May 18, 1962

electronics

A McGraw-Hill Publication 75 Cents

(photo at right)

RADAR TELEVISION

Bright display shows New York Harbor

EXPITAXIAL GROWTH

Process details and new devices, p 49

SONIC WIRE DELAY LINES

How to specify them, p 54

MULTI-HOLE FERRITE CORES

In analog-digital converter, p 62

Now
MEASURE DYNAMIC CHARACTERISTICS of IRON-CORE COILS OVER WIDE RANGES

...measure incremental resistance in the presence of d-c of solid-state rectifiers, Zener diodes, thermistors, and other non-linear resistances

Type 1266-A Line-Frequency Supply . . . $345. (Relay Rack Model)
. . . a 60-cycle multi-range source of voltage to 1250v, and current to 5a at power outputs to 200 va.

Type 1265-A D-C Power Supply . . . $875.
. . . a multi-range source providing constant voltage up to 400v, constant current up to 5a at power outputs to 200w.

Type 1630-AL Inductance Measuring Assembly
. . . including Relay Rack and all interconnections . . . $2300. complete.

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New Active Bridge for Wide-Range Inductance Measurements at high levels of dc and ac excitation.

★ Wide impedance ranges: L — 0.1 μh to 1000h; R — 10 mΩ to 1 MΩ
★ Indicates Q or R of inductor directly at any of nine frequencies between 50c and 15.75 kc; no sliding balance.
★ Output for checking waveform with scope.
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★ Highly selective null detector is built in.
★ Incremental inductance can be measured while inductor is operating in circuit — voltage across the inductor is unaffected by bridge balance controls; voltage can be set and maintained throughout the test procedure.
★ ±1% accuracy for L; ±2% for R and Q.

Under Development — Type 1308-A Power Oscillator . will provide up to 1250v rms, and currents to 5 amps with a power rating of 200 va . . . frequency range from 20c to 20 kc.

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May 18, 1962

electronics

A McGraw-Hill Publication 75 Cents

W. W. MacDONALD, Editor

Contents continued

electronics

May 18, 1962 Volume 35 No. 20

Published weekly, with Electronics Buyers' Guide and Reference issue, as part of the subscription, by McGraw-Hill Publishing Company, Inc. Founder: James H. McGraw (1860-1948).

Indexed Annually in Buyers' Guide and Reference issue.

Executive, editorial, circulation and advertising offices McGraw-Hill Building, 330 West 42nd Street, New York 36, N. Y. Telephone Longacre 4-3000. Teletype TWX N.Y. 1-1636. Cable McGrawhill, N. Y. PRINTED IN ALBANY, N. Y.; second class postage paid at Albany, N. Y.

OFFICERS OF THE PUBLICATIONS DIVISION: Nelson L. Bond, President; Shelton Fisher, Wallace F. Traendly, Senior Vice Presidents; John R. Callaham, Vice President and Editorial Director; Joseph H. Allen, Vice President and Director of Advertising Sales; A. R. Venezian, Vice President and Circulation Coordinator; Daniel F. Crowley, Vice President and Controller.

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Subscriptions are solicited only from those actively engaged in the field of the publication. Position and company connection must be indicated on orders. Subscription rates: United States and Possessions, $6.00 one year; $9.00 two years; $12.00 three years. Canada, $10.00 one year. All other countries $20.00 one year. Single Copies, United States and Possessions and Canada 75¢. Single copies all other countries $1.50.

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Postmaster: Please send Form 3579 to Fulfillment Manager, Electronics, 330 West 42nd Street, New York 36, New York.

Audited Paid Circulation

CONTENTS continued

DEPARTMENTS

CROSSTALK

EARTH SCIENCES. As we have indicated a number of times in the past, the earth sciences equipment field is becoming more important.

One group of companies aware of this—and profiting by it—are the geophysical equipment and services companies in and around the Texas and Oklahoma oil fields. When oil prospecting slumped, they tapped seismic equipment for nuclear explosion detection and gained millions of dollars in new business (p 28, this issue). One company hopes to see its earth science division doing $100 million a year within 10 years.

Nuclear detection may prove to be a temporary necessity. But the better equipment developed to meet the military necessity will undoubtedly be welcomed by people and nations seeking to find and control natural resources.

A parallel can be found between military seismology and military radar. Radar was developed for defense against planes and ships. Now it also provides a defense against sudden storms and hurricanes.

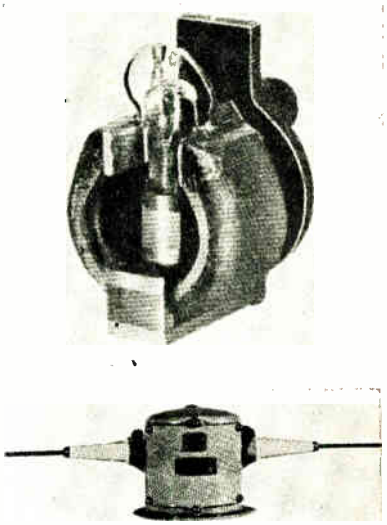
Seismic analysis techniques being developed under Project Vela (ELECTRONICS, p 28, Feb. 23) could in the future provide a defense against the earthquakes and volcanic eruptions that have killed tens of thousands of people in a single day. With the proper warning equipment and understanding of what happens underground, such disasters could be detected in time. The day may come when preventive measures can be taken.

This is perhaps more a humanitarian than a business reason for welcoming a boom in seismology. But man has always welcomed the opportunity to turn his swords into plowshares—there is more satisfaction and profit in plowshares in the long run.

HISTORY IN THE MAKING. Yesterday's breakthrough is today's commonplace. Take the antiques in the photos. We reproduced them from a much earlier edition (ELECTRONICS, p 18, Sept., 1935) which carried an article headed:

"Telefunken reveals details of ten-centimeter 'mystery ray' system capable of locating position of aircraft through fog, smoke and clouds. Rumor indicates that U. S. and Italian armies are experimenting with similar system, expected to revolutionize military tactics."

The British, who were to make such excellent use of the "mystery ray" during the Battle of Britain, had apparently been keeping mum about their interest. The system, of course, became radar.



With that clue, you may recognize the upper photo as an early form of magnetron with an external tuning arrangement. The lower photo is a transmitter incorporating this magnetron and horizontal dipole radiators.

Since the 1930's there have been numerous advances in microwave techniques. Many of them have revolved around development of higher-frequency signal sources. One of the biggest steps was getting away from the conventional tuned circuit and applying more fundamental techniques for controlling and concentrating electrons. The klystron and cavity magnetron, to name two now-familiar devices, behave nothing like conventional tube oscillators.

Today, klystrons and cavity magnetrons are generally available. Twenty years ago, the Navy considered itself fortunate to find that it could overrun transmitter tubes designed for other gear—amateurs often push their hardware—and get enough power for 20-Kw airborne radar.

The axiom that yesterday's breakthrough is today's commonplace is demonstrated well in an eight-page survey we will publish next week. Written by W. W. Teich, of Raytheon, it brings the reader up to date on power generators for millimeter wavelengths. Such devices are edging in frequency toward the laser range. One of the latest is the rebatron, developed at the University of Illinois. The predicted capability of this device is up to one teracycle. There are now a number of devices that will operate at tens of gigacycles and a few at hundreds of gigacycles. By comparison, that old 10-cm magnetron operating around 3 Gc is pretty slow. But then, it is by now a great-great-grandfather.

COMMENT

War and Peace

Recent articles in business periodicals have publicized the use of certain scientific discoveries as potential war-deterent devices, but have failed to reveal their equally important applications in advanced manufacturing techniques.

I refer, for example, to reference to the high-intensity light beam, the laser, as a "death ray," with no reference to its effectiveness to industry for metal removal.

The Newark College of Engineering has originated a series of engineering seminars which will attempt to focus attention on engineering research and its accomplishments for the benefit of mankind generally.

We believe these seminars will provide added knowledge for practicing engineers and be a stimulus to their creative efforts.

CLARENCE H. STEPHANS
Director of Relations
with Industry
Newark College of Engineering
Newark, New Jersey

The April 28 seminar concerned nuclear power in the space age, and the May 15 program was on advanced manufacturing techniques.

The series will continue in the fall, with seminars on such subjects as ceramics, plastics, and technical problems in urban renewal.

Abbr.

I'm taking just several sec and a couple cm of paper to indicate to you the max deg to which my temp C rises when I read an article heavily seeded with abbreviations.

Not that I don't understand what you mean by a d-c cro, a HOR OSC, a SIG GEN, or a FREQ CONV. It's just that I hate like h (henry, that is) to see the Eng. lang chopped to pcs. How much nicer in print is the pleasant It.-Fr. combination of volt-ampere than the emaciated and truncated v-a, which slows up my reading by conjuring up such images as Veterans Administration, vice-admiral, and vixit annos.

All right, there are some abbreviations that would take up entirely too much space if spelled out, such as iff, spdt, avc and prf. (Honestly, how many of those did you recognize instantly just now?) But how much smoother the text runs when words like minute, microsecond and inch are used in full, rather than chopped down to min, μsec and in.

CHARLES F. ROBERTS
Homer, New York

Reader Roberts has a point, and it is especially valid when dealing with fiction or even nontechnical articles. But we are dealing with facts and figures, and one big advantage in using abbreviations is that more facts can be squeezed into a magazine page. For instance, the above letter would be seven lines longer if all the abbreviations were spelled out.

Mail Queries

If I were to send an order by mail today to the Entwhistle Company for a dozen flubbers, chances are that I'd receive the flubbers within a week. But if I write to Entwhistle and merely ask for a brochure, it may be weeks or months before I get an answer, if at all.

Now, if a company is interested only in doing business on an order basis, they may do fairly well if their product is an established one. But suppose it's a new product, and I want to know something about it before ordering?

A large company may be able to ignore information requests, although I've found that the large ones answer firstest with the mostest. Perhaps small companies feel they have neither the time nor personnel to handle what may often seem to be rather trivial requests.

Why does it take so long? After all, most of the time all I ask for is a simple brochure and price list. Why should it take a week for somebody to drop the brochure in a mailing envelope and address it?

Must I send an order for a dozen flubbers along with my request for the brochure on flubbers before I get an answer? There are several products I've lost interest in, simply because I received no answer to two or even three letters of inquiry.

JAMES O. PENICK
Coral Gables, Florida

ON THE SHELF—
ARNOLD CORES
IN WAREHOUSE STOCK
FOR IMMEDIATE DELIVERY

Let us handle your inventory problems and save you time and money on your magnetic core requirements.

Extensive stocks of four types of Arnold cores in the most popular sizes have been set up in our Marengo, Illinois and Fullerton, Calif. plants. Subject of course to temporary exhaustion of stock by prior sales, these cores will be shipped *the same day* on orders received at the warehouse by 12:00 noon. When cores are out of stock at the nearest plant, we may be able to ship within 24 hours from the other.

Arnold core products covered by this warehouse stock program include: 1) Silectron C, E and O cores in 2, 4 and 12-mil tape. 2) Type 6T aluminum-cased cores of Deltamax, Square Permalloy and Supermalloy, in 1, 2 and 4-mil tape. 3) Mo-Permalloy powder cores, both temperature-stabilized and unstabilized types, ranging down to 0.260″ diameter. 4) Iron powder toroids, threaded cores and insert cores.

All four products are available in a wide range of selection, for your convenience and economy in ordering either prototype design lots or regular production quantities. ● Stock lists, bulletins, etc. are available—write for information. *The Arnold Engineering Company, Marengo, Ill.* 2998A

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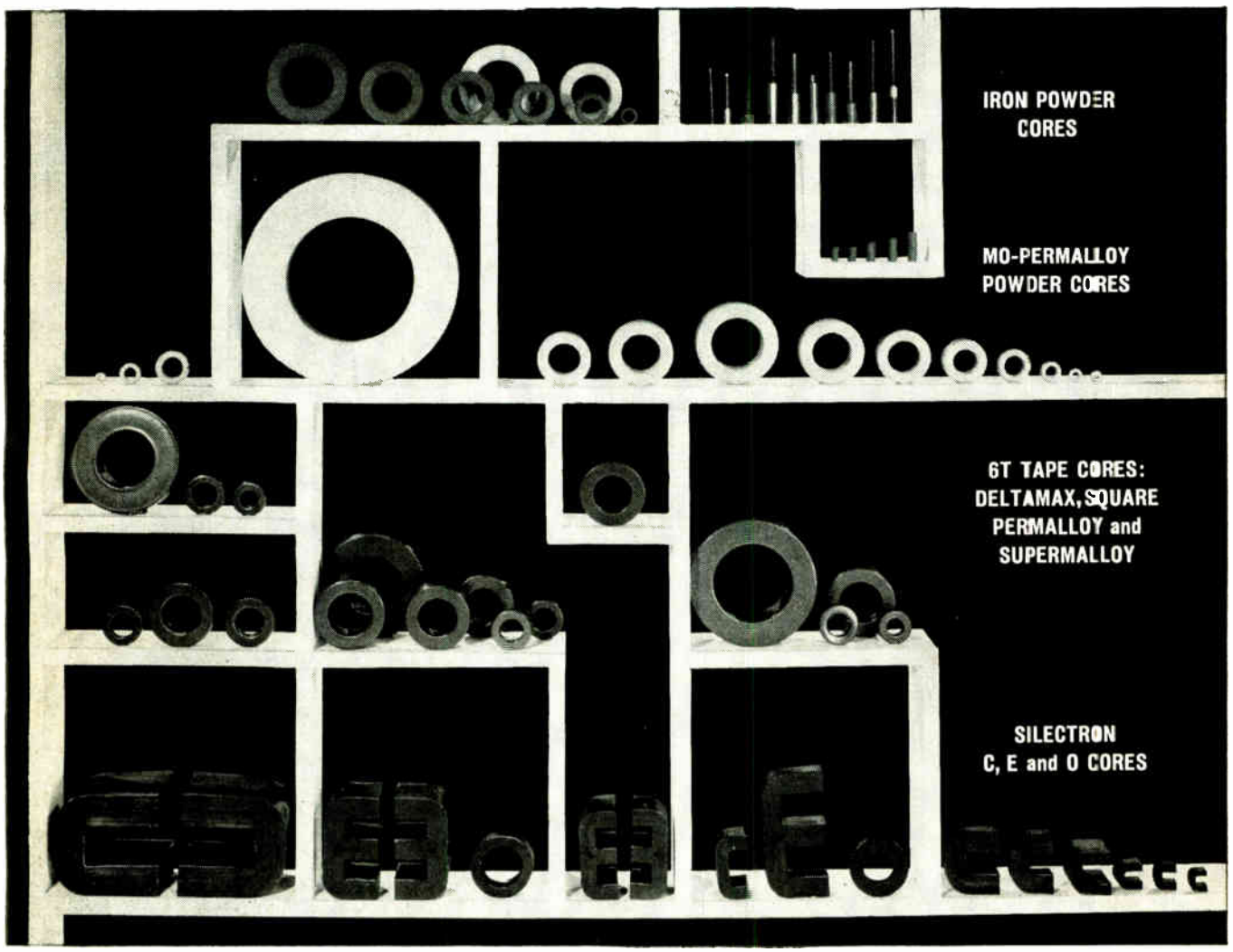
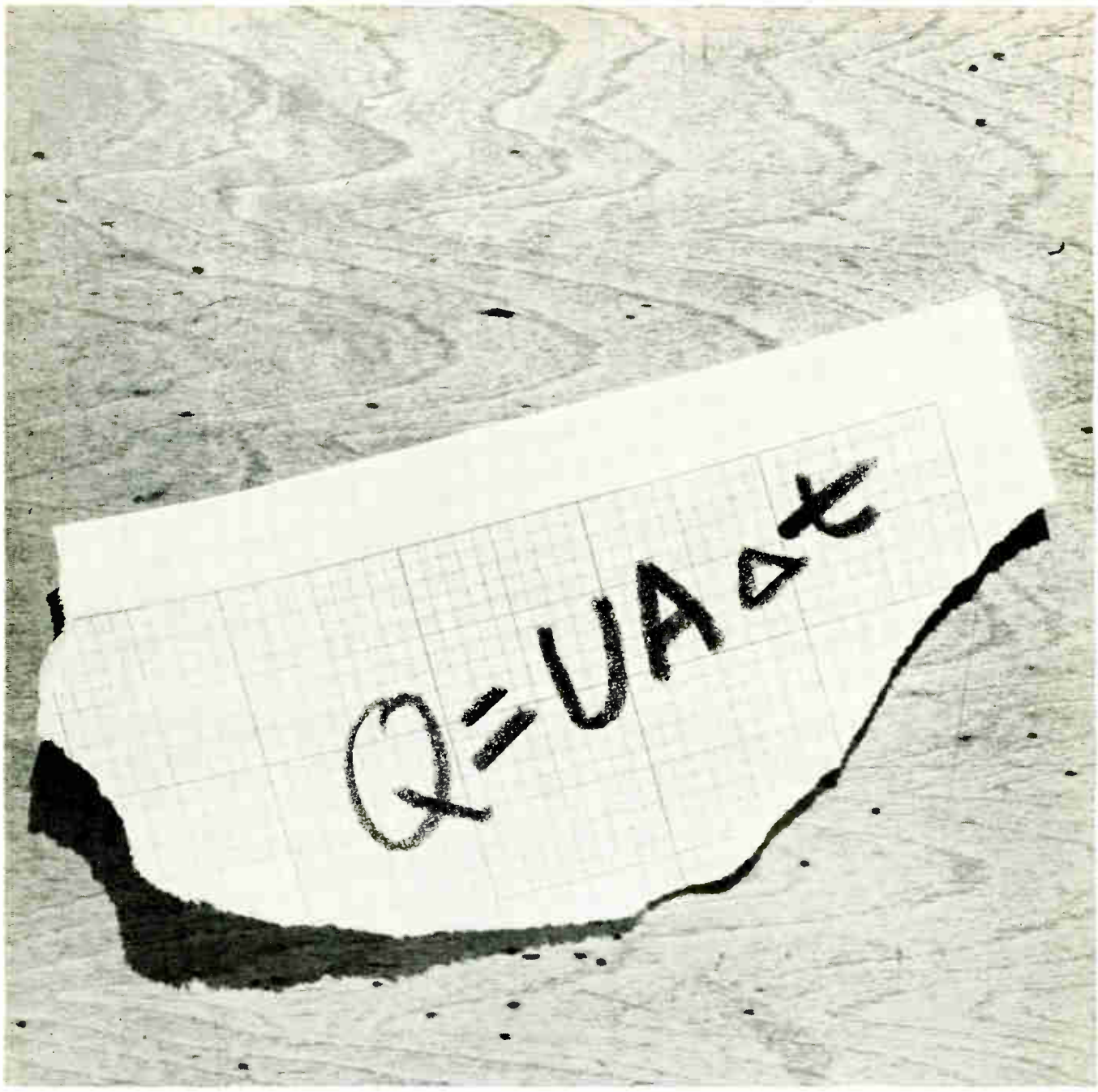




