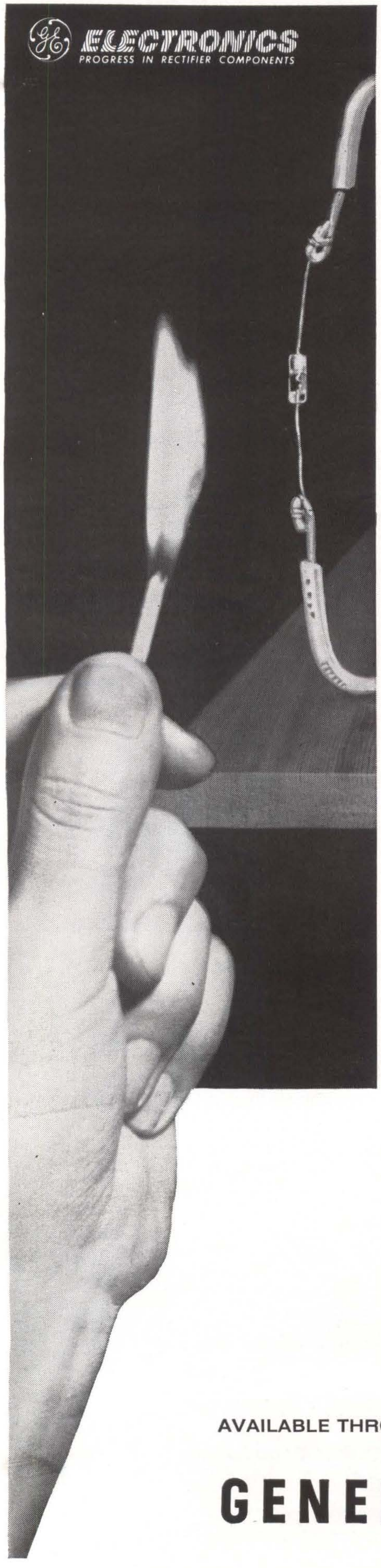
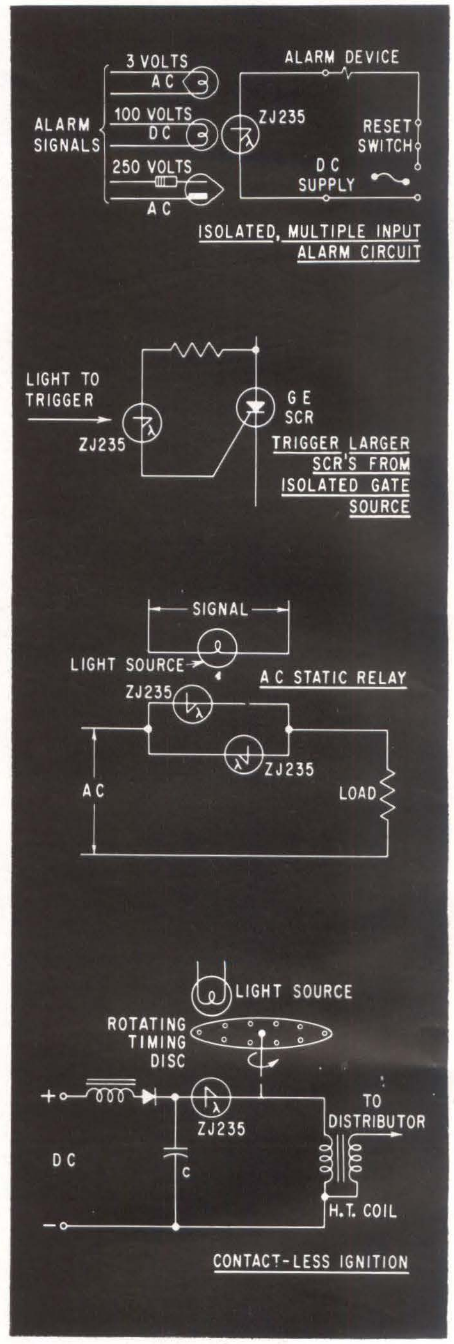


NEW LIGHT ACTIVATED PNPN SWITCH

ALL VOLTAGES IN STOCK



New applications are being found every day for the new ZJ235 subminiature silicon switch that can handle up to 160 watts of power continuously with complete electrical isolation between input and output. The circuits shown are just a few samples. The ZJ235 is 1/3 inch long, 1/8 inch diameter, rated at 400 ma d.c. in latching applications, with surge current rating of 5 amps. A short impulse of light of as little as 80 foot candles will trigger the ZJ235 into conduction, making it ideal for applications such as card and tape reading, character recognition, logic circuits, relay replacement, explosion proof static switches, tower light monitoring, and many others.

Available from stock in all voltage ratings from 50 PRV to 400 PRV, ZJ235 prices range from as low as $5 to $25 in single lot sample quantities. Ask your G-E Semiconductor Products District Sales Manager about the help available from our Application Engineering Center. Or write Section 16G66, Rectifier Components Department, General Electric Company, Auburn, New York. In Canada: Canadian General Electric, 189 Dufferin St., Toronto, Ont. Export: International General Electric, 159 Madison Avenue, New York 16, N.Y.

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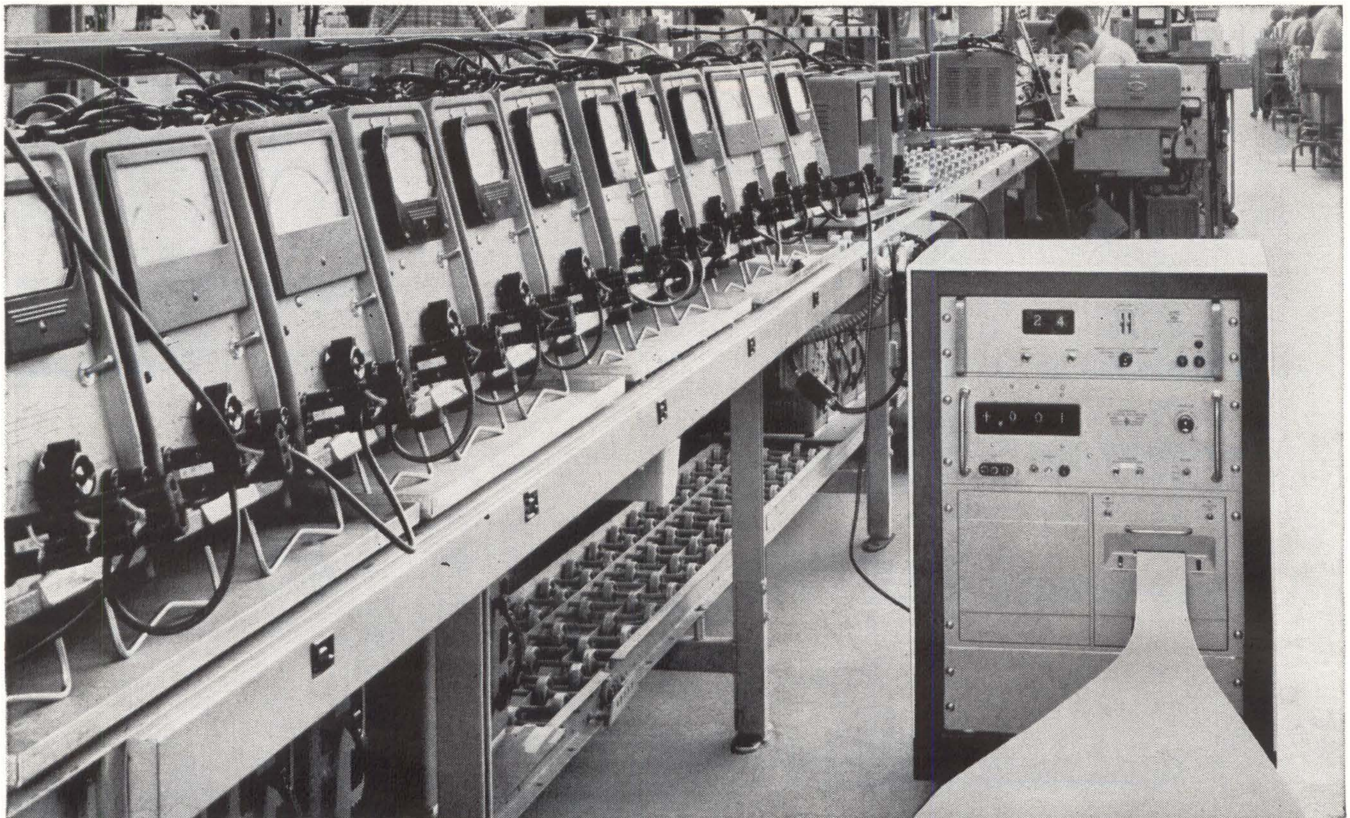

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50 CHANNEL DATA MONITORING FOR JUST $3100

AUTOMATIC

DYMEC'S Model 6100 Industrial Voltage Scanning System permits automatic, unattended data monitoring, complete with printed record, of 50 single-wire or 25 two-wire channels. The inexpensive system is useful in quality control, production checkout, routine lab measurements, system checkout, environmental and reliability tests . . . in any application where dc voltage is the parameter of measurement. With a converter, the DY-6100 also permits multi-point ac measurements.

The basic system consists of the Dymec Model 2900A Input Scanner, an hp 405CR Digital Voltmeter and hp 561B Recorder. It measures dc voltages 0.001 to 750 volts with automatic ranging and polarity, and it provides visual and printed readout of measurement, channel identification and polarity.

A scan limit selector switch permits simple omission of unused channel points, and the scanner provides four operating modes: System scans continuously, system scans all data points once and then stops, system is manually stepped by front-panel or remote control, system repeatedly measures a single point.

Input impedance is 11 megohms for minimum circuit loading. Accuracy is better than ± 0.2% of reading ± 1 digit. Effective rejection of 60 cps permits accurate measurements even in the presence of noise.

Optional equipment available for the system includes a digital clock which mounts adjacent to the recorder and permits time data logging and automatic programming, plus an ac converter (hp 457A) which permits measurement of ac voltages in ranges of 1, 10, 100 and 1000 volts, 300 volts rms maximum, 50 cps to 100 KC.

You may purchase the entire basic system for just $3100 (cabinet optional at extra cost) or, merely add the DY-2900A Scanner to your present hp 405CR and 561B for $950 (plus cabling). Write or call today for complete information or a demonstration on your bench.

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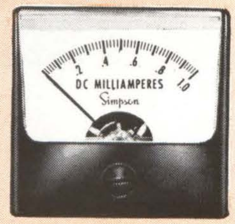
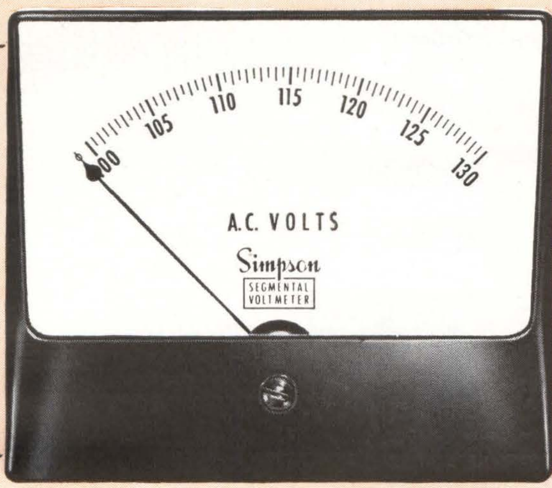
Another new member in this popular family. Needs only 3.1 sq inches of panel area. Supplied in DC, AC (rectifier), and VU types. Colors are standard black or your choice. Self-shielded core magnet type movements. *Forty-seven stock ranges in six types . . .* Model 1212C, DC; Model 1214C, AC and VU. This very popular style of meter is also stocked in 2½″, 3½″, and 4½″ sizes. *See your electronic distributor for the many stock ranges.*



All Meters Shown 60% Actual Size



Wide-Vue Case Style

Segmental (Expanded Scale) AC Voltmeters—3½″ and 4½″

Stock meter reads 100 to 130 AC volts. Other ranges supplied on special order. Frequency range is 20-2,000 cps. Accuracy is ±0.5% of center scale value at 25°C and 60 cps sine wave. Self-shielded core type movement; rectangular cases. Stock units are 3½″ Model 1347C (Wide-Vue Style), 4½″ Model 1349C (Wide-Vue Style), and 4½″ Model 49C. *See your electronic distributor.*

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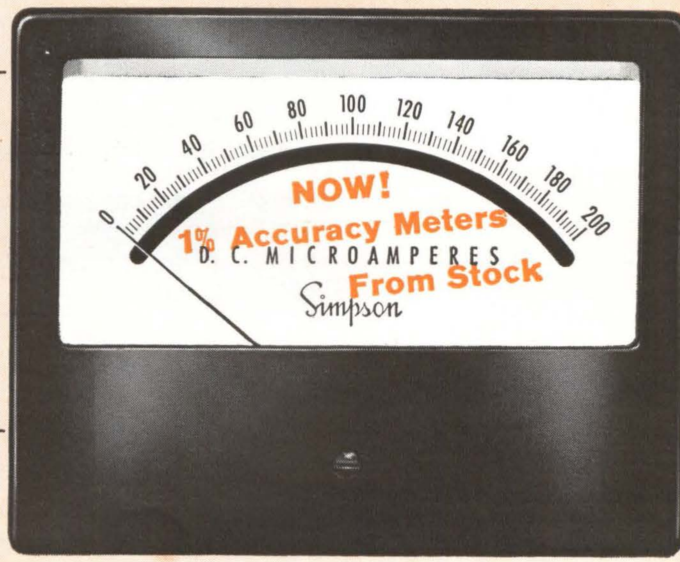
Rectangular 6″ cases. Mirror scales on 1% meters. Self-shielded core movement or external magnet type depending on range. Order Model 1150-E and specify either 1% or 2% accuracy. Milliammeters and microammeters stocked in both accuracies; voltmeters, millivoltmeters, and ammeters stocked in 2% only. *See your electronic distributor*. For other than stock ranges, send us your specifications.



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Lasting bond depends on how quickly many problems are solved

IRE + AIEE = IEEE — Will

NEW YORK—Approval of the merger of the Institute of Radio Engineers and the American Institute of Electrical Engineers into a giant 150,000-member Institute of Electrical and Electronic Engineers was a foregone conclusion even before the formal IRE balloting this week. The actual merger is scheduled to take place on January 1, 1963.

Last month, AIEE members voted 29,464 to 4,381 in favor of the merger, with the remainder of the 55,156 eligible members abstaining. IRE proxy votes had been running nine to one in favor.

IMPLEMENTATION—Next on the agenda will be meetings of the implementation committee, composed of seven leaders of each society. The committee's job will be to:

- Select a general manager for IEEE, with the approval of the IRE and AIEE boards of directors.
- Nominate new directors and officers of IEEE.
- Make recommendations to IRE and AIEE boards on geographical boundaries of regions, sections and other IEEE units.
- Take all necessary steps to implement the merger on January 1, 1963, then turn over the reins of the new society to its officers and the general manager.

The general manager is to reconcile the differences between practices and policies of IRE and AIEE with respect to the full-time administrative staff.

PROBLEMS — It seems unlikely that the merger could miscarry, but there is a possibility that the bond may not be a firm one unless many problems facing the combined society are ironed out in a reasonable time (see p 3, this issue).

An appreciable minority feels that the merger has been rushed too fast and that a necessary catalyst in the form of adequate membership consultation has been lacking. Relatively few question the overall logic of the merger, but some express reservations about what they consider overcentralization.

One implication is that electrical and electronics engineers may find themselves divided by issues and practices when membership action is attempted at the level of the professional technical groups and chapters.

Another impression is that IRE traits will dominate in the IEEE, not only because of IRE's larger membership, but because of a point in the agreement of merger.

Paraghaph 5 says the agreement will be terminated unless AIEE amends its constitution to conform to the IEEE constitution. There is no mention of amending the IRE constitution. This, we are told, was done to avoid the hiatus in corporate existance that would occur if both societies ceased to exist before the actual merger. The IRE will be discontinued first and merged into the AIEE, so there will be no IRE constitution to amend.

CONSTITUTION — Even so, the IEEE constitution is expected to reflect more of the IRE constitution than the AIEE's.

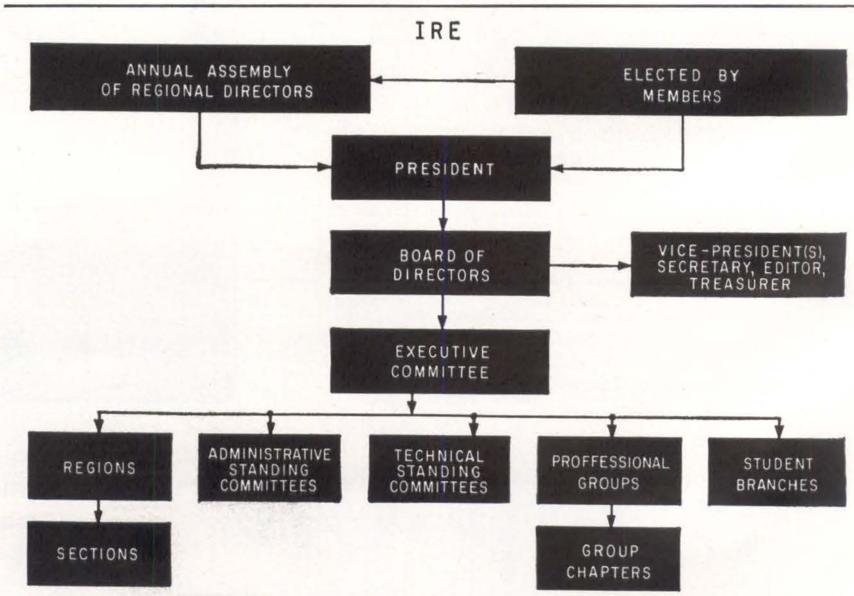
A point that bothers some AIEE members is the replacement of their technical committees with professional technical groups "wherever possible." The new society may contain 35, 40, or more such groups, raising fears that former AIEE members will have less control over technical guidance and publications.

Also, in AIEE, the board and the technical committees have equal representation. IEEE will probably adopt an IRE type of governing board, which has much greater power.

Signatures required for independent nomination will be raised from 25 to "at least one-third of one percent of the total number of voting members" of IEEE—close to 500 signatures. This may tend to

MERGER HIGHLIGHTS

IEEE's Constitution will resemble IRE's more closely than AIEE's.
IEEE may contain 40 or more professional technical groups.
AIEE Technical Committee will be replaced by Professional Technical Groups wherever possible.
IEEE will retain the IRE type of governing board.
IEEE operating expenses will exceed income for the first two years.



"FEDERAL" MAKEUP OF IRE. *This organizational structure is likely to be adopted in large part by the IEEE*

the Merger Prosper?

delegate independent nominations of officers essentially to the larger metropolitan area sections.

Basic items, such as membership qualifications, terms of office of the directors and details of nominations are to be included in bylaws that can be changed by the board.

ADVANTAGES—The majority in favor of the merger say it will:

- Bring closer together the various specialties in engineering.
- Form a single institution more efficient than the two separate ones (some 5,000 to 6,000 engineers are members of both IRE and AIEE).
- Remove the duplication in meetings, technical conferences and engineering committees.
- Advance the cause of unity in the engineering profession.

IRE and AIEE leaders say the merger must be done quickly to work out the practical details of the new organization.

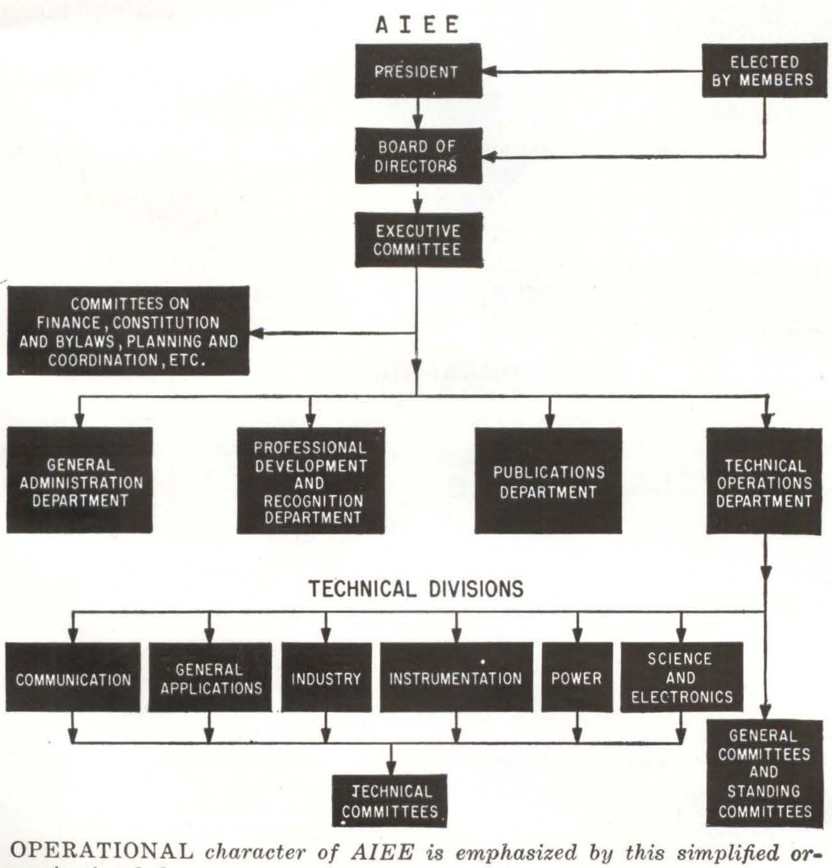
IMPLEMENTATION COMMITTEE

IRE members:

L. V. Berkner, Past IRE President
P. E. Haggerty, IRE President
R. L. McFarlane, Past President
Haraden Pratt, IRE Secretary
3 Additional Members

AIEE members:

C. H. Binder, former AIEE President
Hendley Blackmon, Westinghouse's Engineering Manager of Association Activities
W. H. Chase, AIEE President
W. R. Clark, AIEE Treasurer
Elgin B. Robertson, former AIEE President
L. M. Robertson, Manager of Engineering at Public Service Co. of Colorado
B. R. Teare, Dean of Science and Engineering at Carnegie Tech and president-elect of AIEE



OPERATIONAL *character of AIEE is emphasized by this simplified organizational chart*

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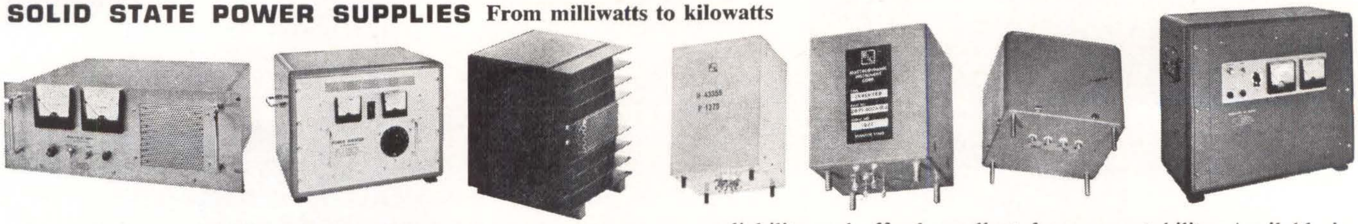

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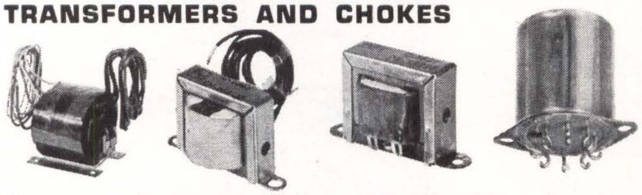

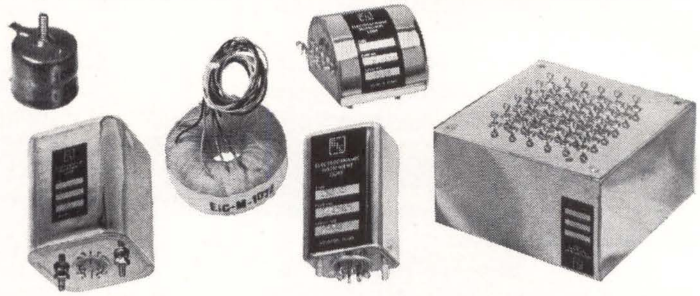

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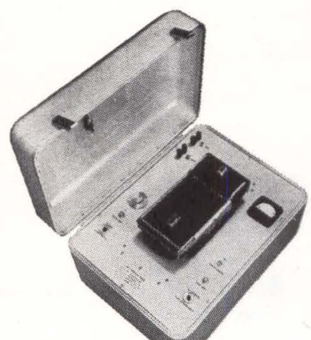

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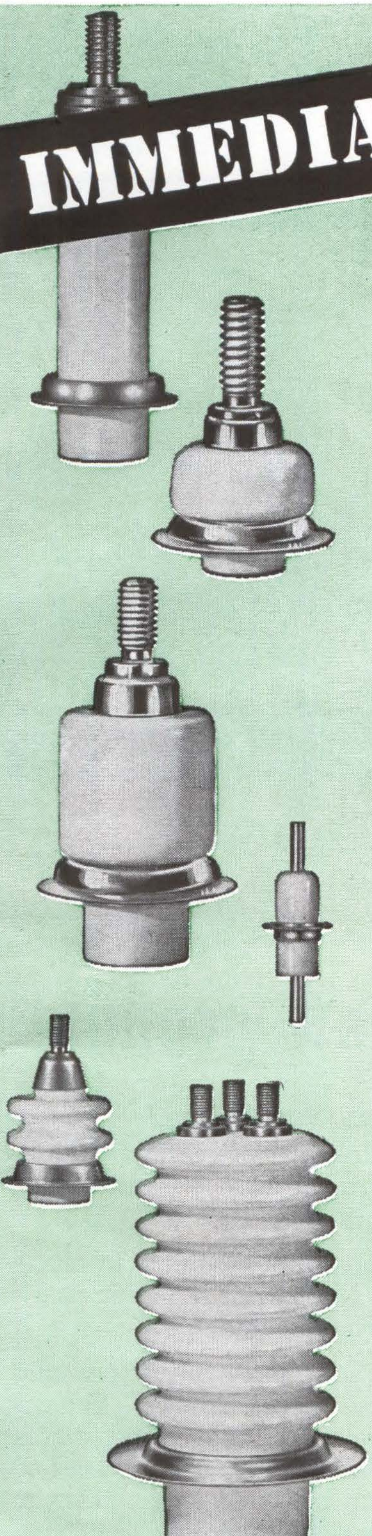

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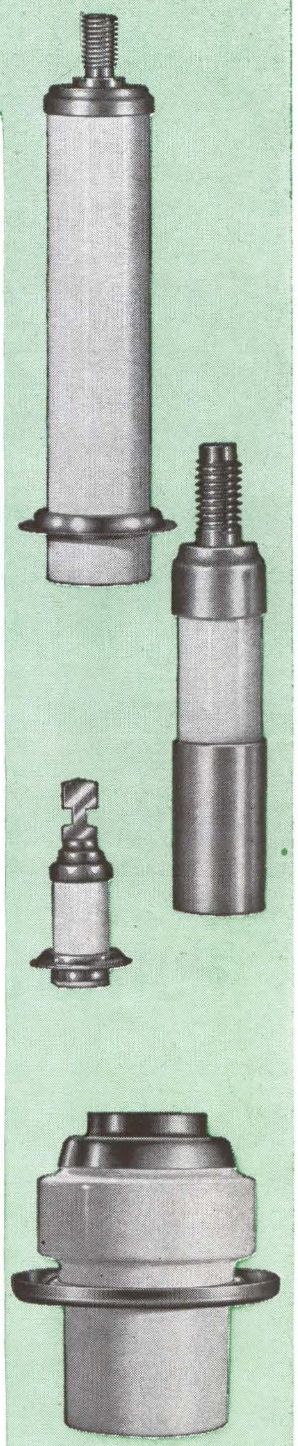

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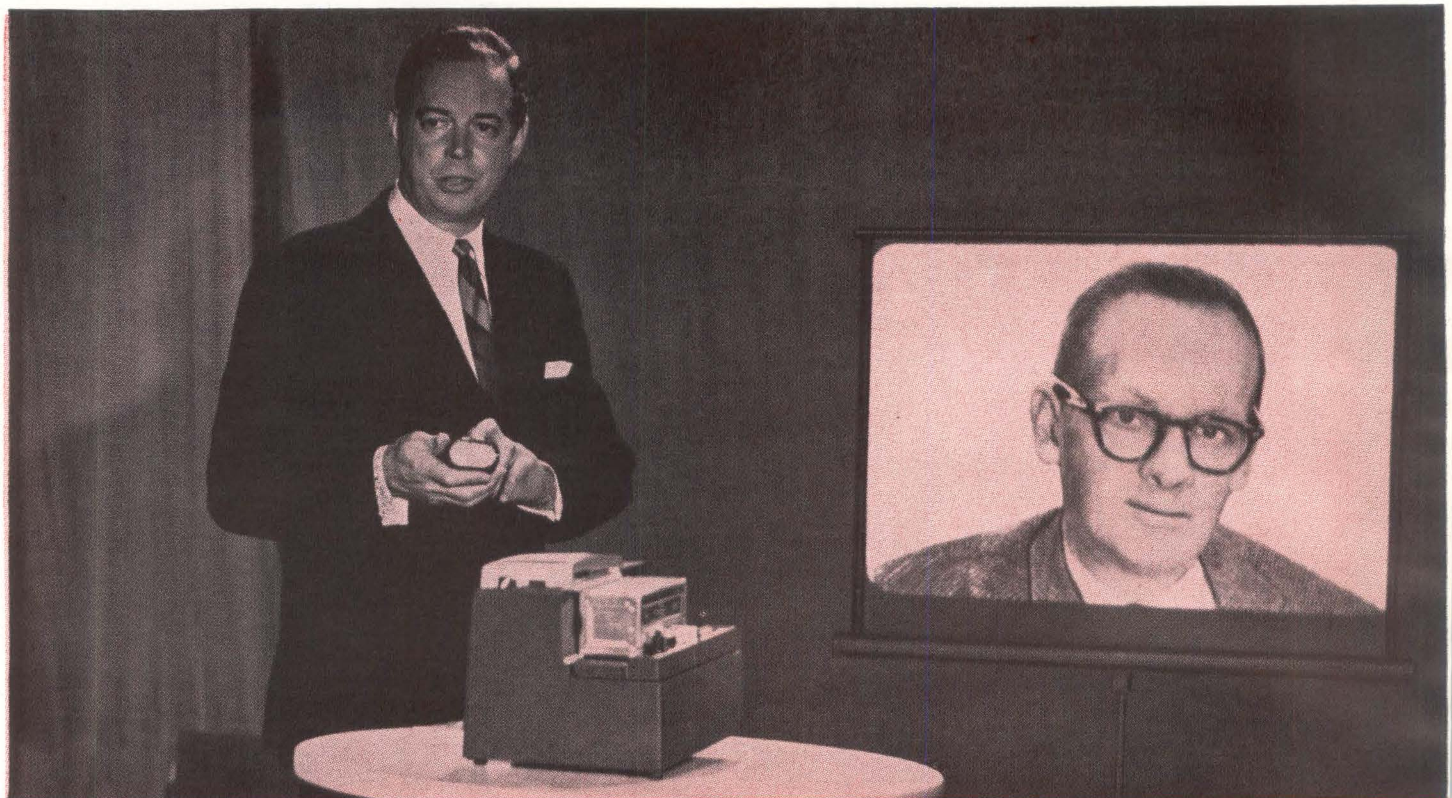

SLIDE SHOW BY REMOTE CONTROL Slides are changed and focus is sharpened by tiny wireless remote control unit with new Airequipt Superba Sonic projector. Mallory Mercury Batteries were chosen for control unit because of their higher energy content, lower internal resistance, long service life . . . plus greater convenience to the user because of less frequent battery changes.

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Scale down the size of your new product. Make it more easily portable. Add to its service life and dependability. Turn battery power into selling power . . . by designing with Mallory Mercury Batteries.

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Mallory Mercury Batteries deliver 3 to 4 times more energy per unit volume, last 3 to 5 times longer than conventional batteries. Voltage remains steady during their discharge life, relatively unaffected by temperature from —65° to +80°C. They withstand temporary overloads of up to 1 amp. Mallory Mercury Batteries can be stored for six years or more without serious loss of capacity. And they're leakproof.

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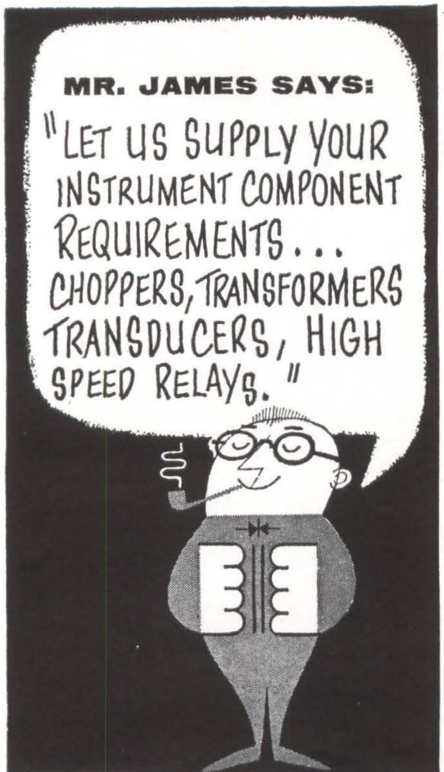

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- 7 Pin, 9 Pin, Octal and Printed Circuit Board Models.

Model	Nominal Freq.	Ckts.	Closures	Pkg.
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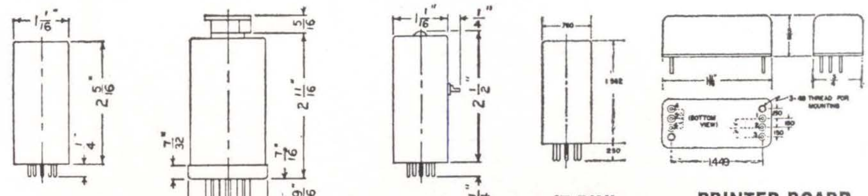
C-1202	60	DPDT	MBB	A
C-1210	400	DPDT	BBM	A
C-1204	60	DPDT	BBM	B
C-1205	60	DPDT	MBB	B
C-1275	400	DPDT	BBM	B
C-1276	400	DPDT	MBB	B
C-1281	60	SPDT	BBM	B
C-1282	60	SPDT	MBB	B
C-1968	60	DPDT	BBM	I
C-1969	60	DPDT	MBB	I
C-1970	400	DPDT	BBM	I
C-2701	60	SPDT	BBM	V
C-2702	60	SPDT	MBB	V
C-2703	400	SPDT	BBM	V
C-2715	400	SPDT	BBM	X

Closures BBM = 45% MBB = 55%



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- LOW THERMALS—Less than 1 μv
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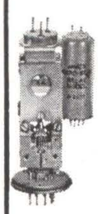
- VIBRATION AND SHOCK RESISTANT
- MODELS FOR ALL SWITCHING SPEEDS AND CIRCUITS

Model	CKT	Coil Voltage	Pkg.
C-2207	DPDT	6	I
C-2216	SPDT	6	V
C-2350	DPDT	18	I
C-2769	SPDT	6	X



MICRO-SCAN RELAYS

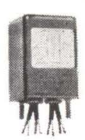
Micro second switching of microvolt signals for data handling, transducer sampling and analogue computation.

INSTRUMENT TRANSFORMERS

- Balanced 4 windings to .05%
- Electrostatic shields on all windings to 105 db
- Magnetic Shielding to 135 db
- Low thermal shielded lead out

Model	Pri. Imp.	Sec. Imp.	Mag. Shielding
7100	630 K	630 K	135 db
7101	630 K	200 K	135 db
7102	630 K	95 K	135 db
7115	630 K	25 K	75 db
7116	630 K	4 K	75 db
7117	630 K	400	75 db

Impedance with open ckt. at 60 cps.



INSTRUMENT TRANSFORMERS

A complete line of unique input and low power transformers designed for instrumentation circuits where accuracy, balance, precision with both electromagnetic and electrostatic shielding are required.

MINIATURE TRANSFORMER

JAMES "decade box" type miniature transformer kits save time and money in the application of transformers.

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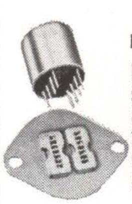
- Model C-2650, a kit of 10 micro-miniature, 25 milliwatt transformers, 4 winding "plug in" or "solder in", ½" dia. x ½" covering the full transformer range.



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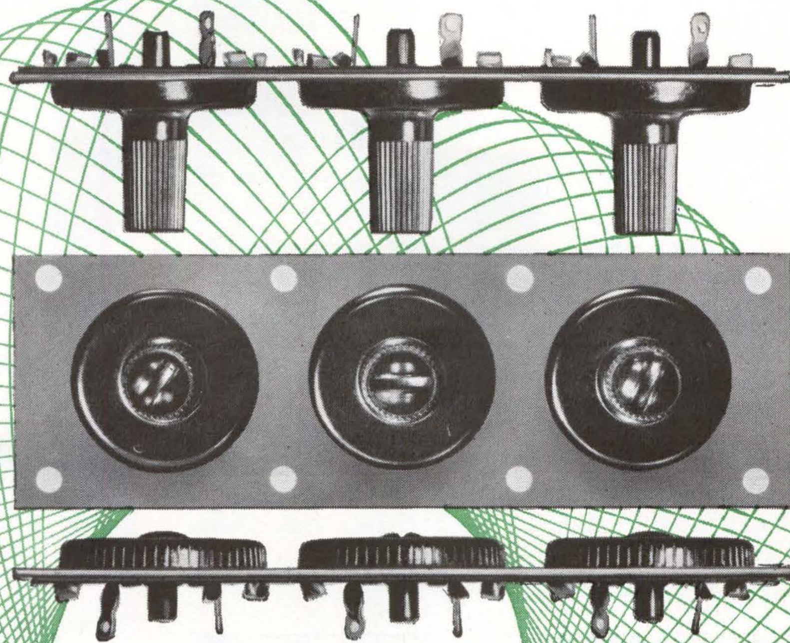

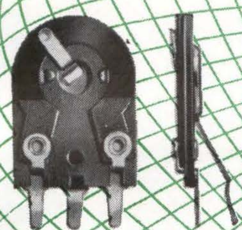

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SPECIFICATIONS

Composition element rated at 0.5 watts @ 40°C, linear; 0.25 watts, tapered.