INTRODUCING: EIMAC VAPOR-PHASE COOLING–A DROP-IN-READY PACKAGE THAT REDUCES EQUIPMENT, CUTS NOISE, INCREASES POWER OUTPUT. SAVES MONEY, TOO

Eimac uses an old principle to bring you a better way to cool high power vacuum tubes: Eimac Vapor-Phase Cooling. It cuts costs by as much as two-thirds. Increases anode dissipation capability 50% and more. And eliminates the pump since it operates on its own steam. (Take away the pump; you take away noise—by the tens of decibels.) It all boils down to the classical thermodynamic relation: heat exchange is proportional to temperature difference. First in the U.S., Eimac's vapor-phase cooling package requires especially designed tubes—five new types are available now from Eimac with anode dissipation ratings from 8 to 75 kw. (Package and application assistance? Gladly.) This is another example of the way Eimac meets tomorrow's tube needs today. Another reason to keep your eye on Eimac — for advanced power grid tubes, high power klystrons, microwave devices, accessory products. Want more details on this new cooling system? Write today to Eitel-McCullough, Inc., San Carlos, California. Subsidiaries: Eimac, S.A., Geneva, Switzerland; National Electronics in Geneva, Illinois.

KEEP YOUR EYE ON

Eimac®

ELECTRONICS NEWSLETTER

Apollo Guidance Contractors Are Selected

WASHINGTON—NASA announced about $40 million in contracts for the Apollo guidance system last week: A.C. Spark Plug gets $16 million for inertial platform, associated electronics, and ground support and checkout; Raytheon will receive about $2 million for on-board digital computer; Kollsman Instrument also gets $2 million, for space sextant, sun finders and navigation display.

The three contractors are to support MIT Instrumentation Lab, which will build the first flight units. The industrial team will then make 10 follow-on units. MIT got overall responsibility for the guidance system—and a $20 million contract—last year. The 10 production units will be used during the moon-landing project's earth orbital test phase.

Apollo's communications system will be built by Collins Radio under a $40 million contract. It will include voice, telemetry and tv links with earth, tracking, ranging and rescue beacons, and on-board tv, intercoms and communications storage. All vital modules will be provided in duplicate.

Mercury Capsule Wake Echoed Like a Meteor

BOSTON—Radar observation of Col. Glenn's reentry indicates that strong echoing characteristics of ionized trails may prove valuable for locating reentering satellites and spacecraft. The recently declassified data also suggests an explanation for meteor "head echoes."

An Avco Everett Research Lab team headed by S. C. Lin observed five clearly separated ionized trails when the Mercury capsule was 370 miles from its impact point. They used an omnidirectional pulsed radar with a carrier frequency of 30.25 Mc, similar to equipment for studying meteor echoes.

The capsule's wake was visible to radar for 20 seconds and displayed at its peak an equivalent isotropic scattering cross-section of about 10^9 square meters. The other four trails, probably due to retrorocket disintegration, showed glints lasting about one second, like the rapidly decaying trails of small meteors.

Overall characteristics of the main trail are believed due to a combination of highlights from a strongly reflecting front segment and diffuse scattering from the turbulent rear wake.

House Committee Approves $3.67 Billion for Space

WASHINGTON — The House Space Committee has cut $116 million from the administration's budget request for space exploration in the coming fiscal year, approving a total of $3.67 billion. The major cut was $75 million from the Nova booster rocket program. Also cut was $23.5 million from the $273.5 million request for space exploration, mostly from Project Prospector for unmanned space exploration. Project Mercury was reduced from $13.2 to $12.2 million. Cuts in the scientific satellite program totalled $8.7 million.

One Man's Opinion

AN ECONOMIST for the Rand Corp., W. H. Meckling, shook up the Second Annual Conference on the Peaceful Uses of Space, in Seattle last week, by casting one vote in the negative for much of the space effort.

He found the future for weather and communications satellites somewhat "fuzzy," saw little point in establishing residence on the moon and worried about glamor displacing science in space policy.

Meckling reserved his sharpest barbs for a communications satellite system that would charge the same prices as other routes. He said that a system "that must be constantly subsidized and protected from competition is not much of an accomplishment and may make us the subject of ridicule rather than admiration."

Other speakers at the conference were more optimistic

Higher-Power Laser Moon-Bounce Planned

BOSTON—MIT plans to repeat during the next few weeks the experiment that reflected an optical maser beam from the moon last week. Plans are also being made to use a higher-power transmitter in the future.

C. H. Townes, MIT provost, called the experiment a benchmark in exploiting the space transmission possibilities of optical masers. The technique may also help determine interplanetary distances and aid in obtaining information on the lunar surface.

A team headed by Louis Smullin used a liquid-nitrogen-cooled ruby laser made by Raytheon. The 50-joule beam was transmitted by a 12-inch telescope. The weak return signal was received by a 48-inch telescope, focused into a multiplier phototube and recorded on an oscilloscope.

Evidence that the reflections were genuine came from analysis of 13 ½-msec bursts. The beam illuminated a two-mile circular area on the moon.

Report Faster Circuits, Purer Gallium Arsenide

IBM RESEARCHERS reported in the company journal last Friday that they have run a full serial binary adder, a basic computer element, at a speed of 125 Mc. The adder is based on tunnel diode circuits that use matched pairs of diodes connected in series. A 250-Mc rate has been achieved with individual circuits, said M. S. Axelrod, A. S. Farber and D. E. Rosenheim.

In one circuit, the diodes are in

series with two delay lines and in the other, in series with two inductors. Both produce an output whose polarity is determined by the polarity of the majority of input signals.

A few days earlier, S. E. Blum, N. G. Ainslie and J. F. Woods told the Electrochemical Society meeting in Los Angeles that they have obtained gallium arsenide with carrier mobilities of 7,000 to over 8,000 cm^2/volt-sec, by limiting silicon pickup.

The lower level is obtained from a melt of gallium and arsenic prepared in an aluminum nitride crucible developed at Alcoa Research Lab., instead of in a quartz crucible. The higher level is obtained by zone melting in a silica reaction tube with oxygen added to suppress dissociation of SiO_2.

Gemini to Tap Fuel Cell For Both D-C and Water

BOSTON—GE has received a multimillion-dollar contract to develop a fuel cell as the power source for Gemini spacecraft. The cell is a hydrogen-oxygen device using an ion-exchange membrane (ELECTRONICS, p. 3, March 30). The cells will also produce drinkable water as a by-product, one pint for each kilowatt-hour of operation.

Fuel cell battery will deliver peak load of 2 Kw d-c as primary source for control of craft, artificial environment, communications and instrumentation. Expected thermal efficiency is 60 percent under normal load. Cryogenic fuel storage will save space in the craft. Cell weight will be about 425 lbs.

First prototype is to be delivered near the end of 1962, other units over two-year period. Gemini, being built by McDonnell Aircraft for NASA, will be used in development of orbital rendezvous and docking techniques prior to three-man lunar exploration in Project Apollo.

High-Flying Telescope May Solve Planetary Puzzles

SPECULATION about Mars' canals, Jupiter's red spot and other planetary mysteries may be answered in a few months when a balloon-borne telescope, called Project Stratosphere II, is sent up 80,000 feet.

The three-ton package is equipped to take visible-light photos of the stars, nebulae and planets, and infrared views of the planets. It contains a 36-inch telescope, two tv cameras, a 40-channel command system and 64 telemetry channels.

Perkin-Elmer built the equipment for Princeton University. The project is supported by the Department of Defense, National Science Foundation and NASA. The balloon will probably be launched in Texas. The flight will last from dawn to dusk and may cover 800 miles.

British Components Sales Rise 10 Percent in 1961

LONDON—British production of electronic components and accessories topped $392 million last year, a 10 percent increase over 1960, the Radio and Electronic Component Manufacturers Federation reports.

Reduced production of tv receivers was more than made up by increases in radio receivers, professional equipment and a nine percent rise in exports. Component exports reached $41.7 million. Exports of tubes and semiconductors totaled $27.7 million. Both categories have increased nearly 50 percent since 1959.

Antenna Array Will Take Radio Pictures of Sun

NEW YORK—A radioheliograph will be built near Sydney, Australia, with a $550,000 grant by the Ford Foundation to the Commonwealth Scientific and Industrial Research Organization.

The instrument will be a circular array of 100 saucer-shaped antennas, each 40 feet in diameter. The array will feed radio waves from the sun into cro recorders to provide a visual image of the sun. The instrument is to be completed in 1965.

Radioheliograph observations will test hypotheses about the causes and nature of solar phenomena observed by radio telescopes.

In Brief . . .

SONY CORP. has been granted a U. S. patent for the tunnel diode developed by Reona Esaki and Yuriko Kurose. The company said in Tokyo that it would not disclose licensing plans, pending negotiations with U. S. companies.

BRITAIN'S Prime Minister MacMillan has endorsed the proposed U. S. nuclear explosion in the Van Allen belt, despite criticism from British scientists. He cited the need to know effects on electronic defense systems.

CENTAUR (p 28, April 13) failed in its first test last week. Also lost because of booster failure was Anna, satellite with flashing lights to aid global mapping.

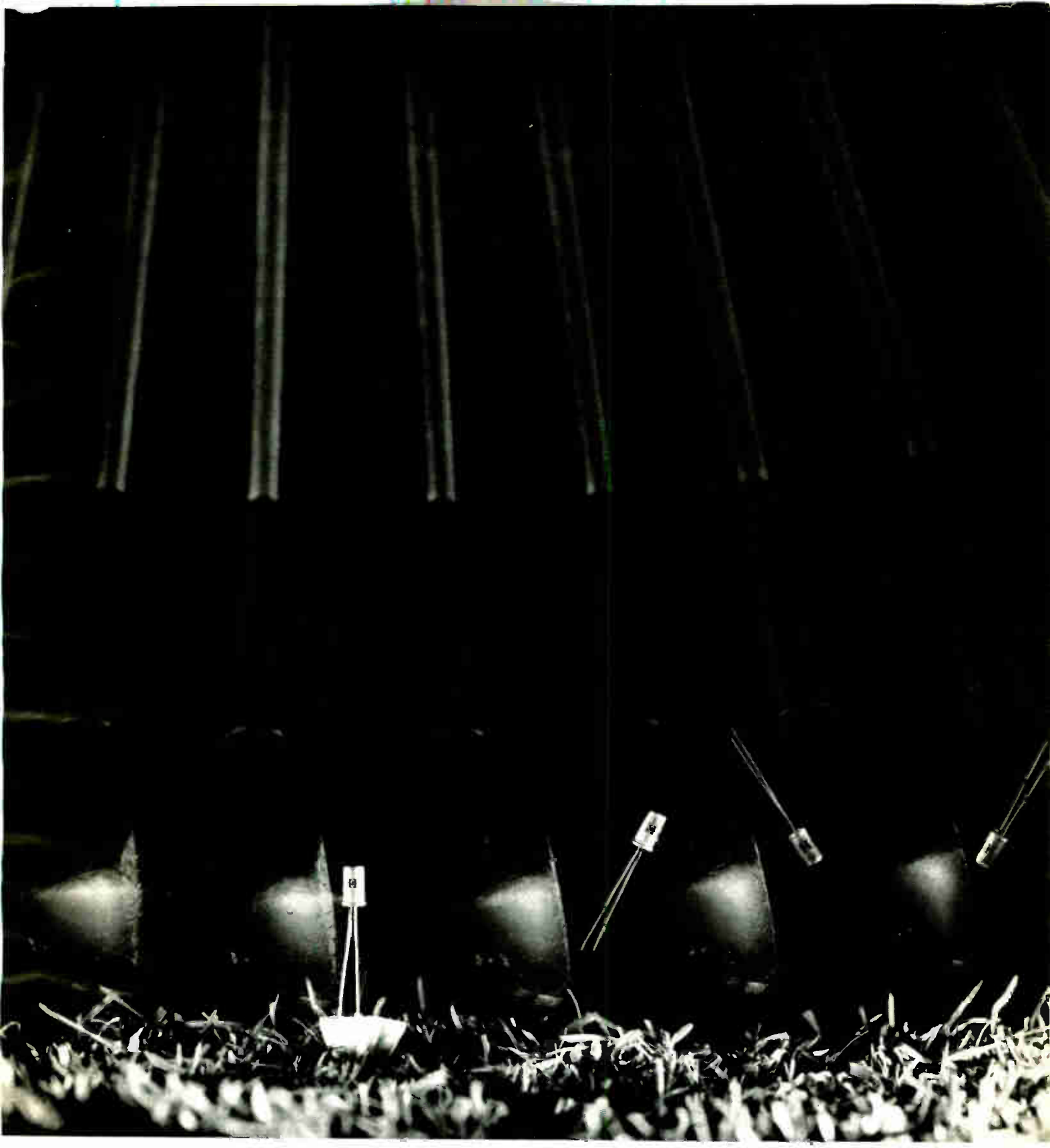
FLIGHT of Comdr. Carpenter's Mercury capsule, scheduled for May 17, was delayed because of trouble in the attitude control system. One report said Carpenter would attempt to track his Atlas booster after separation to gather hints on future rendezvous techniques.

PUSH-BUTTON horse betting system has been introduced by Electronic Assistance Corp. Bettors buy tickets in advance, punch choices on machines scattered around the track and linked to parimutuel equipment.

FRENCH computer manufacturer, La Compagnie des Machines Bull, is moving into Japanese market via agreement with Mitsubishi Shoji Kaisha Ltd.

SHIPMENTS of electronic components in the fourth quarter of 1961 were 13 percent over the third quarter and 14 percent over the fourth quarter of 1960, reports the Business and Defense Services Administration. All major categories went up except receiving tubes, which declined eight percent.

MAJOR military contract awards include $24.6 million to Hughes for Falcon missiles and test systems; $7.8 million to General Dynamics for R&D on Mauler missiles; $3 million to Zenith for bomb proximity fuzes.



FORE!

We had golf pro Bud Holscher take his best shots at a standard Hoffman 1N429 zener. Then we hooked the very same zener into a 6-volt DC circuit. It worked perfectly, of course. And, no wonder. This straight-from-the-bin unit is built to take many times the impact required by current military specifications. It's the same device that has achieved a 99.49% per 1000 hours Survival Rate Factor after two million component operating hours of testing. Our 1N429 stands up in every way, like all Hoffman semiconductor devices.

We specialize in devices for control, regulation and power. You can buy them with confidence that they'll work and keep on working. Confidence that they'll be available when and where needed. That's why so many of the most successful electronics designers keep coming back to Hoffman—again and again and again. Chances are you'll do the same. Try us. Call your nearest Hoffman distributor or sales office today.

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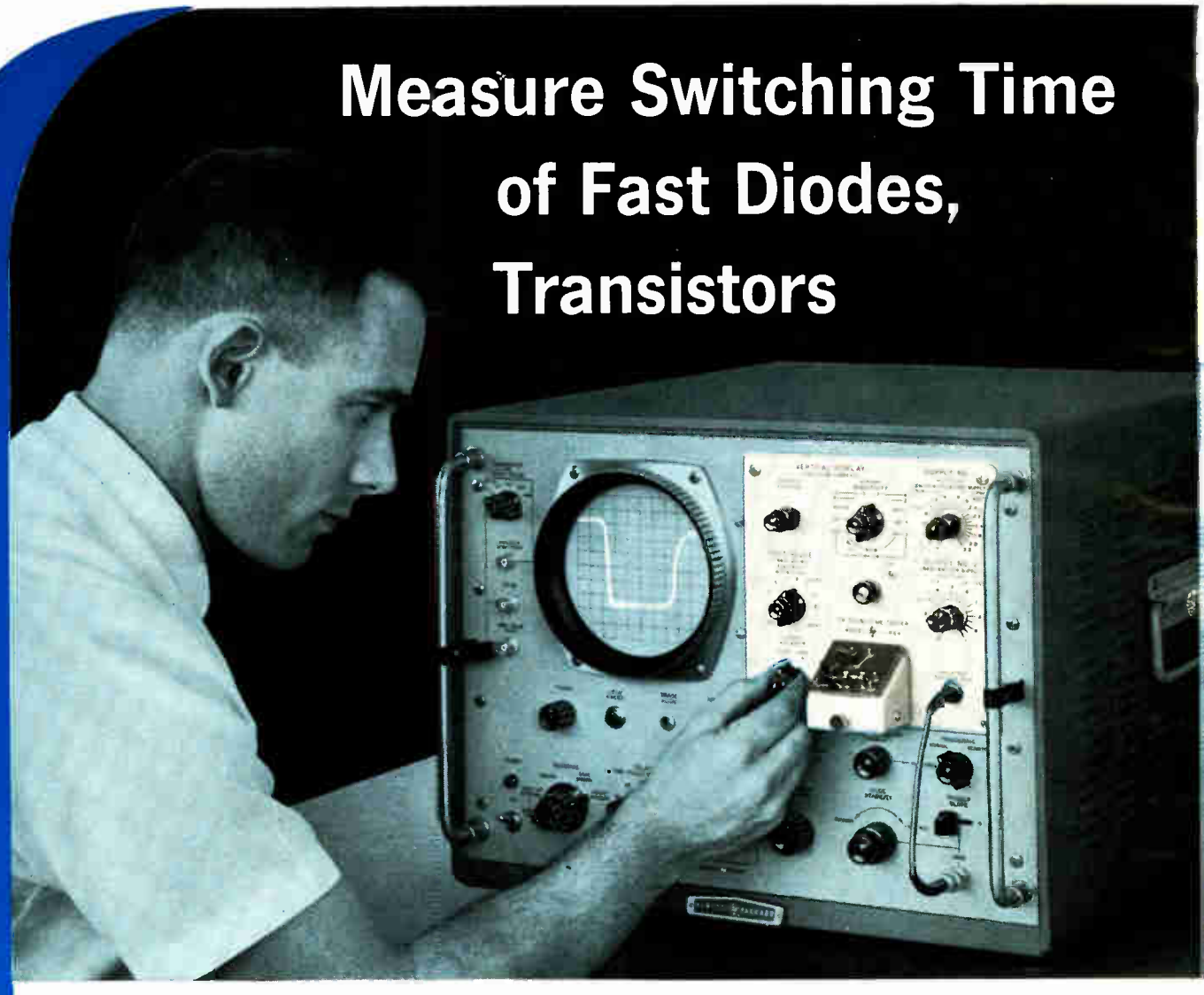
CIRCLE 9 ON READER SERVICE CARD

Measure Switching Time of Fast Diodes, Transistors



1 nsec resolution with new plug-in test set for hp 185 1,000 MC scope

A new "state-of-the-art" plug-in for your hp 185 Oscilloscope measures transistor and diode switching time with nanosecond resolution! Just plug in the hp 186A Switching Time Tester . . . and all the versatility of the 185 1,000 MC scope is yours for making switching time tests on transistors, diodes and tunnel diodes, or testing pulse response of active and passive networks. The 185 displays switching characteristics of test elements powered and pulsed by the 186A plug-in. And what's more . . . you can use the X-Y output of the scope for making permanent records with a Moseley AUTOGRAF® or other standard X-Y recorder.

The 186A includes all instrumentation needed for fast pulse testing. It provides a test pulse generator, vertical amplifier for the oscilloscope, and two bias supplies for the device under test. Pulses with less than 1 nsec rise time and up to 20 v output are available for many types of switching tests. Component and network testing is easy with a series of quick-change test adapters that plug into the front panel of the 186A.

Because the vertical amplifier in the 186A provides a rise time of less than 0.5 nanoseconds, you retain the remarkable versatility of the basic 185 scope. Test measurements are displayed on the 10 by 10 cm scope screen, and the high rep-rate pulse generator in the 186A insures clear, continuous, flicker-free display.

Specifications hp 186A

(when plugged into hp 185A or 185B Sampling Oscilloscope)

PULSE GENERATOR

Amplitude:
0.1, 0.2, 0.5, 1, 2, 5, 10 and 20 volts peak, either polarity

Rise Time:
Less than 1 nsec

Width:
1 μsec or 0.2 μsec

Fall Time:
Less than 3 nsec

Repetition Rate:
Approximately 5 KC to 100 KC, continuously variable

VERTICAL CHANNEL

Sensitivity:
10 mv/cm to 10 v/cm

Bandwidth:
Greater than 800 MC (0.45 nsec rise time)

Noise:
Less than 3 mv

Input Impedance:
50 ohms

BIAS SUPPLIES

Supply #1 (Collector):
0 to ±30 volts 50 ma maximum (0.5 amp with 10% duty cycle)

Supply #2 (Base):
0 to ±10 volts, referable either to ground or supply #1 (20 ma maximum)

TRIGGER OUT

Triggers hp 185A or 185B Oscilloscopes

TEST BOARDS (supplied with 186A)

Transistor Test Board
Diode Test Board
Tunnel Diode Test Board
Universal Adapter for circuit tests (optional)

Price

hp 186A Switching Time Tester, $1,500.00

And Look at the Scope Itself: Hundreds of Different Measurements, DC to 1,000 MC!

Look what you can do with the hp 185B Oscilloscope: Sync on any signal rep rate, look at rf sine waves to 1,000 MC. See clear, bright pictures, 10 cm full scale width, of a single event as long as 100 microseconds, as short as 0.5 nanoseconds. Sync on signals as small as 10 mv. Effectively see any portion of 600,000 sq. cm. display, with a sharp, steady trace!

Besides performing the measurement work of lower frequency scopes, the hp 185B is ideal for analyzing rf carrier signals by viewing rf directly; measuring phase angle on signals to 1,000 MC by dual channel viewing with the 187B Dual Trace Amplifier plug-in; analyzing coaxial connectors, cables, attenuators and other devices by observing reflections of fast pulses. It's the first practical, commercially available answer to the need for measuring and viewing nanosecond pulses . . . and broad sweep speed capability and extreme sensitivity increase its usefulness for viewing all types of repetitive waveforms.

hp experience, know-how, quality manufacturing techniques and careful testing procedures assure performance according to specs, long life and exceptional instrument value. Check the specifications on these pages, then call your hp rep for a demonstration on your bench.

Specifications hp 185B with hp 187B Dual Trace Amplifier

VERTICAL (Dual Channel)

Bandwidth:	Greater than 800 MC, usable to 1,000 MC; less than 0.5 nsec rise time for any input signal.
Sensitivity:	Calibrated ranges, 10 to 200 mv/cm. Vernier increases sensitivity to 4 mv/cm. Attenuator accuracy, ±3%.
Voltage Calibrator:	20 to 1,000 mv, ±3% accuracy.
Input Impedance:	100 K ohms shunted by 2 pf.

HORIZONTAL

Sweep Speeds:	10 ranges, 10 nsec/cm to 10 μsec/cm, calibrated within ±5%. Vernier increases fastest speed to 4 nsec/cm, provides continuous adjustment between ranges.
Time Scale Magnifier:	7 calibrated ranges x1, x2, x5, x10, x20, x50, x100. Increases maximum calibrated speed to 0.1 nsec/cm, vernier to 0.04 nsec/cm.
Jitter:	Less than 0.03 nsec or 2 mm with x100 expansion, whichever is greater.
Variable Delay Range:	Any portion of the trace may be viewed in detail using the Time Scale Magnifier and the time delay.
Trigger Functions:	(Normal) External trigger 150 mv for 5 nsec or longer, 50 cps to 100 MC. (Sensitive) External trigger 15 mv for 5 nsec or longer, 50 cps to 100 MC. (High Frequency) External trigger 200 mv p-p, 50 MC to 1,000 MC.
Minimum Delay:	Less than 120 nsec, 100 nsec/cm sweep and faster.
Sampling Rep Rate:	100 KC maximum.

SYNC OUTPUT

Amplitude:	Positive, at least 1.5 volts into 50 ohms.
Rise Time:	Less than 2 nsec.
Width:	Approx. 7 μsec.
Recurrence:	One pulse per sample.

GENERAL

X-Y Recorder Output:	Available for making pen recordings of waveforms in MANUAL, RECORD and EXTERNAL scanning modes.
Beam Finder:	Facilitates location of beam that is off-scale vertically or horizontally.
Accessories Furnished:	187A-76A BNC Adapter (2); 187A-76F accessory adapter (2); 185B-21A Sync Probe.
Prices:	hp 185B Oscilloscope, $2,300.00; hp 187B Dual Trace Amplifier, $1,000.00.

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

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1501 Page Mill Road, Palo Alto, California. Area Code 415, DA 6-7000. Sales and service representatives in all principal areas: **Europe**, Hewlett-Packard S.A., Rue du Vieux Billard No. 1, Geneva; **Canada**, Hewlett-Packard (Canada) Ltd., 8270 Mayrand Street, Montreal.

7565

WASHINGTON OUTLOOK

TIGHTEN PROJECT CONTROL

LATEST STEP in the administration's drive to centralize direction of the defense program is a plan by the Pentagon comptroller, Assistant Defense Secretary Charles J. Hitch. He is developing a "self-evaluating" type of report, containing "defined milestones," that military procurement agencies will submit monthly to his office.

He calls this a "more systematic procedure to follow the physical progress" of the more than 200 major military R&D and production projects. The reports will allow Hitch's office to scrutinize in relation to precise objectives such major project stages as tooling up, prototype deliveries and operational tests.

"EXCESS" PROFITS REVIEW

U. S. TAX COURT acceptance of Boeing's petition for review of the court's January ruling on the company's much-publicized renegotiation case takes on added importance in view of the Department of Defense's intent to stress incentive-type contracts in the future.

The court had decided against Boeing's initial appeal and in fact hiked the amount of profit determined as excessive. In its second appeal, Boeing uses an argument by the Navy's general counsel that the original decision represents "fundamental misconceptions of the incentive contract." The court was disturbed that 81 percent of Boeing's profits in the 1952 case stemmed from incentive contracts and declared that such contracts do not actually offer an incentive to reduce costs.

Most Pentagon lawyers contend that the basic objective of the incentive contract is to obtain lower prices by paying the contractor a greater profit measured by the reduction of actual cost under the target costs.

CONGRESS TO NIX PAY HIKES?

PAY HIKES THIS YEAR for government scientists and engineers now appear doubtful. The administration-backed bill to bring salaries more in line with those paid by private industry (ELECTRONICS, p 12, Jan. 12, and p 12, March 2) is finding little support in Congress.

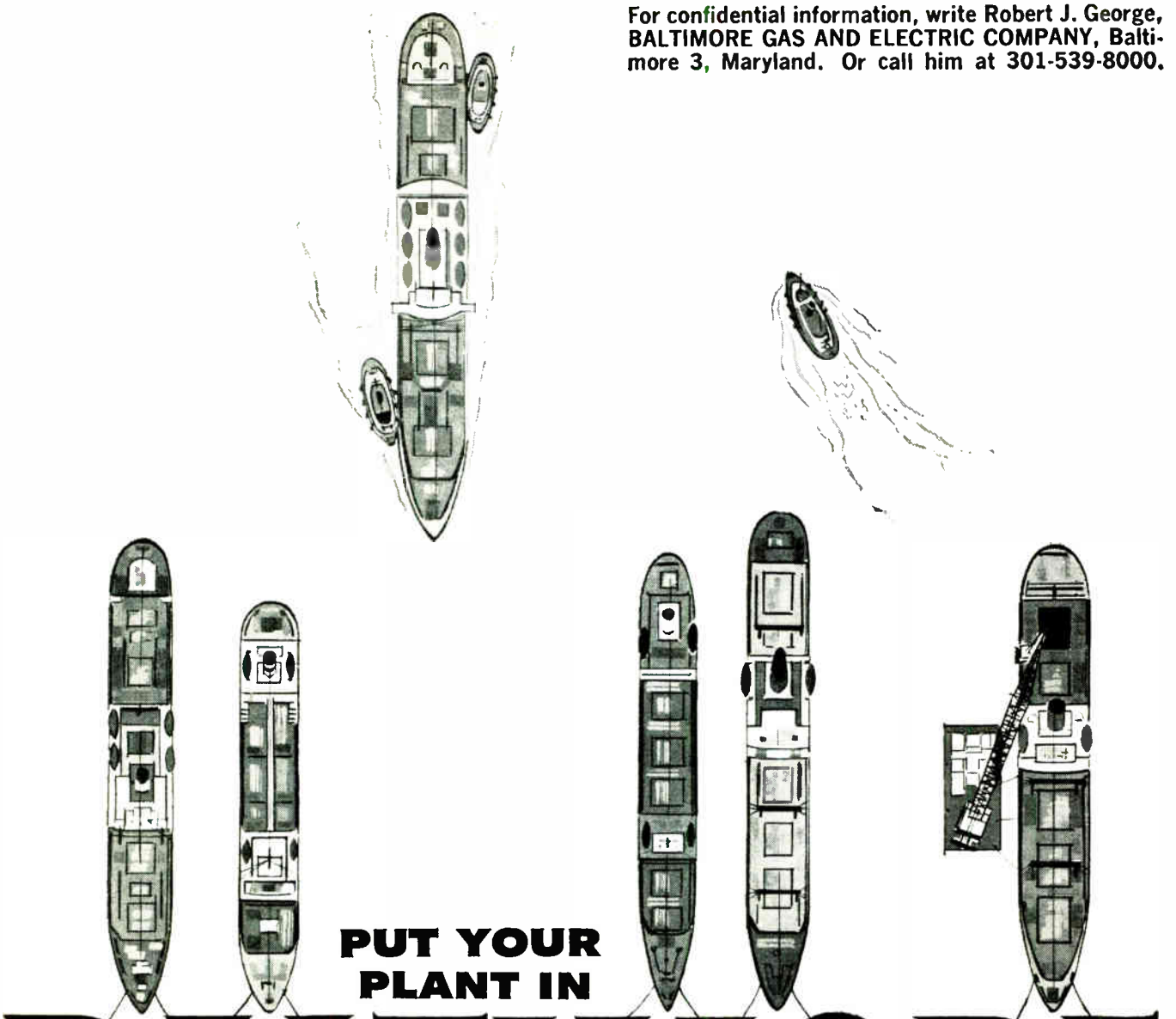
Moreover, some industry opposition is being quietly circulated to the effect that a government pay raise would trigger a similar boost in industry salaries and result in about the same wage spread.

In seeking to bolster salaries for its top men, the administration decided against creating an elite pay group and proposed increases across the board. This blocked some opposition, but created others. Mainly, the economy-minded congressmen are balking now at the added $1 billion a year cost after the proposal is phased in.

MORE FOR RS-70 SYSTEMS

AIR FORCE has reportedly recommended that the RS-70 program be expanded to include production of three reconnaissance-strike aircraft fully equipped with sideview radar and other specially-designed electronic subsystems, instead of three stripped-down prototypes. The recommendation was prepared at Defense Secretary McNamara's request. The House Armed Services Committee authorized another $320 million for RS-70. Odds are McNamara will again veto additional planes, but he is expected to add money for electronics subsystems. The present plan earmarks $52 million for such work.

For confidential information, write Robert J. George, BALTIMORE GAS AND ELECTRIC COMPANY, Baltimore 3, Maryland. Or call him at 301-539-8000.



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NEW Baird-Atomic MODEL OA-1 SCR TEST SET

With the introduction of the new Model OA-1 Tester for Silicon Controlled Rectifiers, Baird-Atomic continues to offer the most complete line of transistor and semiconductor test equipment available. The Model OA-1 tests for:

- V_{BO}: Forward Breakover Voltage . . . also measures gate current to fire at any anode voltage . . . provision for connecting external gate bias . . . front panel current and voltage sensing jacks for graphic display of characteristics on external oscilloscope.
- I_F: Forward Leakage Current
- I_R: Reverse Leakage Current
- V_F: Voltage drop from anode to cathode at forward current I_F; also measures gate firing characteristics.
- I_H: Holding Current

With this new Test Set, Silicon Controlled Rectifiers may be safely evaluated under dynamic circuit conditions, since the power supplies of the Model OA-1 have built-in current limiting load resistors. And rear panel jacks are provided for connecting in additional resistance if required. The Model OA-1 features a high voltage power supply – up to 600V – and a high current supply – up to 10A – and provision is made for continuous control over all power supply ranges.

For the safety and convenience of the operator, an interlock jack is provided for controlling applications of high voltage to the front panel terminals. All components of the Model OA-1 SCR Test Set are conservatively rated for continuous operation at maximum specified currents. Call or write for detailed technical information.