Resistance range from 1,000 ohms to 5 megohms.

Resistance tolerance is plus/minus 20% of stated value.

Tested at 2,000 volts AC breakdown. Recommended maximum operating voltage, 750 volts AC.

Mechanical rotation is 300°. Electrical or effective rotation, 280°.

Standard torque, 1 to 5 oz. in.

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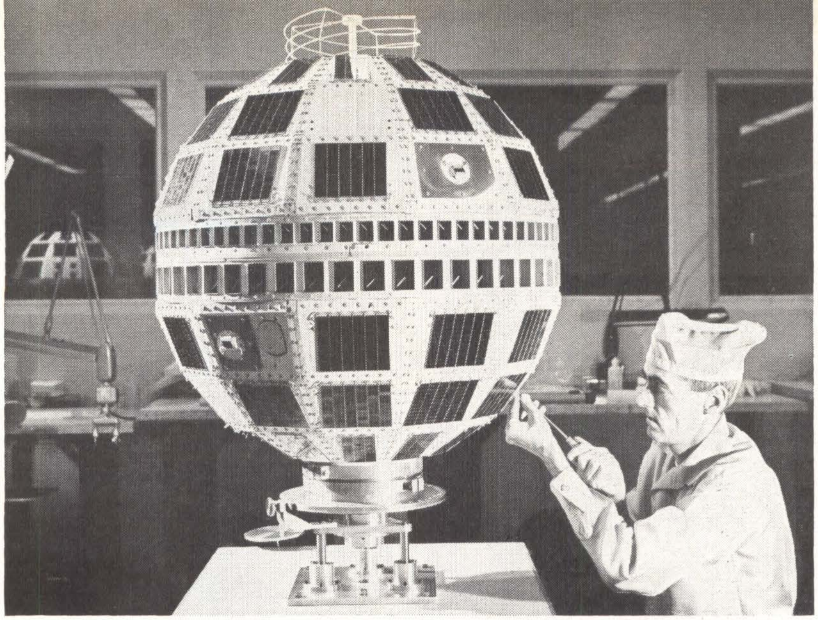
CIRCLE 27 ON READER SERVICE CARD

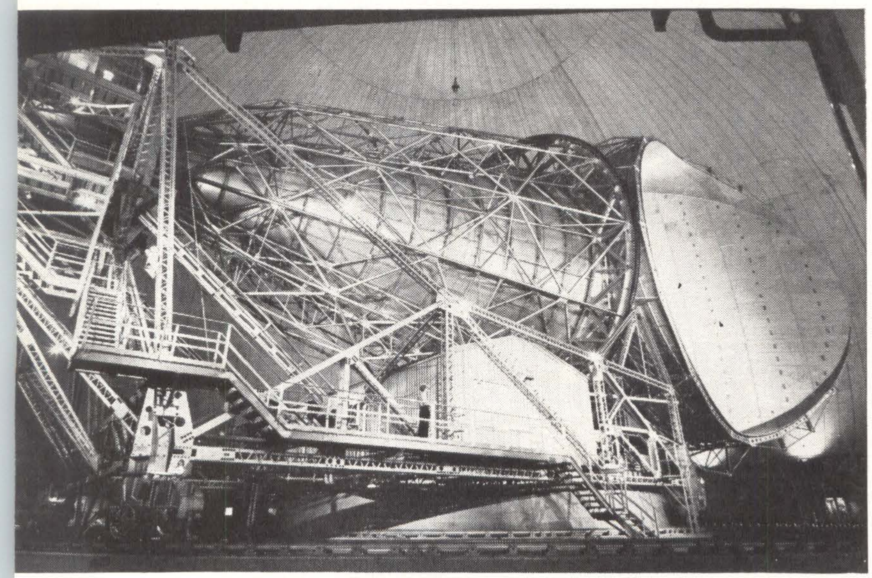
TELSTAR

Last minute antenna changes improve satellite

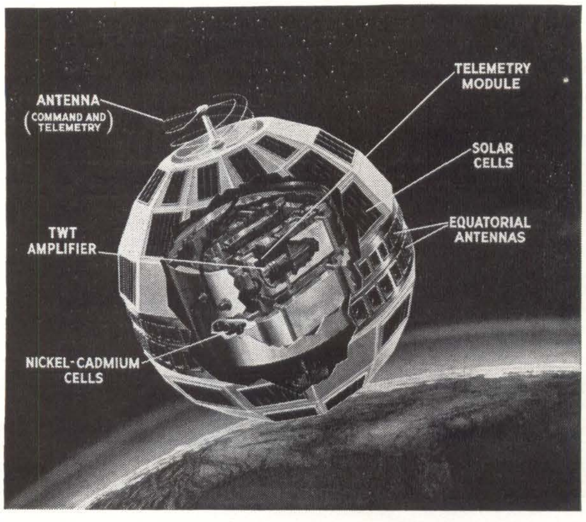
By THOMAS MAGUIRE
New England Editor



TELSTAR *prototype model communication satellite, being assembled in surgically clean environment at Bell Telephone Laboratories in Hillside, N. J.*



HORN REFLECTOR *satellite communications antenna at Andover, Maine, to be used for experiments in broadband communications by the Telstar satellite. Antenna is built as rigidly and accurately as a fine watch*



CUT-AWAY VIEW *of Telstar. Cannister containing Telstar's electronics is laced to inside of satellite frame for shock resistance*

TO ELIMINATE "one more thing that could go wrong" in the first Telstar satellite, which at press time was scheduled for launch early Tuesday, the telemetry-command-beacon antenna system has been modified.

Originally, telemetry during launch was to be sent back to the ground by two small whip antennas at the base of Telstar. After the protective launching nose fairing had been cast off, an antenna atop the satellite was to be extended by a telescoping mechanism.

In recent months, Bell Telephone Laboratories' engineers incorporated a small compact antenna system as part of the top surface of the vehicle. No release mechanism is required, and the whip antennas at the base have been removed.

A Delta vehicle will place the 34-inch sphere into an elliptical orbit of 500 to 3,000 nautical miles. Inclination will be about 45 degrees, and the period of orbit 2 hr, 40 min. Launch of a second Telstar is planned for the Fall.

Nerve center of the historic experiment is in Andover, Maine, at the world's first permanent ground station for satellite communications.

PERFORMANCE—First two or three passes of the orbiting sphere will be used strictly for testing the tracking, command and beacon circuits. Then, also on the day of launch, first domestic communications experiments will be tried between Andover and BTL in Holmdel, N. J. A series of telephone calls, which will probably include the voice of President Kennedy, will be transmitted to and from various parts of the country, using the satellite as just one link in transmission over land telephone lines,

TO OFFER TRANSOCEANIC TV

microwave relay towers and perhaps a short section of underwater cable in the waters of Portland, Me. Transmission of video tape will also be attempted the first day.

Second phase is expected to come about two weeks after the launch, when the system's potentiality for overseas communications will be demonstrated. Transmission will be attempted between Andover and the British General Post Office station at Goonhilly Downs, England, the first of the overseas ground facilities to be ready. Also in this phase, the first live trans-Atlantic telecasts will be attempted, with Eurovision beaming a show from European capitals, and the American networks transmitting to viewers in Europe. Discussions are being held with Soviet officials for possible participation.

ANDOVER SYSTEM — Overall noise temperature of the ground station system is 50 deg K at antenna elevation of 7½ degrees above the horizon. This includes background noise, antenna, maser and receiver. When the antenna is pointed at the zenith, system noise temperature is 26 deg K.

The ruby traveling-wave maser designed by BTL's H. E. D. Scovil contributes only 4 deg K to the system. Engineers say parametric amplifier front-end may also be tried in future Telstar ground stations. The maser at Andover is immersed in liquid helium dewar surrounded by a liquid nitrogen jacket. Later, a closed-cycle continuous refrigeration system, under construction by A. D. Little Inc., will be installed at the Andover site.

A complete receiver system, including maser and fm feedback circuitry, is installed in the cab at the apex of the horn antenna. Telstar satellite will transmit a 3-watt signal, but this will be only about 10^{-12} watt when it is scooped in by the 340-ton cornucopia-shaped antenna.

Also in the cab is the transmitting equipment, providing an unusual combination of high power, extreme bandwidth and continuous operation. Amplification for the broadband Bell System transmitter is provided by a 4 ft, 3 in. long water-cooled traveling-wave tube, one of the largest ever built. Power output on the 25 Mc bandwidth transmitter is about 2 Kw.

Just outside the control building are two tracking antennas. A quadhelix command tracker like the one at Cape Canaveral will pick up the satellite's 136 Mc beacon and telemetry and transmit commands to the satellite on about 120 Mc (ELECTRONICS, p 23, Dec. 22, 1961). Once the satellite has begun to transmit its broadband communications signal and associated 4,080 Mc precision beacon, the other antenna, an 8-ft dish with a parametric amplifier, will track on this signal.

TRACKING—Also as part of the cooperative program to achieve transoceanic broadband communications, a transmitter for NASA's Relay satellite is being installed at the Andover station to help test the first Relay, which will be launched late this Summer. The program also includes cooperation with communications organizations in England, France, Italy, West Germany and Brazil. The Andover station, an identical one close to completion at Pleumeur-Bodou, France, and an 85-ft parabolic antenna at Goonhilly Downs, England, will be used for tv, voice and data communications experiments with both Telstar and Relay. Voice and data transmissions via Relay will be conducted from the ITT 40-ft dish at Nutley, N. J., and a 30-ft dish near Rio de Janeiro. The Italian station, a 30-ft dish, near Milan, will have voice receiving capability this year, and a transmitter is being installed for full participation in 1963. An 85-ft dish, being built near Munich, Germany, will be ready next year.

Modulated Ionosphere Offers Secure Communications

MICROWAVE cross-modulation of the ionosphere using the Luxemburg effect may open up intercept-free communication channels, according to Prof. Ladislaus Goldstein, head of the University of Illinois' gaseous electronics lab.

Goldstein's group has modulated several types of plasmas with 5-to-10Gc lab-scale transmitters over the past three years, to demonstrate the possibility that microwaves might control ionospheric propagation.

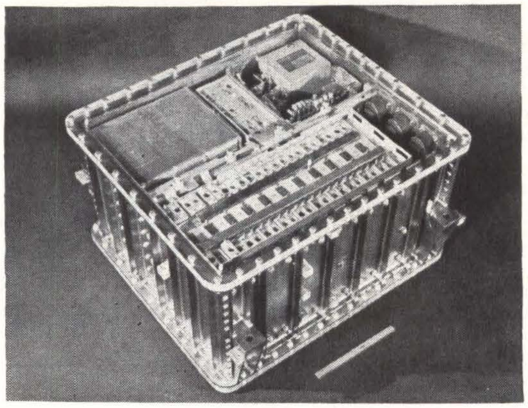
Energy transferred from microwaves to the plasmas, at cyclotron resonance, increased the temperature of free electrons and changed those plasma properties which control propagation, Goldstein said.

An Aerobee rocket fired 40 to 60 miles above Eglin Air Force Base, Fla., in early May provided the first field check on efficiency of microwaves in altering ionospheric propagation. A transmitter abroad fed a pulsed 10-20 μsec signal to 12-foot antenna elements at 1.4 Mc—close to the electron gyro frequency.

Meanwhile, a ground transmitter beamed a 2.1-Mc signal to a tuned receiver in the rocket. The rocket's transmitter relayed this signal back to earth, where tapes recorded the effects of absence, presence and wake of the excitation pulses at 4 w, 40 w and 400 w.

Although a complete analysis won't be finished for a year, early results have confirmed the lab experiments. Radio waves from ground or a rocket can probably make transmissions easier at certain frequencies and more difficult at others, Goldstein said, by modulating or controlling density of electrons in the ionosphere.

Selective control of these conduction properties, in chosen regions, could open paths for messages which would be denied to any but the addressee alerted and equipped to pick them up, he suggested.



THIN-FILM *memory in this Univac ADD computer has a capacity of 166,000 bits. Modular design allows flexibility in adapting it to various types of guidance systems*

Latest Military Computer Applications

Digital techniques explored at PGMIL Conference

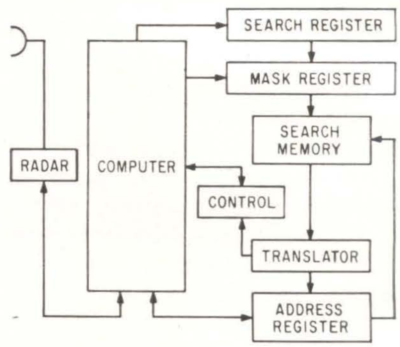
By LAURENCE D. SHERGALIS, Associate Editor

COMPUTERS and their application to military systems were prominent among the wide range of subjects discussed at the Sixth National MIL-E-CON in Washington, D. C., last month. Among the new devices announced was an operational computer using a thin-film memory. Designed by the Univac div. of Sperry Rand Corp., the machine utilizes modules made by the microminiature cordwood technique. The computer weighs 88 lb, occupies 1.2 cu ft and is expected to achieve over 10,000 hours of operational time without a failure.

Called the ADD-1000 (for Aerospace Digital Development), the computer has a random-access memory consisting of 6,656 24-bit words of permanent, and 256 24-bit words of variable storage. Basic operating clock frequency is 1 Mc, and the basic instruction phase cycle is tied to the memory cycle time of 3 microseconds. In describing the capabilities of the computer, B. J. Jansen of Univac's Advanced Engineering Development Dept. indicated that the machine is capable of executing the preflight and inflight programs associated with a number of guidance techniques.

COMPUTER BATTLES — Computer-controlled battles are being simulated at the Army Electronic Proving Ground, Ft. Huachuca, Arizona, to determine effectiveness of communication systems in a combat environment. Some of the parameters fed into the computer include the range of a radio set, reliability, electromagnetic environment, and attrition of personnel and materiel.

Digital control of aerial cameras was described by C. Walter Diem of the Librascope div. of General Precision, Inc. His system uses an adaptive calibration technique with a digital computer to control film velocity. Camera functions that are controlled include image motion compensation, shutter speed, diaphragm opening and exposure rate. To reduce blur caused by image motion, and adaptive calibration technique used in a digital servo moves the film across the camera focal plane at the velocity of the image.



SEARCH MEMORY *in a system consists of these six basic parts in addition to the computer and radar equipment*

SEARCH MEMORY—Digital computers have been supplemented by a search memory to reduce the computational time in determining a radar target track. In a paper by E. C. Joseph and A. Kaplan, Remington Rand Univac, a system was disclosed that reduces the time devoted to correlation of target tracks by a factor of 400. The search memory complements the conventional memory. Where input to a conventional memory is an address and the output is the data contained in that address, the input to the search memory is the data and the output is the address of data that matches the input data. When a match occurs, the address is used to retrieve

WHAT ROLE FOR NONPROFIT LABS?

Panel discussion on the role of government and nonprofit laboratories in the national defense effort revealed that technical standards in government laboratories must be raised and morale improved to avoid mediocrity. The panel, consisting of representatives from government, industry, a nonprofit corporation and a university, also indicated that the role of the nonprofit laboratory is to develop concepts and evaluate advanced techniques; it must not undertake applied research and development nor produce hardware. Also, panel members said, it must have stringent policies against conflict of interest.

associated information.

Therefore, the function of the target track correlator is to associate a set of radar returns with existing returns. The association begins when a radar return is compared with the predicted positions in track storage. This is done by determining whether the radar return lies within a volume of space around a predicted target position.

Gerald B. Speen, ITT Federal Laboratories, described an all-pneumatic gyro that rotates on gas films. The device is reported to have a better drift rate than that of conventional gyros.

DIGITAL MODULES — Martin Marietta Corp., Electronic Systems and Products div., announced the availability of a set of digital module patchboards, unique in that jumpers are used from one patchboard to another to breadboard an entire system. Consisting of 32 modules and four patchboards, the system permits a designer to set up any logic scheme. Terminal connections are standardized to provide flexibility in placing the modules in receptacles.

Computers Developed for Spacecraft, Aircraft

MINNEAPOLIS—Two new computer developments for support and checkout systems were recently announced by Minneapolis-Honeywell.

For long-term space missions, a check-out computer will permit continuous in-flight monitoring of entire spacecraft systems. Operational performance of subsystems is calculated by scanning a small number of major test points rapidly enough to approximate simultaneous sampling. Impending failure is predicted long enough in advance for the electronic subsystem to be repaired before failure occurs.

In another development, maintenance requirements for a number of aircraft weapon systems can be checked in one central ground location. Data from on-board automatic systems analyzers are transmitted to a ground-based digital computer. Modularized microminiature NOR circuits and digital mechanization are used in the monitor systems.

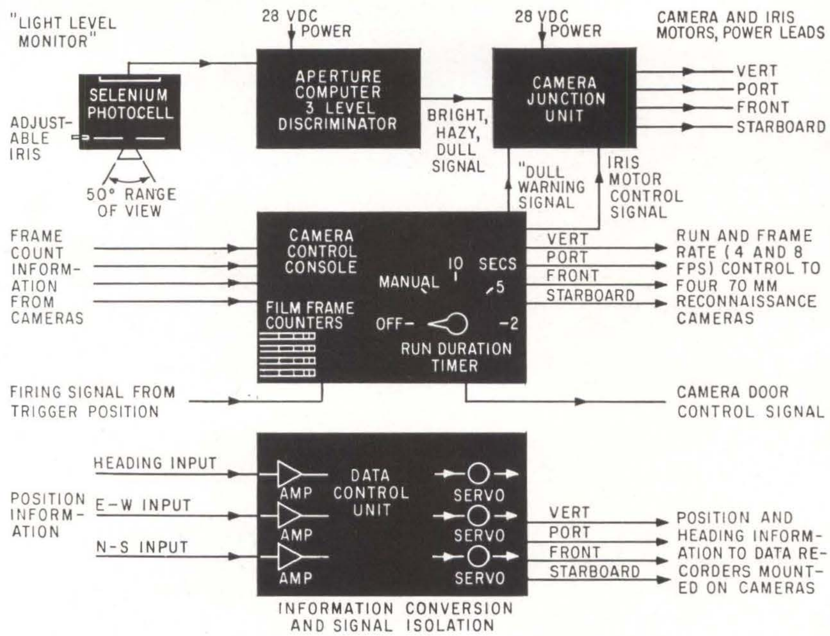


PHOTO RECONNAISSANCE *system records navigation data direct on film edge. Four-camera design is shown*

AIRCRAFT CAMERA
Records Position Automatically

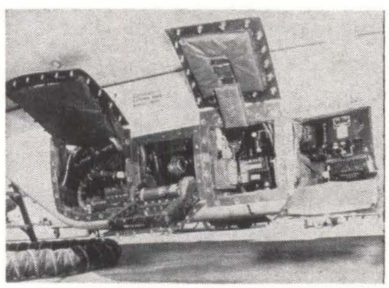
THE ROYAL CANADIAN Air Force has taken delivery of a photo-reconnaissance system that automatically records position and heading information.

The system processes navigation information and applies it to a data recorder mounted on each of the cameras. Position is printed on each exposed frame. The RCAF installation, in a pod slung below the aircraft, operates four cameras.

The system was designed for low-level, high-speed aircraft reconnaissance by Computing Devices of Canada Ltd. in Ottawa, Ontario, and employs cameras of British manufacture.

The 70-mm cameras receive automatic exposure control signals to compensate for three possible lighting conditions. A light level monitor views down and slightly ahead of the aircraft. Signals are fed to an aperture computer that automatically adjusts the camera irises.

A camera junction unit distributes power and control signals, and a control console incorporates a run-duration timer and film-rate control. The data-control unit accepts position and heading information from the aircraft's navigation system and converts it for opera-



CAMERAS *in equipment pod below CF-104 are aligned in various attitudes*

tion of the data recorders. Servo control loops and synchros are used and supply a synchro receiver and counter in the data recorder mounted on each camera. An optical system on the camera relays the numerical image to the film edge. Navigational data recorded on the film is printed directly with the photo during processing. Transistor circuits and modular packaging are used in the aperture computer for light control, and the data-control unit that converts information to proper form for the data recorders.

An in-flight processing system is being developed by the Canadian firm to handle 100 feet of standard 70-mm film in a magazine using a saturated web monobath process.

MEETINGS AHEAD

RADIO PROPAGATION COURSE, National Bureau of Standards and University of Colorado; NBS Boulder Laboratories, Boulder, Colo., **July 16-Aug. 3.**

LUNAR MISSIONS MEETING, American Rocket Society; Pick-Carter and Statler-Hilton Hotels, Cleveland, Ohio, **July 17-19.**

MEDICINE & BIOLOGY DATA ACQUISITION AND PROCESSING, IRE-PGME, AIEE, ISA.; Strong Memorial Hosp., Rochester, N. Y., **July 18-19.**

INTERNATIONAL SOUND FAIR, Institute of High Fidelity Manufacturers, Magnetic Recording Industry Assoc., et al; Cobo Hall, Detroit, **July 25-29.**

ENERGY CONVERSION PACIFIC CONFERENCE, AIEE; Fairmount Hotel, San Francisco, Calif., **Aug. 13-16.**

CRYOGENIC ENGINEERING CONFERENCE, University of California; Los Angeles, Calif., **Aug. 14-16.**

PRECISION ELECTRONIC MEASUREMENTS INTERNATIONAL CONFERENCE, IRE-PGI, NBS, AIEE; NBS Boulder Labs, Boulder, Colo., **Aug. 14-16.**

ELECTRONIC CIRCUIT PACKAGING SYMPOSIUM, U. of Colorado, et al; Boulder, Colo.; **Aug. 15-17.**

APPLICATIONS & RELIABILITY SYMPOSIUM, Precision Potentiometer Manufacturer's Assoc., Statler-Hilton Hotel, Los Angeles, **August 20.**

WESTERN ELECTRONICS SHOW AND CONFERENCE, WEMA, IRE; Los Angeles, Calif., **Aug. 21-24.**

METALLURGY OF SEMICONDUCTOR CONFERENCE; the American Institute of Mining, et al; Ben Franklin Hotel, Philadelphia, Pa., **Aug. 27-29.**

MAINTAINABILITY OF ELECTRONIC EQUIPMENT, EIA Engineering Dept. & Dept. of Defense; U. of Colorado, Boulder, Colo., **Aug. 28-30.**

INFORMATION PROCESSING INTERNATIONAL CONFERENCE, IRE-PGEC, IFIPS, AIFPS; Munich, Germany, Aug. 29-Sept. 1.

INFORMATION THEORY INTERNATIONAL SYMPOSIUM, PGIT and Benelux Section of IRE; Brussels, Belgium, **Sept. 3-7.**

DATA PROCESSING INTERNATIONAL EXHIBIT, Assoc., for Computing Machinery; Syracuse, N. Y. **Sept. 4-7.**

ADVANCE REPORT

ELECTROMAGNETIC COMPATIBILITY CONFERENCE, *Army, Navy, Air Force,* IRE; *Arrour Research Foundation, Chicago, Ill., Oct. 30-Nov. 1. Aug. 1 is the deadline for submitting a 150-word abstract or a copy of the paper to: J. E. McManus, Conference Chairman, Armour Research Foundation, 10 West 35th Street, Chicago 16, Illinois. Areas of interest include: interference prediction; equipment design techniques; instruments; measurement techniques; intereference reduction measures.*

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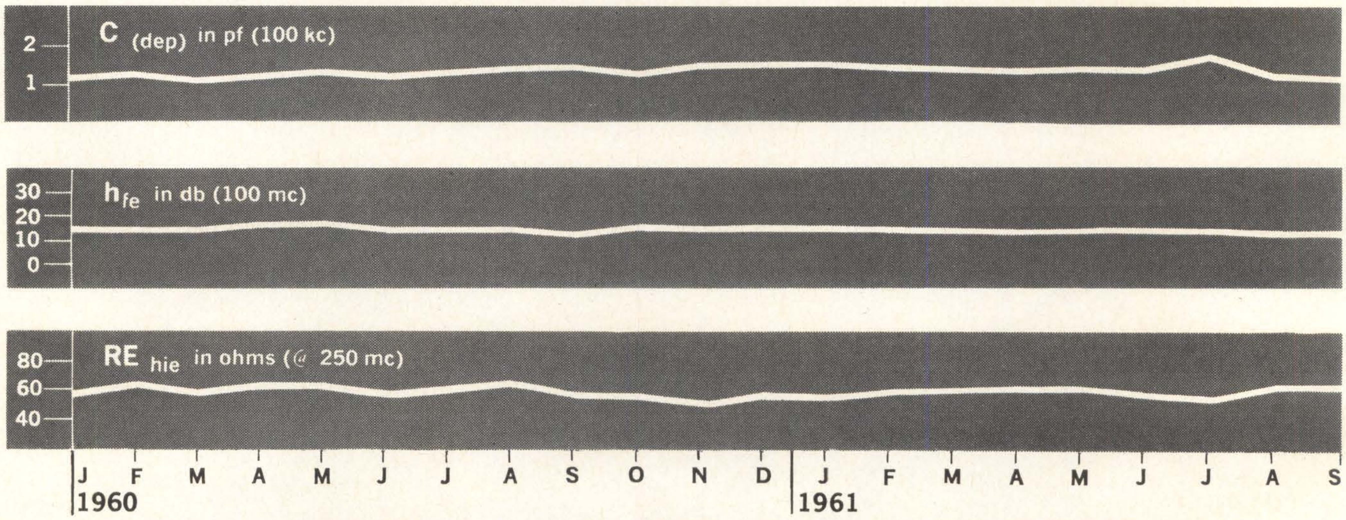

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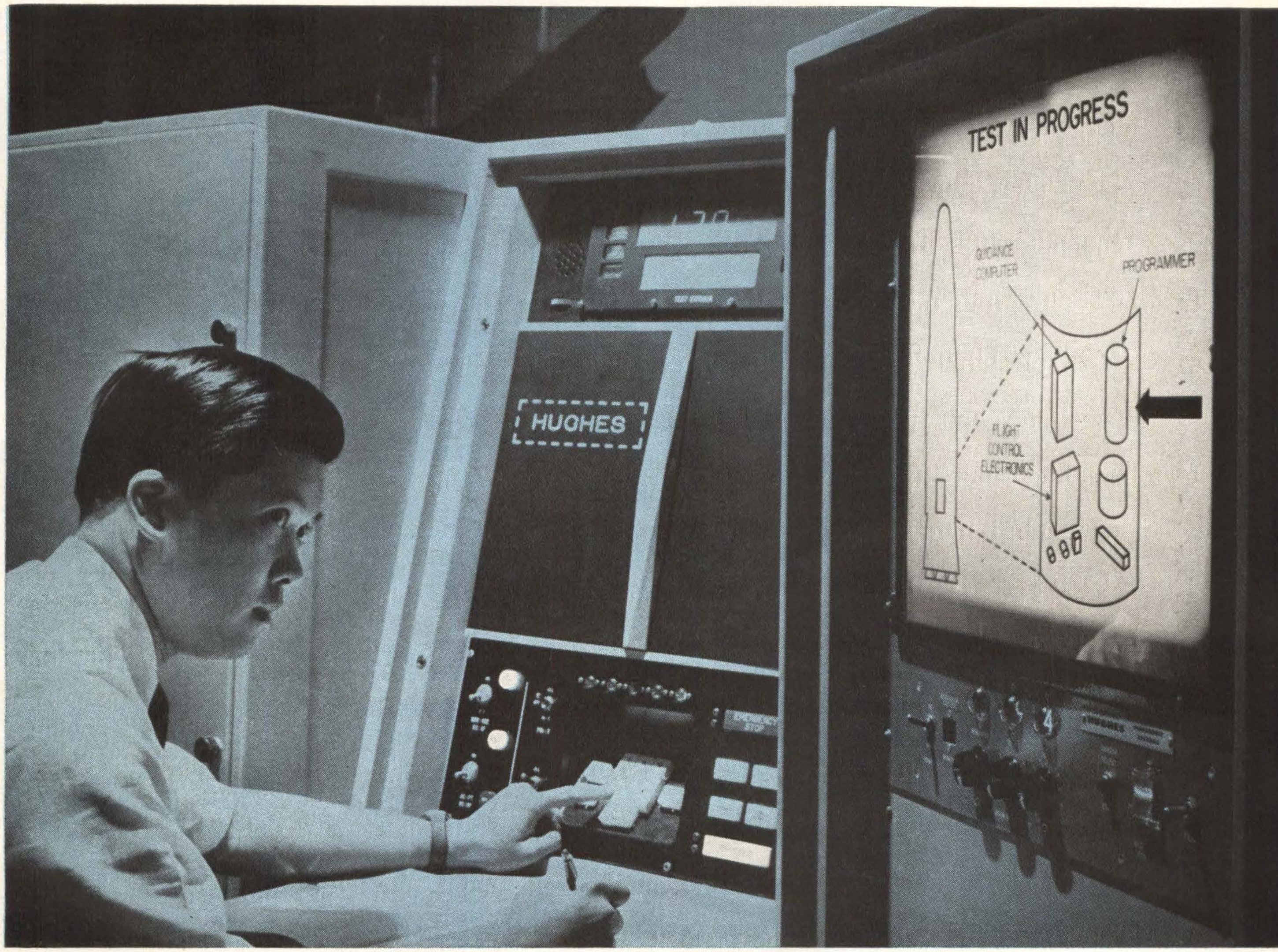


AUTOMATIC ELECTRONIC ANALYZER D-PAT *(Drum-programmed Automatic Tester) by Hughes Aircraft uses digital computer control to test ICBMs and predict operation. System flashes large-screen picture of missile electronics with arrow indicating malfunctioning component*

Automatic Checkout Equipment

FOR TODAY'S COMPLEX SYSTEMS

With automatic checkout equipment coming into general use, new trends are emerging in its development. This report summarizes recent approaches to equipment and system design, where and how to use automatic checkout equipment

By GEORGE V. NOVOTNY, Assistant Editor

AS ELECTRONIC SYSTEMS become more and more complex, and the number of components in a system approaches the order of one million, the mean time between failures (MTBF) of the equipment as a whole tends to grow shorter. Thus, a system containing one million components, each with a reliability of 99.9999 percent, might have an overall reliability of nearly zero, with a correspondingly low confidence that it can ever perform its mission.

The electronic system in a modern supersonic bomber has an MTBF of the order of ten hours. At the same time, its complexity makes it impossible to check the entire system in that time, using conventional manual methods: the system may fail long before a normal checkout procedure can be carried out.

To perform a confidence check on such a system and still have enough of the operating lifetime to perform a mission, the check must be done by a high-speed automatic tester. Hence, automatic testing today is not a luxury but a necessity; this justifies its sometimes high cost.

Automatic testing, coupled with the corresponding repair ability, is one technique for improving equipment reliability. Testing and repair imply the availability of spare parts for replacement of faulty ones. In fully automated test-and-repair systems, such as will be used aboard advanced space vehicles, spare parts and provision for their installation will be carried aboard, and the system will thus have become a self-adapting redundant one.

Automatic system checkout minimizes the need for trained operators, saving training time. By eliminating the chance of human error, a high degree of test uniformity is attained. The on time of the equipment under test is reduced, thus eliminating some failures and allowing longer useful service life.

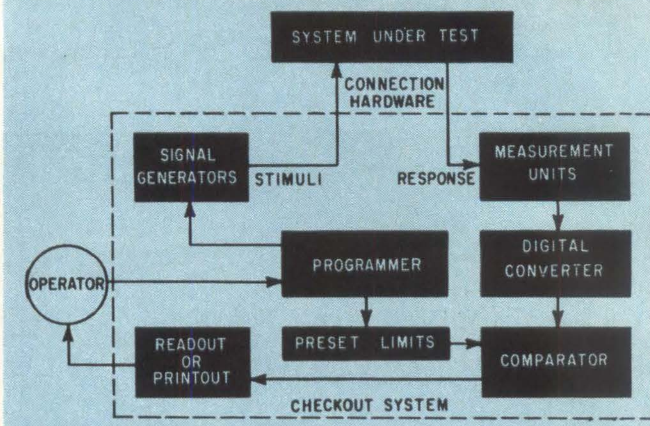
Automatic testing techniques have been applied to testing components as well as to system testing. Since component testers as a rule are much less complex than system checkout units, this report is not concerned with them.

BASIC KINDS OF TESTS—There are three basic kinds of tests to be done on an electronic system. All of these can be performed manually or with varying degrees of automation.

• *Confidence check* merely assesses the readiness of a system to function or to perform a mission. The confidence check usually takes place in the field or on the flight line, with time severely limited, and little or no chance for repair. It may be a GO-NO GO test, or it may determine the possibility of a limited-performance mission by measuring how far outside normal limits the system is functioning. Example: pre-flight checkout.

• *Certification test.* This is usually a periodic test, done on a system kept in readiness; its purpose is to certify the system's reliability and to predict the success of a possible mission. Time may be limited, but there is more chance for fault isolation and for replacement of major components. Example: periodic testing of a Polaris missile's gyroscope aboard the parent submarine, with spare gyroscope units available for replacement.

• *Maintenance test.* Involves primarily the isolation of malfunctioning parts and their replacement, hence it's a diagnostic test. Depending on limitations of time and equipment, an attempt is made to isolate malfunctions to the smallest replaceable component. The faulty parts are then replaced and a certification test usually follows before the equipment is considered in readiness.



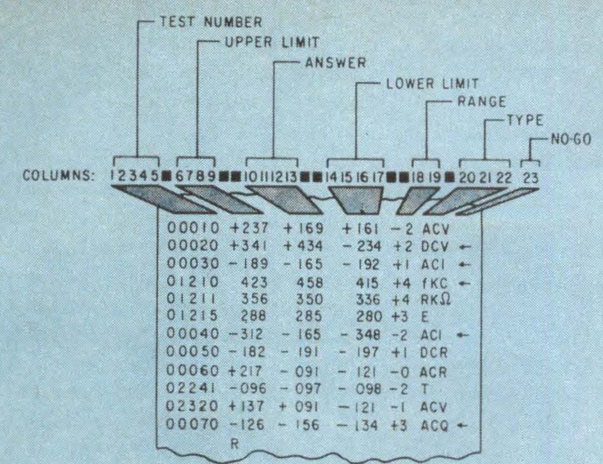
BLOCK DIAGRAM *of automatic checkout system illustrates the main functions found in most contemporary systems—Fig. 1*

While this classification is based on military and space systems, it applies as well to industrial and civilian equipment, with simplifications. However, the time squeeze produced by the high complexity of an electronic system rarely occurs, at the present time, in industrial systems. When automatic testing equipment is applied to such systems, it is usually a simplified version of a military or space checkout system, or a single-function production testing machine of a lower order of complexity.

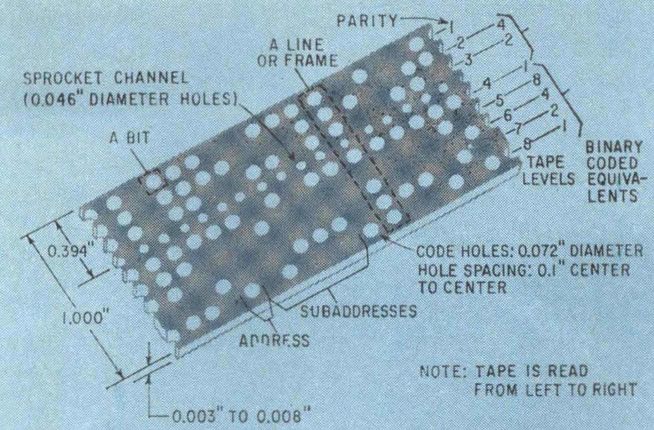
HOW TO TEST EQUIPMENT—There are a number of ways of testing a piece of equipment: inspection and testing of individual components, signal tracing, transfer-function analysis and white-noise techniques and transient response analysis. However, most present-day automatic checkout systems use the approach derived from signal-tracing servicing of radio receivers. See Fig. 1.

• *Stimulation.* A stimulus, such as a voltage, current or r-f signal, is fed into the equipment under test. Often this stimulus is intended to be a close approximation of the working conditions, however, some systems use stimuli such as step voltages, transients or white noise, when these can better reveal malfunctions of the unit. Included under stimulation are dummy loads, used to approximate operating conditions. Power is supplied to the equipment under test within limits of normal power-supply operation.

• *Measurement.* The response of the equipment to the applied excitation is then measured at convenient output points. Again the measurement may be a voltage, frequency or any other physical quantity, that is then converted by a transducer into an electrical signal. Enough measurements must be made at enough points to insure satisfactory diagnosis. In a fault isolation test, more measurements will generally be made than in a confidence check. Present-day checkout systems generally have the following measurement capability: a-c and d-c voltage, a-c and d-c current, frequency, time interval, events per unit time, voltage ratio, phase, continuity and



EXAMPLE OF A PRINTOUT TAPE, *identifying the test number, test limits, measurement value, type of measurement and* GO-NO-GO *result—Fig. 2*



PUNCHED MYLAR TAPE *is typical of 8-channel programming tapes used by automatic checkout systems—Fig. 3*

leakage, resistance and impedance.

• *Conversion to digital information.* Since as a rule the comparison and logic circuits are digital, measured quantities must be converted into digital data. This is often done by a separate analog-to-digital converter. Or a digital measuring device, such as a voltmeter, may be used. The closer the conversion to the point of measurement, the less degradation of the signal occurs. The output of the converter is generally a binary train.