Engineers and scientists: *Investigate challenging opportunities with Baird-Atomic. Write Industrial Relations Director. All qualified applicants will receive consideration for employment without regard to race, creed, color or national origin.*

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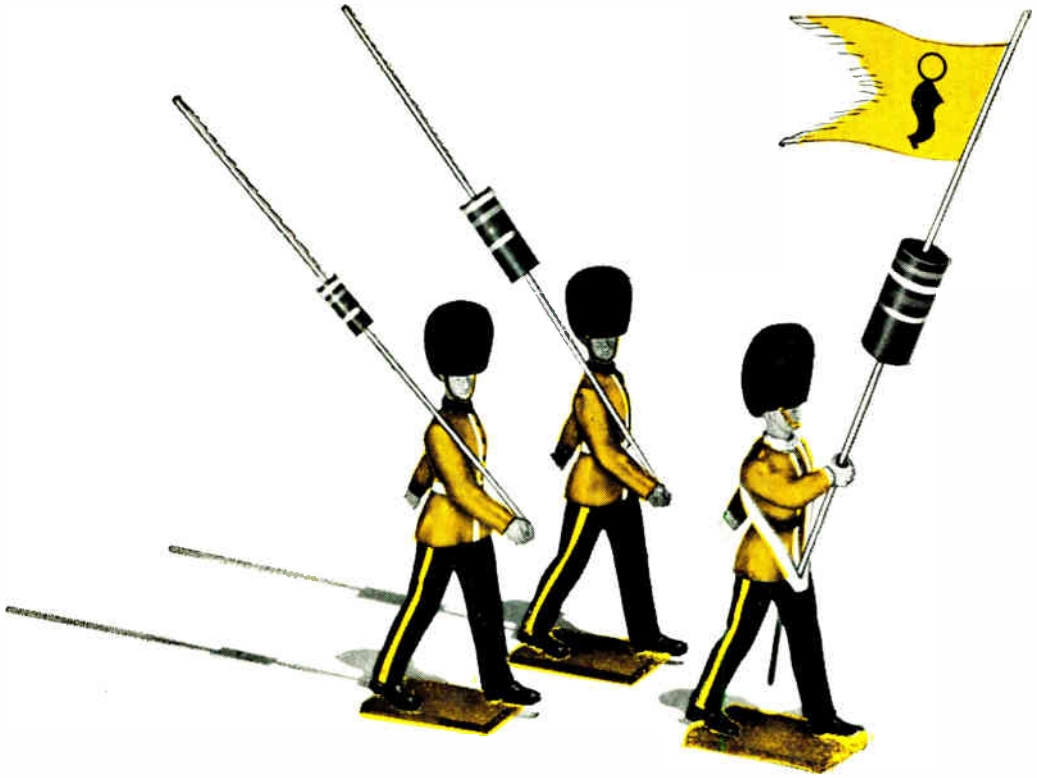

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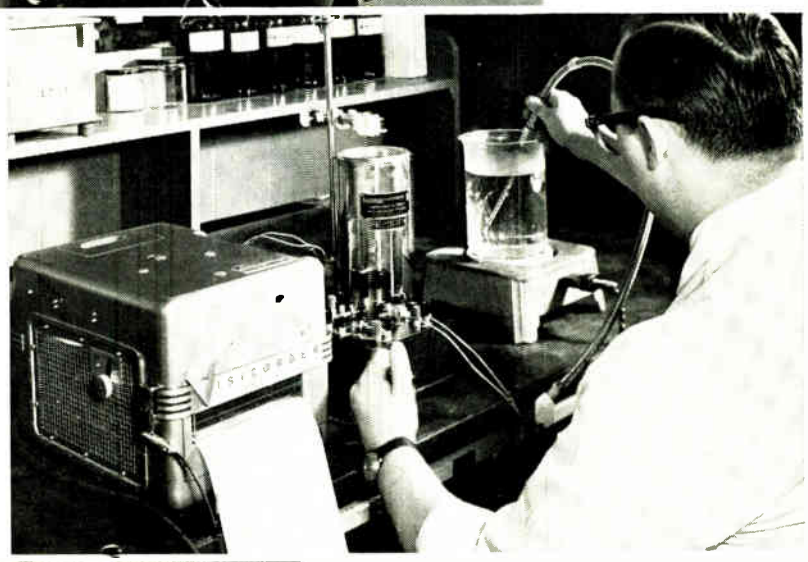
CERAMAG® FERRITE CORES • VARIABLE COMPOSITION RESISTORS • SLIDE & SNAP SWITCHES • CERAMAGNET® CERAMIC MAGNETS • FIXED COMPOSITION CAPACITORS • BRUSHES FOR ALL ROTATING ELECTRICAL EQUIPMENT ELECTRICAL CONTACTS • GRAPHITE BEARINGS, SEAL RINGS, ANODES • HUNDREDS OF RELATED CARBON & GRAPHITE PRODUCTS.

The Visicorder

1



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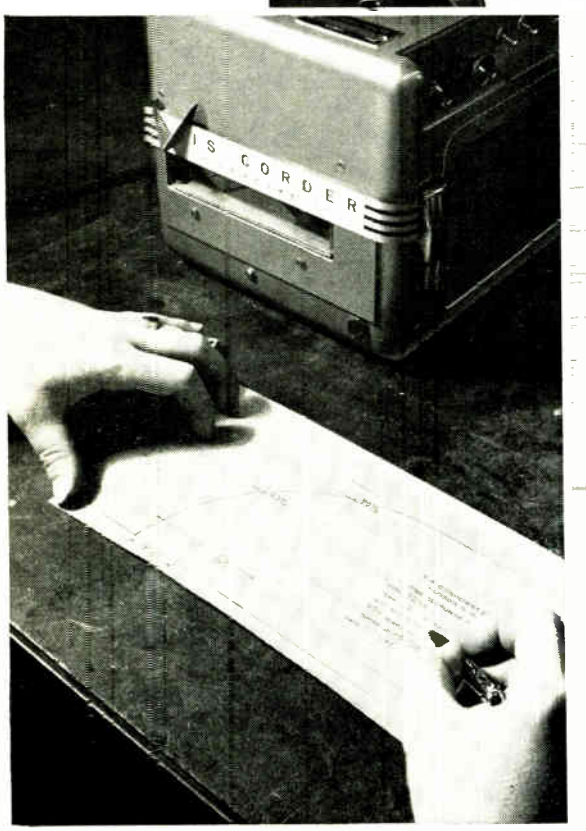

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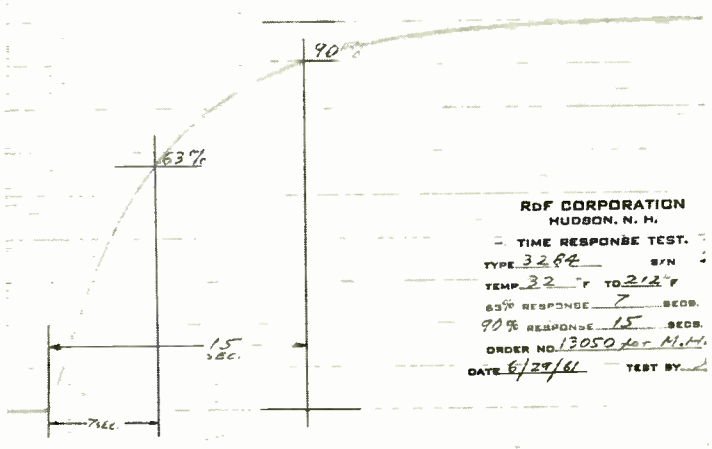

4

Oscillograph directly records transducer temperature response

A Type RN-100 "Stikon" temperature transducer, one of many types manufactured by the RdF Corporation of Hudson, N.H., is being tested for quality in this photo-story.

The tiny nickel grid inside the transducer—only .0007 in diameter—must be completely bonded to its silicone rubber carrier matrix. If the metal-to-silicone bond is not adequate and there is a free space between, the response of the transducer to a step change in temperature is seriously changed.

Test-proved performance of these RdF products is mandatory because inconstancies in time response can mean failure to every mission where fast action is important.

To test the quality of this bond formed during manufacture, RdF uses a Visicorder Oscillograph.

Figure 1 shows an RdF quality control engineer immersing the transducer in an ice bath. Figure 2 shows immersion in boiling water. Figure 3 shows analysis of the response curve that results from the step-change in temperature. Figure 4 is a closeup of the Visicorder record, which indicates that the transducer met the specified time response to the temperature change. The metal-to-silicone bond was adequate.

In countless applications, Visicorder Oscillographs can give you as many as 36 simultaneously recorded channels of information about your products—on instantly readable records, at frequencies from 0 to 5000 cps.

For details write Minneapolis-Honeywell, Heiland Division, 4800 E. Dry Creek Road, P. O. Box 8776, Denver 10, Colorado.

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Klein has kept pace with the development of the electrical field, meeting each new challenge with tools specially designed to do the wiring job better . . . more economically.

Shown here are a few of the many highly specialized Klein Pliers carried in stock to meet the needs of electrical and electronics manufacturers.

You will find your assemblies go together more smoothly and wiring is done more rapidly when the right Klein Plier is used.

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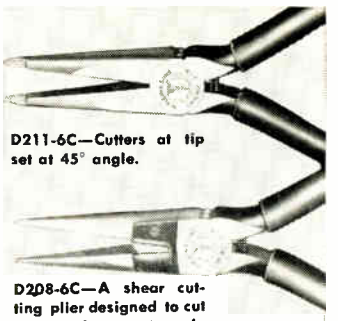
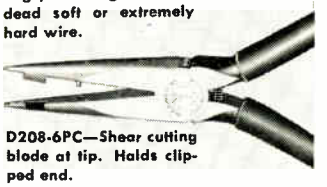


D211-6C—Cutters at tip set at 45° angle.

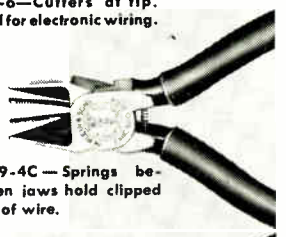
D208-6C—A shear cutting plier designed to cut dead soft or extremely hard wire.



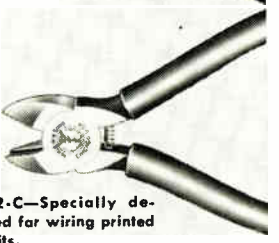
D208-6PC—Shear cutting blade at tip. Holds clipped end.

D318-5½—Long needle nose for reaching confined space.

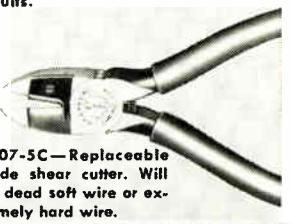
204-6—Cutters at tip. Ideal for electronic wiring.



D229-4C — Springs between jaws hold clipped end of wire.



D052-C—Specially designed for wiring printed circuits.



D207-5C—Replaceable blade shear cutter. Will cut dead soft wire or extremely hard wire.

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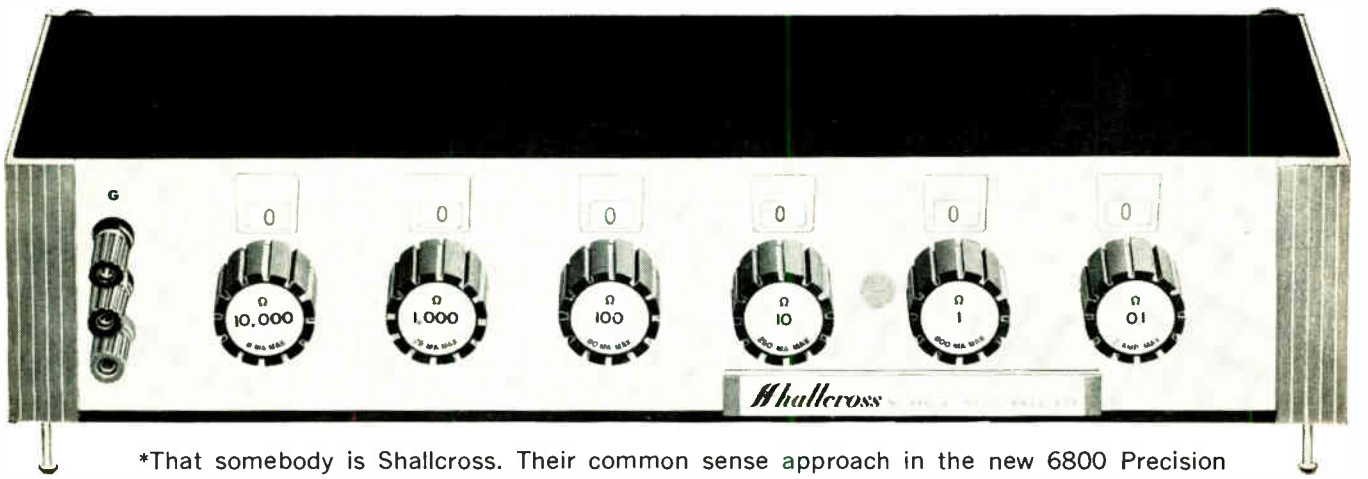
AT LAST SOMEBODY* HAS A COMMON SENSE APPROACH TO PRECISION RESISTANCE DECADES



*That somebody is Shallcross. Their common sense approach in the new 6800 Precision Resistance Decade Series eliminates the nuisance operational shortcomings of previous Decade instruments. The informed engineer will be interested in these features:

1 **VERTICAL AND HORIZONTAL READOUTS** adaptable to any test equipment layout with complete flexibility and convenience. Simple slide adjustment sets window readouts for either horizontal or vertical viewing.

2 **CONVENIENT WIDE ANGLE IN-LINE READOUTS** may be viewed from any angle within 120° plane. Window readouts present actual vertical or horizontal in-line resistance readings.

3 **BENCH OR RACK MOUNTING** Removal of the instrument case provides for rack mounting.

4 **VARIABLE ANGLE BENCH MOUNTING** Adjustable rubber tipped legs permit angular horizontal positioning from 0°-30°.

5 **CALCULATED WEIGHT CONSTRUCTION** Instrument remains stable when in use—is not bulky or cumbersome. Rubber mountings prevent skidding and bench damage.

6 **SMOOTH "POSITION POSITIVE" DIAL SETTINGS** A new rotary switch employs special detent tested for 100,000 trouble-free operations.

7 **.03% DC ACCURACY** when operated 20°-30° C. with resistance readings above 100 ohms. (Closer tolerances available on request.)

8 **SPECIAL WIRE-WOUND CARD AND BOBBIN RESISTORS FOR MINIMUM AC ERROR;** to 1 mc. Minimum noise and low TC (±10 ppm 20°-30° C.).

9 **LONG TERM ACCURACY** Resistors are stabilized to .001% per year. Switch contact resistance variations average ± 1 milliohm for 20,000 operations.

10 **LOW COST** Despite the precise accuracy and many functional features available in the 6800 series, an attractive price structure is possible because all parts are manufactured by Shallcross.

Careful consideration of your needs and working conditions played a major role in the development and design of this Shallcross Decade. It influenced our use of the adjustable wide angle in-line readout feature, the shape and positioning of the knobs, cabinet styling, color and weight. **We think you'll be pleased with this fine instrument.**

• • •

UNMOUNTED DECADES

The same high quality Decades found in the 6800 series are available as unmounted units. Over 250 standard Decade models including high megohm and bench type Decades are also available from Shallcross, manufacturer of fine resistance measurement instruments for over 30 years.

(Certification traceable to National Bureau of Standards)

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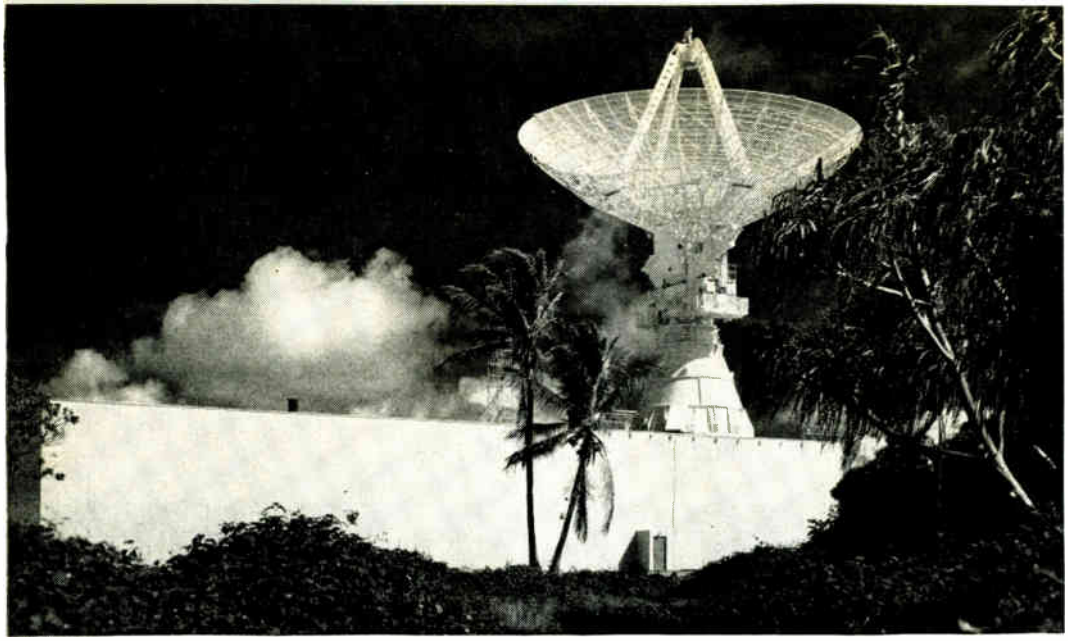
INSTRUMENTS RESISTORS SWITCHES ATTENUATORS DELAY LINES



Tradex radar (target resolution and discrimination experiments) on Roi Namur atoll will study ICBMs fired from Vandenberg AFB, Calif. during Nike-Zeus tests as part of Project Press (Pacific range electromagnetic signature study). With 84-ft antenna, the RCA radar measures range, azimuth, elevation and velocity using doppler. It operates at both uhf and L-band. When it is fully operational, peak power will be 5 Mw and average power, 300 Kw

ARPA Asks $257 Million for Military R&D

By JOHN F. MASON
Associate Editor

MAJOR WORK AREAS scheduled for 1963 by the Advanced Research Projects Agency may be slightly modified—but not appreciably altered—when the Senate votes later this month on the agency's request. The House has already passed its proposal with a $10 million cut from ARPA's $257 million request. Reason for this cut was ARPA's large carry-over of unobligated funds ($51,737,000) from 1962.

Most of ARPA's projects fall within the interest of more than one military department, or else outside of the specific missions of them all. ARPA is an integral part of the Office of the Director of Defense Research and Engineering, but is also assigned projects by the Secretary of Defense.

Ballistic Missile Defense

Largest effort in the agency's workload is again Project Defender, R&D in ballistic missile defense, with an allotment of $110 million. Research includes understanding fundamental phenomena, interpreting experimental data, formulating new systems concepts, and uncovering and developing new techniques and ideas for advanced defense capabilities.

In addition, Defender now has the job of studying the effectiveness of the present and future U. S. program in penetration aids for strategic weapons.

General Research — Study of basic physical and chemical processes applicable to defense against ballistic missiles at various points in their trajectories will get an important new tool, the end of this calendar year, when the 1,000-ft hole-in-the-ground radar is completed in Arecibo, Puerto Rico. It will study electron and ion-density profiles of the ionosphere.

Techniques and Devices—This research covers advanced sensor and interception technology, kill mechanisms, and an area which includes lasers and infrared, ultraviolet and visible techniques for detecting space objects.

One kind of kill mechanism involves hypervelocity impact. The primary mission is to determine the type of material—its mass and shape—that will do this. Primary objective in the visible light research is to develop components and techniques to detect and track space objects during their ballistic flight from a space platform.

Missile Phenomenology — Major effort for 1963 will be study of a missile's characteristics during reentry phase. Work will also continue on target and background measurements during launch phase.

Downrange measurements for reentry studies will continue to be made by the Damp ship using radar and optical equipment. Major effort for reentry will be Project Press, which will take advantage of missiles launched from California to be intercepted by Nike-Zeus fired from Kwajalein Island in the Pacific. Principal instruments will be Tradex radar and optical instrumentation carrier in aircraft. Part of Lincoln Labs' $20 million allocation from ARPA for 1963 goes for technical management of Press. The rest is for work on a high-power tube and for exploration of new

ARPA'S BUDGET REQUEST

Projects	(millions)
Ballistic missile defense	$110
Nuclear test detection	63
Remote area field conflict technique	18
Advanced propellant chemistry	23
Materials sciences	22
Other projects including energy conversion	5
Command and control research	9
Weather control	2
Technical studies	5
Total	$257
Funds brought forward from 1962	51.7
House reduction	—10
Total available for 1963	$298.7

radar techniques.

Program to study the launch phase is called Tabstone, which began in the spring of 1961. Almost all measurements are being made from aircraft and rocket probes. Within the next year, satellites will be used.

Systems—All proposed systems are studied. For full-scale development, they are farmed out to the military services. The two most significant systems now under study are Bambi, for kill during boost phase, and Arpat, during terminal phase.

Penetration Aids—Missile systems are evaluated for penetration capability.

Nuclear Test Detection

A $63-million request has been made for Project Vela. Vela-Uniform is the research program for detection of nuclear blasts underground. Vela-Sierra is to detect high-altitude explosions by ground-based instrumentation. Vela-Hotel is to detect explosions beyond the atmosphere by space-based sensors.

Most of the effort on Vela-Uniform has involved seismology. Other methods studied include detectable electromagnetic signals, variation in the earth's magnetic field, and air pressure variations. Eventually 125 seismographic stations will be established throughout the world. Also, a prototype detection system will be developed, feeding data into a central analysis center. Another task is development of on-site inspection techniques.

Planning for Vela-Sierra includes development of techniques for detecting detonations and then using these techniques in an integrated system. ARPA is now studying detection of light emitted from the detonation, the detection of changes in the amosphere induced by radiation or debris, and the detection of electromagnetic waves produced by the nuclear detonation.

Space-based sensors, in Vela-Hotel, depend on the x-rays, gamma rays and neutrons emitted from a nuclear explosion in space; a secondary effort involves use of r-f signals from a nuclear detonation.

According to ARPA's director, J. P. Ruina, the U. S. and the Soviet Union have the capability to adequately detect atmospheric tests; the sensitivity of underground detection is far lower. The British are experimenting with use of an array of 24 seismometers to detect a signal, thereby enhancing the strength of the signal, Ruina said.

Field conflict technique research, Project Agile—Some $18 million will be spent to study communications and firepower problems peculiar to distinctive battle environments — such as tropical or mountainous areas.

Materials sciences—This work has been budgeted at $22 million. ARPA has established interdisciplinary laboratories at 11 universities for work on structural, electric, and electronic materials capable of operating under extreme conditions. The crystal growth program has been slow in getting underway. ARPA promised the House to initiate requests for contracts this month.

Laser Operates at Atmospheric Window

CALCIUM FLUORIDE lasers have been operated at RCA's Princeton labs. One of these, requiring only a joule of input energy, has an output wavelength of 2.36 microns. The output is at an atmospheric window, making the laser suitable for communications on earth with minimum attenuation.

In the one-joule unit, calcium fluoride is doped with 0.05 molar percent of divalent dysprosium. Pump power is provided by an FX-100 flash tube, unfocused and one inch from the crystal. The laser's low threshold is obtained in part by full utilization of pumping energy from one micron through ultraviolet.

Laser action is obtained with one joule input energy at liquid nitrogen temperature, 78 K, or 0.1 joule at liquid helium temperature, 4.2 K. In pulse operation, average output power in milliwatts, pulse width of 100 μsec have been obtained. Fluorescent line width of three angstroms is considered exceptionally narrow.

Continuous-wave operation is expected from this crystal, using a different pumping configuration: two spherical mirrors with a light-gathering aperture of f/0.25 and a 500-w tungsten lamp. The long, 10-msec, fluorescent lifetime of dysprosium suits it for c-w operation.

The same pulsed pumping configuration is used for two other new lasers.

One is calcium fluoride doped with 0.05 molar percent of divalent thulium. It uses an input energy of 40 joules at 4.2 K and has an output at 1.16 microns. Operation is as a three-level maser.

Laser with 2.36-micron output wavelength is readied for operation

The second is calcium tungstate doped with 1.0 molar percent of trivalent erbium. Input energy is 80 joules at 78 K and output is at 1.61 microns. Both have output power of milliwatts and line widths wider than three angstroms.

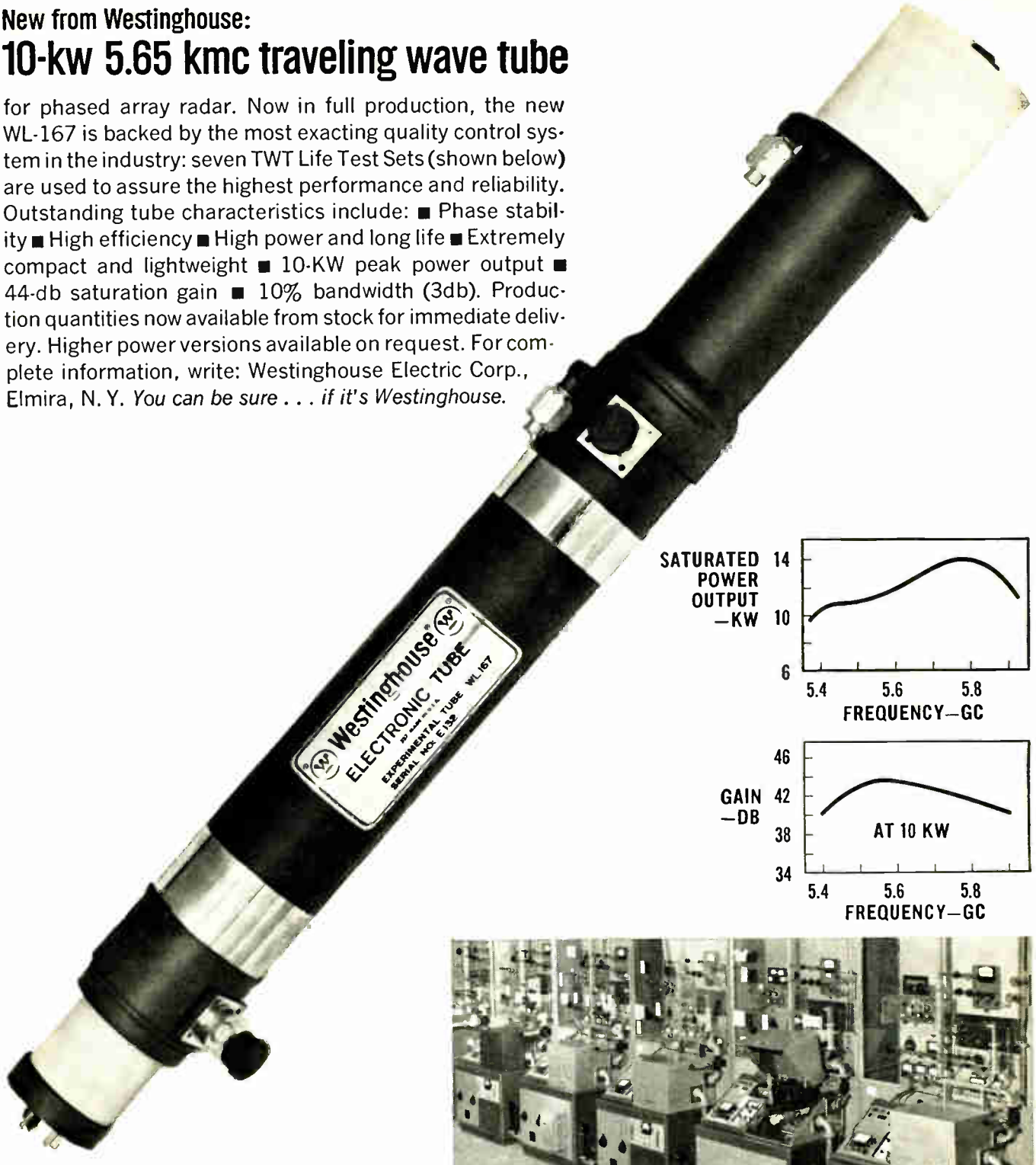
One-inch-long crystals in two geometrics were used. One form is a $\frac{3}{16}$-inch diameter rod, the other a $\frac{3}{16}$ by $\frac{3}{16}$-inch slab. For c-w service, the rods will be used as they allow pumping light to be focused from all directions.

The work at RCA was led by Zoltan Kiss, working with R. C. Duncan and G. Goldsmith on the laser. Materials were developed by M. Kestigian and N. Yocom. A disclosure was made in a post-deadline paper for the recent meeting of the American Physical Society in Washington.

New from Westinghouse:

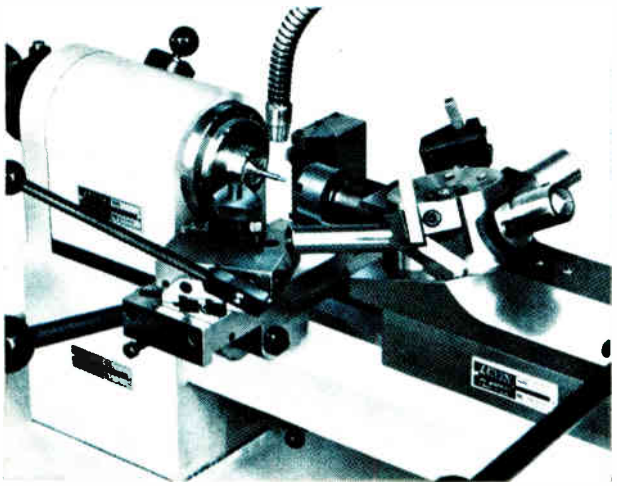
10-kw 5.65 kmc traveling wave tube

for phased array radar. Now in full production, the new WL-167 is backed by the most exacting quality control system in the industry: seven TWT Life Test Sets (shown below) are used to assure the highest performance and reliability. Outstanding tube characteristics include: ■ Phase stability ■ High efficiency ■ High power and long life ■ Extremely compact and lightweight ■ 10-KW peak power output ■ 44-db saturation gain ■ 10% bandwidth (3db). Production quantities now available from stock for immediate delivery. Higher power versions available on request. For complete information, write: Westinghouse Electric Corp., Elmira, N. Y. *You can be sure . . . if it's Westinghouse.*



Westinghouse

SMALL PART PROBLEMS ?



LEVIN Heavy duty instrument lathes offer the best solution to small part lathe operations. 29 standard models for first and second operation work in 3/16", 5/16", and 1/2" collet capacities.

Shown above, an ACAF turret lathe set up to produce the small needle valve, illustrated, with a 0.0118" bleed hole. The self indexing turret is extremely sensitive for fine work. Speed regulation is continuously variable from 0 to 4000 r.p.m. with IR drop compensation.

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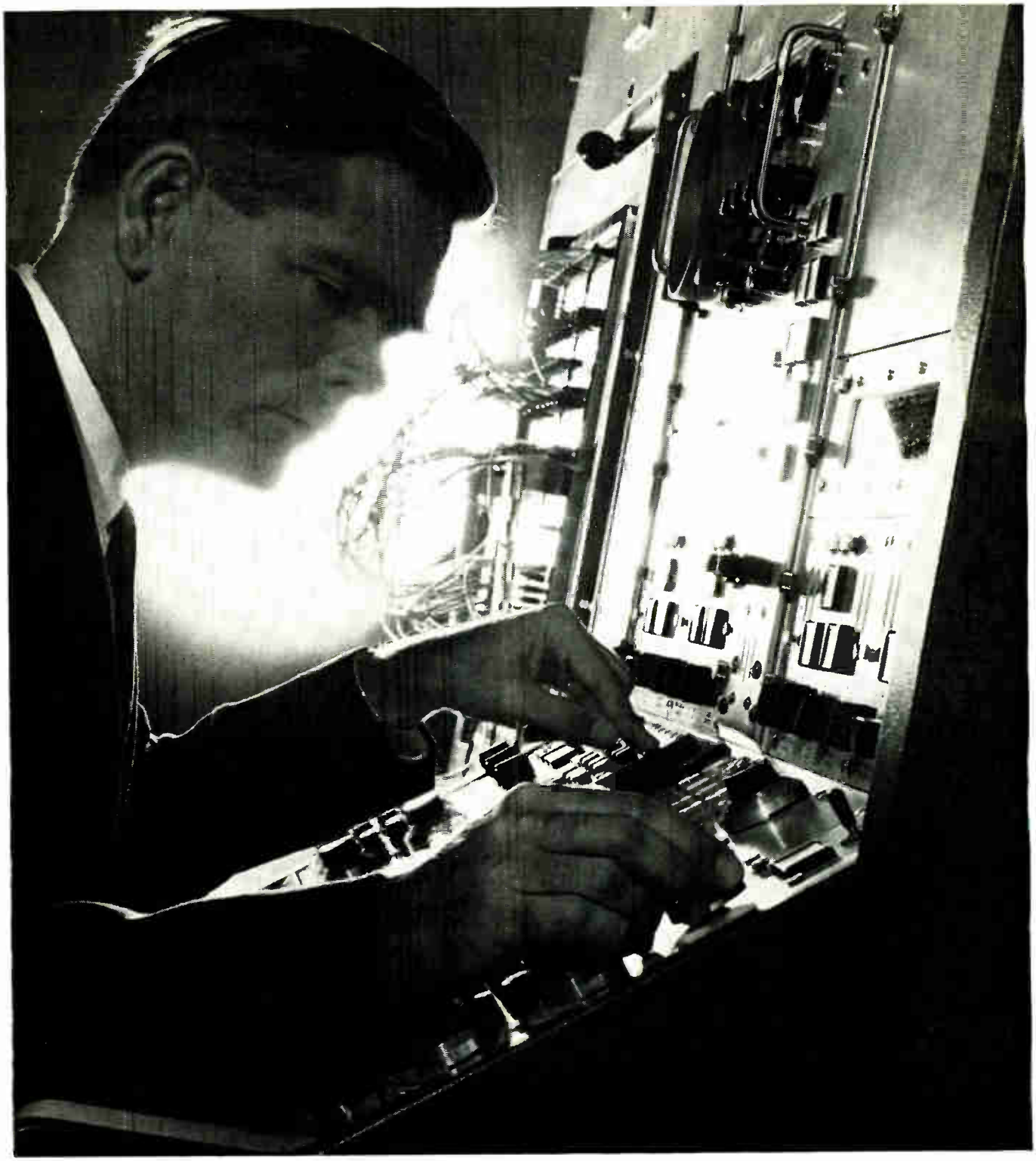

TRULY CENTRALIZED PROBLEM CONTROL is now offered in the new 2100 Series EASE® Analog Computer. Pinboard control for iterative (IDA™) or non-iterative (ELDA™) operation. Domain control. Sector time scale control. As many as 36 different asynchronous computing groups. These are only a few of the advanced features that make this the most flexible and complete simulation tool available. For extensive details, ask for brochure A2100.