• *Comparison.* This operation compares the digital information from the measurements against preset quantities or acceptable limits, which are stored in a memory or supplied by the programmer for each measurement. The comparator has logic and arithmetic units, their complexity depending on the kind of readout and the nature of the check. The comparator may be required to give a simple GO-NO GO readout, or it may be designed to compute the amount and direction off limits.

In a fault isolation test, a considerable number of logic circuits may be needed to determine which component is faulty, using the available measurements. A trade-off situation exists: the fewer measurements are made, the more sophisticated the logic circuits must be; on the other hand, if enough tests have been made (which consumes more time) the analysis is simpler and the faulty module is more easily isolated. The final compromise depends on required speed, space and weight limitations, cost and other factors. Some advanced automatic test systems have the data-processing capacity and speed of a medium-size computer.

• *Printout and display.* This may be a simple GO-NO GO indicator, depending on the equipment and the test, HIGH-GO-LOW, or even more detailed. For example the early DATS (Dynamic Accuracy Test System, by RCA) checkout system for aircraft fire control equipment was designed to indicate, in addition to GO and NO GO, the miss distance in azimuth and elevation, in yards, and also to indicate whether the armament fired early or late. This quantitative readout enables the operator to make a decision in a tactical situation where a somewhat defective system may still be acceptable, providing the deviation from normal is known. Quantitative readout, of course, requires an arithmetic unit such as the DATS miss computer.

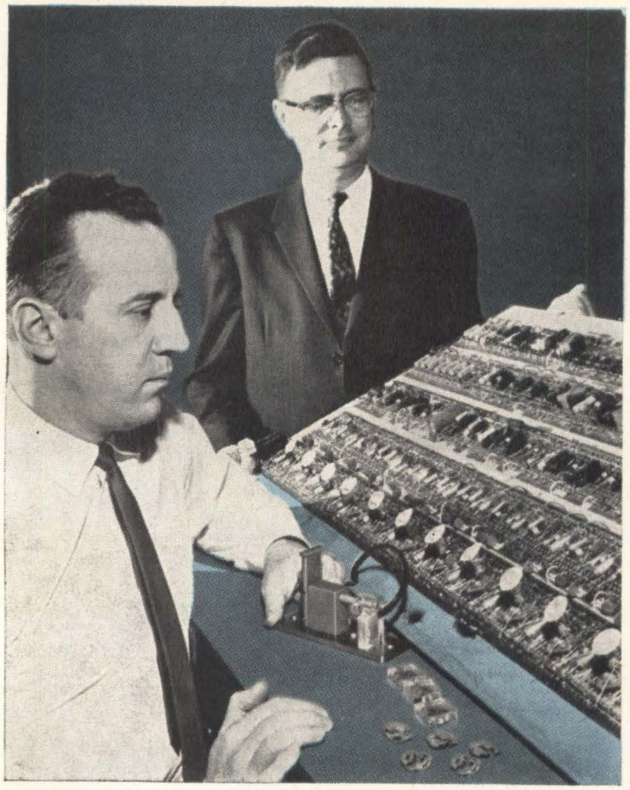
In a fault isolation test, the printout unit gives the serial number of the NO GO check, and often gives the faulty reading. See Fig. 2. Some systems will print out instructions for the operator to make an adjustment or to replace a specific module.

• *Controlling unit or programmer.* This unit sequences the tests according to a predetermined program. The program may be inserted as punched paper or plastic tape, magnetic tape or punched cards. Punched 8-channel Mylar tape, see Fig 3, is popular in medium-speed checkout systems. Some systems, such as Race, read off the program from a tape and then store it on a magnetic drum. The selection of the programming medium depends on the duration, number, speed and repeatability of the tests. The programming medium may also tell the allowable limits on each measurement.

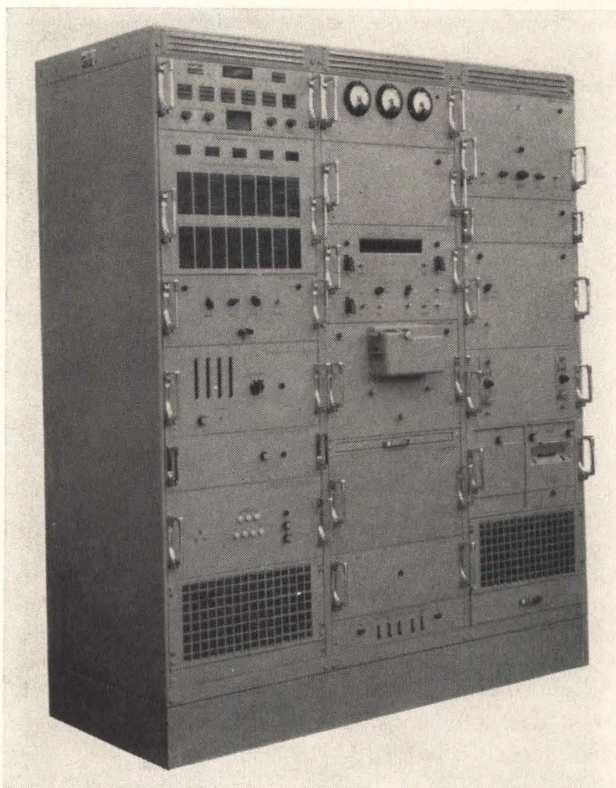
The automatic programmer will generally sound an alarm and stop the testing sequence when a NO GO reading is entered, forcing the operator to acknowledge the situation by manually restarting the sequence. Alternately, the programmer may switch into a fault-isolation subroutine. In testing missile engines a NO GO reading will be programmed to automatically disable the unit under test to prevent damage.

Other functions of the control unit include introducing time delays into the sequence as required by the unit under test, and selection and insertion of tolerances into measurement-limit storage. Periodically the programmer may switch in a self-check sequence to test the automatic tester itself.

• *Self checking provisions.* The automatic checkout system is highly complex and likely to fail occasionally. To increase confidence in the testing, most modern systems contain provisions for self-check, which is carried out automatically at intervals as a subroutine, sometimes while a test is in progress. Motorola's Pate system, for example, carries out a self check periodically, and if a NO GO reading is encountered, switches itself into a further self-test sequence, which then isolates and identifies the faulty module of the test system. The self-check exercises all Plate's digital circuits; their



INDUSTRIAL *automatic tester is Bulova Watch analyzer for Accutron electronic watch movements. Analyzer checks 15 functions sequentially in one second. Such systems are not designed to be adaptable to other uses—Fig. 4*



DATICO EQUIPMENT *for Polaris missile checkout, installed aboard the USS George Washington and Patrick Henry. Later version is installed aboard all Polaris submarines—Fig. 5*

logical response is compared against the response that should occur. The measuring units are also tested, by connecting them to secondary standards and evaluating the measurements against known values.

• *Means of access to equipment under test.* Connections must be made from the tester to the unit under test. This includes connecting the stimuli to the input points, connecting dummy loads to output points, and making measurement connections. Since automatic checkout must be done rapidly, connecting and disconnecting must be quick and easy. Most testing systems have adapter cables for each kind of unit tested; this accommodates the requirement for a variety of connectors, simplifies test system design and reduces required operator skill.

In checking out a large, complex system, 12,000 wires to and from the equipment may be required. This poses a problem with mobile systems, where cable hoists, booms and similar equipment may be needed; another problem is how to store the cables.

Many techniques have been applied to reducing the number of connections. These are mostly switching techniques, including multiplexing with remote switching amplifiers. An increased logic capacity in the test control computer can make many connections unnecessary, since it can draw more conclusions from fewer figures. Usually it is also desirable to use all input and output connections on the equipment, and to take advantage of all interconnections and information channels in the system under test.

DESIGN OF CHECKOUT SYSTEMS—The speed of a checkout procedure is vital. It is speed that forced the introduction of automatic checkout equipment in the first place, and there is a continuing effort to reduce the overall time of each test cycle. It is desirable also to keep to a minimum the on time of the equipment under test to prevent unnecessary failures.

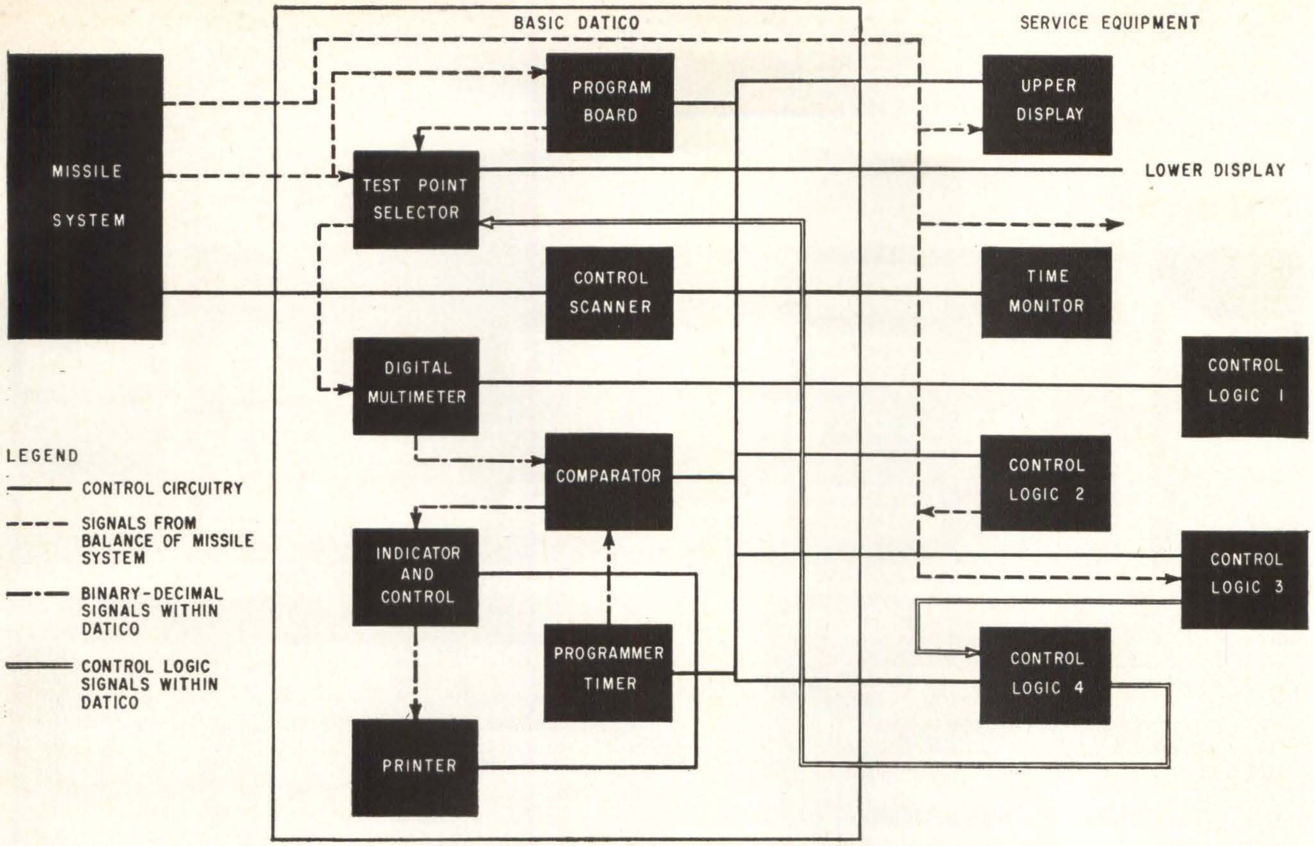
Switching, both at the input and output, limits speed. Most checkout systems use relay-tree switching, cross-bar, stepping-switch and latch relay configurations, although electronic solid-state switching has been introduced in some advanced systems. In contemporary checkout systems millisecond switching times are normal.

Memory access and readout times in most of today's systems are of the order of 5 milliseconds. With punched tape programming, mechanical readers are being replaced with photoelectric readers; this increases readout speed from about 20 frames a second to up to 200. Block readout techniques, supplementary memories and similar approaches have cut readout time to the order of 1 millisecond. Shorter times are encountered in some computer-controlled units.

Another speed limitation is the measurement and conversion speed. These are intrinsic limitations of the measurement units.

However, the overall checkout speed in modern systems is limited not so much by the checkout system itself as by the equipment under test: warmup time, built-in delays, response time, the time taken by the operator to dispose of NO GO indications, to make adjustments, the connecting and disconnecting time.

Early automatic checkout systems were custom built. However, with the rapid obsolescence of space and military equipment types, and their increasing complexity, this proved uneconomical; large amounts of support equip-



BLOCK DIAGRAM *of Nortronics' Datico shows the basic-unit-plus-adapter approach to adaptability—Fig. 6*

ment carried with each electronic system frequently had to be replaced, and were unsuited for anything else. At the same time, the automatic checkout system became more complex and its control and logic circuits came to resemble a general computer.

It soon became apparent that a test system that could be adapted to handle several weapon systems would be more practical and economical, and several ways of building adaptability into test equipment were developed. Most of the large automatic testing systems today are flexible, and some are called universal.

However, custom-designed testing systems, designed for one job only, are common in industrial applications and wherever complexity is low. Testers for repetitive production-line work, such as the one shown in Fig. 4 for testing movements of electronic watches, are not likely to be adaptable to other work.

Similarly, automatic selftesting systems for use aboard space vehicles and intended to perform only one kind of test sequence do not have to be adaptable; in these applications the equipment is expendable and space and weight must be saved.

MARTIN-DENVER'S MARTAC *checkout system has central unit (center and left) that can control remote units (right) at equipment locations. System uses photoelectric tape reader, is set up for missile launch control and checkout—Fig. 7*

MAKING TEST GEAR ADAPTABLE—The ideal automatic tester, of course, would have no limitations. Since voltages, currents, time phenomena and other physical quantities occur in all electronic equipment, with proper programming the ideal tester could test almost anything. For each piece of new equipment a new program tape would be inserted, connections made, and a test run immediately.

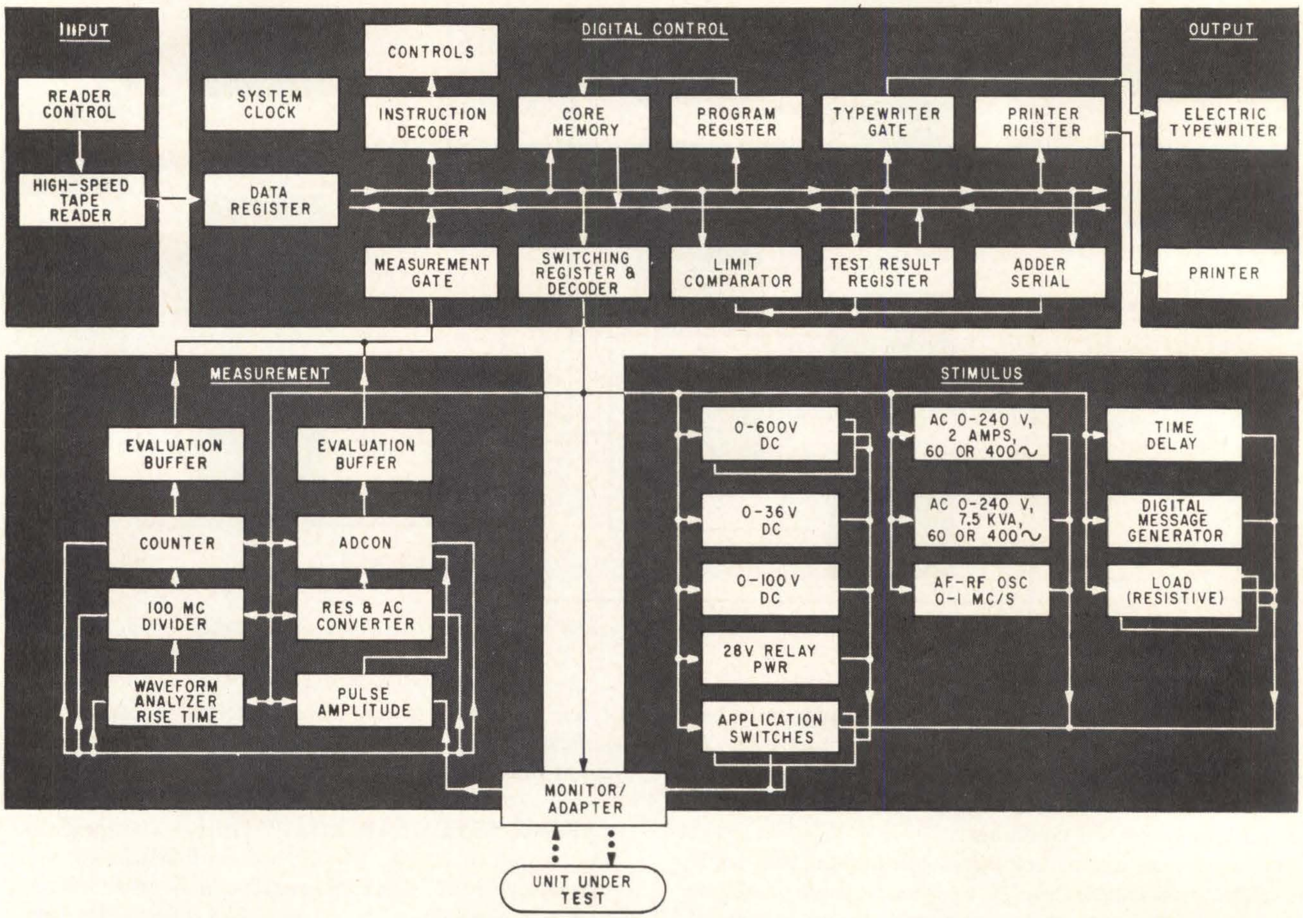
In practice this is not so simple, because universality carries with it certain penalties. Several basic approaches have been developed toward making automatic checkout equipment adaptable.

• *Basic-unit-plus-adapter system.* This approach to automatic testing equipment uses one basic unit, comprising the elements that are common to all intended applications, and an adapter that completes the test system. The adapter is custom-built for each kind of equipment to be tested.

An example of this approach is Nortronics' Datico (Digital Automatic Tape Intelligence Checkout) test system, which has been applied to monitoring the readiness of submarine-based Polaris missiles (see Fig. 5), as well as other systems ranging from system checkout to component fault isolation on the Nike-Hercules missile and on automatic pilots.

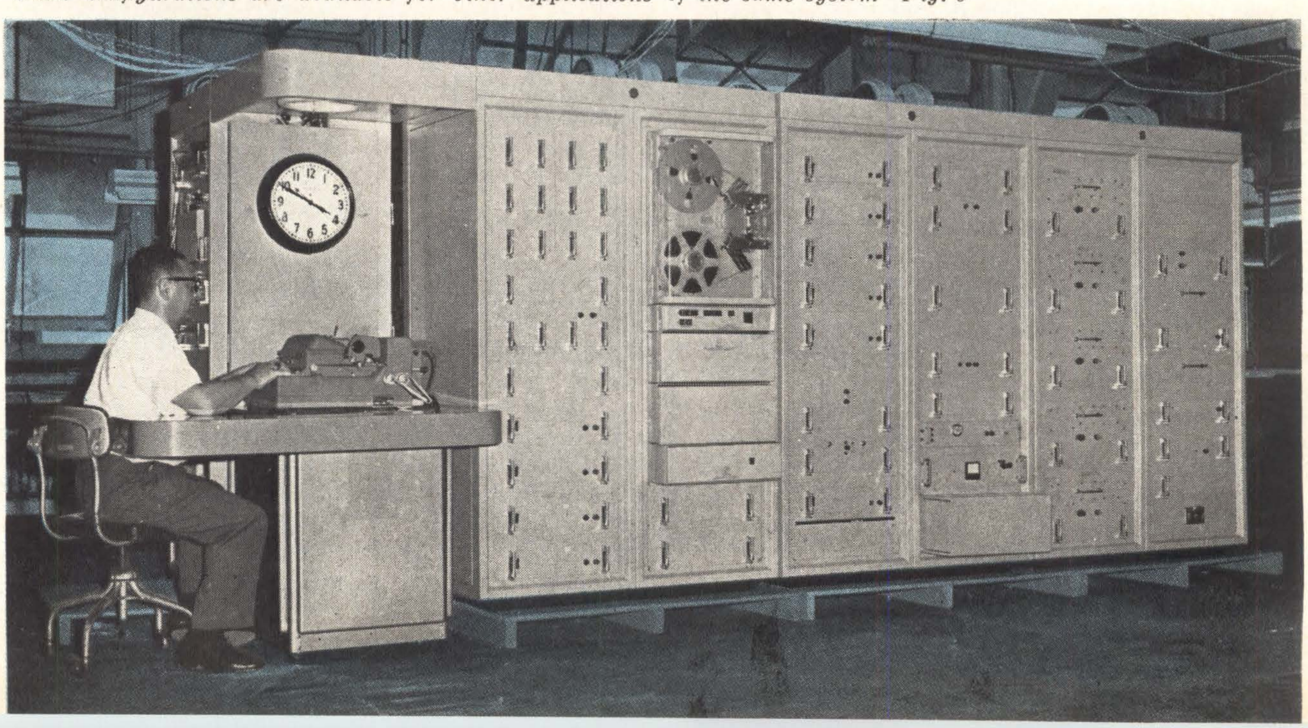
The basic Datico is unchanged in different applications, except for physical characteristics to conform to the different armed services' specifications. The equipment includes the program board, test-point selector, control scanner, comparator, indicator and control, programmer-timer and printer circuits. Figure 6 is a block diagram of Datico.

To this package is added the adapter, which includes the signal (stimuli) generators, measuring devices and displays, as well as connection hardware. Thus units that are common to all testing schemes need not be duplicated, while the specialized features whose requirements vary from system to system can be designed for each, without compromise in measurement accuracies.



DEE, *by RCA, is a flexible universal test system. Equipment is shown in its high-speed automatic configuration, block*

DEE SYSTEM *before delivery to Signal Corps. This is a magnetic-tape system with electric-typewriter printout. Other configurations are available for other applications of the same system—Fig. 9*



The Polaris Datico operates on three levels: watch mode, for continuous monitoring of the readiness of the missile circuits; test mode, a periodic maintenance check to ensure readiness; and operate mode, for the final countdown sequence before launching. The system is controlled by punched Mylar tape.

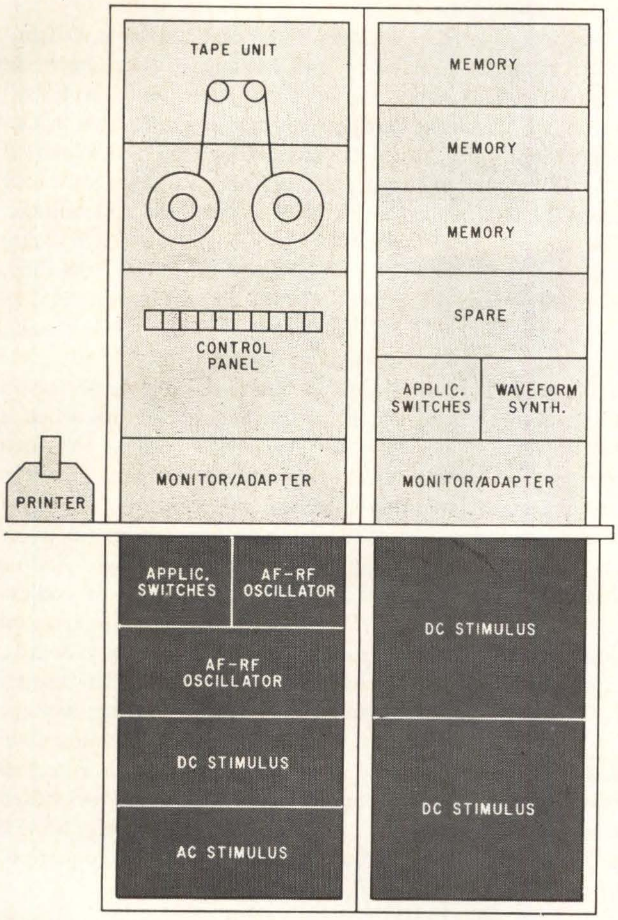
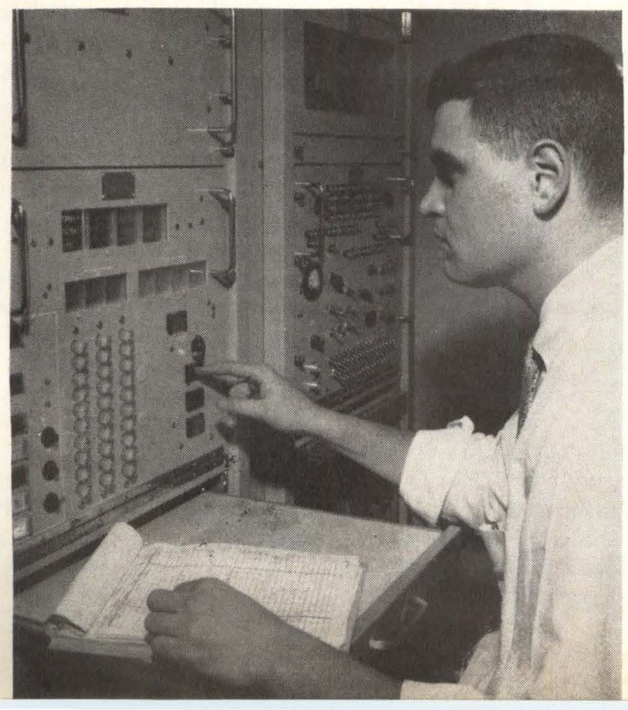


diagram is at left, front panel at right—Fig. 8

SPERRY's RACE *checkout system accomplishes entire sequence by use of two pushbuttons:* START *and* DISPLAY FAULT NUMBERS—*Fig. 10*



The basic-unit-plus-adapter system is also used in the Martin Denver Company's Martac 420 system, a solid-state, high-speed automatic checkout system. Martac has the additional feature of one central unit controlling a number of remote units located at the equipment sites. A system is illustrated in Fig. 7.

• *Erector-set approach.* Called also the functional building-block principle, this approach uses an assortment of physical modules each of which has only one function, such as tape reader, voltmeter, counter or printer. The modules have standardized physical dimensions; electrical characteristics can be also standardized.

For any automatic testing program, only the relevant functional modules are selected and assembled. A programming unit is selected according to the speed and complexity of the test, and connection made to the equipment. This approach is illustrated by RCA's DEE (Digital Evaluation Equipment) system. The basic DEE has 108 different modules, built in five standard module sizes. Fieldata code is the program language.

This system assumes that the basic physical measurements will recur in different systems to be tested, and that measuring units will not be made obsolete by new equipment or increased accuracy requirements. Its advantage is that in any testing program only the necessary units are carried, thus saving space and weight, and that modules can be interchanged to accommodate changing requirements. Obsolescence of individual modules does not necessitate redesign of the system, and expansion capability is maximum.

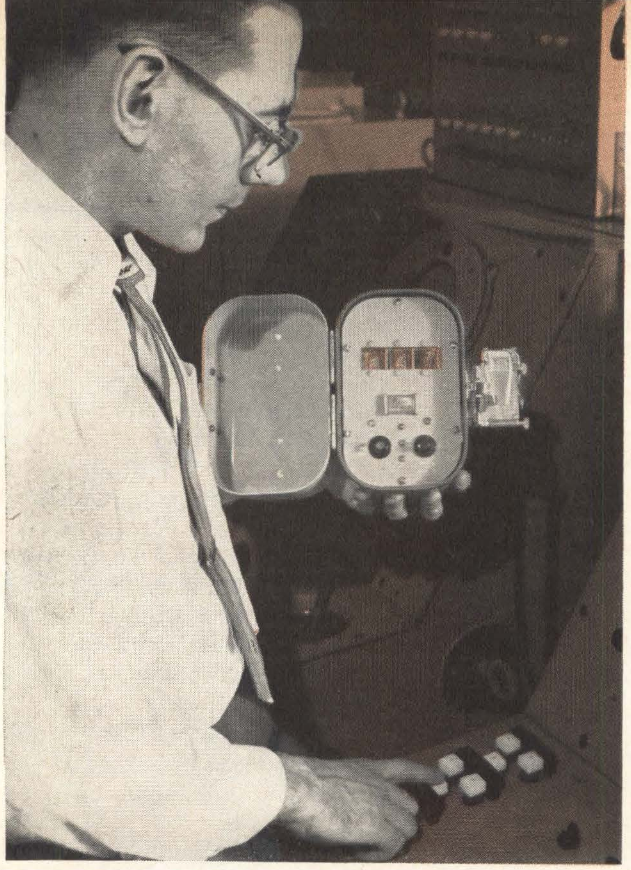
Thus the DEE open-end system makes possible a variety of testing programs, ranging from semi automated punched-card-programmed units, suitable for production testing and component grading, to computer-controlled research and development evaluation systems, see Fig. 8 and 9. An interface converter available with DEE makes it possible to control the DEE equipment with a external digital computer, so that the testing program can time-share the computer with other activities.

Here automatic checkout equipment becomes an extension of a computer, a tool that enables the controlling computer to perform checking and analytic functions on other electronic equipment without human intermediaries.

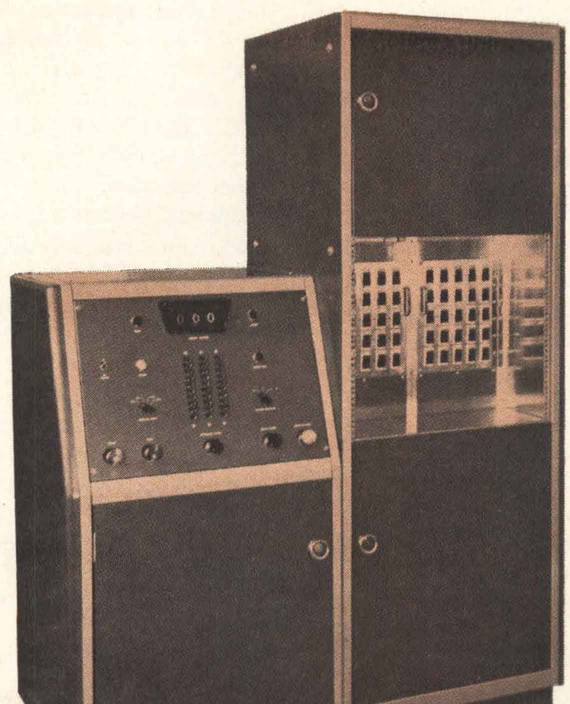
Another modern automatic checkout system that illustrates some of the points mentioned above is Sperry's Race (Rapid Automatic Checkout Equipment), a computer-controlled dynamic test system that uses a 1-megacycle digital computer with a half-million-bit memory, a computing capacity equivalent to a conventional digital business-type computer. The system is adaptable to radar system testing, data processing stations, bombing-navigation systems and countermeasures systems, and is self-adapting to system design variations.

Race, shown in Fig 10, performs about 1,500 test cycles in 30 minutes, completing the equivalent of six man-weeks of testing. Without relay switching-time and human-response delays, the system could complete the 1,500 tests in one minute.

The Race checkout systems use a human operator as part of the checkout loop, to cover all modes of operation in the shortest possible time. The operator has a small box by which he can communicate with the control unit: the control unit requests the operator by a flashing-



REMOTE COMMUNICATOR UNIT *enables checkout system to "converse" with operator of system. By code numbers, checkout system instructs operator to change switch positions, and compare displays. Operator replies by pressing* YES *and* NO *buttons—Fig. 11*



INDUSTRIAL TESTER *by Datronics applies the principles of automatic checkout to continuity and leakage tests—Fig. 12*

light code to select switch positions, verify scope patterns and make adjustments. Operator acknowledges orders and replies by pressing buttons, Fig. 11.

Programming of the Race system is by magnetic-drum memory. The logic circuits operate at a one-megacycle clock rate; the drum runs asynchronously slightly slower, and the system under test has its own clock frequency; thus the entire testing system operates on three simultaneous time scales.

An example of an industrial automatic tester is Datronics' Automatic Continuity and Leakage Tester shown in Fig. 12. This unit can be used in production tests, computer checkout and troubleshooting. It tests a circuit's continuity, with GO limits 0.4 and 5.0 ohms at 10-milliampere d-c test current, and leakage resistance from 20 to 200 megohms at 500 volts d-c test voltage. The tester has a capacity of 1,000 circuits, each being assigned a three-digit decimal code, and will test these in predetermined sequence at 100 circuits a minute.

The readout indicates the number of the tested circuit, continuity and leakage NO GO lights, test-cycle-complete light, and a fault alarm is sounded in NO GO cases. Programming is by patchboard. Sequence stops when a NO GO reading is obtained. The fault reading can then be repeated or bypassed at the operator's option. Switching is done by stepping switches and relays.

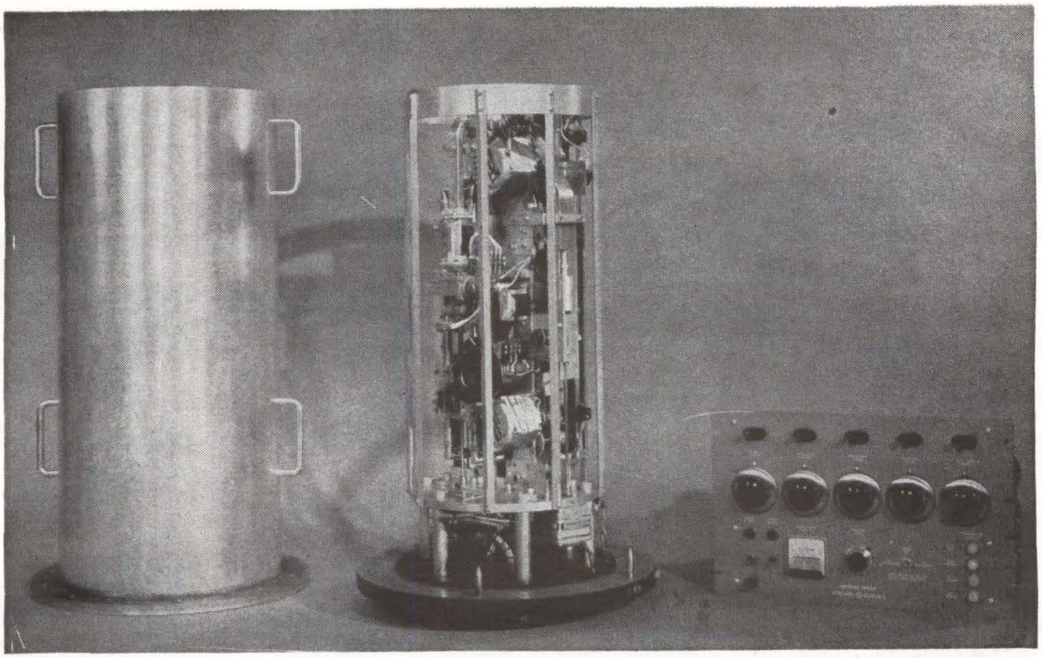
An example of an industrial on-line automatic tester is the DIT-MCO company's model 720 logic-module tester. Programmed by punched Mylar tape in endless loop, the model 720 performs static and dynamic tests on active or passive logic modules, such as memory boards, computer logic cards and component cards. The testing is GO-NO GO, measurements are made of resistance, voltage and current. Marginal tests can be programmed to evaluate a logic module under conditions of lowered or raised supply levels, combined with lowered or raised signal levels. Passive logic circuits can be checked against logical outputs conforming to the logic equation.

TRENDS IN DESIGN—Several trends are emerging in the development of automatic testing systems. They are for the most part in the direction of increased automation, increased speed and smaller physical size.

Computer-controlled checkout systems, capable of analyzing the performance of a unit under test from only a limited number of measurements, will be able to isolate and identify the smallest replaceable component and instruct the operator to that effect. From logical analysis of operation, future systems will probably be able to predict the remaining useful life of any piece of equipment, and also to determine tolerance limits of operation for selected portions of a system where they are contingent on actual performance values measured in other portions of the system. Through computer-controlled checkout equipment, interconnecting cables will be kept to a minimum.

Other features recently appearing in checkout systems are all-solid-state circuits, fully digital circuits, expandable modular design, flat-wire cabling, wire-wrapped connections, use of standard logic modules, photoelectric rather than electromechanical punched-tape readers, and less reliance on operating technicians.

A major part of the automatic checkout equipment made today is designed in conformance with USAF specification MIL-D-9412, covering data for aerospace ground equipment (AGE).



Weatherproof container for the paramp (left) permits its mounting at the feed point of the antenna. Control panel (right) is in a ground-level control room

FIRST CIRCUIT DETAILS

Paramp that Tracked Pioneer IV Deep-Space Probe

Rapid tuning over a broad frequency range at low noise is made possible by a unique three-cavity design and varactor-diode mount

By A. P. HEYMANN
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General Electric Company,
Syracuse, New York

THREE CAVITIES, tightly coupled at the varactor diode, but tuned separately, overcome tuning-range limitations of the usual parametric amplifier. This negative-resistance amplifier tunes from 375 to 1,200 Mc with a noise figure of less than 2.5 db. Frequency-selective filters in all the tuning circuits allow independent tuning. The filters and cavities are arranged around the diode so that there is no spurious resonance or interaction between tuning controls.

A rectangular waveguide H-plane cross is used for the pump and idler circuits with the diode at the center of the cross. Pump frequency, fixed at 10 Gc, is supplied by a 100-milliwatt reflex klystron.

Mounted directly on the cross assembly, the coaxial cavity is tuned to the signal frequency. The signal cavity is a modified $\frac{1}{4}$ or $\frac{3}{4}$ wavelength shorted line capacitively loaded by the diode. A coaxial low-pass filter keeps out X-band frequencies.

The cross design is mechanically simple and lends itself ideally to the electrical requirements.

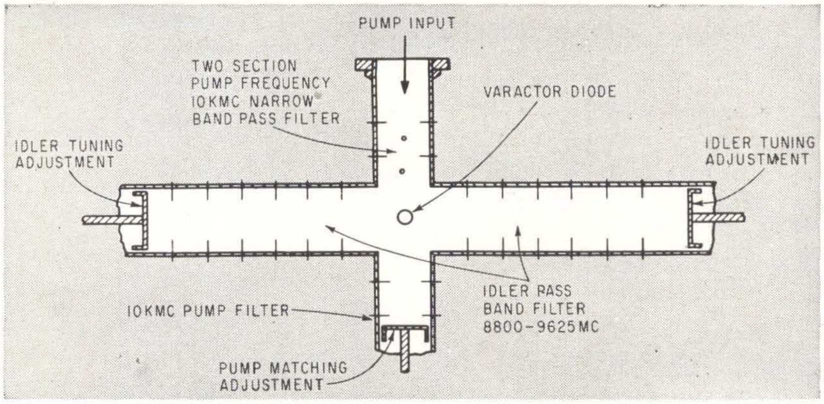
The physical size of the common frequency area containing the diode is small and of a shape that blends perfectly with the three cavity structures. This simplifies theoretical design.

This configuration permits the use of up to six filter and cavity tuning elements, which are coupled closely to the diode. This relatively large number of independent tuning and matching adjustments results in the unusually wide tuning range.

Two idler-frequency filters and two idler tuning adjustments are arranged in a line with the diode in the center, Fig. 1. The complete circuit may be viewed as a multi-wavelength waveguide cavity loaded in the center by the diode.

Two idler adjustments prevent a voltage standing wave minimum from falling at the diode position and decoupling the idler circuit at spot frequencies.

Because both filters are tuned in the same frequency, the two tuning



WAVEGUIDE CROSS ASSEMBLY *for mounting the varactor diode is shaped to match the three-cavity structure—Fig. 1*

adjustments interact with each other, providing a tuning adjustment and a diode coupling adjustment for the circuit. The two filters prevent interaction with the pump circuit adjustments.

Band-pass idler filters cover the idler tuning range of 8,800 to 9,625 Mc and have over 30 db attenuation at the pump (10 Gc) and upper-sideband frequencies. The filters are a Tchebyscheff design with maximum passband attenuation of ½ db and sharp cutoff slope.

The pump circuit is similar to the idler circuit except that, because of fixed-frequency operation, the filters are narrow band-pass units. With the source at one end of the pump circuit, a sliding short is a matching device at the other end. The sliding short matches the diode to the pump to conserve pump power.

SIGNAL CAVITY—Because of the wide-band tuning requirement plus the requirements of the antenna and post-receiver coupling, the signal cavity (Fig. 2) is the most critical portion of the amplifier. The cavity operates as a coaxial quarter-wave resonant line, which is foreshortened by the diode capacitance, for frequencies up to 550 Mc. The three-quarter mode is used above 550 Mc because its length is more convenient.

The filter section of the signal cavity, a two-section constant-K filter of coaxial design with a cutoff frequency of 4 Gc, is designed for high attenuation in the pump and sideband region (8 to 12 Gc) and the pump second harmonic region (20 Gc). High attenuation at these frequencies assures their absence from the signal cavity resonant circuits, simplifying the design of the signal cavity and providing independence for quick and easy adjustment.

A unique split-conductor construction is used in which both inner and outer conductors are divided for the full length of the cavity to permit the insertion of an adjustable shorting bar. This bar controls both the signal frequency tuning of the amplifier and the coupling between the signal cavity and the signal input and output circuits.

To adjust the signal frequency, the bar is moved to vary the length of the resonant portion of the cavity, which lies between the bar and the varactor diode. The remainder of the cavity acts as a coaxial line to connect the resonant portion to the signal input and output circuits.

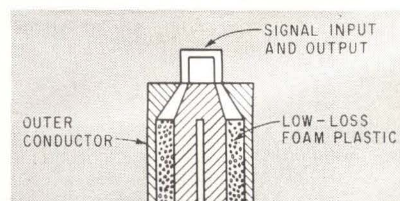
The shorting bar is a leaky short that permits energy to couple into and out of the resonant cavity. Coupling is controlled by varying the cross-section of the shorting bar. By making the bar with a lengthwise taper, its effective cross-section is adjusted by moving it into or out of the split signal cavity.

The bar makes contact at all times to both halves of the center and outer portions of the signal cavity. Six rhodium-plated beryllium-copper contact strips make high-pressure contact with the rhodium-plated shorting bar. The split-center conductor is supported by a low-loss foamed-in-place plastic that is almost completely transparent to the signal-frequency energy. This construction makes the signal cavity a rugged structure, practically immune to shock, vibration or moisture and dirt contamination.

A phasing adjustment, Fig. 3, allows optimum matching between the antenna and the signal cavity. This is a trombone-type constant-impedance coaxial line stretcher.

COUPLER—A wide-band directional coupler couples signal input and output lines to the amplifier. A circulator would be better but no circulator covers more than a small fraction of the tuning range of the amplifier. It may be possible to cover the 825 Mc tuning range using two circulators with coaxial switching. These devices have not yet been developed but their use would double the bandwidth of the amplifier and increase its stability.

Any conventional circulator can be used with the amplifier over a tuning range determined by the passband of the circulator. Such a circulator could either directly replace the directional coupler or be installed external to the amplifier and the directional coupler left in place.



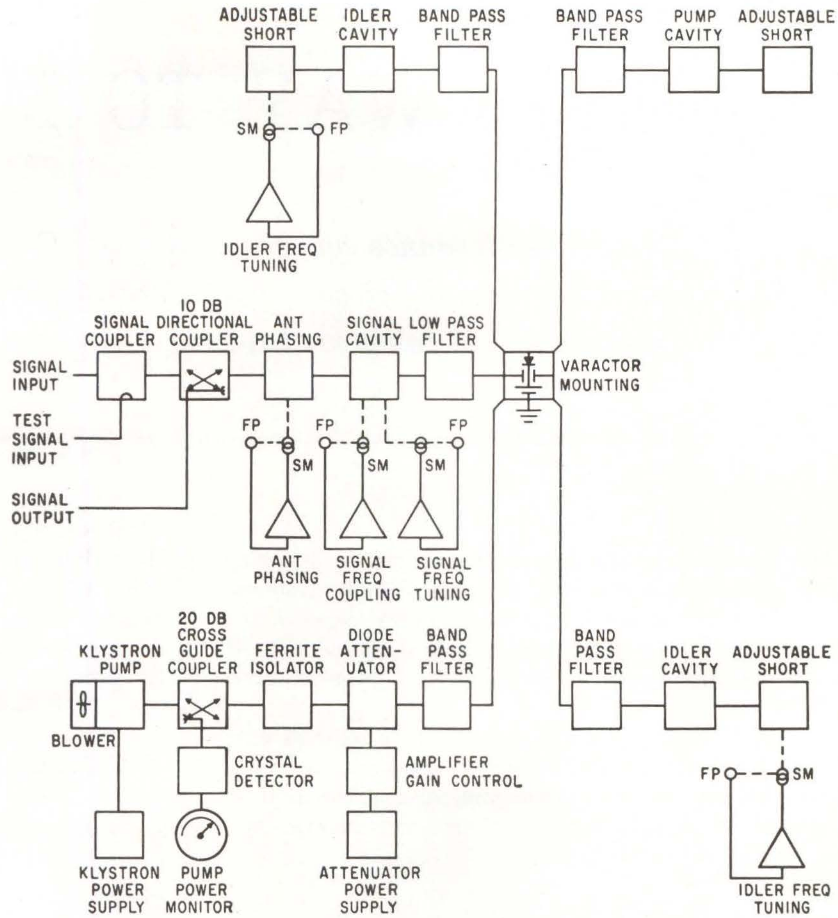
FILTER SECTION *of this signal cavity reduces possibility of unwanted resonant circuits—Fig. 2*

A loop coupler introduces a test signal into the amplifier for adjusting and verifying operation.

In the pump circuit a 20-db cross-guide coupler diverts 1 percent of the pump power to a crystal detector. The rectified current goes to a 0-1 milliameter that monitors pump power. An attenuator diode across the pump waveguide acts as an electrically-operated control of the pump power reaching the varactor diode. This controls amplifier gain which is a function of pump power. A low-noise high-stability power supply furnishes bias voltage to the attenuator diode.

The varactor diode is operated with a fixed bias of 1.35 volts from a Mallory PX13 mercury battery.

As shown in Fig. 3 five servo motors in the amplifier operate the adjustments. These are conventional a-c servos with carbon-film stepless reference and feedback potentiometers.



VARACTOR MOUNTING *in this block diagram shows the bypass capacitor and the bias battery; FP is a feedback potentiometer and SM is a servomotor—Fig. 3*

MOUNTING—The amplifier is mounted on, but thermally isolated from, a round aluminum base plate. The cylindrical aluminum cover is double walled with a foamed-in-place plastic thermal insulation. To reduce radiant heat pickup from sunlight, the outer surface is polished and bright anodized. The cover bolts to the base plate with an O-ring seal to provide a weather-tight joint.

To avoid artificial cooling, the amplifier is operated at an internal temperature of 125 F. The temperature control system consists of four thermoswitches and a number of heater units distributed over the amplifier structure.

For wide-range operation on a parabolic antenna, a broadband feed must be used. A log periodic structure would meet this requirement.

Since this is a regenerative amplifier, its gain is limited only by self oscillation. In laboratory tests it operated with gains as high as 50 db. However, stability, bandwidth and system noise usually limit the paramp gain to 20 db or less. At 20-db gain the bandwidth is between 100 Kc and 300 Kc at 400 Mc and between 250 Kc and 700 Kc at 1,000 Mc. Bandwidth is determined by the antenna phasing control. Use of a circulator will result in the doubling of the bandwidth. With 20-db gain the noise figure is approximately 1.3 db at 375 Mc and 2 db at 1,200 Mc using a Microwave Associates MA-460H varactor diode.

In spite of the apparent complexity of its controls, the amplifier can be tuned to any frequency within its range in less than 30 seconds by an unskilled operator using calibration curves and checking equipment.

Although the paramp was designed to enhance the capabilities of space tracking and space communication facilities it is a general-purpose, signal-frequency, low-noise, 50-ohm amplifier, which can be used with any radar, radio-astronomy or noise-measuring equipment. A developmental prototype of this amplifier was used in March 1959 to track the Pioneer IV deep-space probe to a range of 407,000 miles. An 18-foot parabolic antenna was used with a phase-lock receiver. Signal frequency was 960 Mc.

Although this unit was specifically designed for a tuning range of 375 to 1,200 Mc it can be made to operate at any frequency up to about 2,500 Mc by changes in the passband of the idler filters. With a redesign of the waveguide cross to accommodate a higher frequency pump, the amplifier can be made to operate at signal frequencies up to 5,000 Mc.

REFERENCES

1. Gittinger, N. C., "Tunable Parametric Amplifier for the 350-1200 mc Frequency Range," Proceedings of the National Electronics Conference, Vol. 16, pp. 462-467, October 10-12, 1960.

2. Reed, E. D., "The Variable-Capacitance Parametric Amplifier," IRE Trans. on Electron Devices, Vol. ED-6, pp. 216-225, April 1959.

3. Heffner, H., Wade, G., "Gain, Bandwidth, and Noise Characteristics of a Variable-Parameter Amplifier," J. of Appl. Phys., Vol. 29, pp. 1321-1331, Sept., 1958.

NEW WAY TO MULTIPLY Q

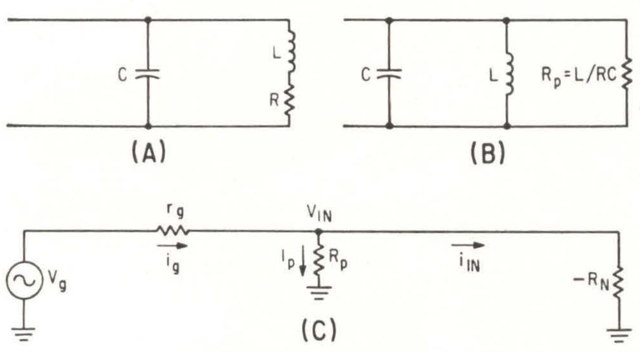
Negative-impedance converter increases Q by a factor of 4 or more, by reducing circuit losses. Transistor matching is not necessary, and component tolerances are not critical

By T. ORMOND, Sylvania Electric Products, Inc., Woburn, Mass.

TUNED CIRCUITS in the audio range seldom achieve a high circuit Q. The difficulty is a combination of low operating frequency and high series losses with inductors. This article presents a method for reducing circuit losses, thereby increasing over-all circuit Q.

Consider a tank circuit composed of a lossless capacitor in parallel with a lossy inductor, Fig. 1A. Figure 1B also represents the circuit, and the analysis lends itself more readily to this representation. For Fig. 1B, Q is given by

$$Q = \left(\frac{R_p}{wL}\right) \qquad (1)$$



TANK CIRCUIT *(A) is also represented as (B); tank circuit with negative resistance added (C) — Fig. 1*

Multiplication of Q can be obtained by raising the value of R_p. This is most easily accomplished by adding some negative resistance to the circuit as shown in Fig. 1C (the tank circuit losses are represented by resistance R_p). The new circuit Q will be

$$Q = \frac{Rx}{wL}, \quad \text{where } Rx = -\frac{R_p R_N}{R_p - R_N} \qquad (2)$$

Since Rx must be positive to prevent oscillation, the magnitude of R_N must be greater than R_p. Referring to Fig. 1C,

$$V_{in} = Vg - i_g r_g$$

$$i_p = V_{in}/R_p$$

$$\text{and } i_g = \frac{V_g}{r_g + R_x}$$

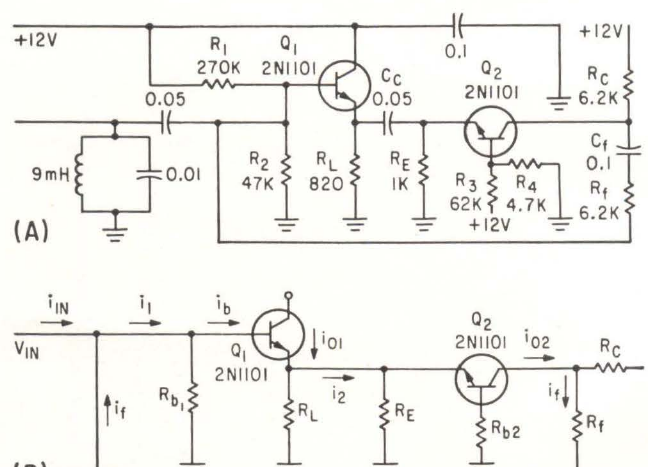
The equation for V_{in} can be rewritten as

$$V_{in} = Rx\,(i_p + i_{in}) \qquad (3)$$

Solving Eq. 3 for i_{in}

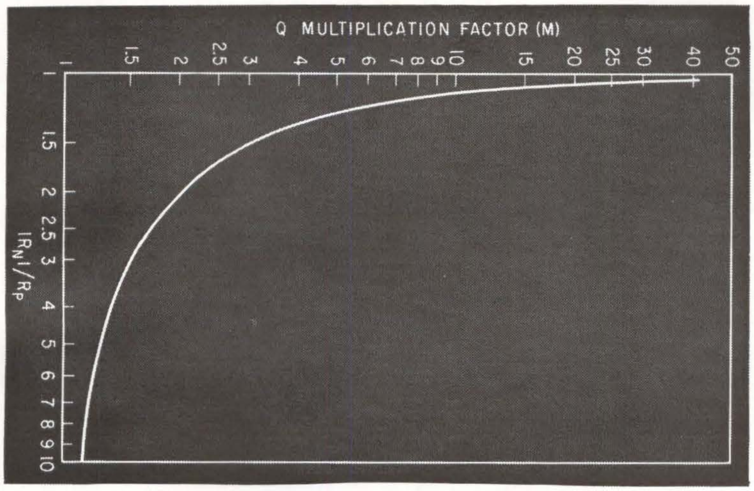
$$i_{in} = \frac{V_{in} - i_p R_x}{Rx} \qquad (4)$$

Defining a multiplication factor M, such that $Rx =$



NEGATIVE-IMPEDANCE *converter (A); equivalent circuit for analysis (B)—Fig. 2*

WITH TRANSISTORS



CAPABILITIES *of the negative-impedance converter for Q-multiplication—Fig. 3*

MR_p, then

$$i_{in} = \frac{V_{in} - Mi_p R_p}{MR_p} = \frac{V_{in}(1 - M)}{MR_p} \quad (5)$$

$$\frac{V_{in}}{i_{in}} = R_N = \frac{MR_p}{1 - M} \quad (6)$$

The designer will have all the information necessary to solve Eq. 5 and 6.

Figure 2A is a schematic of a negative impedance converter. It consists of an emitter follower and grounded base amplifier, with positive feedback from the collector of Q_2 to the base of Q_1. The circuit of Fig. 2A may be reduced to that shown in Fig. 2B. Resistance Rb_1 represents the parallel combination of R_1 and R_2, Rb_2 represents the parallel combination of R_3 and R_4, and all capacitances have been omitted since their reactances can be made negligible at the operating frequency. Referring to Fig. 2B, and using only magnitudes for α and β

$$i_b = Ki_1 \quad \text{where } K = \frac{Rb_1}{Rb_1 + (\beta_1 + 1) R_L}$$

$$i_{01} = (\beta_1 + 1)\, i_b = K(\beta_1 + 1)\, i_1$$

$$i_2 = \frac{R_L}{R_L + R'}\, i_{01}$$

where R' equals R_E in parallel with the input resistance of Q_2

$$i_2 = \frac{KR_L(\beta_1 + 1)\, i_1}{R_L + R'}$$

Since R' will be much smaller than R_L and can be neglected, and $(\beta_1 + 1)$ is essentially β_1,

$$i_2 = K\beta_1 i_1$$

Neglecting the small current that will flow in R_E,

$$i_{02} = \alpha_2 i_2 = \alpha_2 K \beta_1 i_1$$

$$i_f = \frac{R_c}{R_c + R_f}\, i_{02} = \frac{\alpha_2 K \beta_1 i_1 R_c}{R_c + R_f}$$

At the input

$$i_{in} = i_1 - i_f$$

$$= i_1 - i_1 \frac{\alpha_2 K \beta_1 R_c}{R_c + R_f}$$

$$i_{in} = i_1 \frac{(R_c + R_f - \alpha_2 K \beta_1 R_c)}{(R_c + R_f)}$$

Solving for R_f yields

$$R_f = i_1 \frac{(1 - \alpha_2 K \beta_1)\, R_c - i_{in} R_c}{i_{in} - i_1}$$

Assume $\alpha_2 = 1$ and

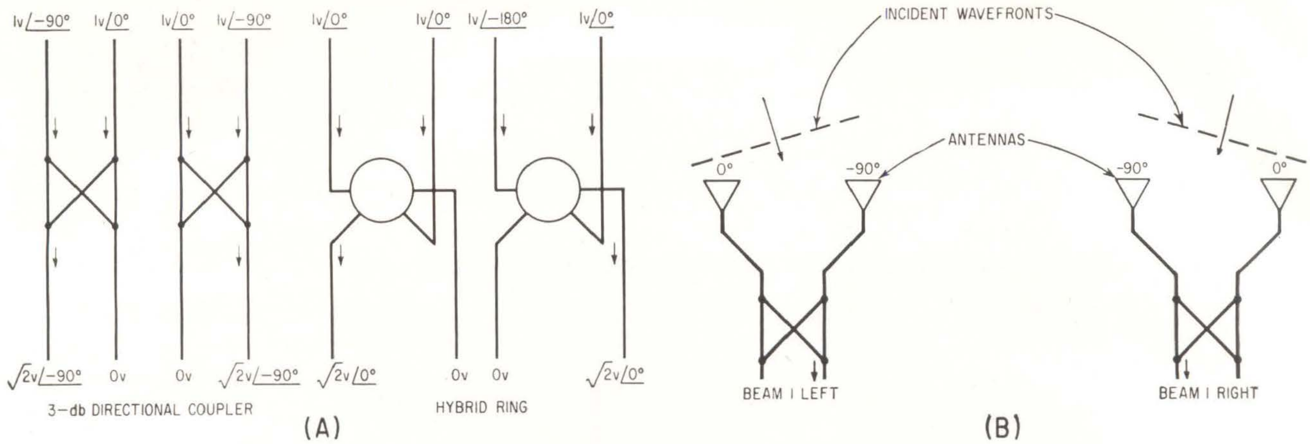
$$R_f = \frac{i_1(1 - K\beta_1)\, R_c - i_{in} R_c}{i_{in} - i_1} \quad (7)$$

Conventional biasing techniques will determine the values of the biasing resistors shown in Fig. 3 (R_1, R_2, R_L, R_E, R_3, R_4, R_C). The original circuit conditions give values of V_{in} and R_p. With these two values and the desired multiplication factor M, Eq. 5 can be solved for i_{in}. Current i_1 can be found from

$$i_1 = \frac{V_{in}}{Rb_1(1 - K)}$$

Equation 7 can be solved for R_f. Making R_f variable will allow for any corrections that may be necessary due to assumptions made in the analysis.

Figure 3 shows the multiplication capabilities of the circuit. Transistor matching is not necessary and component tolerances are not critical. Lead lengths could become critical when large multiplication factors are desired, so good wiring practice should be observed. Figure 2A gives component values of a circuit built in the lab to demonstrate Q multiplication. The tank circuit Q was multiplied by 4, giving an overall circuit Q of 20. As shown in Fig. 3, much higher multiplication may be obtained, the limit being the condition where $|R_N| = R_p$ and oscillations result.



PHASE-SHIFT CONVENTIONS *(A) for directional couplers and hybrid rings. Simplest beam forming matrix (B) uses two antenna elements and one coupler—Fig. 1*

Steering Radar Antenna Beams

Made from passive microwave elements, beam-forming matrix can be placed next to antenna array, is theoretically lossless and forms as many simultaneous beams as there are antenna elements in the array

By WILLIAM P. DELANEY
MIT Lincoln Laboratory,
Lexington, Mass.

MANY PRESENT and future radar systems require a rapid and flexible means of steering the antenna beam. Some of the limitations inherent in mechanical steering methods can be overcome by the phased array radar, which uses electronic beam-forming and beam-scanning.

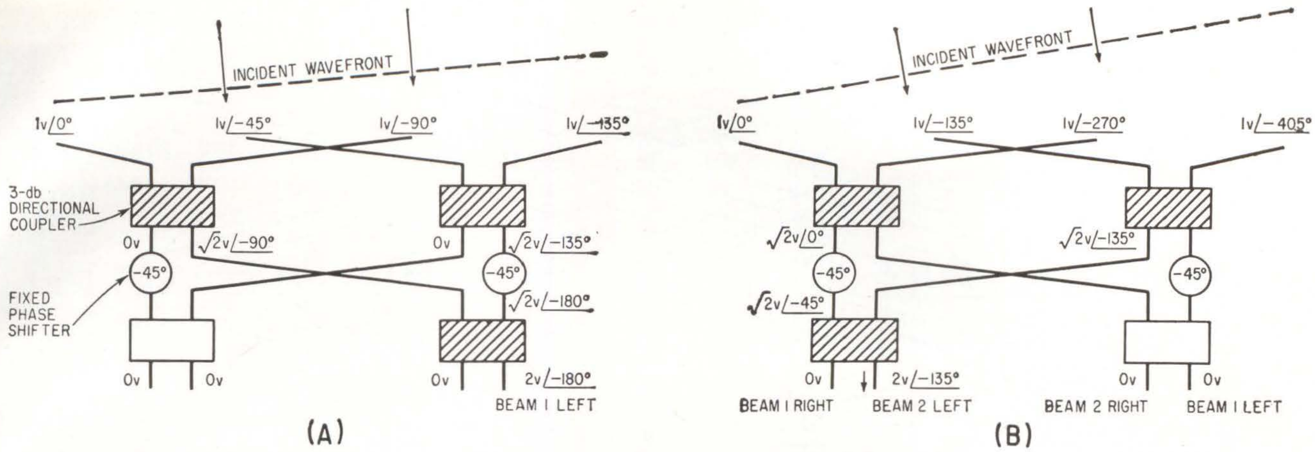
All phased array receivers combine the outputs of discrete antenna elements to form one or more antenna beams. This combining process can take place in the r-f or i-f portions of the receiver. One major disadvantage of forming the beam in the lower frequency portions of the receiver is the need for amplitude- and phase-stable mixing and amplifying circuits between the antennas and the low-frequency beam former.

A theoretically lossless multiple-beam forming technique can be used to form n simultaneous beams from an n element linear array. The beam-forming matrix operates directly at the r-f carrier frequency and thus can be located directly behind the antenna elements. All the beams formed by this technique have the full gain of the array aperture. Since the technique uses a matrix of passive microwave devices, it can be rugged and reliable, and is not susceptible to the phase and amplitude instabilities common in active r-f devices.

COUPLERS & PHASE SHIFTERS—Basic components of the matrix are 3-db directional couplers or hybrid rings and fixed phase shifters. Conventions concerning the phase shift through hybrids and directional couplers are shown in Fig. 1A. When the input voltages have the amplitudes and relative phase angles shown in Fig. 1A, all the input signal power will appear at the indicated terminal.

The simplest multibeam array is formed with two antenna elements plus one hybrid ring or one 3-db directional coupler. Figure 1B shows a two-beam, two-element array using a 3-db directional coupler. A certain incident wavefront will excite antenna element currents that are 90 degrees out of phase, and therefore all the received signal energy will appear at one terminal of the directional coupler. Thus, a beam right and a beam left are formed. If a hybrid ring is used, the two-element array has a broadside beam and an endfire beam, assuming an antenna element spacing close to one-half wavelength.

A four-beam matrix can be built by interlacing two two-beam matrices and then providing a second level of directional couplers or hybrid rings to combine the outputs. Fixed phase shifters are required between the upper and lower levels of couplers. Figure 2A shows a four-element, four-beam array using directional couplers. The amplitudes and phases of an incident beam-1-left signal are shown at various points in the matrix. Figure 2B shows the amplitudes and phases of an incident beam-2-left signal. The directional couplers shown shaded are used to form



AMPLITUDES AND PHASES *of voltages in a 4-element matrix for a beam-1-left signal (A) and a beam-2-left signal (B). Couplers shown shaded form the beams—Fig. 2*

With a Lossless R-F Matrix

the particular beam. Thus, the beam-forming matrix behaves like a multiple port feed structure that routes a signal originating at a particular point in space to a particular output port of the matrix. Since the matrix is symmetrical about a vertical line through the center, the 1-right and 2-right beams can be found by using the same approach.

SIXTEEN-ELEMENT MATRIX —This can be thought of as four interlaced four-element matrices. Two extra levels of phase shifters and combining elements (directional couplers or hybrid rings) are required. Figure 3 is a diagram of the 16-element matrix used to obtain the experimental measurements presented here.

The beam-forming technique can be used in planar arrays by first combining the columns of antenna elements in matrices and then combining the outputs of the column matrices in a group of row matrices. Some of the fundamental characteristics of the r-f beam-forming matrix are given in Table I.

The basic antenna beams formed using the r-f matrix will have the same beam shape as a uniformly illuminated antenna array. Thus first sidelobe levels of -13 db are to be expected for arrays of eight elements or more. The beams formed by this technique occupy fixed positions in space for fixed values of antenna element spacing and frequency. When the frequency is changed the beam positions will shift. Typically, a 10 percent frequency change will shift the positions of the beams near broadside by 10 percent and the beams furthest removed from broadside by as much as 28 percent.

The adjacent beams formed by this technique overlap each other with the cross-overs at the $2/\pi$ (at -4 db) points. The top portion of Fig. 4 shows three typical beams: 1R = first beam to the right of broadside, 2R = second beam to right.

Figure 4 also shows how two adjacent beams (1R and 2R for example) can be added to form a new beam (1R + 2R), which is somewhat broader than the component beams but has lower sidelobe levels. This addition of two adjacent beams changes the array illumination from a uniform distribution to a cosine distribution and thus first sidelobe levels of -23 db are to be expected in a large array. These reduced sidelobe levels are

CHARACTERISTICS OF R-F BEAM FORMING MATRICES—TABLE I

Number of beams: Number of beams formed is equal to the number of antenna elements. Number of antenna elements must be equal to a power of 2

Number of Directional Couplers or Hybrids: Number of combining devices is equal to $(N/2)\ \log_2 N$, where N = number of elements in the array

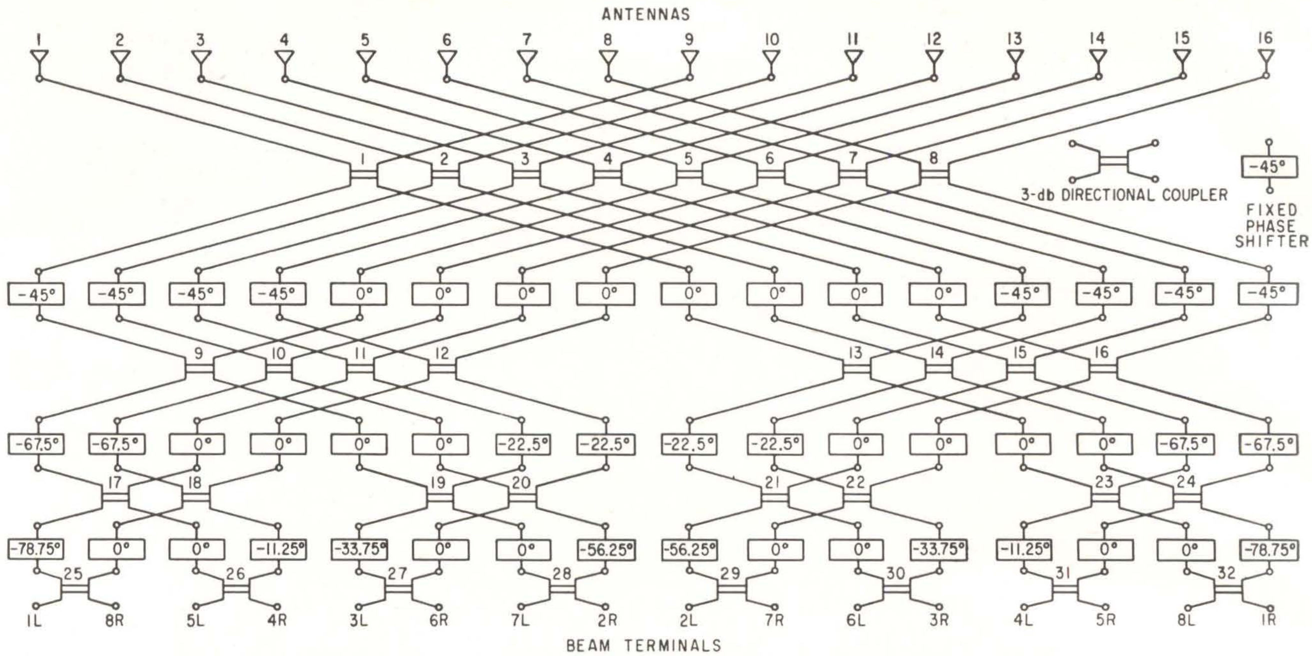
Number of Fixed Phase Shifters: Number of phase shifters is $(N/2)\ (\log_2 N - 1)$

Operating Frequency: Operating frequency is limited only by the practicality of building and interconnecting fixed phase shifters and directional couplers or hybrids. Hybrid transformers can be used in low-frequency matrices

Bandwidth: Phase shifters and directional couplers can be built with bandwidths greater than 30 percent but there are problems, such as beam movement with frequency, in operating phased arrays over bandwidths this wide

Insertion Loss: Beam-forming technique is theoretically lossless and in practice matrices can be built with low insertion loss. The 16 element matrix tested has an insertion loss of 0.75 db at 900 Mc

Antenna Array Illumination: Matrix provides a uniform illumination of array elements. However, simple beam-combining techniques can yield $(\text{cosine})^n$ illuminations of the antenna aperture



SIXTEEN-ELEMENT *beam-forming matrix, showing how directional couplers and fixed phase shifters are combined. Such a matrix was used to obtain the data in this article—Fig. 3*

achieved at the expense of a 0.9-db decrease in antenna gain and a 35 percent increase in half-power beamwidth. Adjacent cosine illumination beams shown at the bottom of Fig. 5 cannot be realized both simultaneously and without loss.

Three uniform-illumination beams can be added to form a cosine-squared illumination of the aperture; in general, $n + 1$ beams can be added to give a (cosine)^n illumination. Directional couplers in the matrix are of the coupled-strip type[2]. This type of coupler, shown schematically in Fig. 5A, has broadband characteristics.

Input power to port 1 is split equally between ports 2 and 4, with no power coupled to port 3. Power transfer from port 1 to 2 is accomplished by electromagnetic coupling between the two center conductor strips. Figure 5B shows a cross section of this coupler in strip transmission line.

EXPERIMENTAL RESULTS—The couplers used in the matrix coupled 3 db $\pm 1/4$ db over the 880 to 1,160 Mc range, with good isolation (26 db minimum) and low vswr (1.10 to 1 maximum). The phase shifters in the matrix also utilize a coupled-line technique[3] to obtain a broadband phase characteristic.

Figure 5C shows a network with close to constant differential phase shift between the output ports for a wide range of frequencies. The phase shift, ϕ_1, from input to output port 1 is a linear function of frequency since this path contains a straight piece of transmission line. Phase shifts ϕ_2 from input to output port 3, has a different characteristic because of the coupled line in this path. Differential phase shift $\Delta\phi$ is reasonably constant from 0.67 f_o to 1.33 f_o.

The technique was fully explored using broadband couplers and phase shifters (see Table II). The beam-forming matrix was tested in a 16-element linear array of parallel dipoles 0.58 wavelength apart. Figure 6A shows the major lobes of all 16 beams. Beam peaks occur close to theoretical positions, with a worst case error of 1.2 degrees in beam-7-right. The envelope of the beam peaks follows the antenna element pattern closely, as would be expected from the principle of pattern multiplications. The near-in beam, (1-right, Fig. 6B) has first sidelobes of -13 db. The antenna element spacing of 0.58 λ in this test allows grating lobes to form for beams further than 45 degrees off broadside. The start of this grating lobe structure is evident in beam-7-right.

A cosine illumination of the aperture can be achieved by adding two adjacent beams. Figure 6D shows a cosine illumination beam obtained by adding beams 4-right and 5-right in a hybrid ring. The first sidelobe in this beam is about 22 db down, which is close to the theoretical value of -23 db for a cosine illumination on a 16-element array. The hybrid ring also provides the difference of the two adjacent beams corresponding to a sine illumination. The difference pattern has a sharp null at the same position as the peak of the sum pattern and may be useful for amplitude-comparison monopulse applications.

Acknowledgement is due J. Blass,[4] J. Butler and R. Lowe,[5] and J. Shelton and K. Kelleher[6]; the matrix was designed and built by Sanders Associates.

REFERENCES

(1) W. P. Delaney, An RF Multiple Beam Forming Technique, MIT Lincoln Laboratory Group Report 41G-0012 (Astia 262 017) Aug. 9, 1961.

(2) J. K. Shimizu, A Strip Line 3-db Directional Coupler, SRI Project 1592, Scientific Report No. 1 (AF 19 604-1571), June, 1957.

(3) B. M. Schiffman, A New Class of Broadband Microwave 90 Degree Phase Shifters, *IRE Trans on Microwave Theory and Techniques*, p 232, April 1958.

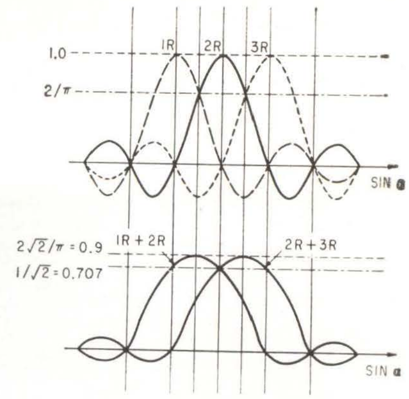
(4) J. Blass Multidirectional Antenna—A New Approach to Stacked Beams, *IRE Convention Record Part 1*, p 48, 1960.

(5) J. Butler and R. Lowe, Beam Forming Matrix Simplifies Design of Electronically Scanned Antennas, *Electronic Design*, p 170, April 12, 1961.

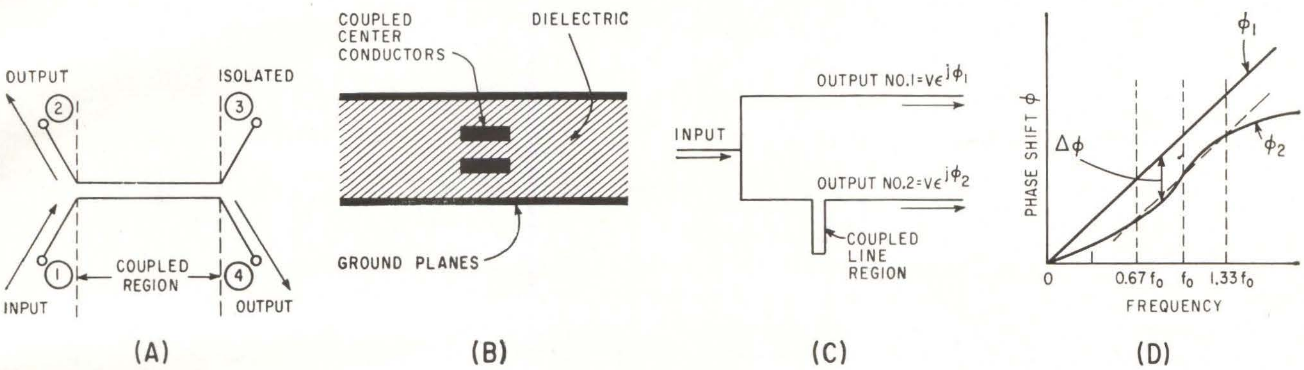
(6) J. P. Shelton and K. S. Kelleher, Multiple Beams from Linear Arrays, *IRE TRANS on Antennas and Propagation*, Vol. AP-9, No. 2, p 154, March, 1961.