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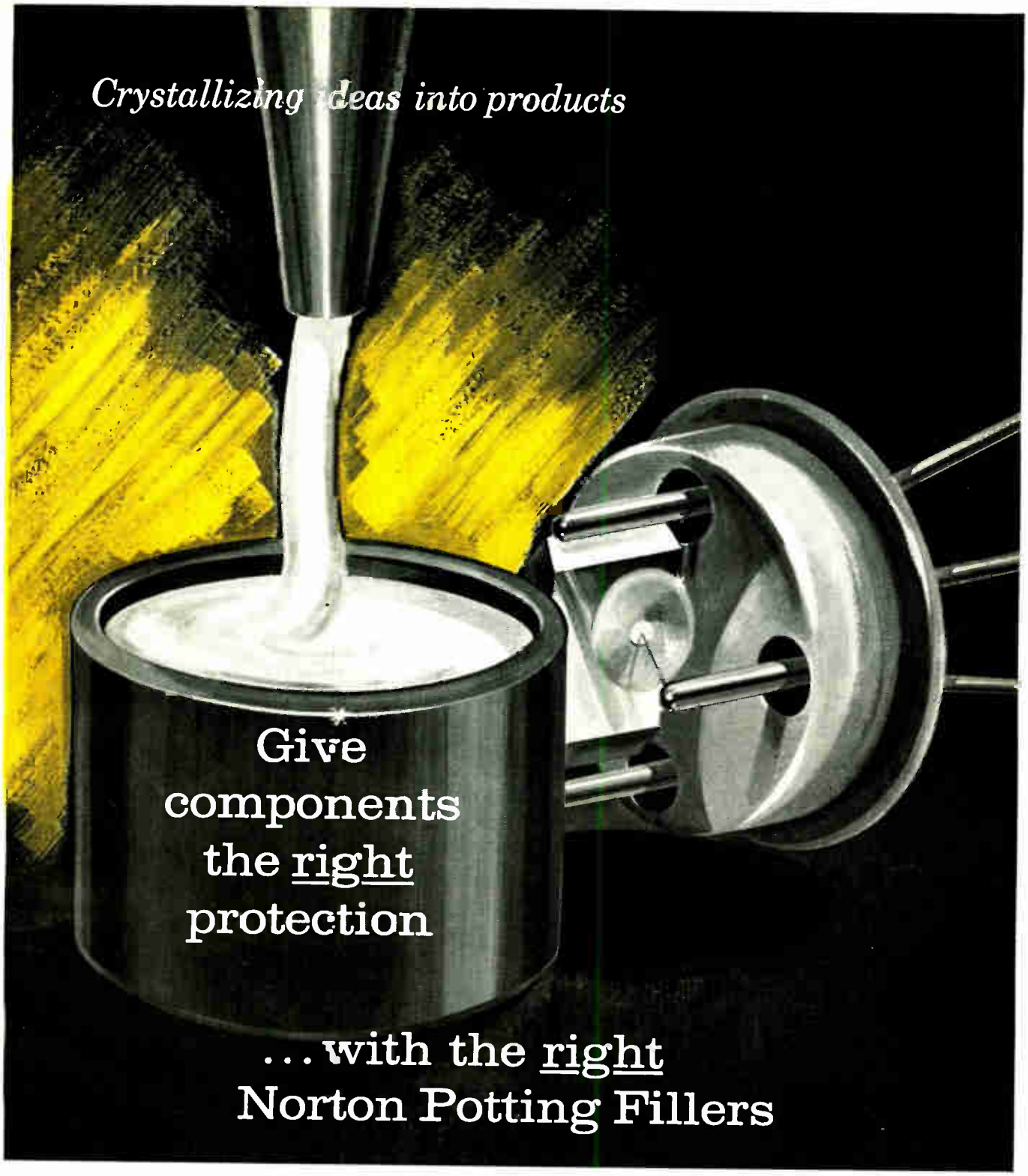

Norton ALUNDUM* fused alumina and MAGNORITE* fused magnesia have proved outstanding as fillers in potting compounds for electronic components — including transistors, resistors, capacitors, coils, small power and pulse transformers. Engineered to provide high, even heat dissipation, high dielectric strength and low leakage current, these Norton materials provide a chemically and physically stable addition to unfilled compounds to improve component performance.

For increased filler versatility, ALUNDUM fused alumina is available in four fine powder sizes (average particle size: 3½, 5, 12, 20 microns) as well as coarser. MAGNORITE fused magnesia is obtainable in an average particle size of 10 microns as well as coarser. These materials enable potted components to operate at a lower temperature or higher ratings, with increased reliability and longer life.

For details on how ALUNDUM Al_2O_3 or MAGNORITE MgO assure important benefits that ordinary fillers cannot provide, write to NORTON COMPANY, 684 New Bond Street, Worcester 6, Massachusetts.

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to make your products better

☐ VSWR measurements of extreme precision
☐ FXR coax switch cuts Norden Laboratory test time
☐ How to reduce your cable inventory

VSWR measurements of extreme precision

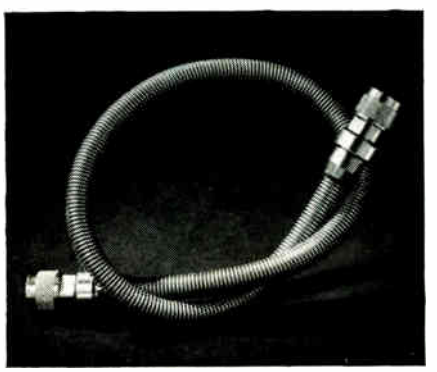
FXR's Model B813T VSWR Amplifier is a fully transistorized portable standing-wave amplifier with a full-scale maximum error at 5 db of ±0.05 db. We think it's the most accurate on the market.

The unit is designed for use on battery power for applications in the field where power is not available or in the laboratory where line noise might cause inaccuracies in measurement. Where power is available, however, the unit can be operated from the line in the normal manner.

Calibrated range of the B813T is 75 db. Normal, expanded and compressed meter scales are provided and can be used interchangeably without the need for readjustment of the gain control. The unit has special circuitry for bolometer protection and a meter display for bolometer resistance checking and current adjustment.

Other features of the B813T include controls and circuitry for selective meter damping, bandwidth selection and frequency peaking, range selection in 5-db steps, battery voltage checking and self-contained charging. Price: $285.00. *For more information circle Reader Service Card 252.* ■

Need a high temperature cable for nuclear application?



AMPHENOL ultra-high temperature flexible rf cable is capable of continuous operation at 1000°F with short excursions to higher temperatures.

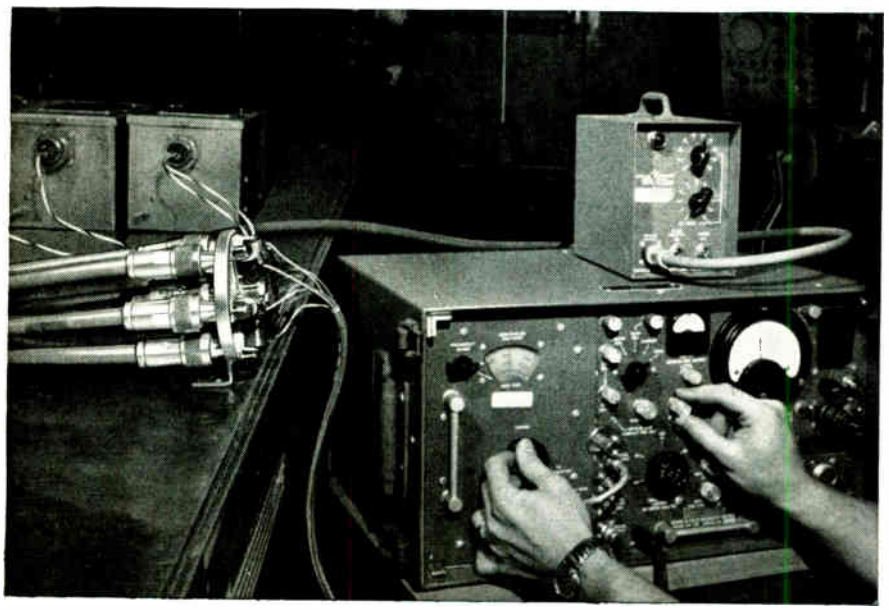
Application engineered for aircraft and missile temperature environments, the cable is a completely sealed rf transmission system consisting of inner and outer conductors separated by a dielectric of modified semi-solid silica.

Over all is a protective-sealed metallic-convoluted jacket. Cable ends are terminated at the factory with hermetically sealed 1000°F Series N plugs. System is resistant to nuclear radiation and is ideal for reactor use.

DATA

Altitude Insensitive-Moisture Resistant	Capacitance: 30.0 f/ft.
Resistant to Shock and Vibration	Velocity of Propagation: 69.0%
Resistant to Nuclear Radiation	Voltage Breakdown: 3500 Volts RMS
Connectors: Series N Plugs	Maximum Operating Voltage: 1000 VRMS
Impedance: 50 Ohms	Weight: Cable, 17½ lbs pr 100 ft.
	Connectors, 2½ ounces each

1000°F flexible rf cable is available in standard lengths up to 200 feet. Part number is 777-502. Specify length desired in order or quotation request. Length is measured from connector mating end to connector mating end. *For more information circle Reader Card 253.* ■



FXR coax switch cuts Norden Laboratory test time

Norden, a division of United Aircraft Corporation, operates an environmental test laboratory at its Norwalk, Conn., plant.

Faced with an ever-increasing number of systems requiring noise and interference tests under military specifications, Norden engineers asked FXR to design a 50-ohm resistor-terminated coaxial switch that would have identical electrical characteristics through each of six outputs. Now, to check different channels, instead of disconnecting and connecting cable, Norden engineers just flick a small knob. All unused channels are grounded through 50-ohm terminations, with no significant crosstalk to interfere with the measurements being recorded.

The result is a faster, more convenient test procedure. If you're running noise tests under MIL-I 6181B, 6181D, 26600 or 19610 you'll find that this new coaxial switch will save hours of tedious work.

Maybe you have some other unusual rf switching problem. Why not ask us about it? *For more information circle Reader Service Card 254.* ■

How to reduce your cable inventory

Most people we know cut up the cable they purchase, then put connectors on each end.

Why not let us make your cable assemblies? As the only major manufacturer of coaxial cable and coaxial connectors, FXR can probably save you money. We can certainly save you time.

How? Well, for one thing, you don't have to inventory so much cable or so many connectors. You don't have to set up production facilities for making these cable assemblies. And, you don't have to worry about quality control. We can produce sophisticated electrical assemblies to your rigid specifications. We have the people, facilities, and know-how to guarantee quality.

FXR manufactures Amphenol coaxial cable, Amphenol and "ipc" coaxial connectors and DK coaxial switches. Together, they constitute the industry's broadest line of coaxial components. Why not let us put them together for you? *For more information circle Reader Service Card 255.* ■

The RF Products and Microwave Division Amphenol-Borg Electronics Corporation; 33 East Franklin Street, Danbury, Connecticut.

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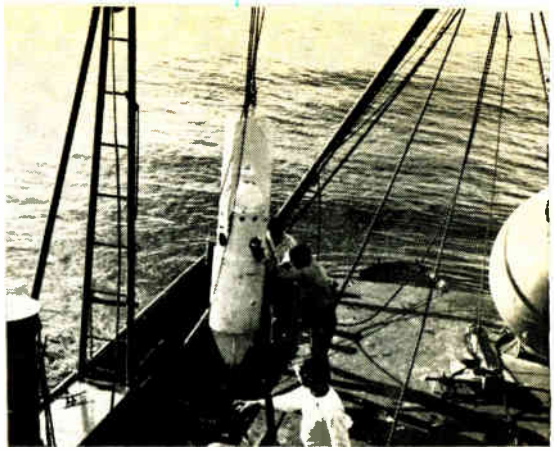


Bomb-shaped object is ocean-bottom recording seismograph developed by Texas Instruments for Project Vela-Uniform. It will operate at depths to 10,000 ft (first photo). Worden gravity meter is used to map water reservoir sands in the Sudan desert (middle photo). National Science Foundation's USNS Eltanin is designed for oceanography and other earth sciences research in the Antarctic. The three forward antennas are for radar meteorology, vlf noise and h-f noise studies, (photo, far right)

By MARVIN REID, McGraw-Hill World News

Boom in Earth Sciences Program Helps

DALLAS — Booming government earth sciences programs are helping reshape and expand southwestern firms known in the past primarily for geophysical exploration for oil.

Faced by a prolonged slump in oil prospecting, some firms are finding new horizons in nuclear explosion detection projects, oceanography, and other military, scientific and commercial applications for talents and electronic equipment capabilities developed during oil exploration work.

The Department of Defense's Project Vela-Uniform (see p 20) has benefited such companies as Texas Instruments; Geotechnical Corp., of Garland, Texas; Century Geophysical Corp., of Tulsa, and Dresser Industries' SIE group, in Houston.

While Project Vela, the nuclear explosion detection program, has been a major spur to business, it is not the only one. Seismograph Service Corp., of Tulsa, for example, is not yet in Project Vela, but has supplied long-range positioning apparatus used by recovery ships during space shots.

TI's Science Services division recently outfitted a Corps of Engineers radar installation at Vicksburg, Miss. This novel facility, called Westar (Waterways Experiment Station Terrain Analysis Radar) will do terrain research for immediate military applications and might be adapted for mapping lunar soil conditions in space efforts.

TI will also develop water resources in the Sudan, under contract to the Department of State's Agency for International Development. The Science Services division will use the same techniques to map the base of reservoir sands as its Geophysical Services, Inc., used to find oil-bearing sands.

The buildup in government-sponsored earth sciences work during the past three years has had a great impact on Geotechnical Corp. Geotech left the oil field completely in 1958 for earth sciences. In three years, its gross sales have jumped from $1.5 million to over $10 million. It is now seeking commercial markets for telemetry, data processing and other equipment developed in earth sciences efforts.

The company started aggressively seeking government-sponsored work in the mid-1950's, and got several contracts to supply seismological equipment. It developed the nuclear explosion detection station at Fort Sill, Okla., as part of Vela-Uniform. Geotech now has subcontracts to supply instruments and equipment for three similar stations to be built in Oregon, Utah and Tennessee.

TI's Science Services division has more than $2 million in contracts to construct and operate these observatories. The division now has between $4 million and $5 million in Vela-Uniform contracts. P. E. Haggerty, TI president, has said the division can be doing a $100-million-a-year business in 10 years.

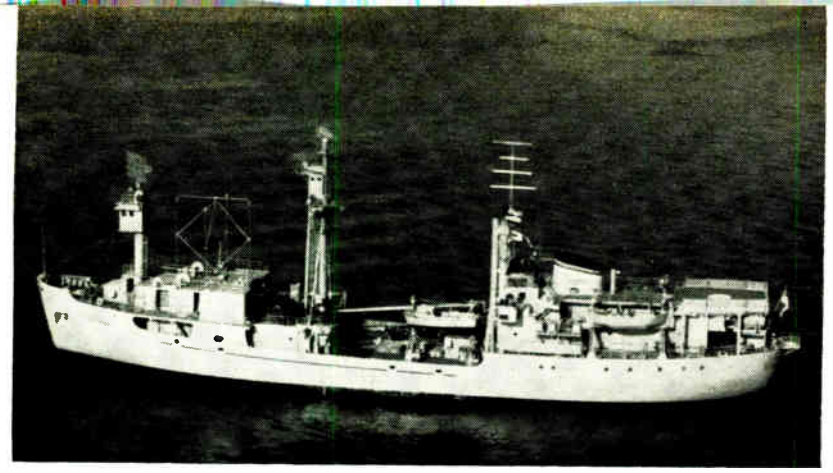
The division includes a Geosciences department set up three years ago to seek earth sciences work. R. E. Kinsley, department manager, was one of four men TI pulled out of Geophysical Services and the Apparatus division in 1959 to see how GSI's capabilities could be used. The department now has 135 people.

Kinsley believes that oil exploration firms are way out in front of other electronic firms in getting oceanography, earth study and certain types of space measurement contracts. He says "it took us 20 years or more to build up our capabilities in geophysics."

Kinsley's group is also active in such fields as seismic propagation studies. He thinks the earth can be opened up for communications. A TI project to evaluate seismic communications has shown this to be feasible, he says.

Oceanography techniques developed by GSI for underwater oil exploration may be the department's biggest potential market, Kinsley says. The government, for instance, is outfitting 30 ships for hydrographic studies. He believes TI will be a leading supplier of sensors and other equipment. A TI maintenance and research team is aboard the National Science Foundation research vessel *USNS Eltanin*.

(TI, by the way, denies its oil exploration business has declined. R. C. Dunlap, vice president in charge of the Science Services division, says that the company began stressing R&D in 1950, resulting in more growth for GSI in the last seven years than during GSI's



Oil-Oriented Companies Stage Comeback

first 25 years of operation.)

J. Vance Holdam, Dresser Industries vice president, is another who sees a tremendous potential in earth sciences. Dresser's Southwestern Industrial Electronics, one of the largest seismograph suppliers, has set up a separate group for earth sciences equipment.

The firm has designed unmanned seismograph stations for remote locations and electronic seismometers that can measure very low frequencies for Project Vela.

Some geophysical firms see the earth sciences boom as a good way to move further into diversified commercial electronics markets.

Century Geophysical now holds "three or four" Vela contracts. But one of its officials says Century is not interested in concentrating on government-backed R&D. Instead, it is keeping a sharp eye out for commercial applications of gear developed in earth sciences R&D.

The firm started diversifying in 1946 and now has a separate R&D division and "more research people than we could possibly afford if it were not for Vela and other earth sciences work." For example, Century is doing computer systems research that can also be applied to other fields.