MEASUREMENTS OF 16-ELEMENT AT 900 MC—TABLE II

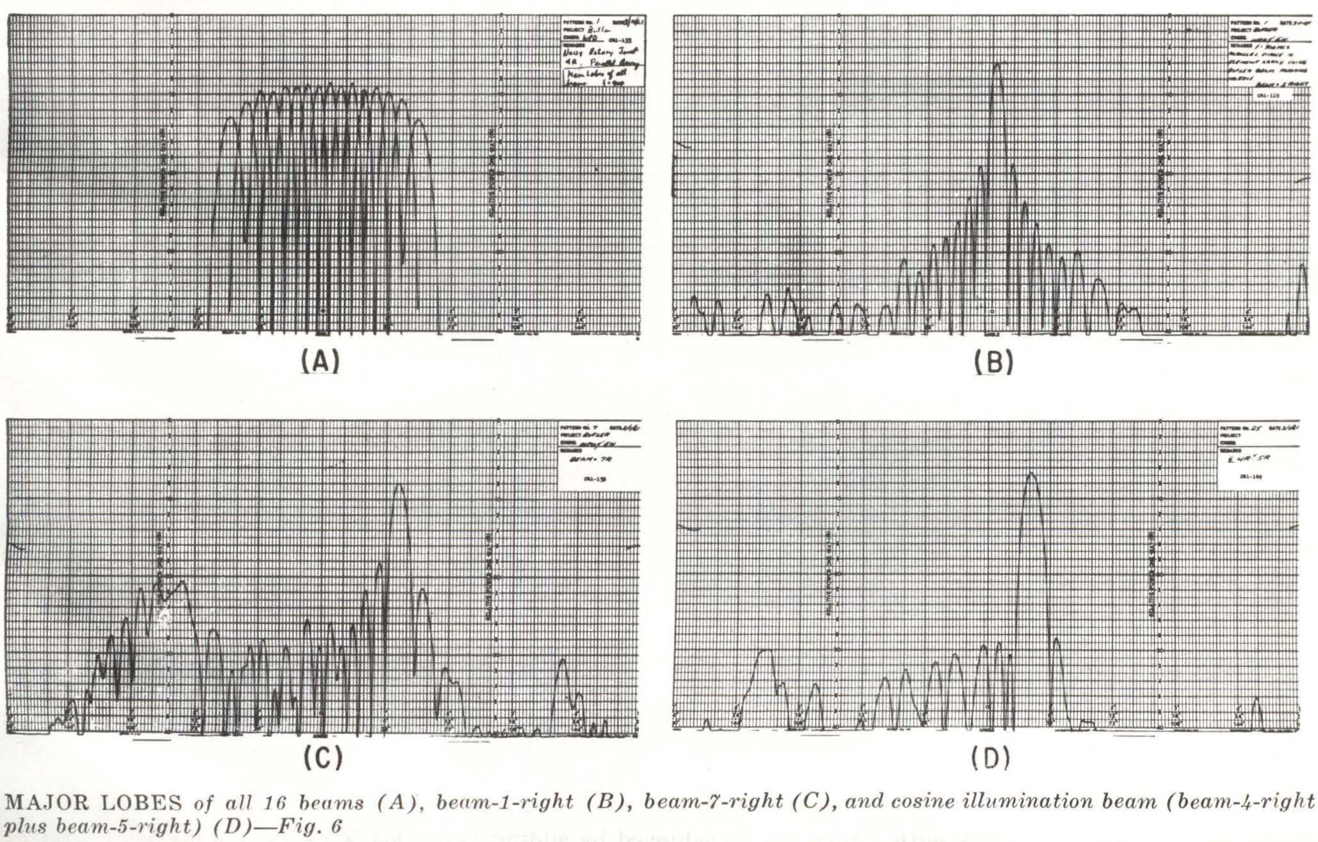
Maximum Input or Output Vswr	1.27 to 1
Minimum Isolation Between Beam Terminals	15 db (average isolation = 28 db)
Minimum Isolation Between Antenna terminals	20 db (" " = 30 db)
Insertion Loss	0.75 db
Average of Rms Amplitude Errors in Matrix output	0.3 db
Average of Rms Phase Errors in Output	4.8 deg



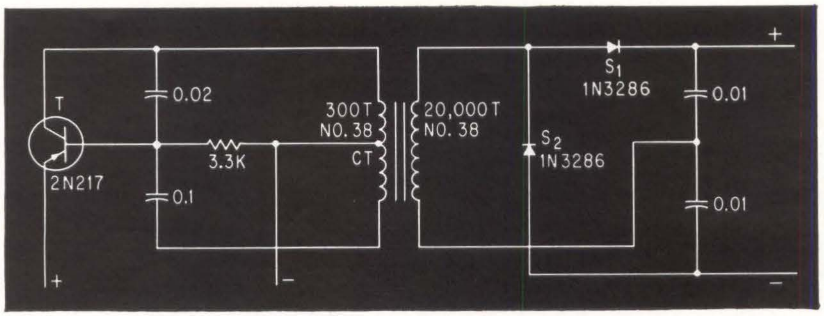
THREE MATRIX BEAMS *and the formation of cosine illumination beams—Fig. 4*



COUPLED-STRIP *directional coupler (A); cross section of a 3-db coupler (B). Broadband differential phase-shift network (C) and its phase characteristics (D)—Fig. 5*



MAJOR LOBES *of all 16 beams (A), beam-1-right (B), beam-7-right (C), and cosine illumination beam (beam-4-right plus beam-5-right) (D)—Fig. 6*



OSCILLATOR *operates at about 22 percent overall efficiency in commercial unit, slightly higher in military version*

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Converter uses sinusoidal oscillator rather than relaxation type; voltage-doubling capacitors provide smoothing with less than 0.01-percent ripple

By R. D. MORROW Morrow Products Inc., Baltimore, Md.

THE NEED FOR a high-performance high-voltage power supply has led to the design of a unit $2\frac{1}{2}$ in. high by $1\frac{1}{2}$ in. square with an output of 5,000 v d-c at $50\mu a$. Input is 26 volt d-c with a current drain of 44 ma for the military model and 26 v d-c at 60 ma for the commercial model.

The circuit uses a voltage-doubler rectifier output, although more expensive transistors used in experimental models have permitted the use of a single silicon rectifier at full voltage to achieve the same out put characteristics.

OPERATION — The transformer acts as a voltage step-up and oscillator section and the transformer core is the transistor heat sink. The $0.01\mu f$ capacitors in the voltage-doubler section provide sufficient filtering for most applications. However, in the military unit additional filter capacitance has been added to attenuate a-c ripple to less than 0.01 percent over the range.

The transformer secondary loading characteristics require silicon rectifiers having piv (peak inverse voltage) ratings of not less than 3,000 volt d-c, permitting $1\mu a$ to flow at 3,000 volts for the 1N3286 rectifier. Leakage in inexpensive diodes causes high loading and distortion of the sine wave.

The design characteristics of the coil are rigid, yet it can be wound on multiple winding machines in production. The ferrite core is a Q_1 type used in tv flyback transformers and is hollow in the center, thus permitting the core to be used as the transistor heat sink. The transformer primary was wound with No. 38 Mylar wire to determine empirically the best oscillatory characteristic of an inexpensive 2N217 transistor. After checking of 2N217s in various circuits, it was determined that 175 turns either side of the center tap was optimal disregarding the inductance of the secondary. The No. 38 wire was selected to give 40 ohms total d-c winding resistance of the transformer primary to match the collector-to-base voltage ratio (BV_{cbo}) of the 2N217 transistor in series with its base resistor. This design resulted in 8 volts rms from the primary winding on the ferrite core. Using 20,000 secondary turns gave 2,500 volts output, which when doubled gave the necessary 5,000 volts d-c.

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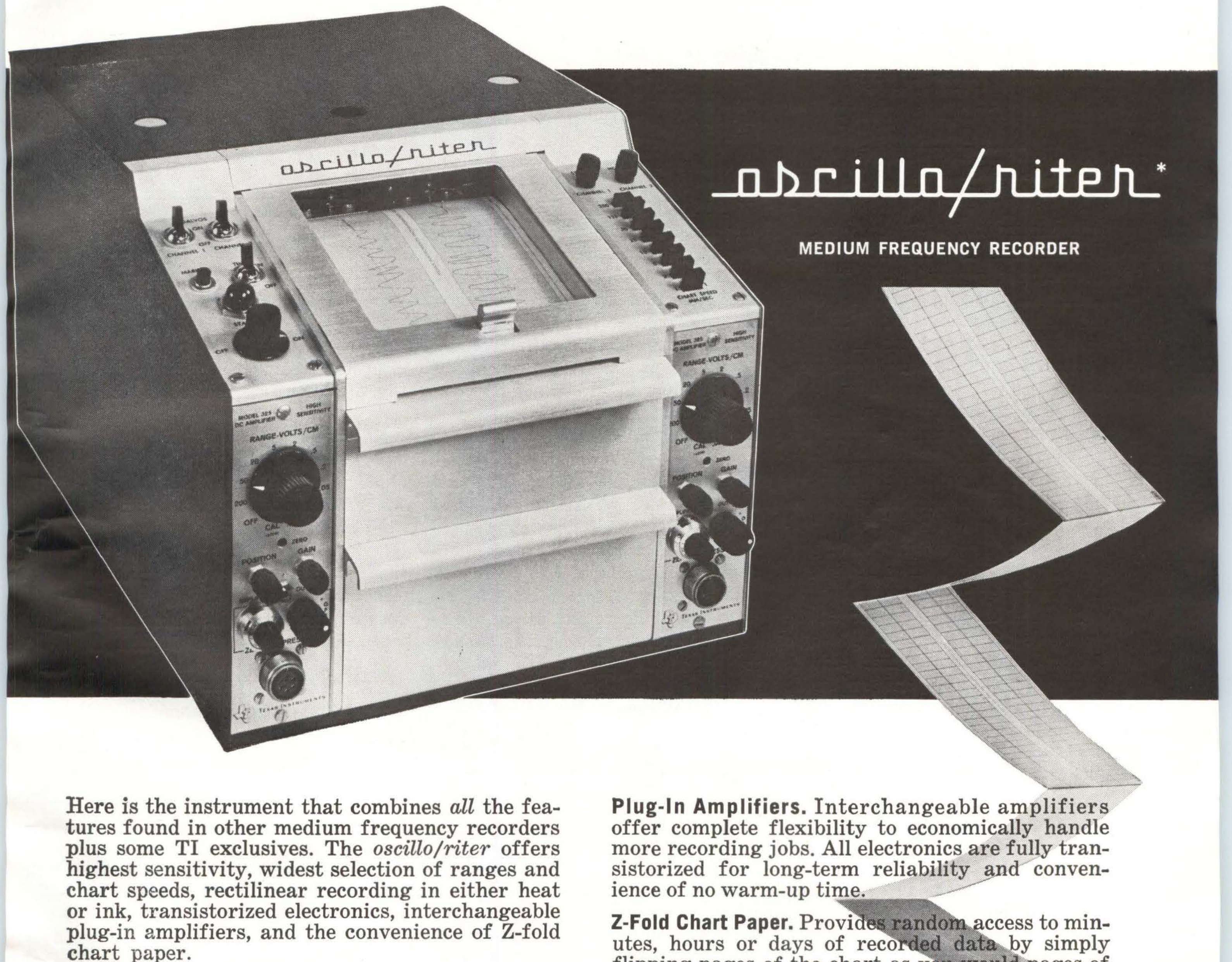

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Do Field-Effect Transistors Resist Nuclear Radiation?

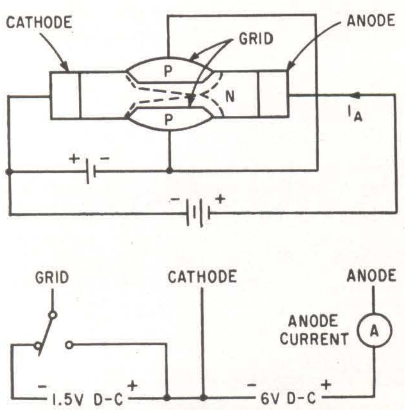
Semiconductor majority carrier characteristics may determine resistance

By ALVIN B. KAUFMAN
Litton Systems, Inc.,
Woodland Hills, Calif.

IRRADIATION of field-effect transistors indicates that majority-carrier characteristics may be the limiting factor in obtaining nuclear-resistant semiconductors. This implication results from tests in which degradation of gain to a predetermined value required about the same level of exposure as with high alpha cutoff frequency transistors.

The tests also indicate that majority-carrier properties may be improved by lowering semiconductor resistivity and possibly by better surface passivation. Use of germanium rather than silicon may also improve nuclear resistance.

The field-effect transistor at the top of Fig. 1 consists of an *n*-type silicon bar with an ohmic cathode contact at one end and an anode contact at the other. Positive voltage is applied to the anode or drain electrode. Two *pn* junctions built into the middle of the bar and connected in parallel serve as the grid or gate. Negative bias applied to the grid projects the depletion layers shown by broken lines into the silicon, increasing effective anode-to-cathode resistance.

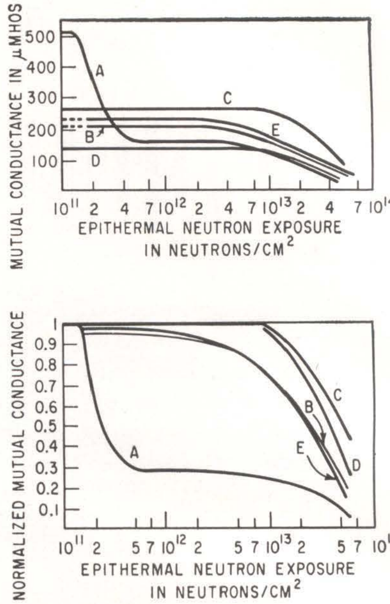


FIELD-EFFECT *transistor construction is shown above test arrangement used to determine mutual conductance—Fig. 1*

OPERATION—As anode voltage increases, the voltage drop resulting from anode current reverse biases the grid junctions so that the deplection layers are extended and finally meet in the bulk material. Increasing anode voltage further does not increase anode current appreciably. Pinch-off voltage is the anode potential at which anode current reaches saturation, and pinch-off current is anode current after pinch-off voltage has been reached. With zero grid bias, pinch-off current is maximum specified anode current. The field-effect transistor is said to be in the triode region before pinch-off and in the pentode region after pinch-off has been reached. Interchanging anode and cathode terminals results in little or no change in operating parameters.

Since there are no junctions in the output current path, the major source of noise is the thermal noise of the anode-to-cathode resistance, which is typically 1,000 to 10,000 ohms. In transistors, emitter and collector junctions change contact potential and leakage resistance under irradiation, shifting operating characteristics. These junctions are lacking in the field-effect transistor, which also depends on majority-carrier characteristics instead of the majority-minority properties used in transistor operation.

During irradiation in the General Dynamics reactor at Fort Worth, mutual gain was measured dynamically. The observed change in anode current was divided by the variation in gate voltage using the circuit at the bottom of Fig. 1 to compute mutual conductance.



EPITHERMAL *neutron exposure is compared to mutual conductance in upper graph and to normalized mutual conductance—Fig. 2*

Radiation exposure was determined by the Litton microfoil technique.[1] It is estimated from previous experiments that the gamma-ray exposure, measured in ergs/gm (C), was 2.7 × 10^{-3} as intense as the epithermal neutron exposure, measured in neutrons/cm², with E_n greater than 0.48 ev. Irradiation was carried out at 17.5 degrees C.

TEST RESULTS—Mutual conductance of the Crystalonics C652 silicon *npn* field-effect devices before and during irradiation is shown at the top of Fig. 2. Resistivity of units A and B is about 10 ohms/cm and of the remaining units is 3 to 5 ohms/cm. The same data, normalized by dividing observed values by baseline values is shown at the bottom of the figure.

Although the number of samples was small, apparently low-resistance devices might withstand exposure twice as great as high-resistance devices. This interpretation requires that devices A and E be neglected, performance of A being questionable at any rate.

Exposure needed to degrade gain to 0.7 of baseline value was about 2 × 10^{13} epithermal neutrons per cm² ($nv_e t$), about the same as required to damage high alpha cutoff

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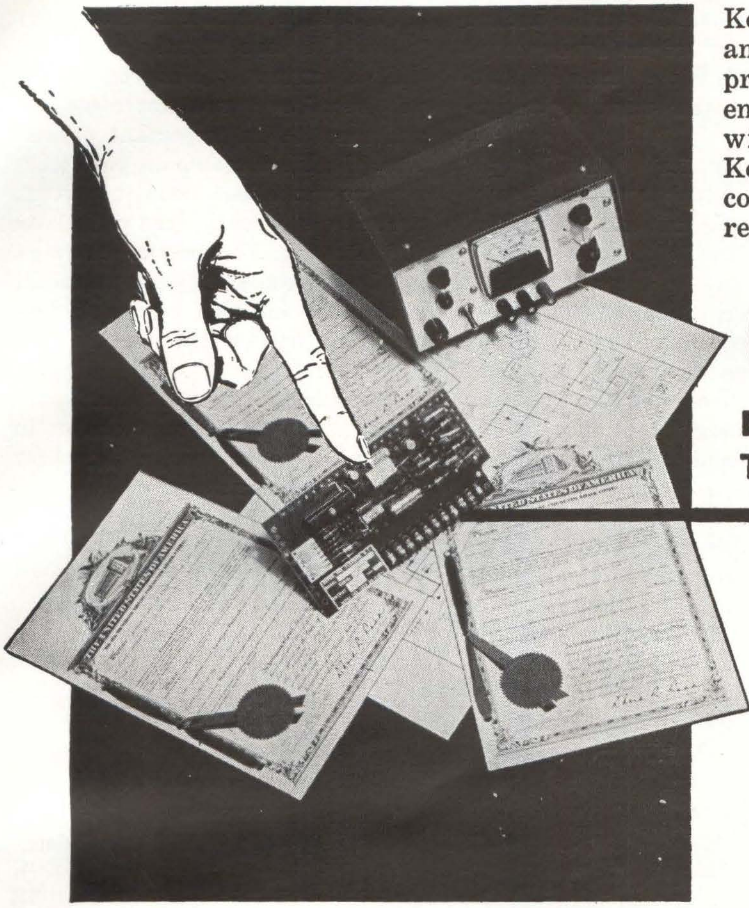

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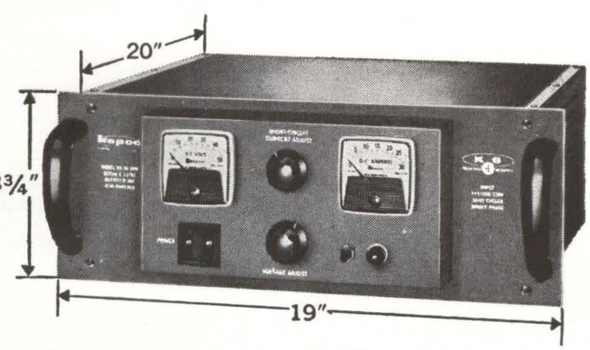

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KS 18-50M	0-18	50	0.01	0.01	0.01	0.0004	0.02	0.1	1 mv	1400	24	1,295.00
KS 36-30M	0-36	30	0.01	0.01	0.01	0.0006	0.03	0.1	1 mv	1400	24	1,195.00
KS 60-20M	0-60	20	0.01	0.01	0.01	0.001	0.05	0.1	1mv	1500	26	1,295.00

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kepco inc. 131-48 SANFORD AVENUE • FLUSHING 52, N. Y. • Area Code 212 IN 1-7000 • TWX # NY 4-5196 frequency transistors.[2,3] Thus majority-carrier characteristics may be the significant factor in nuclear resistance and might be improved by lowering semiconductor resistivity and by better surface passivation.

Degradation for specified exposure does not appear to be the same at different nuclear facilities. Basically these differences result from differences in reactor neutron energy spectra and energy above which neutron flux is specified and from differences among specimens.

For exposures that could be compared, the energy point above which all neutrons are reported should include all neutrons producing damage and exclude all neutrons not producing damage. This point is not easily selected, particularly in a device containing materials of different atomic weights and with widely varying operational requirements.

Lattice displacements occur with a transfer of 25 ev kinetic energy to the typical atom, and their magnitude and effect on components or hardware may differ. Seitz has shown that maximum energy imparted to a target atom in perfect collision is $E_{max} = E_n [1 - (m - 1)^2/(m + 1)^2]$, where E_n is initial neutron energy and m is target atom mass. Thus for germanium semiconductors, minimum energy of the neutron is 450 ev if 25 ev is transferred to its target atom and if the secondary neutron recoils straight back. Otherwise initial energy must be higher.

For silicon, the value is 175 ev. This difference in threshold energy for damage might account for the difference in radiation sensitivity between silicon and germanium.

NEUTRON ENERGY—If all factors are equal, degradation of a given semiconductor for the same exposure should be invariant in different neutron environments if the neutrons measured are those above the threshold damage point. Presently the epicadium point (nv_et) is the closest to the desired energy threshold. With improved resonant-foil techniques, measurement of nv_ft at E_n greater than 450 or 175 ev may show closer correlation of component performance in different reactors. Semiconductor data reported at nv_ft exposures with various energies should be converted (by multiplication of ratio values of differential flux for reactor used) to nv_et for correlation.

Gate current, which reflects input impedance, was not measured and may be an important parameter. Severe increase in gate leakage current has been reported[4], probably induced by the high level of ionization. Considering the high input resistance, the leakage might have been induced in the instrumentation rather than in the test specimen.

Degradation of normalized gain to about 0.9 at 10^{13} nvt shown in Fig. 2 has been reported for other field-effect transistors.[5]

REFERENCES

(1) L. B. Gardner, A. B. Kaufman and R. Gaz, Nuclear Dosimetry Techniques, internal Technical Note available from Litton.

(2) L. B. Gardner and A. B. Kaufman, NGL Platform Nuclear Radiation Program, 1, *ASD Technical Report 61-511*.

(3) L. B. Gardner and A. B. Kaufman, The Feasibility of Nuclear Resistance Inertial Platform and Control Systems, NAECON 1962.

(4) R. V. Babcock, Radiation Damage to Unipolar Transistors, *Amer Nuc Soc Trans*, 4, p 60, June 1961.

Laser-Pumped Maser Shows Way to Fill Spectrum Gap

RUBY CRYSTAL pumped by coherent optical radiation from a ruby laser has generated and amplified microwaves at 22.4 Gc. The optically pumped maser extends the frequency range over which maser devices can be pumped by three orders of magnitude.

The laser-pumped maser was developed at the research laboratories of Hughes Aircraft Co. under a one-year contract with the U. S. Army Signal Corps, Fort Monmouth, N. J.

The maser cavity consisted of a section of 0.05 by 0.13 inch waveguide that was beyond cutoff at 22.4 Gc. The waveguide was loaded with a 0.078-inch length of 0.05-percent ruby. The structure functioned as a ruby-loaded reflection cavity that was resonant in a perturbed TE_{011} mode at 22.4 Gc. Optical pumping was effected through the waveguide.

The ruby cavity structure was oriented so that the crystalline C axis was at 67 degrees to a magnetic field of 6,700 oersteds. This arrangement split the ground and

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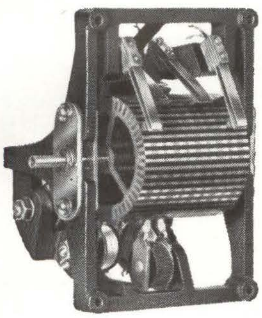

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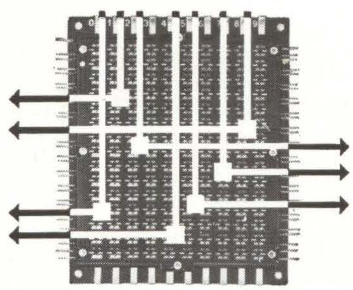

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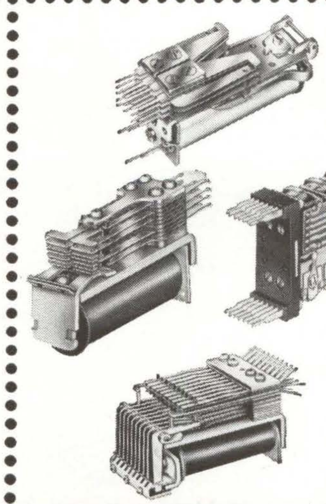

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excited states of the ruby so that a particular level could be pumped by coherent emission from the ruby laser, which resulted in the inversion of a pair of ground-state levels. At the transition between these levels, amplification and emission were observed at 22.4 Gc.

Optical pumping is expected to be useful in low-noise maser amplifiers and in the generation of coherent radiation in the region of the spectrum from submillimeter waves to the near infrared. Optical pumping can lower noise temperature in maser amplifiers and increase gain-bandwidth product while allowing operating temperature to be raised.

Efforts to increase operating frequency of masers have been hampered by the lack of sources for pumping at frequencies above 150 Gc. Thus, even with harmonic pumping and cross relaxation at idler frequencies, the most optimistic operating frequency limit of masers was about 400 Gc. The optical pumping technique should lead to filling the gap between submillimeter and infrared.

Wind-Tunnel Models Are Magnetically Supported

BOSTON—Magnetic suspension and balance system eliminates the interference caused by supports of models in a wind tunnel. The system is being used at the Naval supersonic facility at Massachusetts Institute of Technology.

The technique developed at MIT is a modification of the method first successfully used by French aeronautics researchers in 1957. At the MIT wind tunnel, a half-inch diameter, 20-ounce brass model containing a ferromagnetic cylinder is magnetically suspended and controlled by lift, drag and lateral coils.

The control system for the magnetic suspension equipment includes position-sensing light beams. Thyratons are connected in a six-phase, half-wave star configuration to form the basic power supply.

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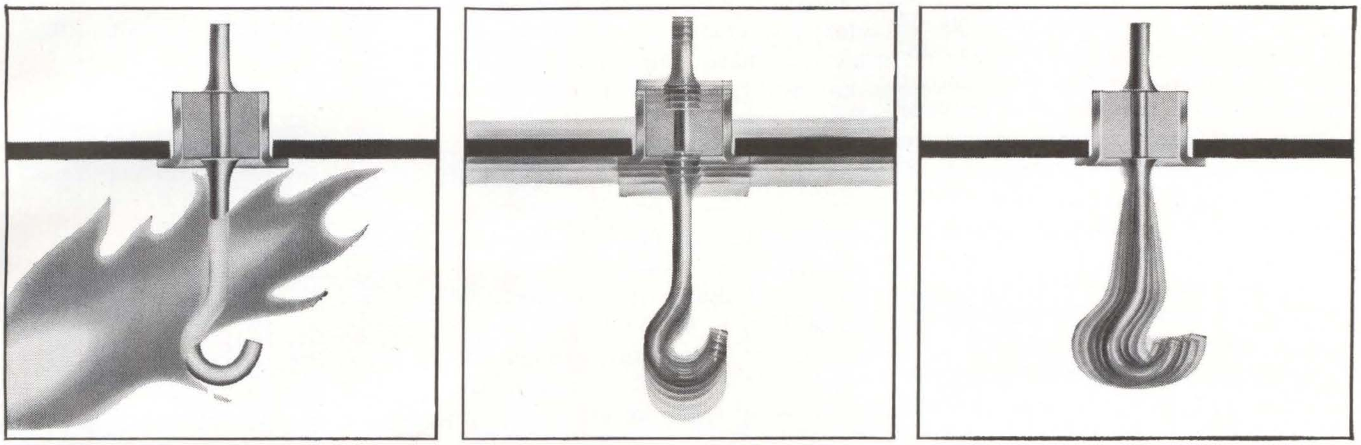

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CIRCLE 61 ON READER SERVICE CARD

New Magnetic Rods Simplify Circuits

Major advances also offer increased stability with temperature change

By T. A. O. GROSS, President
Spectran Electronics Corp., Maynard, Massachusetts

EFFICIENCY and dynamic range of magnetostrictive filters have improved at least several db in recent months, but the big step forward has been improved stability with variations in ambient temperature. New high-efficiency rods now offer opportunity for simplified and more reliable circuit design.

Improvements in transfer efficiency is illustrated by a simple circuit adopted for Spectran's own use, Fig. 1. This circuit takes advantage of these new high-efficiency rods, and permits oscillation with a single transistor stage.

A temperature coefficient of 2 ppm per deg C is now representative. Much of the advance is due to the introduction of modified Elinvar constant modulus materials, but small refinements in the many steps of manufacture have been major contributions to the performance and reliability of magnetostrictive rods.

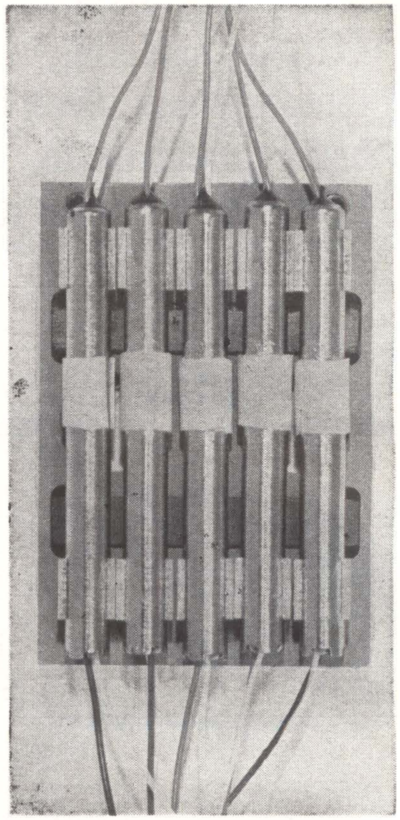
The rods are now cut to lengths accurate to 2×10^{-4} inches. This precision minimizes the amount of final tailoring necessary which contributes to the stability of the resonator.

Magnetostrictive rods are now the principal type of filter used in multiple-filter spectrum analyzers, and resonant rods are rapidly assuming a dominant position in telemetry and command systems.

New applications of resonant rods in space programs account for some of the increased activity in magnetostrictive filters, just as the closely related magnetostrictive delay lines have benefitted by the recent upsurge in digital equipment. More important, however, has been the increased acceptance of magnetostrictive devices in established applications—in transducers, magnetostriction oscillators, filters and storage delay lines—representing a method of converting an electrical pulse into a mechanical pulse or conversely. This upsurge in activity has been due to improvement of the rod elements themselves.

IMPROVED MATERIALS—Present studies includes work with ferromagnetics having greater magnetostrictive effects. The most promising materials are variations on the nickel-zinc ferrites which have been modified to improve their frequency versus temperature characteristics. The coupling coefficient of these materials is much higher than for the Elinvar and their higher resistivity permits operation with much lower losses.

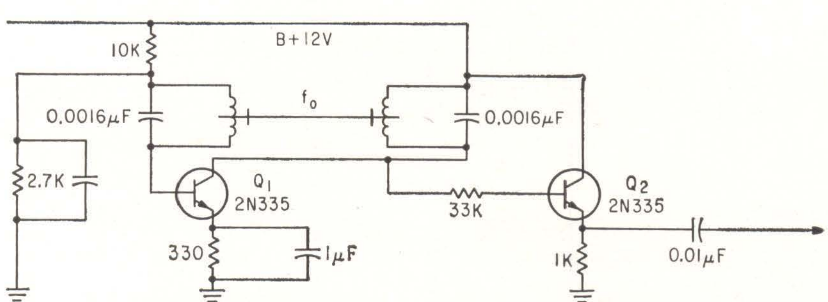
The assembly shown in Fig. 2 shows a bank of filters used to separate subcarrier modulation tones in satellite and rocket command-control and command-destruct receivers. Great pains were taken to minimize weight. Excess material has been drilled out of the base plate so that the weight of the entire assembly is two ounces.



FILTER BANK *assembly, shown actual size, separates subcarrier modulation tones in satellite and rocket command-control and command-destruct receivers. Important design consideration was to minimize weight. Excess material was drilled out of base plate to keep weight of entire assembly down to two ounces*—*Fig. 2*

Present day magnetostrictive filters have a Q range of 2,000 to 20,000 and a resonant frequency range of 10 Kc to 500 Kc. Not all Q's can be obtained over the entire frequency range so that the practicable range in half-power bandwidth is about one cps to 200 cps.

This article discusses only four-terminal resonant devices used as filters and as frequency standards. The nonresonant devices are used in different fields of application. Intriguing possibilities of the two-



TRANSFER EFFICIENCY *improvements of magnetostrictive rods permits design of 100 Kc magnetrostrictive-rod controlled stable oscillator with a single transistor stage, Q_1. Transistor Q_2 is an emitter follower whose sole function is to reduce pulling by variations in load*—*Fig. 1*

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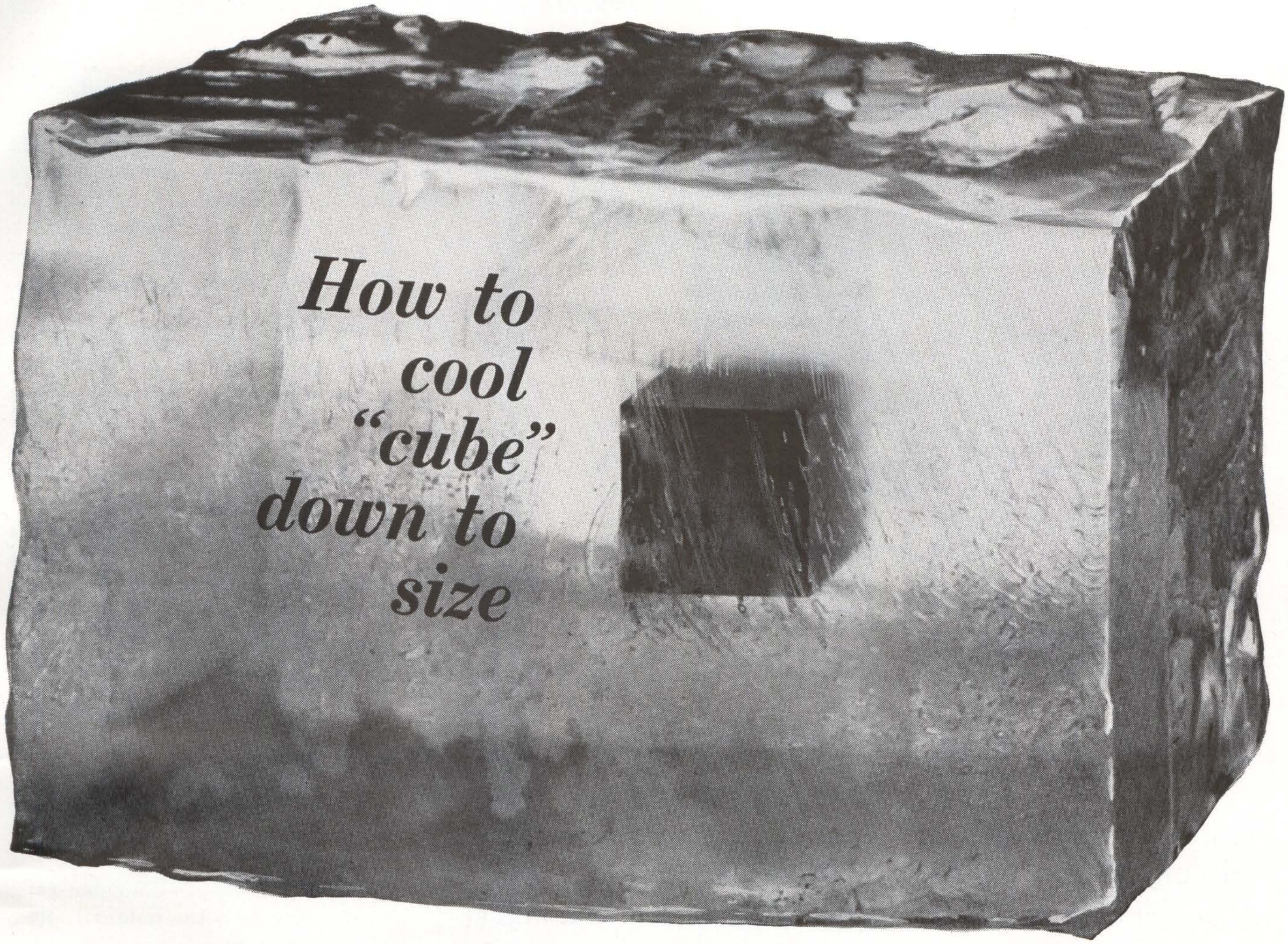

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Dissipation factor (75°F) (1000 cycles)	<0.0005	<0.0005

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Density	1.88	1.77
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Thermal stability	600°F	700°F
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Radiation resistance	25% change @ 1×10^8 rads	25% change @ 1×10^8 rads

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terminal devices must await more development to make them practical.

The resonant element, Fig. 3A, in a typical 100 Kc/s magnetostrictive resonator is a nickel-iron alloy rod or tube supported by two or more node washers—so named because they are located at the motional nodes. At no other point may the rod touch coils or other objects lest the motion become damped. The vibratory motion of the rod is longitudinal; it becomes alternately longer and shorter by about 200 microinches at resonance with a strong signal. This motion is small to the engineer who would use it to actuate some sort of readout, but it is large to the metallurgist concerned with the elastic limit of the material. The enormous stresses cause no permanent damage but the Q falls off during excitation with excessively large signals.

The rod is driven by a coil accurately positioned so as not to interfere with its motion. This coil produces an axial field which alternates with the signal to add or subtract from the flux produced by the bias magnet.