One of the biggest hurdles geophysical firms had to jump to crack the earth sciences market was ignorance about their capabilities. Several said they found congressional and other government people totally unaware of the type of work they had done for the oil industry. Some admitted it was their own fault, because oil-searching operations have been secretive. But they believe they have now gotten their story across.

Geophysical Oil Exploration in Prolonged Slump

DALLAS—In 1952 more than 110 geophysical contracting firms were searching for oil deposits in the U. S. There are now less than 70, and many of these are operating on a standby basis—they can rake up a crew if they can get some business.

While there is some indication that the bottom has been reached, geophysical contractors have suffered sharply from a general retrenchment in the oil industry since the mid-fifties.

The oil industry's exploration people measure their activity in crew months, each 30 days a crew works in the field. Between 1952 and 1960, the crew-months figure dropped in the U. S. from 710 to 359, the lowest since 1946.

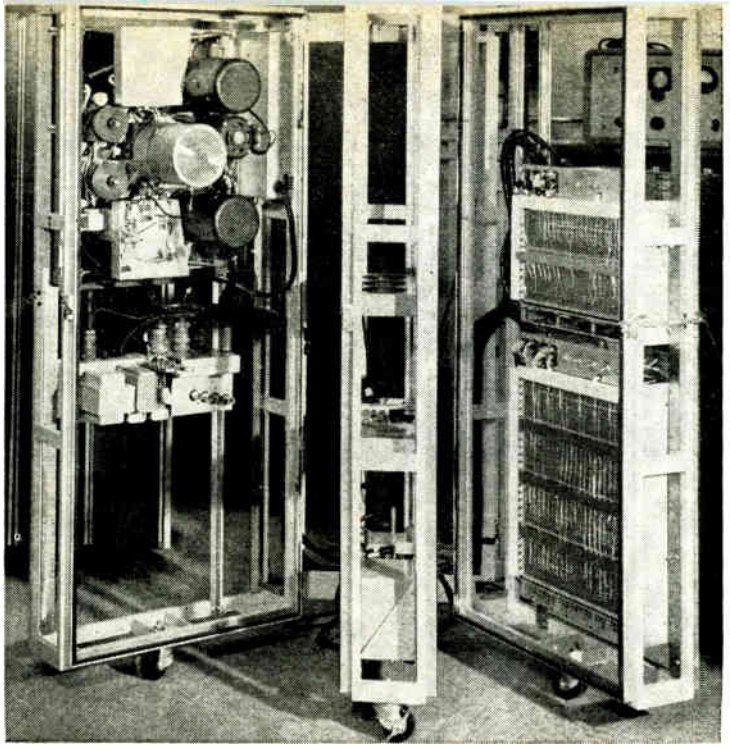
To make matters worse for geophysical contractors, much of the work that is left today is being done by the oil companies with their own crews. Virtually all geophysical firms in the Southwest today report their oil business is down 50 percent or more from 1953-55.

The slump in oil search activity can be traced back to the Korean War, and much of the blame can be laid to the law of supply and demand. The oil industry has been in a constant state of oversupply for several years. The pressure on prices has caused most companies to cut operating expenses, including exploration expenditures.

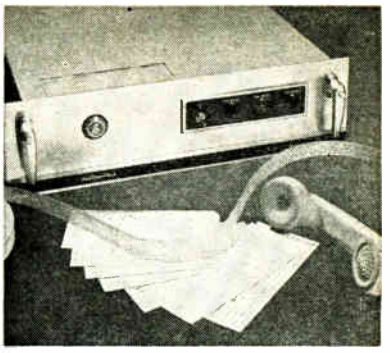
During the 1930's and 1940's companies concentrated management skill on finding and developing crude and gas reserves. Since 1958, many U. S. oil firms have switched their emphasis from finding oil to selling it.

Some geophysical contractors now say their oil business is picking up slightly. However, none is optimistic about a boom. This is one reason why most of the bigger ones are bent on diversifying into other fields. Foreign work has held up at a fairly steady pace.

"We aren't getting out of oil," the official of one firm says. "There is still enough business to bring in a few dollars, but we don't think we'll ever see again the big years we once had in oil."



Ampex showed tape memory versions of its tape handlers. Electronic equipment is in cabinet at right



Data model for Hallicrafters digital communications systems handles 600, 1,200 or 2,400 bauds

AT THE SPRING JOINT COMPUTER CONFERENCE:

Five Companies Introduce Computers

SAN FRANCISCO—The main hardware news at the Spring Joint Computer Conference was the introduction of new computers, including several low-cost models, and a variety of peripheral data handling and transmitting equipment. Attendance at the show—about 4,000—was considered good.

Computers introduced included:

• Digital Equipment Corp. now has smaller versions of its PDP-1. The single-address parallel PDP-4 has a 9-μsec magnetic core memory and performs 55,000 additions a second. It is available in two models, the PDP-4A with a memory of 1,024 18-bit words, priced at $52,000, and the PDP-4B, with a 4,096-word memory, priced at $65,000.

Both models have a paper tape reader and control. Optional equipment includes a 16-in. crt display and a photoelectric "light pen" that detects information displayed on the crt.

• Scientific Data Systems' 900 series computers were shown in two models. Selling points include all-silicon semiconductor components and interchangeability of programs.

The SDS 920, priced at $89,000, has a larger memory and shorter execution times than the 910 at $41,000. Multiply time is 248 μsec on the 910 and 32 μsec on the 920. The 910's core memory holds 2,048 24-bit words, the 920 holds 4,096 words and both are expandable to 16,384 words.

• Collins Radio showed its line of communications-oriented computers. The C-8400 is for communication network applications and satellite and centralized computing operations. The C-8451 is a teletypewriter and high-speed data switching center. The central data processor has a transfer link that permits data transfer in a single step. It can transfer up to 48 million bits a second between input and output devices.

• Control Data reported that its 3600 large-scale digital computer will be ready for delivery in about a year, with a complete programming system included.

The basic system, including in-

COMMERCIAL SESSIONS TRIED AT SJCC

SAN FRANCISCO—Something new was tried at the Spring Joint Computer Conference. Manufacturers with important new equipment were permitted to buy time at evening commercial technical sessions.

D. C. Lincicome, of Stanford Research Institute, in charge of the sessions, said they were effective for companies with good material, but the reverse was also true.

The audience at one session grew from 50 to 70 in 20 minutes. At the following session, the 70 people dwindled to 20 in the same time. One participant reported an audience of 150.

Also new were concurrent educational sessions, designed to orient non-computer people on information processing

put-output equipment, sells at $2 million to $2.5 million and rents for $55,000 to $60,000 a month. Its core memory is expandable in increments of 1.5 million up to a total of more than 12.5 million bits. Access time is 0.7 μsec. Tunnel diode circuits speed up basic arithmetic processes in the nanosecond range.

• Electronic Associates' Hydac analog-digital computer (ELECTRONICS, p 21, May 11) features in the digital portion a patch panel and modular construction.

The basic digital building block is a NAND gate with an inverter, that also provides the AND function. These 20-Mc AND-NAND gates are of potted welded cordwood construction and are combined on printed circuit cards to form more complex functions programmed by the 3,450-hole patch panel.

• Ampex showed its tape memory, the TM-4100. This combines a TM-4 transport with a solid-state DE-100 electronics series. Another series works with the TM-2 transport.

The DE-100 series can operate with a single tape unit or as a shared system with up to 16 tape units. The tape format is compatible with the IBM 729 II and IV tapes. Operating densities are up to 600 bits an inch, or 800 bits using a clock channel.

• Control data also introduced a magnetic tape transport, the 606, which controls the tape by pneumatic capstans, vacuum brakes and vacuum columns.

As the tape passes over the recording head, air jets force the tape against the head to reduce tape and head wear. Recording densities are 200 or 556 bits an inch and maximum data transfer rate is 83,400 characters a second. A single source will control as many as eight transports.

• Hallicrafters introduced a commercial version of the carrier phase reversal digital data communications system it has been building for military applications (ELECTRONICS, p 56, May 26, 1961). The system has been changed to handle a 9-bit code instead of a 5-bit one and the code has nonconsecutive ONES in the translated data. Equipment can be used for transmission over wire, radio or microwave links.

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You can adapt your Type 561 Oscilloscope to wideband applications simply and conveniently—by using two new sampling plug-in units.

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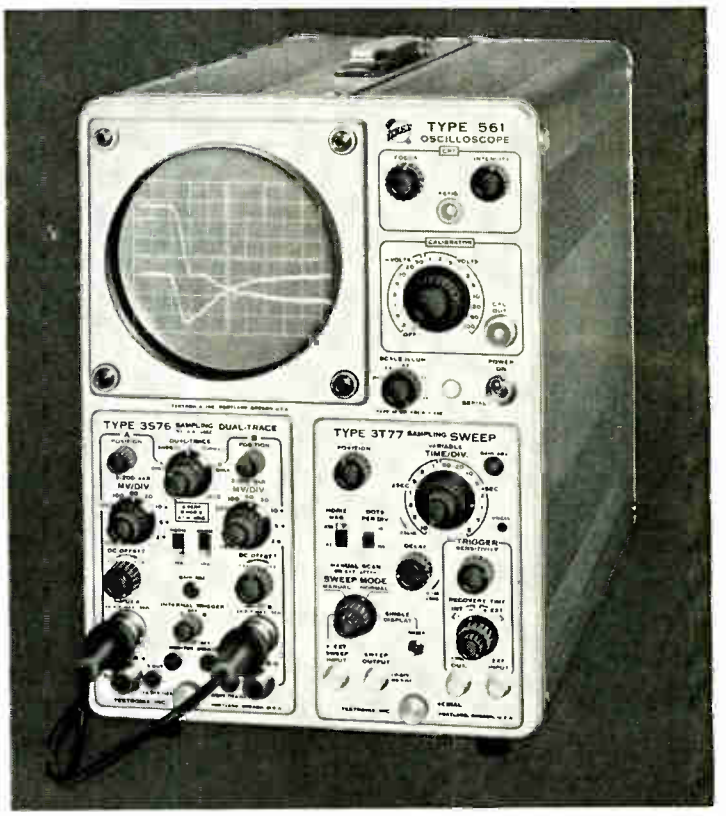

WHAT YOU CAN DO WITH A TYPE 561 USING TYPE 3S76 AND TYPE 3T77 PLUG-IN UNITS

Trigger internally from A and B signals.
Matched internal delay lines in both channels assure accurate time comparisons.

Measure pulse risetimes with 0.4 nanosecond response or better in both channels. Time-measurement range extends to 100 microseconds.

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Change the probes' signal source without affecting the dot transient response.

Reduce time jitter and amplitude noise, if needed, on the more sensitive vertical ranges and faster sweep rates by means of a smoothing control.

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Show lissajous patterns, observe single or dual-trace displays, add signals algebraically.

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Use other plug-in units for applications other than pulse sampling.

Type 561 Oscilloscope (without plug-ins)	$ 440
Type 3S76 Dual-Trace Sampling Unit	$1100
Type 3T77 Sampling Sweep Unit.	$ 650
Probes:	
Type P6026 Passive Probe	$ 140
Type P6032 Cathode-Follower Probe	$ 160

10 other plug-in units available—to provide special performance adapted to particular applications.

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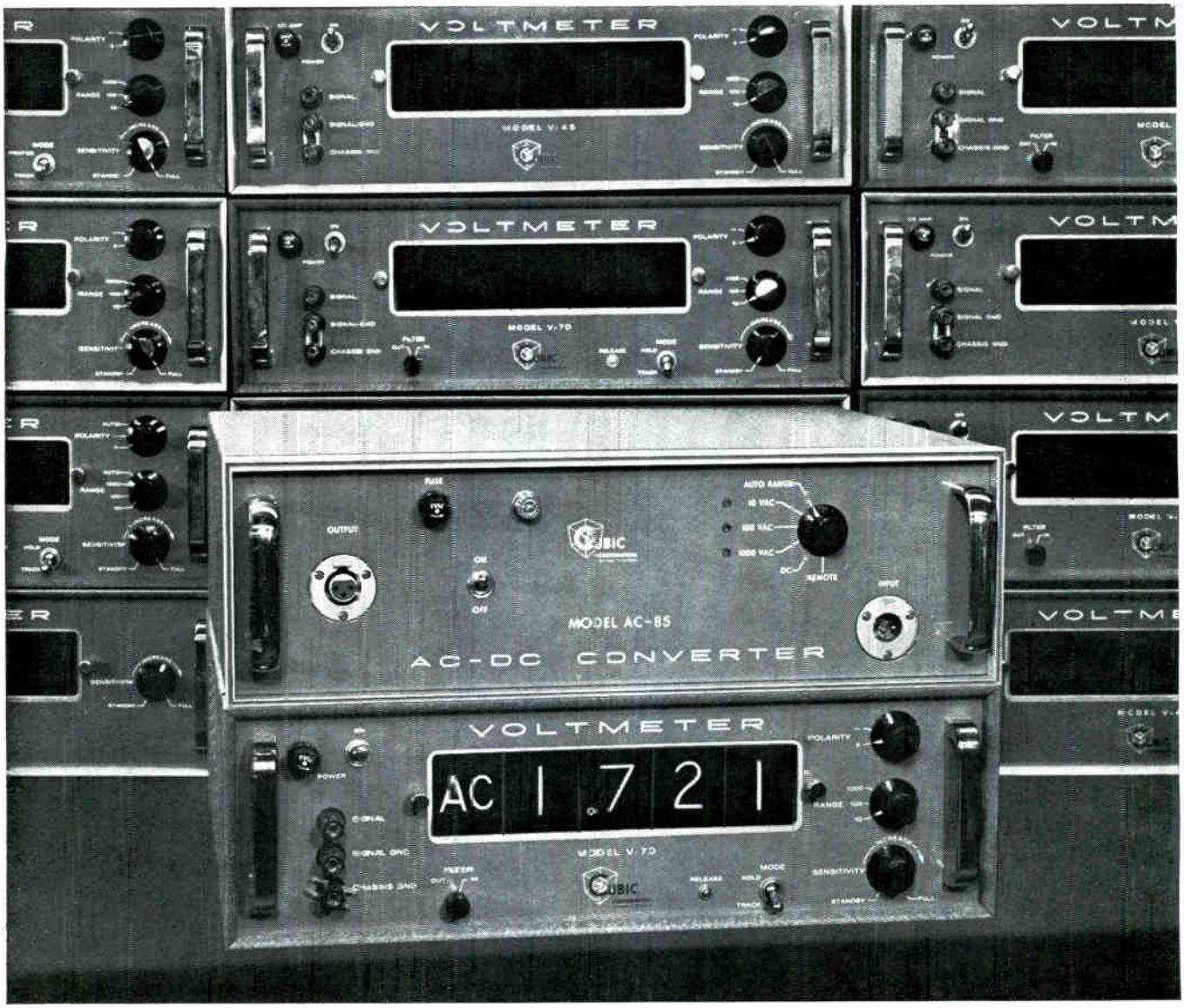

Cubic announces an a-c converter that works with ANY digital voltmeter!

The new, universal Model AC-85 Converter is now available from Cubic Corporation to provide a means by which precision A-C measurements may be made with all floating input D-C digital voltmeters, pen recorders or *any* similar measuring device. It is a self-contained, self-powered converter that is not dependent upon the device with which it is used.

The AC-85 is fully automatic. It thinks for itself; it senses input voltage and automatically places itself in the correct range. Ordinary automatic ranging converters depend on the voltmeter to tell them when to change ranges and go through a multiple nulling process if a range change is required. This self-ranging converter is faster operating because it only nulls once. The AC-85 has all these features: Nuvistor input for maximum stability; input may be floated to 500 volts DC; common mode rejection in excess of 70 db at 60 cps; frequency range 30 cps to 20 kc; accuracy 0.1%; sensitivity 1 millivolt. Price $1400. For more details, write to Dept. A-135, Cubic Corp., San Diego 11, California; or Cubic Europa S.p.A., Via Archimede 181, Rome, Italy.

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Typical properties of 10-mil Kynar insulation extruded over AWG 24 solid soft copper conductor:

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Insulation Resistance, meg-ohm/M	> 1,500
Cold bend, ½" dia., 1 lb. weight at —70°F, volts	8,000
Abrasion Resistance, Janco Tester grade 400 alum., inches	50
Cut through, anvil at 90°, 350 gm. minutes at 280°F	730
Soldering test, flare back	None
Flammability	self extinguishing

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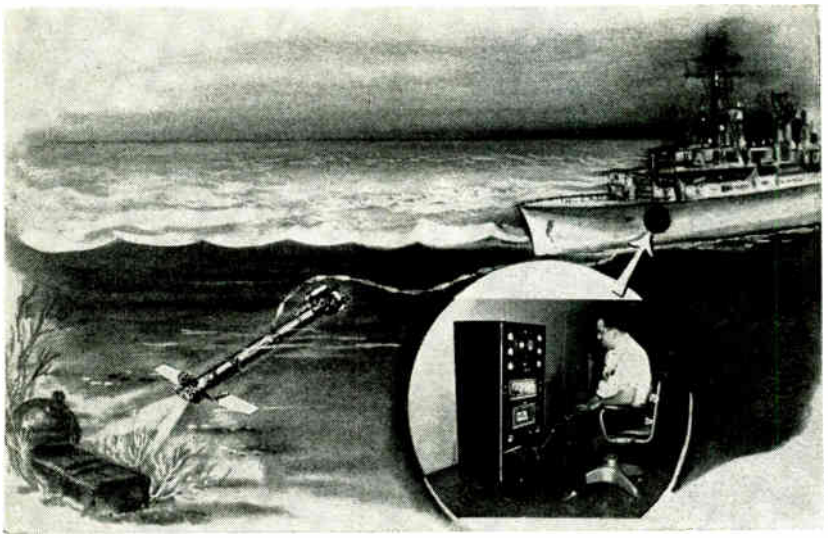

Operator (inset photo) operates plane with joystick and rudder bar. Plane can carry various sensors for underwater scouting

Sonar and Tv Scout Underwater

REMOTELY CONTROLLED and powered version of its Pegasus underwater plane has been developed by Loral Electronics. The plane would be used by submarines, surface ships, helicopters or shore stations for detailed underwater inspection, detection or reconnaissance.