Magnetostriction causes the rod to change its length-diameter ratio with changes in the magnetic flux. The rod can be driven without the bias magnet, but the device then becomes nonlinear with small signals and there are two mechanical cycles for each electrical cycle. There are applications where this frequency multiplication is desirable. The difference in frequency between input and output can be exploited to improve off-resonance isolation and the higher mechanical frequency reduces the length of the filter.

DRIVE AND PICKUP—The output or pickup configuration is similar and often identical to the drive end. The bias magnet, however, now has an essential role because the pickoff signal is generated by its flux. The alternating stress produced by the mechanical vibration produces a corresponding variation in the rod permeability. As the reluctance of the flux path through the coil varies, so does the distribution of the bias magnet flux vary between external leakage and the path linking with the coil.

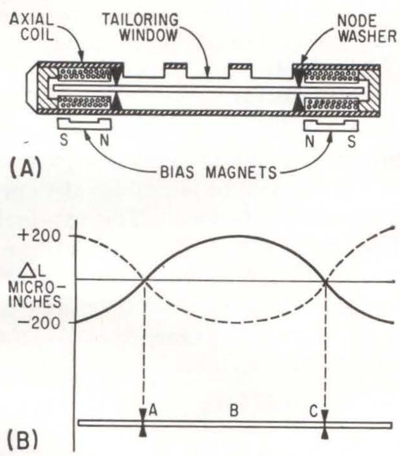
The resonant frequency of the rod is equal to

$$\frac{N}{2L} V$$

where N is an integer, L is the length, and V is the velocity of sound in the rod—about 2×10^5 in./sec.

Simple low frequency filters operate in the second order ($N = 2$) which is the lowest that can be used with two or more node washers. The second order motion diagram is given in Fig. 3B. Higher orders are often used to obtain larger spacing between drive and pickoff coils which improves off-resonance isolation.

The resonant frequency is adjusted within 0.05 percent of the



CONSTRUCTION DETAILS *of typical magnetrostrictive rod resonator (A). Curve (B) shows relative longitudinal motion of rod operating in second order—Fig. 3*

desired value by manipulation of the length alone. Final tailoring is accomplished by removing minute amounts of material from region B in Fig. 3B, if it is desired to raise the frequency, or from region of A or C if it is desired to lower frequency.

If desired, it is practicable to adjust a filter or frequency standard to within 0.1 cycles per second at 200 Kc per second. Interestingly enough, the only difficulty is the time required to read a frequency to the requisite accuracy.

It is the usual practice to multiply the rod frequency by a factor of ten before feeding into the counter, so that the tailoring process can be accomplished rapidly.

BIBLIOGRAPHY

Hawkes, F. C., Investigation of precipitation Hardening Elinvar, *J of Appl Phys*, **30**, No. 4, 1959.

Nevelle E. J. Jr., Multiple Filter Spectrum Analyzers, Electrical Manufacturing, May, 1960.

Nevelle, E. J. Jr., Designing Magnetostrictive Filters, ELECTRONICS, p 88, Dec., 16, 1960.

Pierce, G. W., U. S. Patents:

1,750,124	1,882,395	2,014,411	2,266,070
1,962,154	1,882,396	2,014,412	2,063,946
1,962,155	1,882,398	2,014,413	2,063,948
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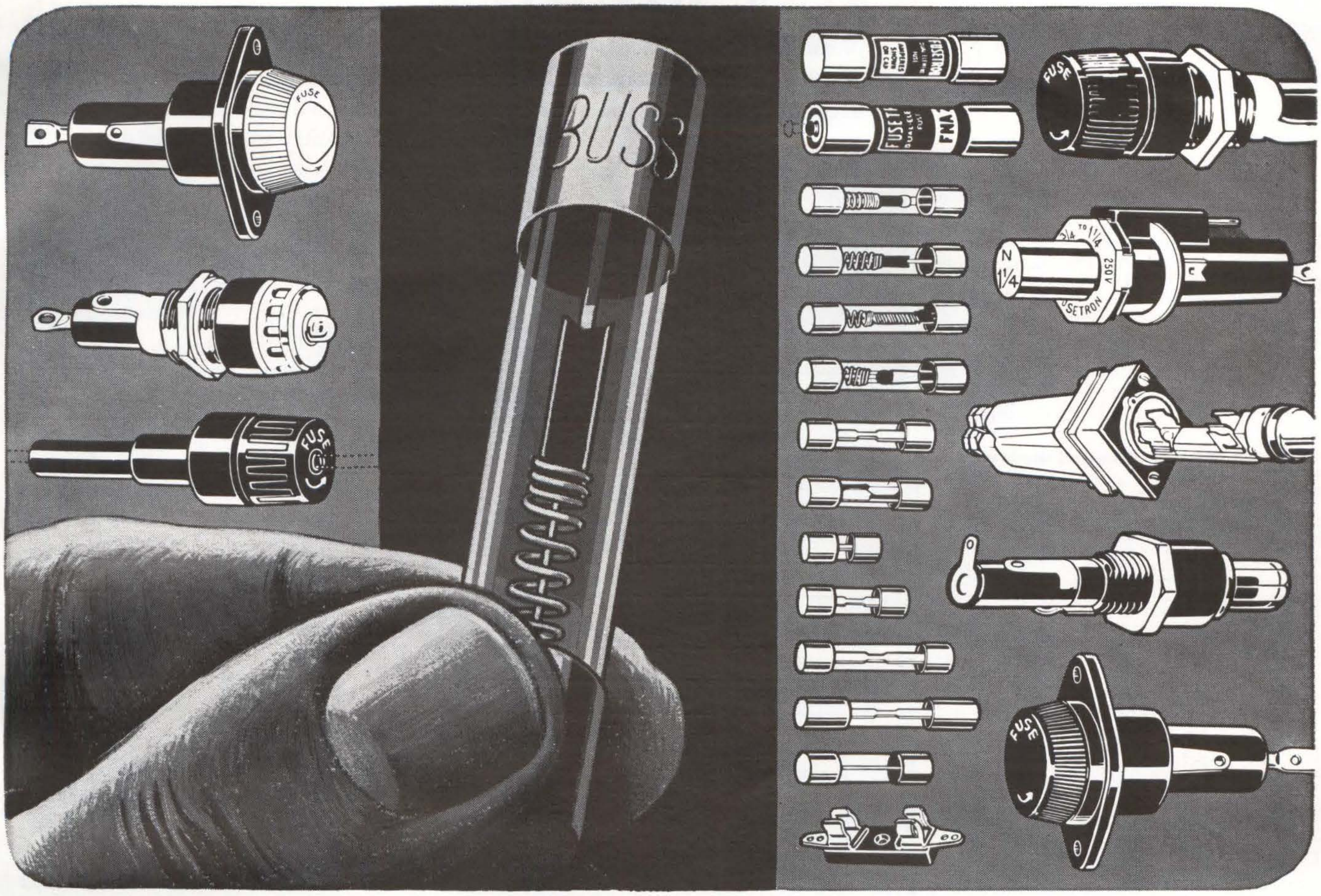
The new tube's precision electrostatically focused electron gun produces a line of light energy that is 0.001 inch in diam at its one-half amplitude level. The five-inch diam tube, WX-4647P16 is designed for use as a high-information-content flying-spot scanner, and as a photographic recorder.

New Microwave Tube Produced in Japan

NEW MICROWAVE tube, the Laddertron, is now being commercially produced at Oki's new Tokyo factory, built exclusively for the production of millimeter and submillimeter tubes.

The new tube was invented at Kobe University by Kazuo Fujisawa. Oki financed research and holds exclusive patent license. Fujisawa recently transferred to Osaka University.

Three to 15 millimeter range versions of the Laddertron are now in production. Other tubes to be produced initially include magnetrons and klystrons in the same frequency range as the Laddertron. Future plans include production of twt and bwo tubes, also extension of frequency range of tubes produced to submillimeter and production of higher power tubes.



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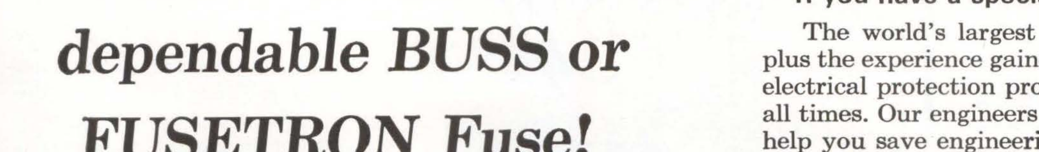

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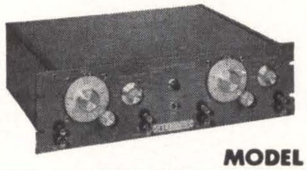

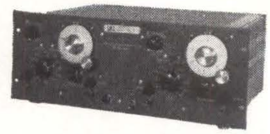

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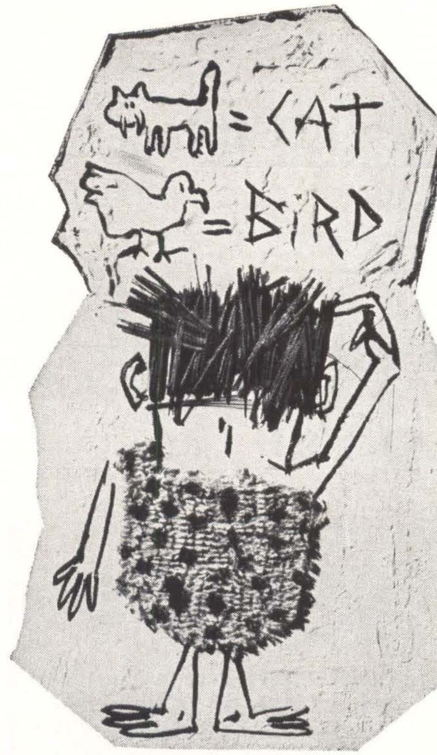

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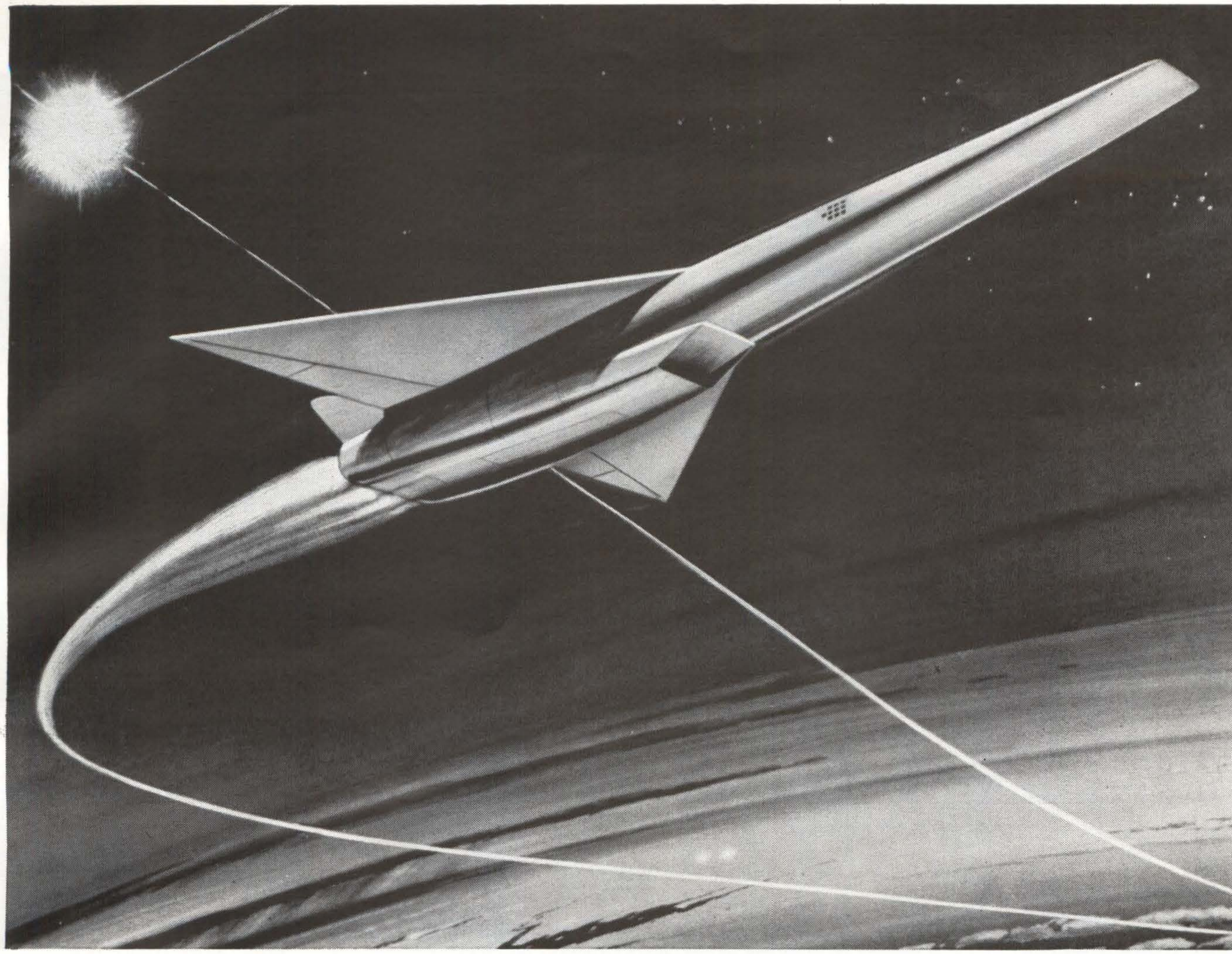
CIRCLE 202 ON READER SERVICE CARD



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Air. Space. Sea. Vast frontiers that challenge Lockheed's scientific creativity, engineering knowledge, manufacturing skills! None offers greater scope than Advanced Aircraft.

The Hypersonic Fighter pictured above is only one example of many advanced concepts. Others—illustrated below—are:

1) The Supersonic Transport design concept typifies the Company's creative thinking and planning.
2) So does the Rigid Rotor Helicopter. Lockheed's helicopter test bed, flying for several years, already has demonstrated outstanding stability and maneuverability.
3) Hydrofoil: its stability, control and noise, now are under intensive study.

Other major projects—in Spacecraft and ASW Systems—engross the attention of Lockheed Scientists and Engineers. Result: Genuine opportunities for genuine career-progress—in an environment in which inventive minds flourish.

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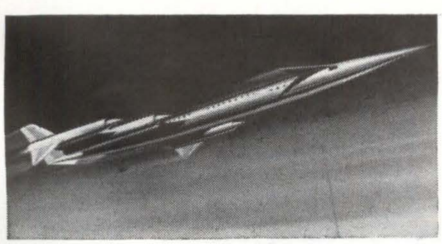
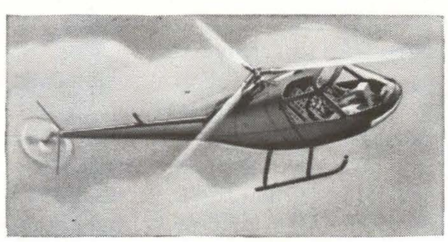




LOCKHEED ***CALIFORNIA COMPANY***

A DIVISION OF LOCKHEED AIRCRAFT CORPORATION

NEW, SMALLER *work benches save space, provide greater comfort to workers, and are a factor in a general improvement in production efficiency*

Making New Production Ideas Work

Systematic effort to find and put best ideas to work pays off

By C. J. GEATING

Westinghouse Air Arm Div., Baltimore, Md.

TO OBTAIN maximum production efficiency, this division has set up a special methods engineering department. Much of the production in the plant is highly complex electronic equipment, but produced in relatively small lots. As a result, highly automated production techniques are not generally economical and thus manual methods are extensively used.

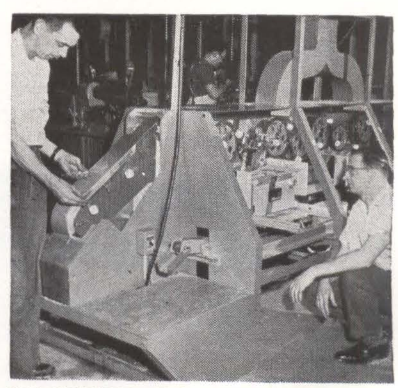
Since the labor costs in manual assembly are relatively high, the Methods Engineering Group was established to determine best practices and to get them accepted throughout the plant. Since, in many cases, past practice has become habitual and is assumed to be best practice, new methods are often criticized and resisted as being too refined or too theoretical; thus special attention is needed in getting acceptance.

One of the first steps in the program was to set up monthly meetings of the members of the line and staff groups immediately concerned with production, including production line supervisors, manufacturing engineers, methods engineers, industrial engineers and quality control. Because of the size of the staff, four meetings, each one and one-half hours long, are held each month; but a given supervisor, for example, will attend only one of the meetings.

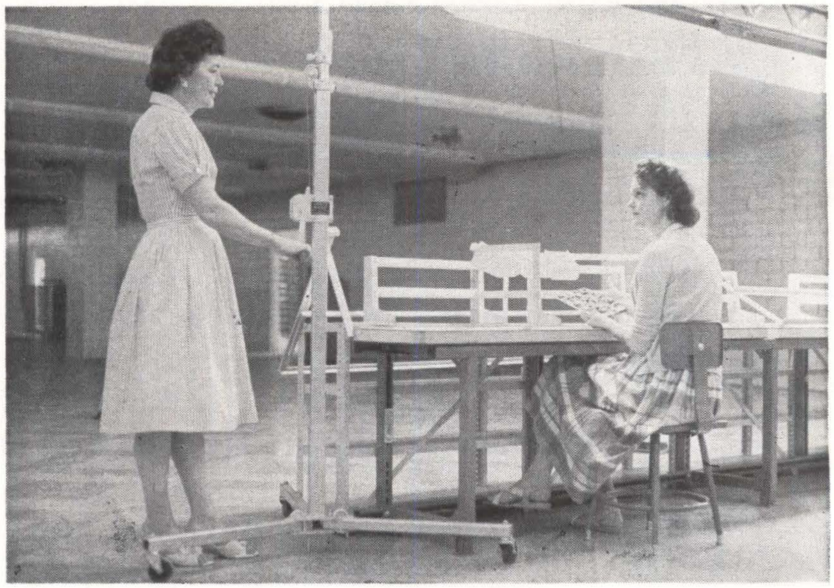
At each meeting, six presentations of various ideas for improving production are made, using samples, charts, drawings, slides, etc., as required by the idea. In addition, each person attending the meeting is required to present, in writing, an idea that he or one of the people in his group has come up with. An incentive is provided to each member of the group, not only to generate new ideas, but to put those that others thought of to work in their own department if they are suitable. Thus, a total of 24 production ideas are presented each month. After the formal presentations, the meeting considers problems raised by those attending.

Movies are made of each presentation and are shown the following month at each of the four sessions, thereby, making possible a complete interchange of ideas. In addition, ten to fifteen minutes are allotted at each session to representatives of outside companies who present ideas using samples or film. Representatives from the engineering department also will occasionally discuss equipment or a process still in development stage.

PRODUCTION LAB—Besides providing a forum for airing produc-



MACHINE TO TIN *component leads automatically was developed under supervision of methods engineering group*



BENCH, WITH LIGHTING *fixture variable both in height and candle-power, before installation in production laboratory. From studies conducted under conditions similar to actual production area, lighting to 200 candle-power was found desirable for some jobs*

tion problems, the methods engineering department also operates a special production laboratory, where systematic attention to production problems of larger scope can be applied, and where special machines can be built.

One of the first ideas for improving production was an investigation into the effect of operator comfort on output. The conventional workbench and highchair, for example, allows the operator to put her feet either on the rung of the chair or on the rail under the bench. But the rail under the bench is sometimes used for storage, in which case only the rung of the chair is available.

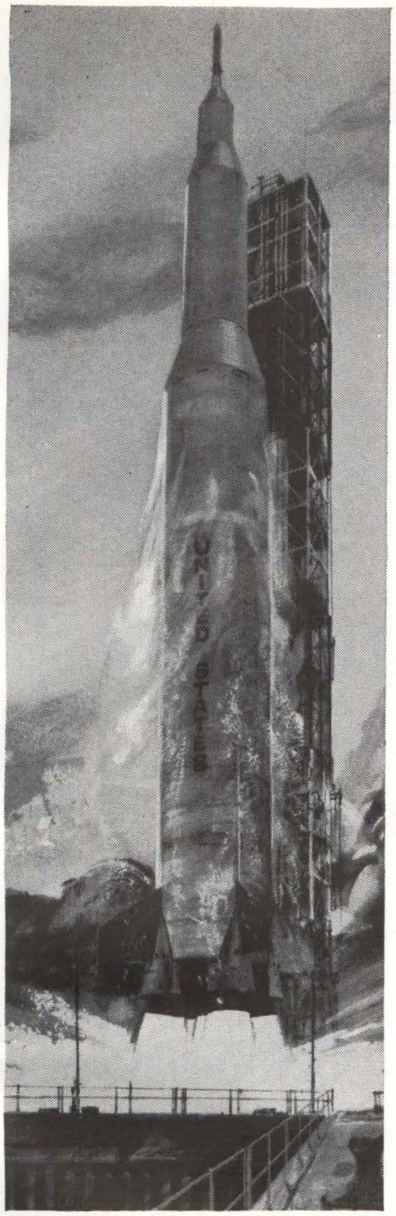
Two types of adjustable workbenches and adjustable stools were purchased so that the effects of varying workbench height could be studied. For small work, such as printed circuit boards and small chassis, the benches were set at normal desk height and the operator has his or her feet on the floor, with consequent freedom of movement. For heavier work, a bench height of 35 inches was found more suitable.

During the study of bench height it was realized that much space was wasted with conventional tables, since workspace 18 inches deep and three feet long was found to be adequate for many operations.

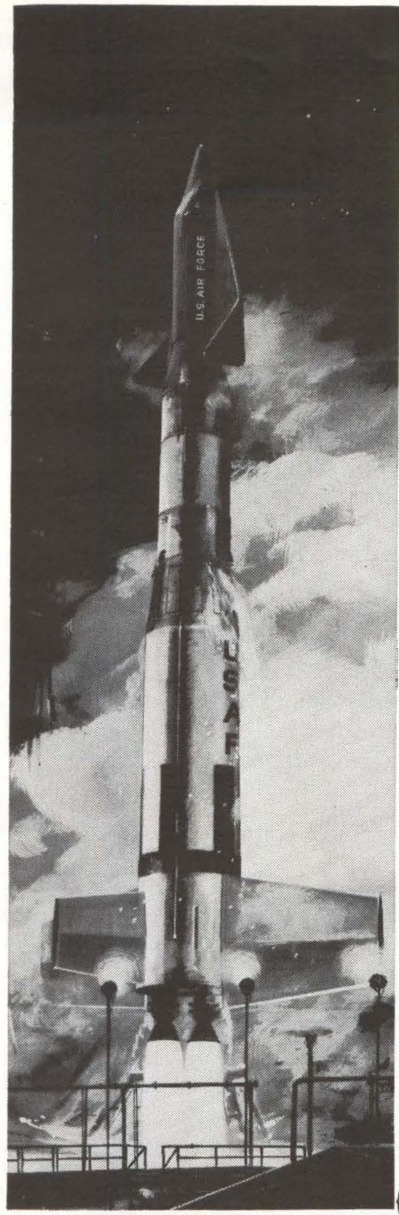
From the studies on workbenches made to date, new low benches and chairs have been installed in part of the production area and more will be installed. The workbenches are 30 inches high, 18 inches deep and six feet long, and provide space for two operators. On the back of the benches are six shelves, 12 inches deep; when the benches are arranged in rows, these shelves are storage space for the operator at the bench in front. Table tops are gray Micarta but pastel greens and blues should also be suitable. For some work, however, a less polished surface is desirable.

Instead of large lazy susan type component storage racks on the tops of the table, which were on the older type tables, racks of component holding trays are provided each operator in the new arrangement; these racks swivel to allow access to the back tier of components. Tops of the new tables are detachable, so that a work space can be moved easily without disturbing the setup of the job in progress.

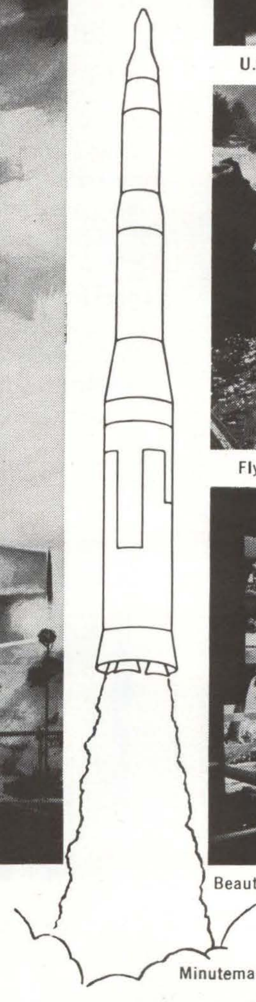
Lighting studies have also been carried out on a systematic basis and one of the photographs shows an adjustable lighting fixture. As a result of the experiments, lighting is being increased for some types of work up to 180 candle power and up to 200 candle power for printed circuit work. Comments from operators indicate a reduction in headache, eyestrain and fatigue. Production increases as a result



Saturn Launch Vehicle



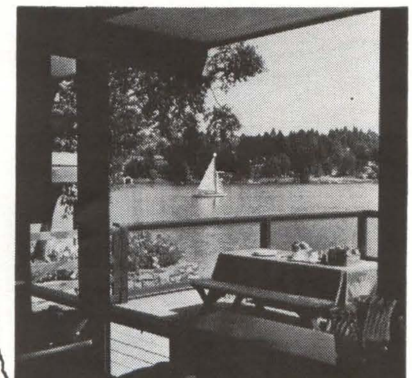
Dyna-Soar Space Glider



Minuteman ICBM

U.S. Science Pavilion at Seattle World's Fair

Fly-casting on Skykomish River near Seattle



Beautiful homes line Seattle's 200 miles of shore

Advanced Boeing openings for Engineers and Scientists

You will find career excitement in many of the challenging programs at Boeing's Aero-Space Division. Some of these programs — the advanced Saturn S-IC first-stage booster, for example — are under the management of newly-formed divisional organizations that can offer you unique ground-floor opportunities.

Other openings with rapid-advancement potential are immediately available on the Dyna-Soar space glider program and the solid-fuel Minuteman ICBM. Assignments are available in many fields of activity, including Research and Development, Design, Manufacturing and Test.

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Send your resume today to Mr. Lawrence W. Blakeley, The Boeing Company, P. O. Box 3822-ECJ, Seattle 24, Washington. Boeing is an equal opportunity employer.

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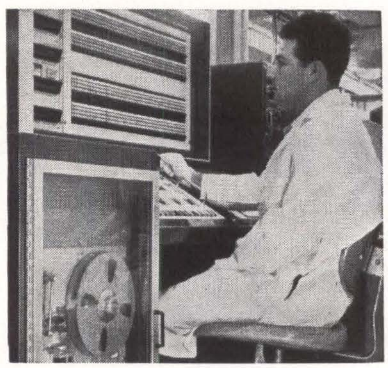
of board can be placed on one tape. of changes in bench and chair height are estimated at about four percent, without taking reduction of rework or increased space utilization into account. It is estimated the improved lighting will increase production an additional four to six percent.

Automatic Tester for Computer Logic Boards

AUTOMATIC EQUIPMENT to test computer logic boards in one-twentieth the time formerly needed has been developed by Autonetics, a division of North American Aviation, Inc.

The machine is being used for functional tests of logic circuit and diode matrix boards for the Air Force Minuteman's airborne digital computer.

Major advantages of the tester are speed, accuracy and versatility; the functional test of a logic board

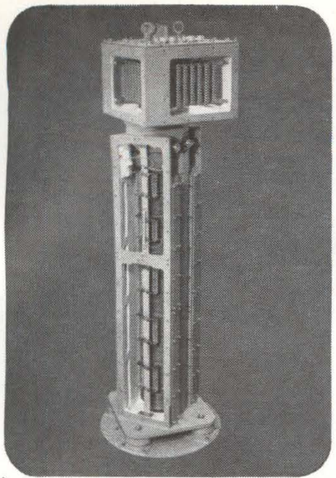


takes 12 minutes instead of the approximately four hours required previously.

Errors have been located that previously were almost impossible to find. Trouble-shooting of finished boards assembled in the computer has been drastically reduced.

If a logic board error is discovered during test, the error is displayed visually and printed out on paper tape. The test continues until the complete board is fully checked. By referring to the tape the operator can immediately locate the error and determine its cause.

Programming is comparatively simple. Schematics are translated onto punched cards and the cards are then fed into a tape converter. Programs for more than one type of board can be placed on one tape.



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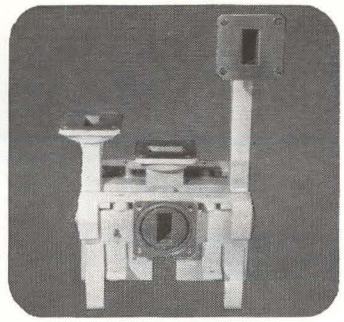
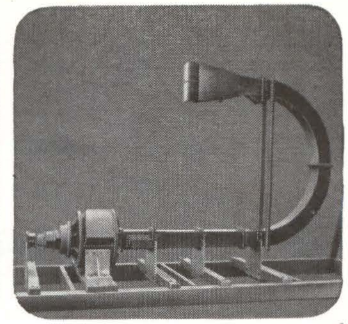
Precision Microwave Castings — We pour aluminum, magnesium and copper base alloys. Precision sand, plaster and investment castings complete with metallurgical tests are processed at our foundry.



WAVEGUIDE ASSEMBLY

Microwave Devices — Typical microwave devices ranging between L and KU Band include duplexers, switches, phase shifters, power dividers, horns, directional couplers and mixers. We test to your specifications.



CIRCULAR LINEAR POLARIZER

Antenna Assemblies — Complex assemblies in the L through KU Band frequency ranges for ground, shipboard, airborne and missile applications are available.

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Slip Ring Assemblies—Our new concept of button type spacing eliminates moisture and dust traps, gives maximum ring capacity within minimum space requirements. Dynamic characteristics are improved because of lower torque, heat dissipation is better and capacitance is reduced. Cost is lower.

PRODUCTS OF PROVEN RELIABILITY

Gorham Electronics has established a reputation of supplying complex precision castings, microwave devices and slip ring assemblies of proven reliability to the country's major contractors. Completely integrated facilities covering design, precision casting, close tolerance machining and assembly, plus final electrical test — all at one location—are your assurance of a quality product, at lowest cost.

Hidden costs associated with vendor liaison, incoming inspection, divided technical responsibilities, and multiple profits are eliminated by placing a single order for timely delivery of a final tested product with an "Integrated Facility of Proven Reliability"—Gorham Electronics. Write today for our brochure.

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BY DELTA DESIGN

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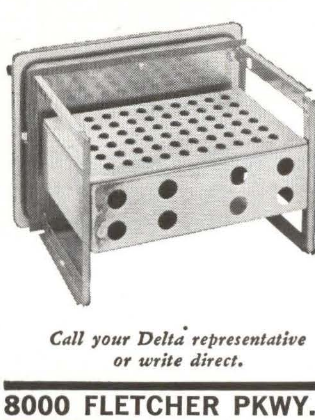

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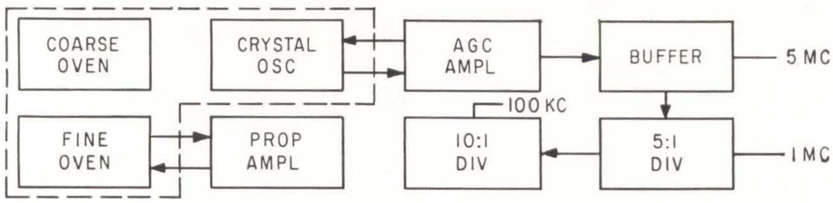
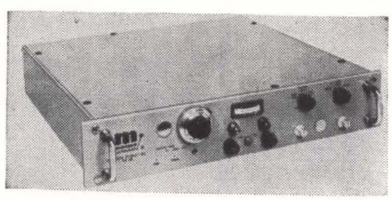
DESIGN AND APPLICATION



Oscillator Ages Less Than 2 Parts in 10^{10}

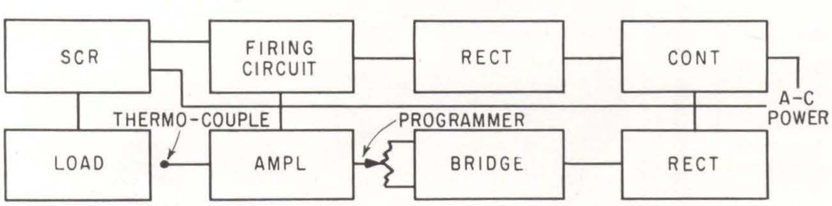
Solid-state device has accurate outputs at 100 Kc, 1 Mc and 5 Mc

MANUFACTURED by Manson Laboratories, 375 Fairfield Ave., Stamford, Conn., the model RD-180A transistorized frequency standard has outputs at 100 Kc and 1 Mc of 0.75 v rms into a 50-ohm load and 5 Mc at 0.25 v rms into a 1,000-ohm load. Frequency stability is 1 to 2 parts in 10^{10} per day after six months continuous operation. Frequency adjustments can be made to 500 parts in 10^{9} total. The standard consists of a high-stability Pierce oscillator using a ruggedized plano-convex 5th overtone precision AT-cut crystal with a three-point mount. The oscillator is enclosed in a glass flask within a temperature-regulated oven. Fine temperature control is by a temperature-sensitive bridge and proportional amplifier. Coarse temperature regulation is by a mercury switch oven. The crystal is nominally operated at the point where oscillations are sustained with minimum current flow and any tendency for the crystal current to increase is cancelled by feedback from the agc amplifier.



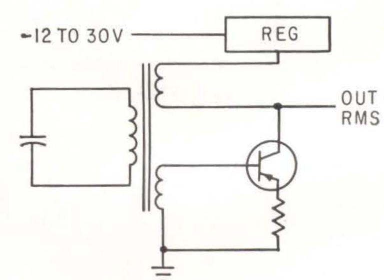
Two locked dividers convert the 5 Mc to 1 Mc and 100 Kc and buffers isolate the oscillator from load variations. The oscillator can be finely tuned by a front panel control. A self-contained 50-hour battery supply is switched on in the event of line failure.

CIRCLE 301, READER SERVICE CARD



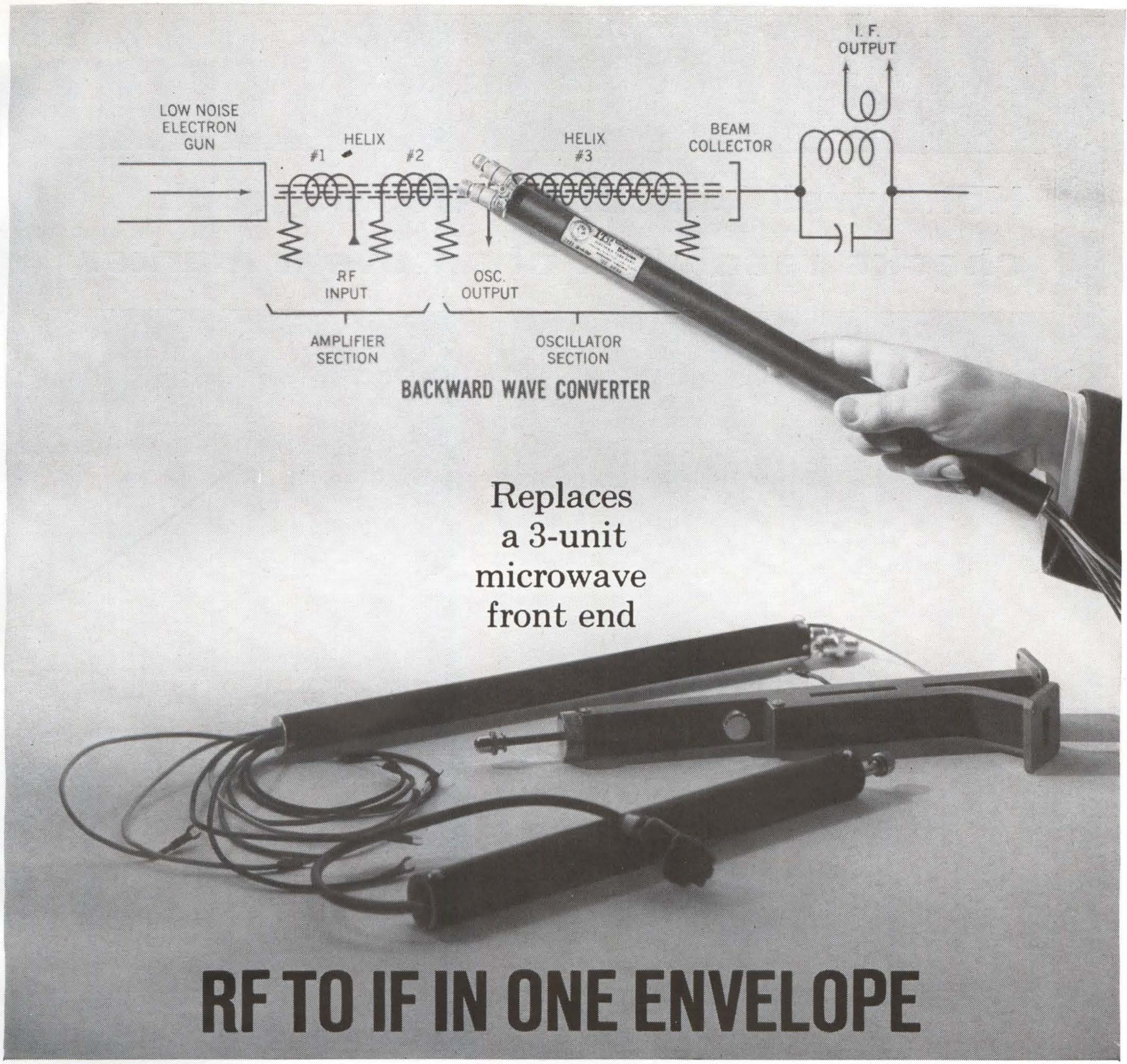
Temperature Programmer Uses Power Proportioning

ANNOUNCED by F & M Scientific Corp., Starr Rd. and Rt 41, Avondale, Pa., the model 240 power proportioning temperature programmer is a lightweight unit in which the amount of power supplied to a heater is increased continuously by silicon controlled rectifier phase control rather than full power being applied intermittently. Heating rates between 0.5, 1, 2, 3, 4, 5, 7.5, 10, 15, 20, 25 and 30 degrees C per minute between 0 and 500 C with power up to 1,500 watts are provided. Phase control of the scr is through a unijunction firing circuit and by controlling the scr firing phase, power applied to the load is controlled. Temperature detection is by a thermocouple reference bridge and microsignal amplifier. Proportional bandwidth is adjustable between 2 and 20 C and temperature control is ±0.1 C or better. The thermocouple bridge is stabilized by a two-stage zener diode regulator. Applications include DTA units, hotstage microscope studies, heated cells for IR, ovens for crystal growing or wherever precise temperature control is needed. (302)



Low-Frequency Oscillator

RECENTLY announced by Grafix Inc., POB 3296, Albuquerque, New Mexico, the new line of solid-state low-frequency oscillators supply fixed tones or timing frequencies comparable to tuning-fork oscillators and are very rugged, have superior reliability and cost less. Frequencies can be supplied between 400 cps and 100 Kc ±0.01 percent. Output is 4 v rms into a 2,000-ohm load. Harmonic distortion is less than 5 percent and can be ordered to essentially zero per-



In a single envelope, ITT's new backward wave converter provides a complete microwave receiver front end, amplifier/pre-selector, a local oscillator and mixer. The BWC operates as a swept superheterodyne receiver with octave coverage without the use of an external local oscillator or external mixer. ■ This design eliminates crystal detectors and their burn-out problems and virtually eliminates blocking by strong signals at the pass band. Seven frequency ranges from 500 to 12,000 MC in seven bands are now available. BWA tubes for use as pre-selectors with the converters are also in production. ■ The ITT microwave tube line includes BWC, BWA and BWO types as well as TWT's for L, S, C and X band.

BACKWARD WAVE CONVERTER SPECIFICATIONS

Tube Type	Nominal Input Frequency Coverage (mc)	Output Intermediate Frequency (mc)	Noise Figure (db)	Minimum Image Rejection (db)	Tube Size* L" x D"
X-388	500 -900	50	20	35	55½x3¼
X-390	850 -1500	50	20	35	49½x2½
X-392	1450-2650	130	20	35	41 x2
X-394	2500-4000	180	20	35	33 x1⅜
X-396	3850-6000	280	20	35	27½x1⅛
X-398	5700-8400	320	20	35	21 x ⅞
X-400	8000-12,000	480	20	35	19 x ⅞

ITT

Write for information on the complete line of ITT traveling wave tubes. Application assistance is available for your specific requirements.

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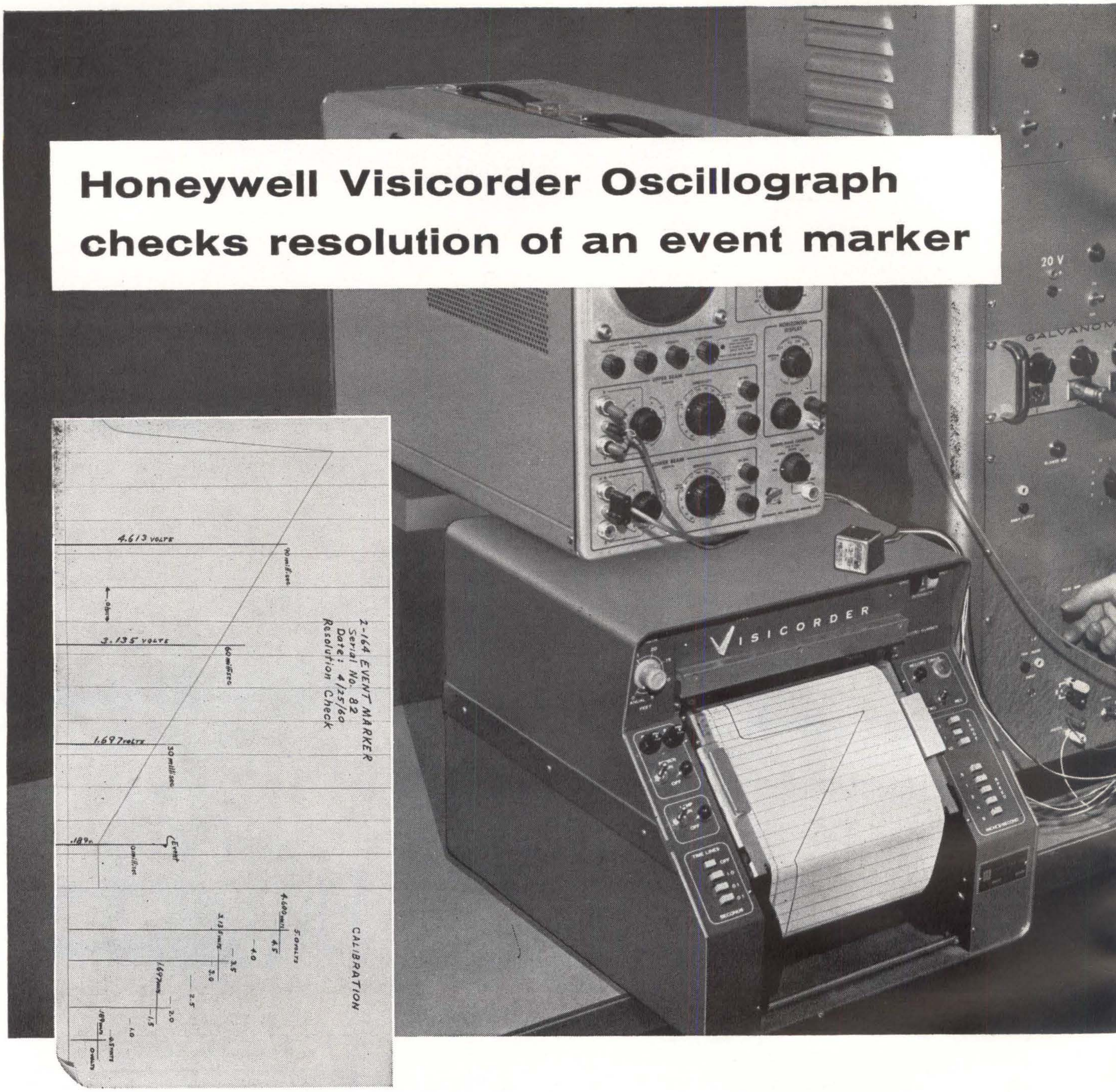
Honeywell Visicorder Oscillograph checks resolution of an event marker



Electro Development Corporation, Seattle, Wash., uses a Model 1108 Honeywell Visicorder Oscillograph to prove the linearity and resolution of signal conditioner-event markers which they supply to the Boeing Company.

A missile telemetering system samples each channel only once every 30 milliseconds, but missile engineers want to know when some events occur to an accuracy of better than one millisecond.

The event marker (the small cube atop the Visicorder) produces a highly-linear ramp output that starts exactly when the marker is triggered by the event in question. This ramp continues for about 100 milliseconds . . . enough time so that the telemeter system can sample the ramp at least three times. A straight line drawn through these points will accurately determine the occurence of the event.

To check event marker linearity, the ramp is recorded at the very high record speed of 80″/sec. It's this high speed, the .01-second timing lines, the ease of operation, and the wide deflection capabilities of Honeywell galvanometers (approx. 7″ in this application) that caused the Electro Development Corporation to select the Model 1108 Honeywell Visicorder.

Honeywell

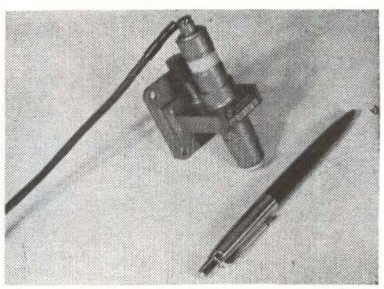
H HONEYWELL *First in Control*

Dick Daniel, EDC Design Engineer, tests linearity of Model 2-164 event marker (small cube atop the Visicorder). Included in the rack at Daniel's right are a voltage calibrator, cathode follower, switching unit, trigger source and power 28V supply designed and built by EDC, and a Honeywell Model T6GA Galvanometer amplifier.

For more details about the Model 1108 (24 channels), the 1012 (36 channels) and other Honeywell Visicorders, write to Minneapolis-Honeywell, Heiland Division, 4800 E. Dry Creek Road, Denver 10, Colorado. Our DDD phone number is 303-794-4311.

cent. The oscillator (sketch p 76) uses two transistors, one for power regulation and the other for the oscillator. A transformer feedback loop, loosely coupled to the tank circuit, minimizes effects of collector capacitance change with temperature. Collector and base windings have much lower impedance than the tank circuit thus allowing output loads as low as 2,000 ohms without significant change in output or frequency. The tank circuit core provides a change of inductance with temperature to compensate changes in tuning capacitor used. By matching these two components, it is practical to achieve stabilities of better than 0.001 percent. The regulator makes output and frequency virtually independent of supply voltage.

CIRCLE **303**, READER SERVICE CARD

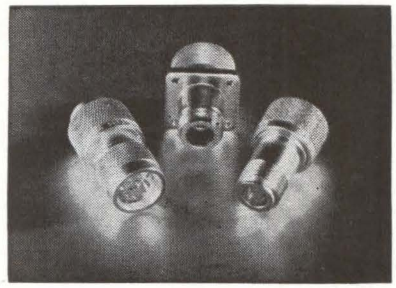


B-W Oscillator Tunes Electronically

MICROWAVE ASSOCIATES, INC., Burlington, Mass. The MA-2200 is a bwo with electrostatic focusing and design for airborne and missile applications at X-band. It generates a minimum of 20 mw over the 8.5-9.6 Gc range. It is equal in size, weight and configuration to reflex klystron oscillators and may be substituted for them in many instances. Unit has all-electronic tuning. **(304)**

Fast Pulse Amplifier Has Wide Response

COMMUNITY ENGINEERING CORP., 234 E. College Ave., State College, Pa. Response of the solid state model 3029 is 20 cps to 50 Mc $\pm$ 0.3 db with an output level of 10 v peak to peak, into 75 ohm load. Rise time is 6 nsec with less than 2 percent ringing. Tilt is 10 percent with a 5 millisec pulse. Input and output impedance is 75 ohms with a vswr better than 1.5 to 1. **(305)**

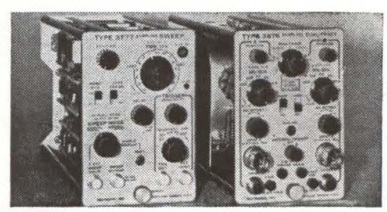


Coax Connectors Feature Low VSWR

GREMAR MFG. CO., INC., 7 North Ave., Wakefield, Mass., offers a series of modified series N precision coax connectors for use with microwave components such as twt's, amplifiers and bwo's. The TWT series connectors feature a low vswr. They are available for X-band and S-band uses and for either RG-55/U flexible cable or 0.140 in.-diameter 50-ohm rigid cable. **(306)**

Connectors

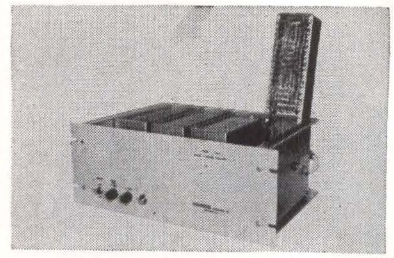
GARDE MFG. CO., 53 John St., Cumberland, R. I. The 630 series of right angle pin and socket connectors for dip soldering to p-c boards meets all requirements of MIL-C-8384 specifications. **(307)**



Sampling Plug-Ins Extend Scope Range

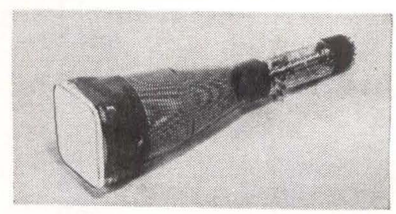
TEKTRONIX, INC., P. O. Box 500, Beaverton, Ore. Two new sampling plug-ins will extend the range of 4 Mc scopes to 875 Mc. Type 3S76 dual-trace sampling unit and type 3T77 sampling sweep unit, when combined with a 561 crt indicator, permit observation of recurrent

pulses with risetimes as brief as 0.4×10^{-9} sec. Internal delay lines provide a convenient, 50 ohm impedance input to signal sources.
CIRCLE 308, READER SERVICE CARD



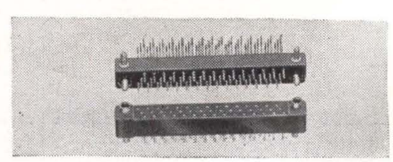
Converters Accept Various Inputs

HOWARD INSTRUMENT CO., Red Bank, N. J. The C series binary-decimal converters are available in capacities up to 7 decimal digits. Model 1007-C, illustrated, accepts 21 bit serial binary inputs, and converts the data in 210 μsec, to 7 digit binary-coded-decimal. Other models accept parallel inputs in true binary, or serial, or parallel reflected binary. **(309)**



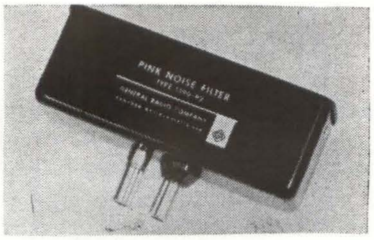
C-R Tubes Use Spiral Acceleration

SYLVANIA ELECTRIC PRODUCTS INC., 1100 Main St., Buffalo 9, N. Y., announces the SC-3377 and SC-3511 high sensitivity crt's, employing spiral acceleration and designed for use with transistor deflection circuits. Overall tube length is only 13¾ in., making the units suitable for compact, efficient scope designs. Pressed faceplates provide good quality and strength. **(310)**



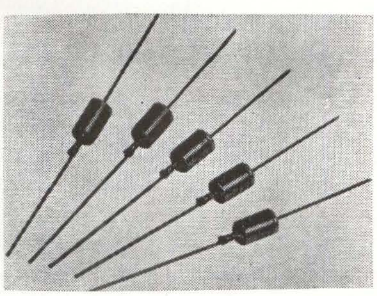
Plug & Socket Connector Designed for P-C Boards

CONTINENTAL CONNECTOR CORP., 34-63 56th St., Woodside 77, N. Y., offers a subminiature right angle plug and socket connector for p-c board applications. Series 600-1-45 has three rows of right angle pins with staggered contact placement having 0.050 in. center-to-center contact spacing. A total of 45 contacts are used in a molding only 2⅜ in. long. Pins solder directly to a p-c board. Pins and guides are polarized to prevent improper mating with the socket. **(311)**



Noise Filter Translates White Output to Pink

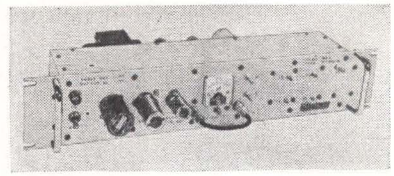
GENERAL RADIO CO., West Concord, Mass. Type 1390-P2 translates the white-noise output of an a-f random-noise generator into pink noise, that is noise with constant energy per octave. Although designed to plug directly into the GR type 1390-B random-noise generator, the pink-noise filter can be used in any circuit where such a characteristic is desired, providing the source impedance is less than 1,000 ohms and the load impedance is at least 20 kilohms. **(312)**



Flangeless Diode Operates From —65 to + 200 C

INTERNATIONAL TELEPHONE AND TELEGRAPH CORP., Clifton, N. J., announces a flangeless 1-w Zener voltage-regulator diode. The regulators will operate over a temperature range of —65 to +200 C. They feature low dynamic impedance with a sharp Zener knee, 100 percent tested, and have controlled forward characteristics. The diodes are available in 33 voltage ranges between 6.8 and 200 v. Prices range from $2.95 to $7.75 in small quantities.

CIRCLE 313, READER SERVICE CARD



R-F Converter Utilizes Nuvistors

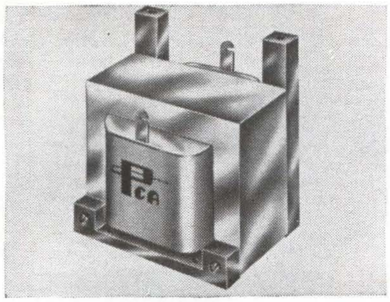
TAPETONE ELECTRONICS LAB., INC., 99 Elm St., West Newton 65, Mass. Model 100-A is designed for telemetry and satellite tracking applications. Available at frequencies from 200 to 500 Mc, with i-f outputs of 5 to 100 Mc. Utilizing Nuvistors as the r-f amplifiers and mixer, this converter has a noise figure of 5 db at 400 Mc, with an overall gain of 25 db. Design incorporates high gain with very high overload resistance. (314)

Precision Clock Has Square Wave Output

TECH SERV, INC., 4911 College Ave., College Park, Md. Precision clock with frequencies of 1000, 100, 10, and 1 pps utilizes tuning fork device as basic generator deriving tolerances of ±0.10 percent. Output pulse trains are symmetrical square waves having a voltage excursion from 0 to −10 v and rise time of less than 1 μsec. (315)

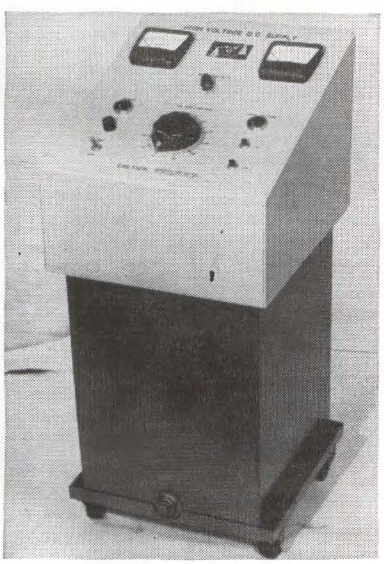
Solid State Converter Offered in Four Models

SOLID STATE ELECTRONICS CO., 15321 Rayen St., Sepulveda, Calif. The Freqmeter is a completely solid state unit which will linearly convert frequency or repetition rate of signals to a proportional d-c voltage. This is accomplished with 4 standard models over an input frequency range extending from 0 to 100 Kc (model 410, 0-100 cps; model 420, 0-1 Kc; model 430, 0 to 10 Kc; model 440, 0-100 Kc). Freqmeter output is virtually insensitive to supply voltage, temperature, input amplitude or waveforms. **(316)**



Power Reactor Used in Filters

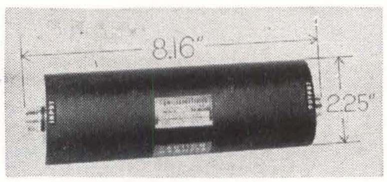
PCA ELECTRONICS, INC., 16799 Schoenborn St., Sepulveda, Calif., offers a 60 cycle power reactor with an inductance swing of 1.5 mh at 13 amp to 15 mh at 1.3 amp. Unit is designed for use in wide variety of power supply filters. Also available in 400 cycles, reactor acts as swinging choke in the filter with varying d-c loads. It is built to meet MIL-T-27A specifications Type TF5SX04ZZ. **(317)**



H-V Power Supplies Have Reversible Polarity

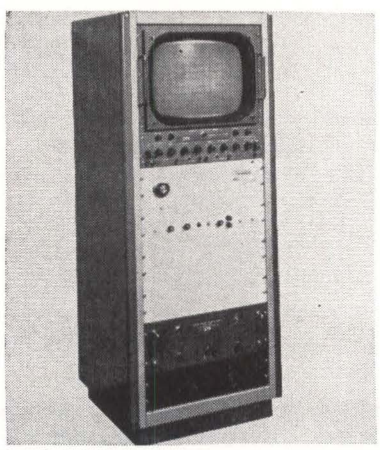
DEL ELECTRONICS CORP., 521 Homestead Ave., Mount Vernon, N. Y. The TC series are multipurpose units available from 30 Kv up to 80 Kv (insteps of 10 Kv) and current up to 5 ma. They are designed for single phase, 115 v, 60 cycle input and output is continuously variable from zero to max voltage. Polarity is reversible. Typical applications include laboratory use; maintenance, such as dielectric testing; industrial, such as power supply for electrostatic painting, flocking, etc.

CIRCLE 318, READER SERVICE CARD



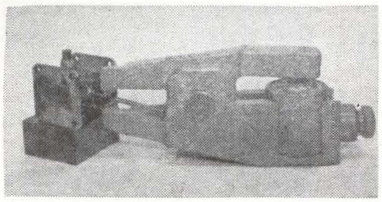
UHF Coax Isolator Features Broad Band

E & M LABORATORIES, 15145 Califa St., Van Nuys, Calif. Model U112LC1 exhibits these characteristics over the entire 600 to 1,000 Mc range: 10 db minimum isolation, 1.0 db max insertion loss, and 1.20 max vswr. Uses include standards and microwave laboratories as well as radar, communications, and telemetry systems and ground support equipment. (319)



Spectrum Analyzers Have Variety of Uses

SPECTRAN ELECTRONICS CORP., 146 Main St., Maynard, Mass. The 480 series spectrum analyzers are now available in a rack mounted assembly providing readout on an ITT model 1735D oscilloscope. The 480-WS assembly provides substantially instantaneous 480 line resolution analysis of both steady state and transient phenomena. Uses include signature studies of sonar signals and doppler radar echoes, mis-distance indication, speech studies, shock and vibration analysis. **(320)**

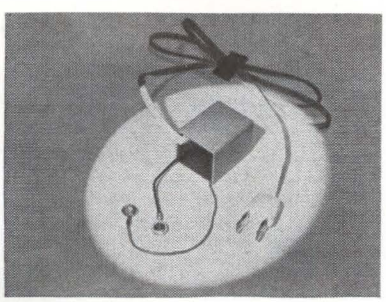


Pinch-Off Presses Reach Inaccessible Areas

CHARRON PRECISION GAGE & TOOL CORP., 821 Washington St., Lynn, Mass., offers pinch-off presses primarily used for pinching off tubing after the exhaust period in the electronic and transistor industry. They are powerful, yet small and compact, which enables them to reach inaccessible areas. Presses, made for either automatic or semi-automatic installations, are manufactured in 2, 4, 10 and 20 ton capacities. **(321)**

Electronic Weatherstrip

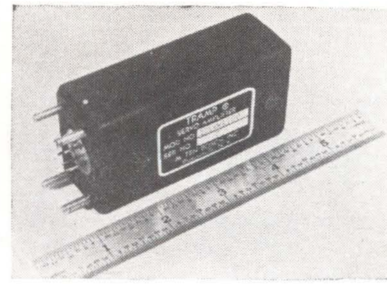
METEX ELECTRONICS CORP., Clark, N. J., announces Metalex, a knitted wire mesh, electronic weatherstrip that is mechanically joined to a solid aluminum extrusion. **(322)**



Battery Chargers Sell in $2 to $5 Range

MILLI-SWITCH CORP., 1400 Mill Creek Rd., Gladwyne, Pa., offers nickel-cadmium battery chargers for portable battery operated equipment. They sell in the range of $2 to $5 depending on rating, terminals and quantity desired. Il-

lustrated is a charger for a 1.25 v cell. It is housed in a $1\frac{3}{8}$ by $1\frac{3}{16}$ by $1\frac{3}{4}$ in. plastic box and encapsulated in a thermosetting plastic.
CIRCLE 323, READER SERVICE CARD



Servo Amplifier Priced at $272

M. TEN BOSCH, INC., Pleasantville, N. Y., offers a 400-cycle servo amplifier capable of yielding 6 w over a temperature range of −55 to +125 C. Hermetically sealed unit is transistorized and weighs 7 oz. Power gain at 2 w output with a 20,000 ohms input impedance is 2,400. Phase shift is adjusted internally to 0 deg. Model 1800-4700 is unit priced at $272 (for orders of 10 to 99). **(324)**

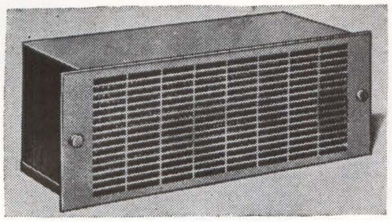
Shielding Material

METEX ELECTRONICS CORP., Clark, N. J., offers a spring-type, formed rfi gasketing material that can be installed or replaced quickly and easily by snapping it into a channel that is either attached to or is an integral part of the unit to be shielded. **(325)**

Power Supply Packaged for Bench Mount

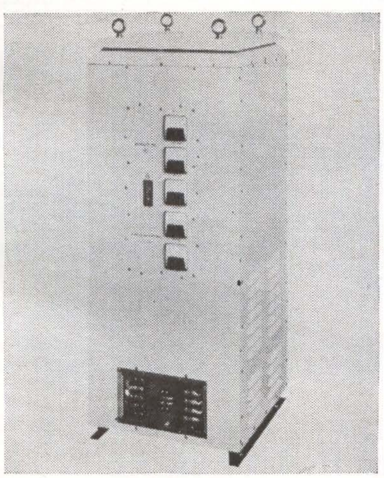
PERKIN ELECTRONICS CORP., 345 Kansas St., El Segundo, Calif. Model 28-10WXA is a magnetic amplifier regulated 28 v at 10 amp d-c power supply for inclusion in ground support systems. It provides 24 to 32 v at 10 amp with automatic voltage regulation of ±0.5

percent and ripple of 1 percent rms. Unit is contained within a $5\frac{1}{4}$ in. high by $16\frac{15}{16}$ in. wide by $14\frac{3}{8}$ in. deep package for bench mount. Price is $375. **(326)**



Blowers Offered in Four Models

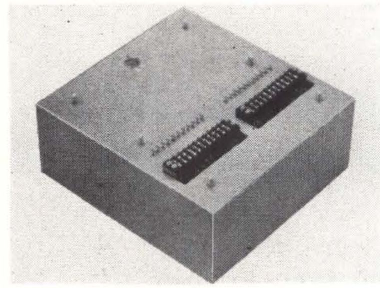
PREMIER METAL PRODUCTS CO., INC., 337 Manida St., New York 59, N. Y. The PMB series of Prem-O-Kool panel mounted blowers, designed for low noise level with minimum of vibration and space, have permanent type washable filters and are available in four models having 150, 285, 410 and 750 cfm. Motors are permanently lubricated with lubricant temperature range from −29 to +148 C. **(327)**



H-V Static Inverter Uses No Moving Parts

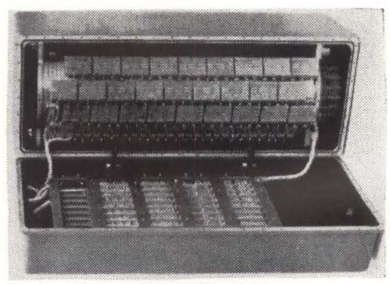
MICRODOT INC., 220 Pasadena Ave., S. Pasadena, Calif. A 5 Kva static inverter, operating from a wide range d-c battery source, supplies up to 5,000 w of a-c power. Conversion system allows an adjustable output frequency over the range of 380 to 2,000 cps. No moving parts are employed in the unit which measures 17 in. by 17 in. by 42 in. and weighs 200 lb. Power conversion system inherently provides excellent voltage regulation of ±1 percent wax over an input voltage range of 190-360 v d-c. Output power is held to 2 percent harmonic distortion and is virtually transient-free.

CIRCLE 328, READER SERVICE CARD



H-V Delay Line Operates From −55 to + 125 C

COLUMBIA TECHNICAL CORP., Woodside 77, N. Y. Type CTC-1411 has an operating input signal level in excess of 200 v. Operating temperature range, from −55 C to +125 C; total delay, 50 μsec (multiple taps); rise time, 0.5 μsec max; delay to rise time ratio, over 100:1; impedance, 500 ohms; accuracy of delay, 0.1 percent or 0.05 μsec whichever is larger; attenuation, less than 2 db; total volume, approximately 200 cu in. **(329)**



Memory Drum Has Over 10 Year Life

DIGITAL DEVELOPMENT CORP., 7541 Eads Ave., LaJolla, Calif., announces a 5.5 million bit magnetic memory drum for industrial process-control computers. The 1100 track drum has a design life in excess of 10 years, and may be operated in an oxygen purged nitrogen atmosphere at 1½ psi N_2, to extend bearing life further. Integral selection diode matrices are designed as an additional feature. All read-write amplifiers and selection drivers are mounted in the housing cover. **(330)**

PRODUCT BRIEFS

D-C CAPACITORS for laser applications. General Electric Co., Hudson Falls, N. Y. **(331)**

PACKAGED CENTRIFUGAL BLOWERS, eight models. McLean Engineering Laboratories, Princeton, N. J. **(332)**

MASS SPECTROMETER LEAK DETECTOR has high sensitivity. Vacuum Instrument Corp., Stepar Place, Huntington Station, N. Y. **(333)**

SPOT WELDERS are small, ultraprecise. Wells Electronics, Inc., 1701 S. Main St., South Bend 23, Ind. **(334)**

MULTIPLE CONNECTOR takes 6 wires. Conolex Corp., Box 468, Silver Spring, Md. **(335)**

RATE GYRO eliminates gimbal. Humphrey, Inc., 2805 Canon St., San Diego 6, Calif. **(336)**

CUSTOMIZED RECORDER, low-cost. Texas Instruments Inc., 3609 Buffalo Speedway, Houston, Texas. **(337)**

SATURABLE REACTOR PACKAGES offer high-gain. Instrument Systems Corp., 129-07 18th Ave., College Point 56, L. I., N. Y. **(338)**

X-BAND T-W AMPLIFIER, ultra-broad bandwidth. Sperry Electronic Tube Division, Gainesville, Fla. **(339)**

DIGITAL ASPECT SYSTEM for rockets and satellites. Adcole Corp., 186 Massachusetts Ave., Cambridge 39, Mass. **(340)**

DUAL ADAPTER simplifies line voltage connectors. The Superior Electric Co., Bristol, Conn. **(341)**

COAXIAL BAND PASS FILTERS for operation from 1,000 Mc to 10 Gc. RLC Electronics, Inc., 25 Martin Place, Port Chester, N. Y. **(342)**

ULTRA-HIGH VACUUM EVAPORATOR for laboratory use. General Vacuum Corp., 81 Hicks Ave., Medford 55, Mass. **(343)**

CROSS FLOW BLOWERS provide high pressure, low noise. The Torrington Mfg. Co., Torrington, Conn. **(344)**

SUPER-THIN FOIL for capacitors. Republic Foil Inc., 55 Triangle St., Danbury, Conn. **(345)**

POWER SUPPLY, constant current and voltage. NJE Corp., 20 Boright Ave., Kenilworth, N. J. **(346)**

TOGGLE SWITCHES are panel mounted devices. Milli-Switch Corp., Gladwyne, Pa. **(347)**

DIGITAL INDICATOR, end-fire-illuminated display. General Radio Co., West Concord, **Mass.(348)**

PNPN SWITCH, light actuated. International Rectifier Corp., 233 Kansas St., El Segundo, Calif. **(349)**

AUDIO CONNECTORS, three circuit contacts. Switchcraft, Inc., 5555 N. Elston Ave., Chicago, Ill.**(350)**

Literature of the Week

TORQUE PICKUPS Baldwin-Lima-Hamilton Corp., 42 Fourth Ave., Waltham 54, Mass. Two types of electronic torque pickups are covered in bulletin 4370-A. **(351)**

TEMPERATURE PROBE Gulton Industries, Inc., 212 Durham Ave., Metuchen, N. J., has issued a bulletin on the Glennite cryogenic temperature probe. **(352)**

DIODE RELIABILITY PROGRAM Sperry Semiconductor, division of Sperry Rand Corp., Norwalk, Conn. Booklet describes company facilities for testing and sorting high reliability silicon diodes. **(353)**

MICROWAVE TEST EQUIPMENT PRD Electronics, Inc., 202 Tillary St., Brooklyn 1, N. Y. Bulletin 801 illustrates and describes precision microwave test equipment. **(354)**

P-C DRAFTING AIDS By-Buk Co., 4314 W. Pico Blvd., Los Angeles 19, Calif. New shapes and sizes of precut pressure sensitive drafting aids appear in bulletin P-40. **(355)**

X-Y PLOTTER The Gerber Scientific Instrument Co., P.O. Box 305, Hartford Conn. An 8-page booklet illustrates and describes the GP-30-D digital X-Y plotter. **(356)**

FERRITES Ferroxcube Corp. of America, Saugerties, N. Y. Bulletin details the company's ferrite materials and applications. **(357)**

SUBCARRIER OSCILLATOR Telemet Co., 185 Dixon Ave., Amityville, N. Y., Single sheet covers subcarrier oscillator that features 11 standard IRIG channels. **(358)**

SPECTROMETER SYSTEM Varian Associates, 611 Hansen Way, Palo Alto, Calif. Brochure describes the high resolution 100 Mc NMR spectrometer system. **(359)**

RELATIVE HUMIDITY INDICATOR Cybernetics, Inc., 136 Washington St., Paterson 1, N. J. Bulletin illustrates and describes the Rhindicator portable relative humidity indicator. **(360)**

SOLID STATE CHOPPERS Airpax Electronics Inc., Cambridge, Md., has available a 2-page article on solid state chopper design. **(361)**

SEMICONDUCTOR PRODUCT GUIDE Radio Corp. of America, Somerville, N. J., offers a 12-page semiconductor product guide which includes a by-application classification. **(362)**

ROTARY EQUIPMENT Beau Electronics, Inc., P.O. Box 624, Waterbury, Conn., announces a catalog illustrating and describing a line of precision rotary equipment. **(363)**

POWER SOURCE Amulex Electronics Inc., 467 Connecticut Ave., S. Norwalk, Conn., announces availability of a power source catalog. **(364)**

L & R ULTRASONIC CLEANING SOLUTIONS

L & R #112
Waterless Ultrasonic Instrument Cleaning Solution (Ammoniated)

L & R #222
Waterless Ultrasonic Instrument Cleaning Solution (Ammonia-free)

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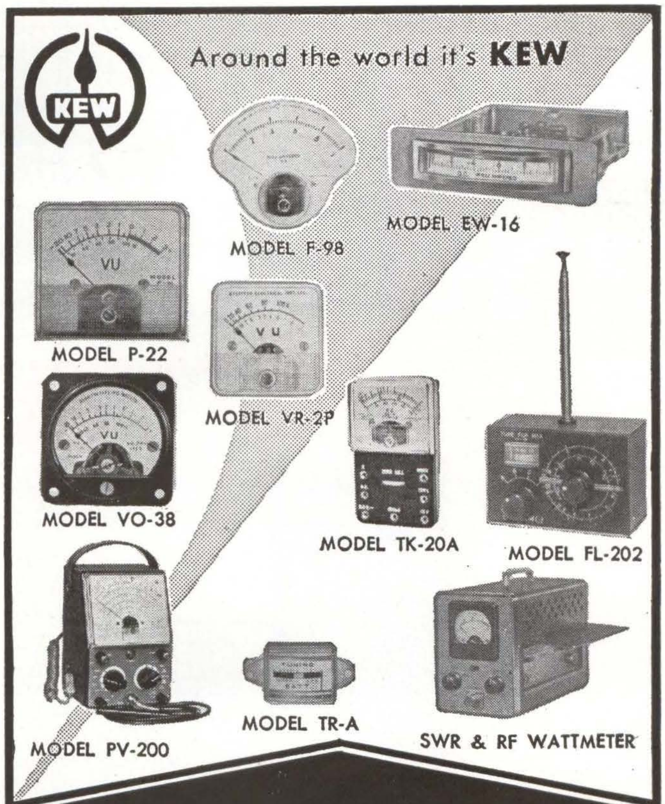

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electronics

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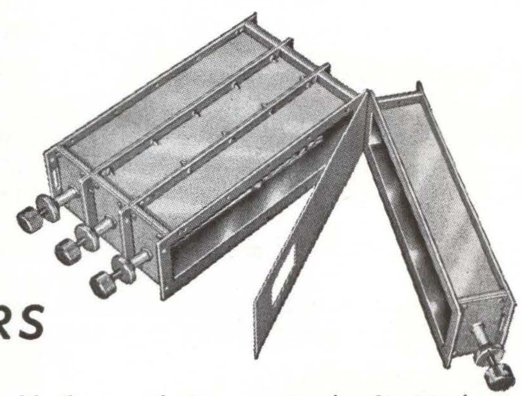
Write **The Editor, electronics, 330 W. 42nd St., New York 36,** stating experience, aspirations and past earnings. Mark the envelope "Confidential" and it will be kept that way.

NEW

MODULAR CONCEPT IN PRESELECTORS



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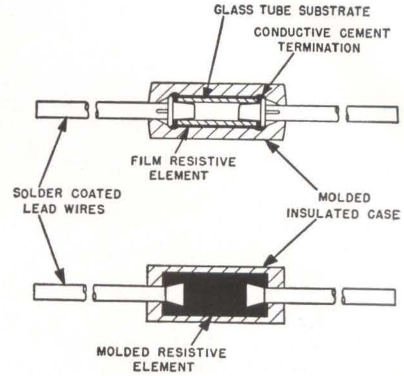
NEW BOOKS



CROSS SECTION *of a slug-type composition resistor, from article on resistors*

The Encyclopedia of Electronics

Edited by CHARLES SUSSKIND

Reinhold Publishing Corporation, New York, 1962, 974 *p*, $22.50

About 500 selected topics in electronics are covered by short articles in alphabetical order. The articles are for the most part state-of-the-art summaries, limited by space requirements to general terms; this makes it difficult to look up a particular specialized term. The book will serve as a fine introduction to topics outside one's own specialty; however, because of the state-of-the-art approach, there will be danger of obsolescence.—G.V.N.

Superconductive Devices

By JOHN W. BREMER

McGraw-Hill Book Co., Inc., New York, 1962, 184 *p*, $8.

A fairly complete introduction to the basic phenomena, theory and applications of superconductivity up to date. Several chapters are devoted to the cryotron and croytron circuits applied to digital computers. Superconductive magnets, a fast-moving subject of research, are mentioned only briefly. The closing section is devoted to low-temperature techniques.

No book can hope to remain up-to-date for long in this fast moving area, or to cover all existing developments; however, "Superconductive Devices" gives the reader a good grounding in the fundamentals that are not likely to change radically.—G.V.N.

Switching Circuits For Engineers

By MITCHELL P. MARCUS

Prentice-Hall, Inc., Englewood Cliffs, N. J., 1962, 296 *p*, $12.

This excellent book is highly useful to the logic design engineer, both for study and reference. Its clear, step-by-step explanations also make it valuable as a school text.

Applications as well as theory are stressed, and the author goes into detail seldom seen elsewhere. An original method is given for obtaining flip-flop excitation expressions.—S.B.G.

Redundancy Techniques for Computing Systems

Edited by RICHARD H. WILCOX and WILLIAM C. MANN

Spartan Books, Washington, D.C., 1962, 403 *p*, $6.50.

A collection of 23 papers presented at the Symposium on Redundancy Techniques in February. The papers range in subject matter from very basic to speculative, and indicate well the present state of the art. A bibliography on redundancy techniques is included and should prove very useful.

Elements of Electronic Circuits

By J. M. PETERS

Iliffe Books Ltd., London, 1962, 98 *p*, $3.00.

These building bricks for circuit design are taken from a feature in British *Wireless World* magazine. The articles are noted for their clear and highly instructive diagrams, most of which are input and output waveforms, and for the easily understood text.

The chapter headings are general principles, two-state circuits, timebases, electronic markers, the logarithmic amplifier, gates and coincidence circuits, and waveforms operated on mathematically.—S.B.G.

continued

Analysis and Design of Non-linear Feedback Control Systems

By GEORGE J. THALER and MARVIN P. PASTEL

McGraw-Hill Book Co., Inc., New York, 1962, 464 *p,* $14.50

A graduate-level text that presupposes an elementary knowledge of the subject, the book has two parts. The first is devoted to analysis, the second to design. Among the topics included are analysis with random inputs, dual-mode servos, self-adaptive control systems and analog simulation. A brief introduction to the Second Method of Lyapunov closes the book.

A Survey of Switching Circuit Theory

Edited by E. J. McCLUSKEY, Jr. and T. C. BARTEE

McGraw-Hill Book Co., Inc., New York, 1962, 205 *p,* $7.75.

This book contains a group of tutorial papers presented at the 1959 Fall and 1960 Winter General Meetings of the AIEE, at sessions sponsored by the Subcommittee on Logic and Switching Theory.

As a short introduction to switching theory, the book covers the field very well. Divided equally between combinational and sequential switching circuits, the chapters deal with such subjects as switching algebra, binary numbers, map methods, minimization theory, and state tables.—S.B.G.

Radiation and Waves in Plasmas

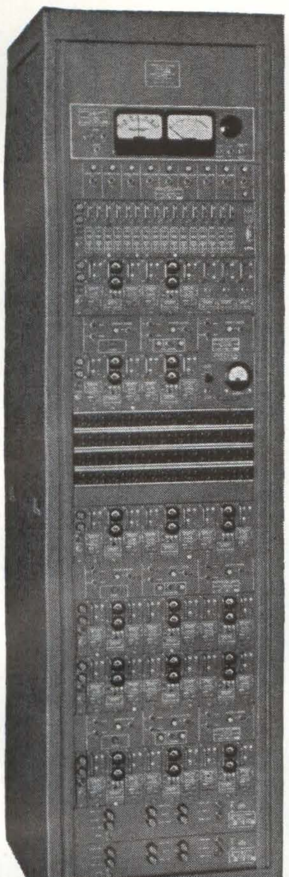
Edited by MORTON MITCHNER

Stanford University Press, Stanford, Calif., 156 *p.* $4.50.

Seven papers presented at the Fifth Lockheed Symposium of magnetohydrodynamics cover experimental and theoretical work in this field.

The first five papers deal with theoretical problems, valuable primarily to those actively engaged in research in this field.

The last two papers on experiments are general enough to be of interest to those not expert in the field.



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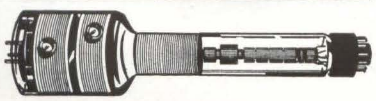
CIRCLE 211 ON READER SERVICE CARD

RECORDING STORAGE TUBE SYSTEMS



Originated and Built By

IMAGE INSTRUMENTS, INC.

■ ELECTROSTATIC PICTURE STORAGE AND RECALL SYSTEMS ■ LOW-LIGHT-LEVEL CAMERA AND DUAL STORAGE TUBE SYSTEMS ■ DOUBLE-ENDED STORAGE TUBE SYSTEMS ■ DATA SUMMATION UNITS ■ COMPUTER OUTPUT STORAGE FOR TELEVISION DISPLAY.

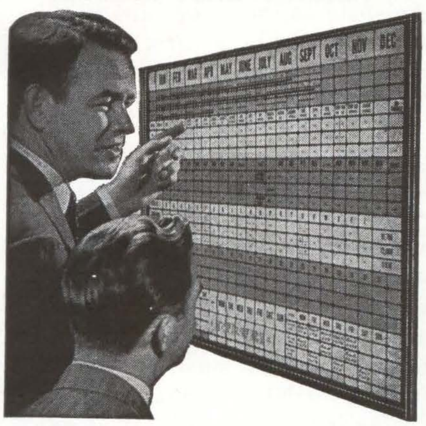
Standard storage tube systems are readily available. A custom-engineered system can be built to meet your special needs.

For further information, write: Dept. A.

IMAGE INSTRUMENTS, Inc.
2300 WASHINGTON STREET
NEWTON LOWER FALLS 62, MASS.
WOODWARD 9-8440

CIRCLE 212 ON READER SERVICE CARD

How To Get Things Done Better And Faster



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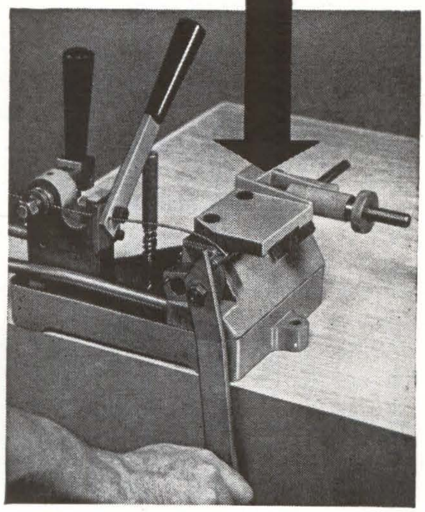
Write for Your Copy Today
GRAPHIC SYSTEMS
YANCEYVILLE, NORTH CAROLINA

CIRCLE 213 ON READER SERVICE CARD

make Springs in Seconds!



Save Costly Special Orders With the NEW

DI-ACRO* Spring Winder

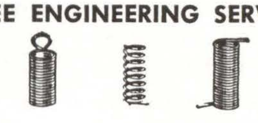
This unique machine eliminates costly special spring orders, saves valuable waiting time. Winds compression and extension springs to 1½" O.D. Handles round, flat and rectangular wire to ⅛" dimension. Note exclusive features in the hand operated Di-Acro Spring Winder which assure accurate tension and fast operation without special experience or skill.

new **TENSION CONTROL**—Simply adjust to desired tension—the control keeps it uniform, for winding one spring or hundreds, and releases when each spring is wound.

new **WIRE CUT-OFF**—After spring is wound, release tension and use cut-off lever to quickly cut end of spring to desired length.

new **CAM LOCK**—Simply feed wire under cam, turn handle and wire is securely locked to arbor while spring is wound. No threading required.

FREE ENGINEERING SERVICE



Send us your spring forming problems—samples or dimension sketches—together with sufficient test material, and let us wind some sample springs for you free of charge. No obligation.

Quick Facts Folder gives details on all Di-Acro Precision Machines. Consult the yellow pages of your phone book under Machinery, Machine Tools, for the name of your Di-Acro distributor or write.

*pronounced Die-ack-ro

di-acro PRECISION METALWORKING MACHINES

DI-ACRO CORPORATION
formerly O'Neil-Irwin Mfg. Co.
437 8th Ave., Lake City, Minn.

CIRCLE 95 ON READER SERVICE CARD

Wilson: Take the initiative

USING HIS QUALITIES of quiet determination to see the job through is a key characteristic of Webster H. Wilson, chairman and president of Hazeltine Corporation. The effectiveness of the Wilson approach was recently made evident in the form of a contract award to a five-company team headed by his firm, for a second phase study of the coordination of electronics into a guided-missile destroyer escort class of ships.

Since World War II when he was in charge of Bureau of Ships installations and maintenance of electronic identification equipment, "Web" has been interested in the concept of merging electronics and architectural functions of ship design. The studies in which Hazeltine is now engaged, in association with Newport News Shipbuilding and Dry Dock, Sperry Rand, DECO Electronics and Nortronics, represent the fruition of Wilson's initial planning.

"Sure, ideas like this have been around for years", says Wilson with his almost shy smile. "But someone has to have the incentive to push and push hard to implement them. So many these days are afraid to try new approaches." Navy's Bureau of Ships has taken the initiative in this case.

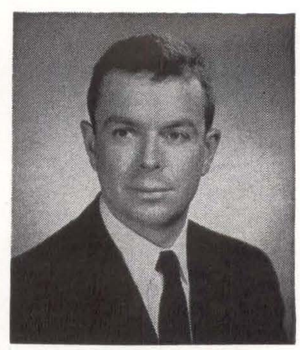
Since graduation from Phillips Andover, Wilson, who was born in Wollaston, Mass., has always had a double barreled approach to his work. Majoring in aeronautical engineering and business administration at Massachusetts Institute of Technology from which he was graduated in 1936, he approaches his corporate decisions with the combined outlook of a businessman and an engineer.

He has been with Hazeltine since leaving the Navy in 1946. Starting then as a project administrator, he soon became a chief project administrator and a vice president in charge of the Government and Commercial Sales department. In 1958 he became executive vice president of the Electronics division and a director of the corporation. He was elected president of Hazeltine in 1960 and last year succeeded the late William A. MacDonald as chairman of the board. In 1961, he was also elected a director of the Western Union Telegraph Company.

His associates appreciate Wilson's friendly, warm good humor and his wide interests. He is a ham radio addict and an avid baseball and football fan. He tempers this with interest in the writings of C. P. Snow, and has developed a green thumb in the garden of his Locust Valley, Long Island home.

This flexibility of character is reflected in some of his actions since taking over the helm at Hazeltine. He feels strongly that the successful company in today's ever-shifting electronics industry must remain flexible both technically and in business methods. One of his recent moves was the formation of the company's International division under which reciprocal technical and sales agreements will be concluded with overseas companies.

A member of many organizations, including IRE, AFCEA, National Security Industrial Association, American Society of Naval Engineers, Air Forces Association, and American Ordnance Association, he served as a member of the U. S. delegation to the First International Meeting on Radio Aids to Marine Navigation held in London in 1946.



Elect J. L. Sprague Senior V-P

JOHN L. SPRAGUE was recently elected a senior vice president of the Sprague Electric Co., North Adams, Mass., and named co-director of the firm's engineering laboratories.

A director of the company since

Available! Ultra-Modern Bldg.
AIR CONDITIONED AND HUMIDITY CONTROLLED

ONE STORY
64,500 SQ. FT.
NEWARK, DELAWARE

Ground for expansion. Excellent loading and shipping.

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CIRCLE 214 ON READER SERVICE CARD

RELIANCE DEVELOPS ADVANCED COMMERCIAL FREQUENCY-CONVERTED D-C POWER SUPPLY

Facts book now ready covering data processing and communications equipment

Converting from 60 to 3000 cycles before rectifying to d-c. this new Reliance D-C Power Supply brings you these major advantages:

1. High frequency A-c. distribution — multiple rectifiers at point of use.
2. Low cost, compact, high frequency components.
3. Maximum protection against line voltage and frequency disturbance.
4. Simplicity in maintaining high quality D-c. voltages.

K-1711

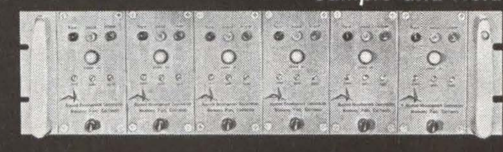
Talk to our people about this new Reliance development . . . and be sure to get the booklet with all technical facts. Write today. Reliance Electric and Engineering Co., Dept. 837-A, Cleveland 17, Ohio. Canadian Division: Toronto, Ontario.

RELIANCE ELECTRIC AND ENGINEERING CO.

CIRCLE 215 ON READER SERVICE CARD

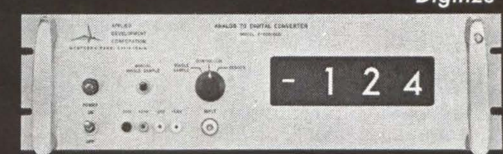
MODULAR!
DATA ACQUISITION INSTRUMENTS

Sample and Hold



Multiplex

Digitize



HIGH SPEED
HIGH ACCURACY
HIGH RELIABILITY

The above instruments are typical of ADC's wide selection of modular data units. Each instrument is completely integrated, with its own power supply and operating controls.

Sample-and-Hold, for accurate, microsecond-aperture sampling of high-frequency analog data.

Multiplexors, for programmed and sequential operation.

High-Speed Analog-to-Digital Converters, for continuous or peak digitizing.

All ADC instruments use plug-in solid-state circuits to simplify future expansion.

The ADC Systems Division can supply complete data-acquisition, data-processing and computing systems.

Write for complete information.

Other ADC Products — card files • equipment drawers cabinet sections • logic modules

Applied Development Corporation
1131 Monterey Pass Road
Monterey Park, California
AN 4-1381

March of this year, Sprague has most recently been head of the Transistor Research department of Sprague Electric's research laboratories.

Applied Dynamics Promotes Three

PROMOTION of three engineering staff members has been announced by Applied Dynamics, Inc., Ann Arbor, Mich., manufacturer of electronic analog computers and components.

The three are: Peter W. Barhydt, named quality control department manager; Jay B. King, advanced to chief designer and staff advisor; and Charles W. Kleekamp, appointed engineering department manager.

General Electric Hires Schulz

JOHN E. SCHULZ has joined the traveling-wave tube product section of GE's Power Tube Dept. as a senior engineer for advanced high-power electronic devices.

His appointment was announced by S. E. Webber, manager-engineering of the Product Section in Palo Alto, Calif.

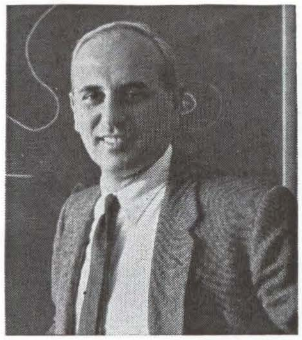
Schulz was formerly manager of the superpower klystron group for Eitel McCullough, San Bruno Calif.

Elco Erecting New Plants

ELCO CORP., Philadelphia, Pa., manufacturer of connectors and components, announces that expanding operation has necessitated construction of two new plants.

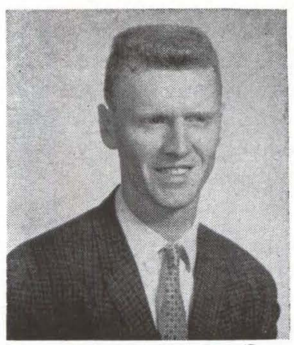
One is a 111,000 sq ft facility in

Willow Grove, Pa., which will take the place of the company's present Philadelphia plant. The second is a 52,000 sq ft building in Huntingdon, Pa. Both are expected to be ready for occupancy in September of this year.



Varian Associates Appoints Miller

SOLOMON L. MILLER has joined the central research staff at Varian Associates, Palo Alto, Calif., as a senior research scientist. He formerly headed research at Rheem Semiconductor Corp. in Mountain View, Calif.



John Royan Joins National Transistor

JOHN ROYAN recently joined the R&D department of National Transistor Mfg., Inc., Lawrence, Mass.

Before joining th̓e firm, Royan was employed by Farranti, Ltd., in Manchester, England, where he specialized in semiconductor devices.

Hi-G, Inc., Continues Facilities Expansion

HI-G, INC., Windsor Locks, Conn., recently announced the completion of a 22,000 sq ft addition to its main production facilities, and the start of a second addition of 9,000 sq ft as an advanced research and engineering center.

Company manufactures components for many switching functions and control circuits in the current space vehicle and computer programs.

Electro-Optical Appoints Munk

ROBERT MUNK has joined the technical staff of Electro-Optical Systems, Inc., Pasadena, Calif., as chief scientist of the company's Advanced Electronics and Information Systems division. He will be responsible for systems research and analysis activities for space vehicles and weapon systems.

Prior to joining EOS, Munk was with Ryan Aeronautical Corp. in San Diego.

Granger Associates Elects Pappenfus

THE BOARD of directors of Granger Associates, Palo Alto, Calif., has elected E. W. Pappenfus vice president, engineering. He will assume wide responsibilities for development of the company's programs in radio communications systems and devices.

Pappenfus spent 19 years with

Collins Radio Co., where he was at the last director of development of the firm's largest design division.

Ford Instrument Names Montani

ANGELO MONTANI has been appointed assistant to the president of Ford Instrument Co., a division of Sperry Rand Corp., Long Island City, N. Y.

He was formerly research manager for Philco Corp.

PEOPLE IN BRIEF

Louis Mager leaves Tyco Inc. to join U. S. Dielectric Inc. as exec v-p. Minneapolis-Honeywell promotes **John S. Blakemore** to mgr. of applied research at its Semiconductor R&D center. **Bernard G. Beck,** ex-Magnavox Co., now with new projects staff of Vitro Laboratories. Lenkurt Electric Co., Inc., ups **Glenn H. Vought** to mgr. of its Rome, N. Y., office. **Bill Strunk,** manufacturing mgr. of Astro-Systems, Inc., elected a v-p. **Malcolm L. Stitch** advances at Hughes Aircraft to mgr. of the Aerospace Laser dept. **Murray G. Wachsman,** formerly with J. A. Maurer, Inc., appointed v-p/g-m of Knight Electronics Corp. **William E. Seaman,** previously head of his own consulting firm, named engineering mgr. for Radiation Counter Laboratories, Inc. **Warren G. Austin,** retired USAF electronic warfare officer, now g-m of Southern Electronics Engineering Co. **C. E. T. White** moves up at Cominco Products, Inc., to mgr. of Electronic Materials div. **Robert J. Orwin** is elevated to technical director of the commercial products div. at The Hallicrafters Co. **Edward M. Hoey** promoted to v-p of Hektor Scientific Co. **Ralph F. Lowe** of GE appointed mgr. of multiplex carrier engineering in the company's telecommunications organization. **Paul Gheorghiu** from Transitron, Inc., to Advanced Research Corp. (a new div. of Hi-G, Inc.) as director of research. **George C. Brown,** ex-Telectro Industries Corp., named senior project engineer for Potter Instrument Co., Inc.

EMPLOYMENT OPPORTUNITIES

electronics

WEEKLY QUALIFICATION FORM FOR POSITIONS AVAILABLE

ATTENTION: ENGINEERS, SCIENTISTS, PHYSICISTS

This Qualification Form is designed to help you advance in the electronics industry. It is unique and compact. Designed with the assistance of professional personnel management, it isolates specific experience in electronics and deals only in essential background information.

The advertisers listed here are seeking professional experience. Fill in the Qualification Form below.

STRICTLY CONFIDENTIAL

Your Qualification form will be handled as "Strictly Confidential" by ELECTRONICS. Our processing system is such that your form will be forwarded within 24 hours to the proper executives in the companies you select. You will be contacted at your home by the interested companies.

WHAT TO DO

1. Review the positions in the advertisements.
2. Select those for which you qualify.
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).

COMPANY	SEE PAGE	KEY #
ATOMIC PERSONNEL INC. Philadelphia, Pennsylvania	103	1
BRISTOL COMPANY Waterbury, Connecticut	104*	2
COLLINS RADIO COMPANY Dallas, Texas	18*	3
DOUGLAS AIRCRAFT CO. Missile and Space Systems Division Santa Monica, California	97*	4
ESQUIRE PERSONNEL SERVICE INC. Chicago, Illinois	103	5
GENERAL DYNAMICS/ELECTRONICS Div. of General Dynamics Corp. Rochester, New York	102*	6
INTERNATIONAL BUSINESS MACHINES CORP. Space Guidance Center Owego, New York	103	7
LOCKHEED CALIFORNIA CO. Div. of Lockheed Aircraft Corp. Burbank, California	69	8
LOCKHEED MISSILES & SPACE CO. Div. of Lockheed Aircraft Corp. Sunnyvale, California	70, 71*	9
MELPAR, INC. Sub. of Westinghouse Air Brake Co. Falls Church, Virginia	101*	10
MICROWAVE SERVICES INTERNATIONAL INC. Denville, New Jersey	103	11
NORTHROP CORP. Norair Division Hawthorne, California	85	12

CONTINUED ON OPPOSITE PAGE

(cut here) **electronics WEEKLY QUALIFICATION FORM FOR POSITIONS AVAILABLE** (cut here)

(Please type or print clearly. Necessary for reproduction.)

Personal Background

NAME ....

HOME ADDRESS ....

CITY ....................ZONE......STATE............

HOME TELEPHONE ....

Education

PROFESSIONAL DEGREE(S) ....

MAJOR(S) ....

UNIVERSITY ....

DATE(S) ....

FIELDS OF EXPERIENCE (Please Check) 71362

☐ 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

EMPLOYMENT OPPORTUNITIES

NATIONAL COVERAGE

The Advertisements in this section include all employment opportunities—executive, management, technical, selling, office, skilled, manual, etc. Look in the forward section of the magazine for Additional Employment Opportunities advertising.

Positions Vacant	Civil Service Opportunities	Employment Agencies
Positions Wanted	Selling Opportunities Wanted	Employment Services
Part Time Work	Selling Opportunities Offered	Labor Bureaus

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An advertising inch is measured 7/8" vertically on a column—3 columns—30 inches to a page.

Subject to Agency Commission.

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To $22,000—No Fee

Individual to assume Technical and Administrative responsibility of a Communications Lab engaged in Surface and Airborne application of Radio and Digital Communications Equipments. MSEE or equiv. Will assist Marketing Div. in attracting New Business.

ESQUIRE PERSONNEL, INC.
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E.E.'s

For professional, individualized fee-paid service write for confidential application.

A national employment agency for the Nuclear & Scientific Fields.

ATOMIC PERSONNEL, INC.
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Immediate Opening for professional-level applicant as Research Associate or Assistant Professor to supervise designing, fabricating, and maintaining specialized electronic equipment for research in science and engineering. A properly qualified person will, if he desires, have the opportunity to participate in electronic research or teach. A staff member on full-time appointment may enroll for one course each semester. Salary in range of $7,500 to $8,500. Annual appointment with one month vacation. Application or further inquiry should be made to Dean Virgil W. Adkisson, Research Coordinator, University of Arkansas, Fayetteville, Arkansas.

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electronics

WEEKLY QUALIFICATIONS FORM FOR POSITIONS AVAILABLE

(Continued from opposite page)

NORTHROP CORP. Space Laboratories, Hawthorne, California	83	13
PHILCO WESTERN DEVELOPMENT LABS Palo Alto, California	103*	14
REPUBLIC AVIATION CORPORATION Farmingdale, L.I., New York	104	15
UNION CARBIDE NUCLEAR CO. Oak Ridge, Tennessee	103	16

*These advertisements appeared in the 7/6/62 issue.

Electronic Instrument Technicians
The Oak Ridge National Laboratory

Operated by
UNION CARBIDE NUCLEAR COMPANY
at
Oak Ridge, Tennessee
Has openings for

Highly skilled electronic instrument technicians to work with electronic engineers in the development, installation and maintenance of electronic systems. Digital data handling, transistorized pulse height analyzers, analog and digital computer systems are only a few examples.

Minimum high school education, with additional training in electronics and at least three years' experience in installation and maintenance of complex electronic systems. Entrance rate $3.10 per hour; $3.16 per hour after six months. Reasonable interview and relocation expenses paid by Company.

Excellent Working Conditions
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Employee Benefit Plans
An Equal Opportunity Employer
Send detailed resume to:

Central Employment Office
UNION CARBIDE NUCLEAR COMPANY
Post Office Box M Oak Ridge, Tennessee

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Analysis of advanced electronic communication systems including radio, carrier, telephone, microwave:

Must have design and marketing experience with commercial and military users.

EE degree, 5 yrs. exp. min.
Send Resume to:

Microwave Services International Inc.
Consulting Engineers
Route 46 Denville, N. J.

"Put Yourself in the Other Fellow's Place"

TO EMPLOYERS

TO EMPLOYEES

Letters written offering Employment or applying for same are written with the hope of satisfying a current need. An answer, regardless of whether it is favorable or not, is usually expected.

MR. EMPLOYER won't you remove the mystery about the status of an employee's application by acknowledging all applicants and not just the promising candidates.

Mr. EMPLOYEE you, too, can help by acknowledging applications and job offers. This would encourage more companies to answer position wanted ads in this section. We make this suggestion in a spirit of helpful cooperation between employers and employees.

This section will be more useful to all as a result of this consideration.

Classified Advertising Division

McGraw-Hill Publishing Co., Inc.
330 West 42nd St., New York 36, N. Y.

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- **Solid State Physicists (Radiation Effects Studies)**
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Fred Guth, Dept. 554T2
Space Guidance Center
IBM Corporation
Owego, New York

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ELECTRONICS ENGINEERS
& PHYSICISTS

JOIN US IN GIVING A NEW DIRECTION TO AEROSPACE TECHNOLOGY thru RESEARCH & DEVELOPMENT in

aerospace electronics

Republic's Paul Moore Research & Development Center is the most sophisticated and integrated research complex in the East. Advances made here in many critical aerospace problem areas have brought Republic a diversity of new and follow-on R & D contracts leading to next-generation space and re-entry vehicles, satellites, space power and communication systems.

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Design and develop space vehicle communications systems including telemetry, command and on-board data handling.

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Design and develop ground station and on-board data handling systems for re-entry and space vehicle applications.

COMMUNICATION TECHNIQUES — B.S., M.S.
Develop advanced communications techniques for aerospace and space craft, includes communications theory and network synthesis.

ADVANCED SPACE RADARS — B.S., M.S.
Develop concepts and components for advanced space radar including rendezvous, mapping, acquisition and tracking applications.

RADAR INTEGRATION — B.S.
Develop specifications, install and integrate advanced radar in hypersonic and space vehicles, including antennas, transmitters, receivers, displays, power supplies, controls.

ANTENNA DESIGN — M.S.
Design and development of antennas for re-entry vehicles. Knowledge of wind effects and general re-entry radiation blackout problems.

RADAR TEST (GSE) — B.S.
Test, checkout and maintain ground radar systems. Make required circuit modifications including range gating circuits, modulators. No travel.

RE-ENTRY INSTRUMENTATION — B.S., M.S.
Design instrumentation for specific re-entry and space vehicles including telemetry systems.

MATHEMATICAL ANALYSIS CONTROLS — PhD.
Theoretical analysis of noise effects and non-linear mechanisms on automatic controls. Includes optimal control theory and generalized stability criteria.

ELECTRONIC INSTRUMENTATION — B.S., M.S.
Develop instrumentation for space vehicles. Knowledge of system integration and telemetry desirable.

SPACE GUIDANCE SYSTEMS — M.S., PhD.
Develop and analyze navigation and guidance systems using inertial and Doppler techniques and advanced nuclear gyros.

ECM REQUIREMENTS — B.S., M.S.
Mathematical analysis of ECM requirements for advanced aerospace and space craft, and specification of equipment.

FLIGHT CONTROL DESIGN — M.S.
Automatic flight controls, servo systems, nonlinear dynamic systems for space craft.

PYROTECHNIC CIRCUIT DESIGN — B.S., M.S.
Develop pyrotechnic missile circuits including safe arm, squib ignition and RFI elimination devices.

EXPERIMENTAL PHYSICIST — PhD.
Conduct experimental studies of the application of nuclear or electron resonance to gyroscopics.

ENVIRONMENTAL TESTING — B.S., M.S.
Undertake test programs to estimate component and system reliability using AGREE type methods; monitor offsite testing.

DESIGN REVIEW — B.S., M.S.
Perform mechanical or electronic design reviews, failure analyses, quantitative analyses and reports. Includes circuit analysis, component selection.

STATISTICAL ANALYSIS — B.S., M.S.
Apply statistical theory and method to prediction and analysis of aerospace component performance.

IDEP PRISM PROCEDURES — B.S., M.S.
Participate in "Interservice Data Exchange Programming" and "Program Reliability Information Systems for Management."

Interested applicants are invited to write in confidence to: Mr. George R. Hickman, Technical Employment Manager, Dept. 11G-2

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AVIATION CORPORATION

FARMINGDALE, LONG ISLAND, NEW YORK
An Equal Opportunity Employer

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(Classified Advertising)

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EQUIPMENT - USED or RESALE

DISPLAYED RATE

The advertising rate is $27.25 per inch for all advertising appearing on other than a contract basis. Contract rates quoted on request. AN ADVERTISING INCH is measured ⅞ inch vertically on one column, 3 columns—30 inches—to a page. EQUIPMENT WANTED or FOR SALE ADVERTISEMENTS acceptable only in Displayed Style.

UNDISPLAYED RATE

$2.70 a line, minimum 3 lines. To figure advance payment count 5 average words as a line.
PROPOSALS, $2.70 a line an insertion.
BOX NUMBERS count as one line additional in undisplayed ads.
DISCOUNT OF 10% if full payment is made in advance for four consecutive insertions of undisplayed ads (not including proposals).

FOR MORE INFORMATION

about Classified Advertising

contact the McGraw-Hill office nearest you.

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This catalog is, therefore, not just a listing of items available 'on order' but, by and large, it is an indication of in-stock items (either as complete units or as ready to assembly components).

The average shipment is made within 48 hours. Where coils and frames require assembly, or relays require special testing or adjustment, shipments are made within one week to ten days.

Universal is completely equipped to assemble, adjust and thoroughly test any type of relay. Assembly and test facilities have been imitated by some relay manufacturers.

A personal interest is taken in every order. This interest is maintained as the order is processed. And, it continues even after the customer receives the merchandise until he makes sure that it satisfies his needs.

All merchandise is guaranteed, subject to customers' inspection and approval, and may be returned within 30 days for replacement or credit.

The catalog is full of items to fill everyday relay requirements".

Catalog E-162 may be obtained by writing directly to:

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OC3	.50	4B31	12.50	35TG	2.50	802	7.50	5787	2.50
OD3	.30	4C35	15.00	FP-54	100.00	803	3.50	5796	10.00
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1AD4	1.50	4CX1000A	125.00	RK-60/1641	1.50	805	7.50	5803/VX-55	5.00
1B24	7.50	4D32	15.00	HY-69	3.00	807	1.50	5814A	1.35
1B24A	12.50	4E27A	27.50	BL-75	3.00	807W	2.25	5829	1.00
1B35A	3.00	4J32	100.00	75TL	17.50	808	2.50	5836	50.00
1B63A	10.00	4J34	100.00	TG-77	7.50	809	5.00	5837	50.00
1C/3B22	5.00	4J50	100.00	HF-100	10.00	810	15.00	5840	2.50
C1K	7.50	4J52	35.00	100TH	12.00	811	2.50	5845	6.00
1P21	32.50	4PR60A	50.00	100TL	12.00	811A	4.00	5852	5.00
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2C43	7.50	5R4GY	1.25	251A	50.00	842	7.50	5965	.85
2C46	5.00	5R4WGA	4.00	254A	3.50	845	7.50	5976	50.00
2C50	4.00	5R4WGB	6.00	FG-258A	100.00	849	75.00	5993	5.00
2C51	1.50	5R4WGY	2.00	259A	3.50	851	50.00	6005/6AQ5W	1.50
2C52	1.50	5RP1A	9.50	262B	3.50	866A	1.90	6012	4.00
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2D21	.50	5Y3WGTB	2.50	271A	12.50	872A	5.00	6032	10.00
2D21W	1.00	6AC7W	.50	274A	3.50	884	1.25	6045	1.15
2E24	2.25	6AC7WA	2.00	283A	3.50	885	.85	6072	1.50
2E26	2.50	6AG5WA	1.50	287A	3.50	889RA	150.00	6073	1.50
2E30	3.50	6AG7Y	1.00	QK-288	250.00	891R	200.00	6074	1.75
2J42	75.00	6AK5W	1.25	HF-300	35.00	913	9.50	6080	3.35
2J51	50.00	6AK5 (WE)	.75	300B	5.00	920	2.50	6080WA	5.00
2J55	90.00	6AL5W	.60	304TH	35.00	927	1.50	6080WB	10.00
2K22	25.00	6AN5	1.75	304TL	35.00	931A	3.50	6082	3.35
2K25	8.50	6AN5WA	3.50	307A	.50	1000T	80.00	6087/5Y3WGTB	2.50
2K26	35.00	6AQ5W	1.00	310A	3.50	R1130B	10.00	6101/6J6WA	1.50
2K28	25.00	6AR6	.75	311A	3.50	1500T	150.00	6106	1.50
2K29	25.00	6AS6W	1.00	313C	1.50	1614	2.75	6115/QK351	50.00
2K30	50.00	6AS7G	2.50	323A	6.00	1620	4.00	6130/3C45	6.50
2K33A	200.00	6AU6WA	1.25	328A	3.50	1624	1.00	6136/6AU6WA	1.25
2K34	75.00	6B4G	3.35	329A	4.50	1625	.50	6146	3.00
2K35	200.00	6BA6W	.75	336A	2.50	1635	2.00	6159	3.50
2K39	150.00	6BE6W	1.50	337A	3.50	1846	50.00	6161	35.00
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2K42	125.00	6BH6W	2.75	348A	4.50	2050	1.25	6189/12AU7WA	1.50
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2K55	15.00	6F4	3.50	388A	2.00	5557/FG17	5.00	6248	250.00
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2P21	40.00	C6J/A	15.00	394A	3.00	5559/FG57	10.00	6265/6BH6W	2.75
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3B28	3.00	6L6WGB	2.00	409A/6AS6	1.00	5651	1.00	6352	7.50
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3K21	125.00	12AU7WA	1.50	701A	5.00	5725/6AS6W	1.50	8008	7.75
3K22	125.00	12AX7W	1.35	703A	1.50	5726/6AL5W	.75	8013A	5.00
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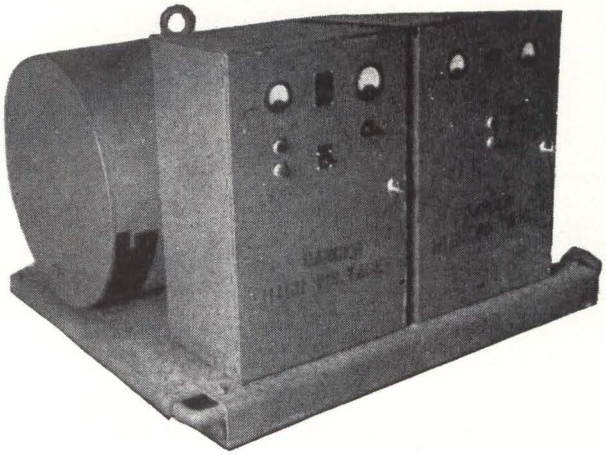

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The SRK-291, a new low-cost K band reflex klystron oscillator offering dramatic cost savings in microwave systems, is now available from Sperry Electronic Tube Division within 60 days from receipt of your order! Sperry's new tube operates at frequencies ranging from 21 to 24.5 Gc. Within these frequency limits, it offers a $1\frac{1}{2}$ Gc mechanical tuning range and a low temperature coefficient. The SRK-291 is priced at only $1495.

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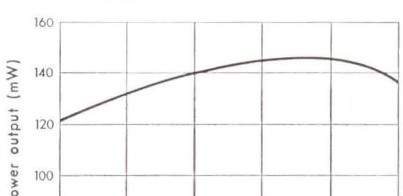

SRK-291, typical P out vs. Freq.

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Integral Cavity Design Means Greater Reliability Over Broader Bandwidth

Broad bandwidth and outstanding power-output uniformity mark the new RCA A15038—a developmental Coaxitron—as a quality, high-mu super-power triode. A linear amplifier incorporating integral circuitry, the A15038 is designed for use in long-range search radar, broad-band multi-channel communications, and wherever electronic pulse-to-pulse frequency agility is important.

This RCA Triode Coaxitron operates with exceptional power-output uniformity in the range of 400 to 450 Mc and covers the range of 385 to 465 Mc to the −3db power-output level.

In short pulse service (pulse duration: 30 μsec), its efficiency is 43 per cent—at a gain of 13 db. Power output capability is 5 megawatts, minimum.

Operation of RCA A15038 over this bandwidth is made possible by integrating the radio-frequency input and output circuitry, high-voltage blocking circuit and the gridded tube structure within a common vacuum envelope. The tube is suited to a variety of modulation techniques—amplifying at any frequency within the pass-band at which it is driven.

Developed by RCA for the Rome Air Development Center, A15038 Coaxitron also features a low temperature matrix-oxide filamentary cathode to provide high emission, long life, and economical operation. These and other features combine to provide greater power output, broader bandwidth, higher power gain, better stability and greater reliability.

For further information contact your RCA Industrial Tube Representative or write: Marketing Manager, Industrial Tube Products, RCA Electron Tube Division, Lancaster, Pennsylvania.

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