Normally, such planes are ridden by a scuba diver. Instead of a diver, the remotely controlled plane has a power and signal cable and sensing devices. Loral says the plane is now equipped with forward and depth sonar, a tv camera and operating instruments.

The plane is guided by a joystick and rudder bars at the control console. Roll, pitch and yaw control surfaces are moved by servos driving electrohydraulic cylinders on the plane. Console displays include sonar, tv, attitude indicator, depth gage, logs and other operating instruments.

Use of remote power supplies enables the plane to operate indefinitely. The manned version is powered by batteries, limiting operation to two hours at the top speed of 3.5 knots.

Television Continues to Grow in Other Countries

U. S. INFORMATION AGENCY has issued a report on the overseas growth of television during 1961. At the end of the year there were 2,047 transmitting stations and almost 54 million tv sets. The figures exclude U. S., Canadian and U. S. Armed forces stations.

In noncommunist countries, the number of stations increased by 442 to 1,666, and the number of sets in use increased by nine million to a total of 44.5 million. In communist countries, the number of stations increased by 117 to a new total of 381 and the number of sets increased two million to 9.5 million.

Pill-Sized Half-Watt Tube Developed for Navy

RCA HAS DEVELOPED a nuvistor triode requiring less than a half-watt of heater power. It is half the size of commercial nuvistors.

As an amplifier, the tube has a range to well over 1 Gc. RCA said it can also be a uhf power oscillator and would have other uses in battery-operated uhf equipment. The tube can be installed in transistor sockets, and in coaxial and printed circuits.

A 50-tube shipment sent to the Navy—which sponsored development—weighed less than 1.5 oz. RCA expects the Navy to evaluate it for use in antisubmarine warfare and aircraft equipment.

in the **R-58**

CHEMINAX

MINIATURE COAXIAL CABLE

replaces **RG 180**

	WEIGHT	CONDUCTOR	CAPACITANCE	ATTENUATION	IMPEDANCE	DIELECTRIC	O. D.
CHEMINAX	9.5 lb	AWG 28 (Copper Covered Steel)	13.5 μμf/ft	10 db/100'	93 ohms	RAYFOAM L	.135"
RG-180	17 lb	AWG 30 (Copper Covered Steel)	14.5 μμf/ft	14 db/100'	93 ohms	*TEFLON	.135"

*DUPONT

LEADER IN RADIATION CHEMISTRY
FOR ELECTRONIC WIRE AND CABLE

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MEETINGS AHEAD

AEROSPACE INSTRUMENTATION SYMPOSIUM, ISA; Marriott Motor Hotel, Washington, D. C., **May 21-23.**

ELECTRONICS PARTS DISTRIBUTORS SHOW, Electronic Industry Show Corp.; Conrad Hilton Hotel, Chicago, **May 21-24.**

SELF-ORGANIZING INFORMATION SYSTEMS CONFERENCE, Office of Naval Research and Armour Research Foundation; Museum of Science & Industry, Chicago, **May 22-24.**

MICROWAVE THEORY & TECHNIQUES NATIONAL SYMPOSIUM, IRE-PGMTT; Boulder, Colo., **May 22-24.**

POWER SOURCES CONFERENCE, U. S. Army Research and Development Laboratory; Shelbourne Hotel, Atlantic City, N. J., **May 22-24.**

TELEMETERING NATIONAL CONFERENCE, IRE-PGSET, AIEE, et al; Sheraton Park Hotel, Washington, D. C., **May 23-25.**

IRE SEVENTH REGION CONFERENCE, Seattle IRE Section; Seattle, Washington, **May 24-26.**

NUCLEAR CONGRESS & EXHIBIT, Engineers Joint Council; Statler Hilton Hotel, New York City, **June 4-7.**

RADAR ANNUAL SYMPOSIUM, University of Michigan; at the University, Ann Arbor, Mich., **June 6-8.**

MOLECULAR BEAMS CONFERENCE, Brookhaven National Laboratory; at the Laboratory, Upton, N. Y., **June 11-13.**

ARMED FORCES COMMUNICATIONS & ELECTRONICS ASSOC. CONVENTION & SHOW; Sheraton Park and Shoreham Hotels, Washington, D. C., **June 12-14.**

AEROSPACE TRANSPORTATION CONFERENCE, AIEE; Denver, Colo., **June 17-22.**

BROADCAST & TELEVISION RECEIVERS CONFERENCE, IRE; O'Hare Inn, Chicago, Ill., **June 18-19.**

VACUUM METALLURGY CONFERENCE, American Vacuum Society and New York University; NYU's University Heights Campus, N. Y. C., **June 18-19.**

SPECTROSCOPY INTERNATIONAL CONFERENCE, Society for Applied Spectroscopy; University of Maryland, College Park, Md., **June 18-22.**

AEROSPACE SCIENCES SUMMER MEETING, Institute of Aerospace Sciences, Los Angeles, Calif., **June 19-22.**

MILITARY ELECTRONICS, 6th National Convention, IRE-PGMIL; Shoreham Hotel, Washington, D. C., **June 25-27.**

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

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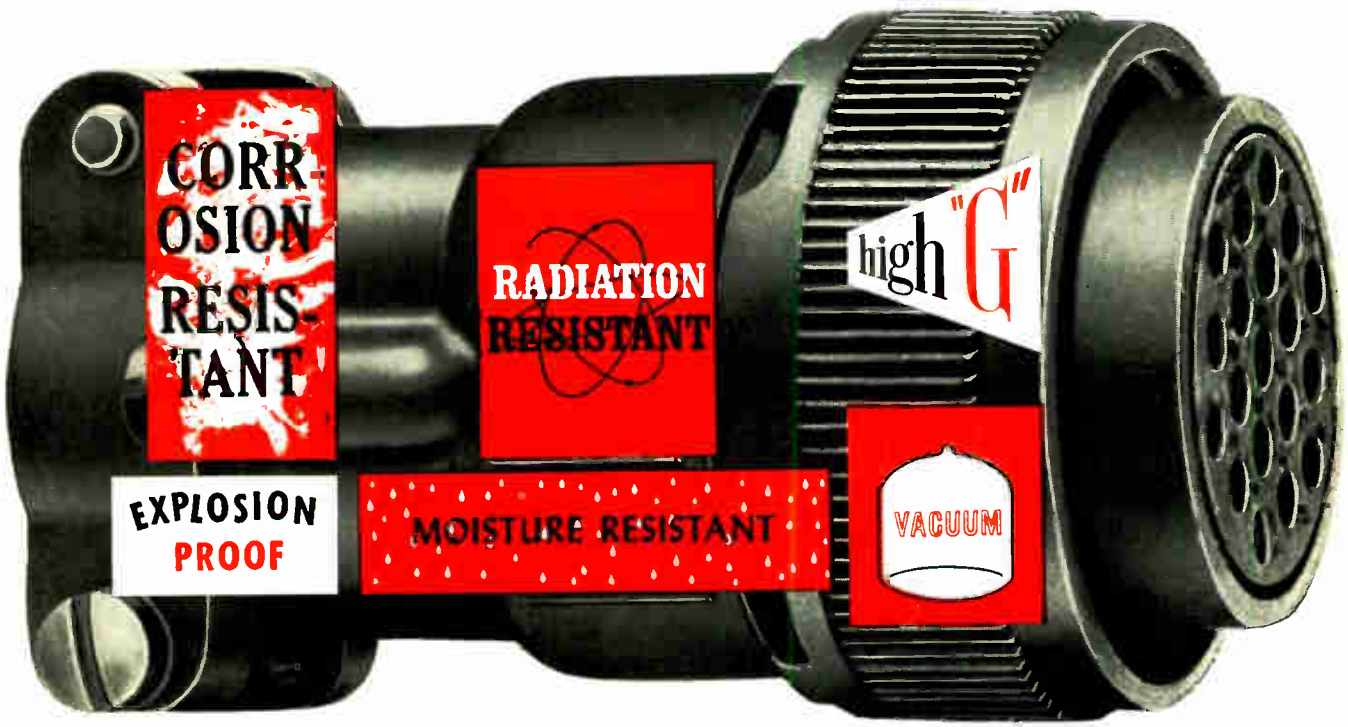

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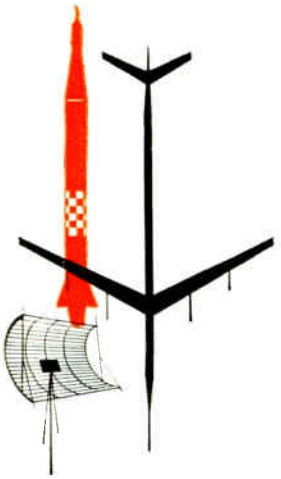

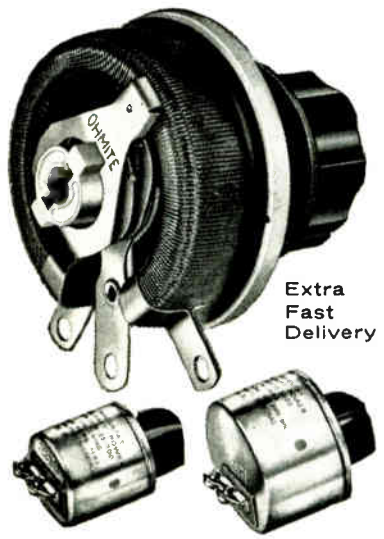

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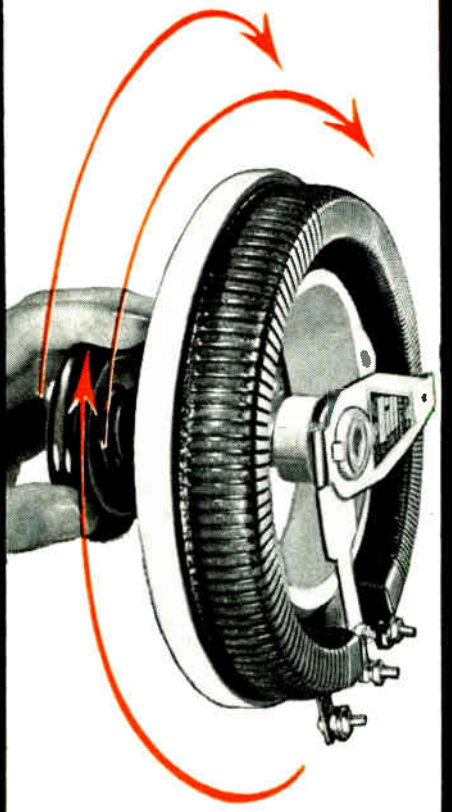

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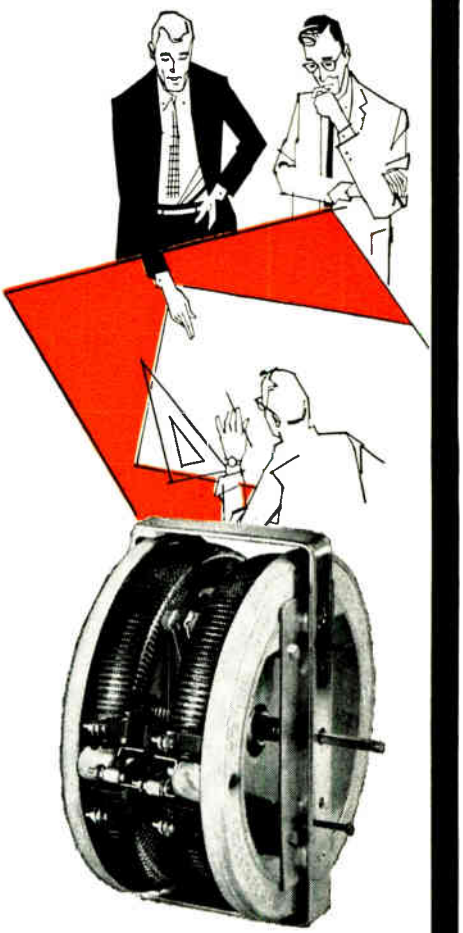

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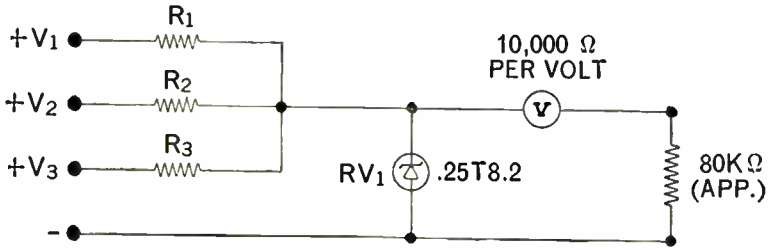
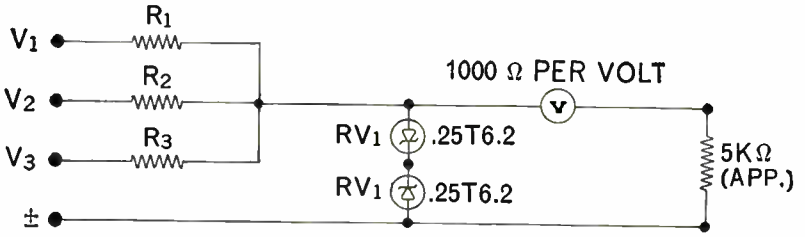


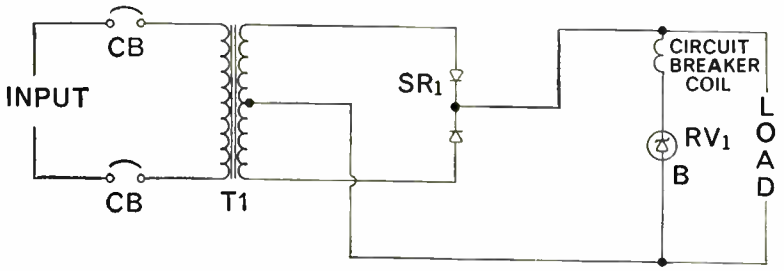
PROTECTION OF DC METER MOVEMENTS

R_1, R_2, and R_3-Meter Multipliers.
RV_1-Sarkes Tarzian Type .25T8.2 Regulator.
V = 100 Microampere Meter Movement.



PROTECTION OF AC METER MOVEMENTS

R_1, R_2, and R_3-Meter Multipliers.
RV_1-Sarkes Tarzian Type .25T6.2 Regulators.
V = 1 Milliampere Meter Movement.

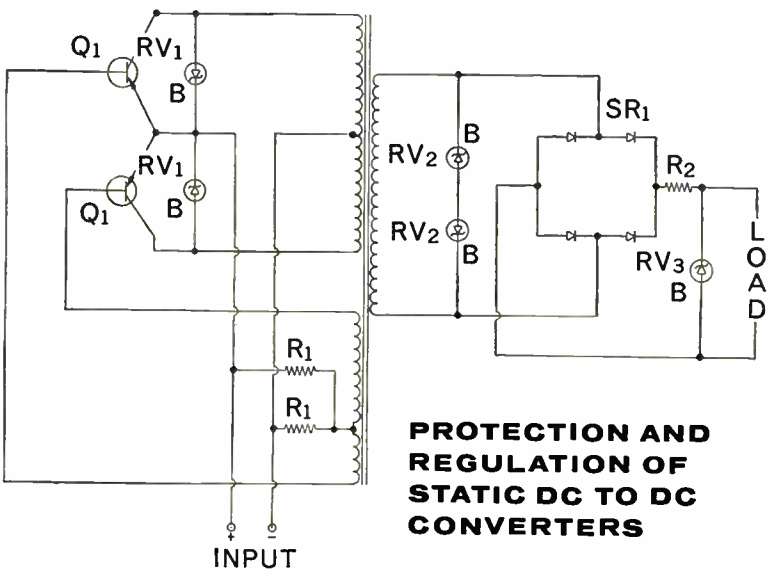


OVERVOLTAGE PROTECTION FOR SENSITIVE LOADS

RV_1-Selected to Avalanche at Critical Voltage and Cause Circuit Breaker to Open.

■ Not too long ago, the regulator diode (Zener) was considered a "luxurious" component, to be used only in the most sophisticated circuit. Progress in processing techniques and predictable voltage yields has made almost any application economically practical. The small size, inherent ruggedness, and physical simplicity of these devices—and their clipping, limiting, and protecting functions—can now be put to work widely.

The four applications shown here, while typical, can only suggest the usefulness of the silicon voltage regulator. We hope they will also suggest some useful answers to your problems, or new ways to improve reliability and performance. Our new catalog, 61-VR-11, contains data on five Tarzian series of silicon voltage regulators, plus design and test information. We will include prices. (You may be pleasantly surprised!) Prompt engineering service is also available.



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RV_2-Transient Voltage Suppressors.
RV_3-Voltage Regulator-Transient Suppressors.

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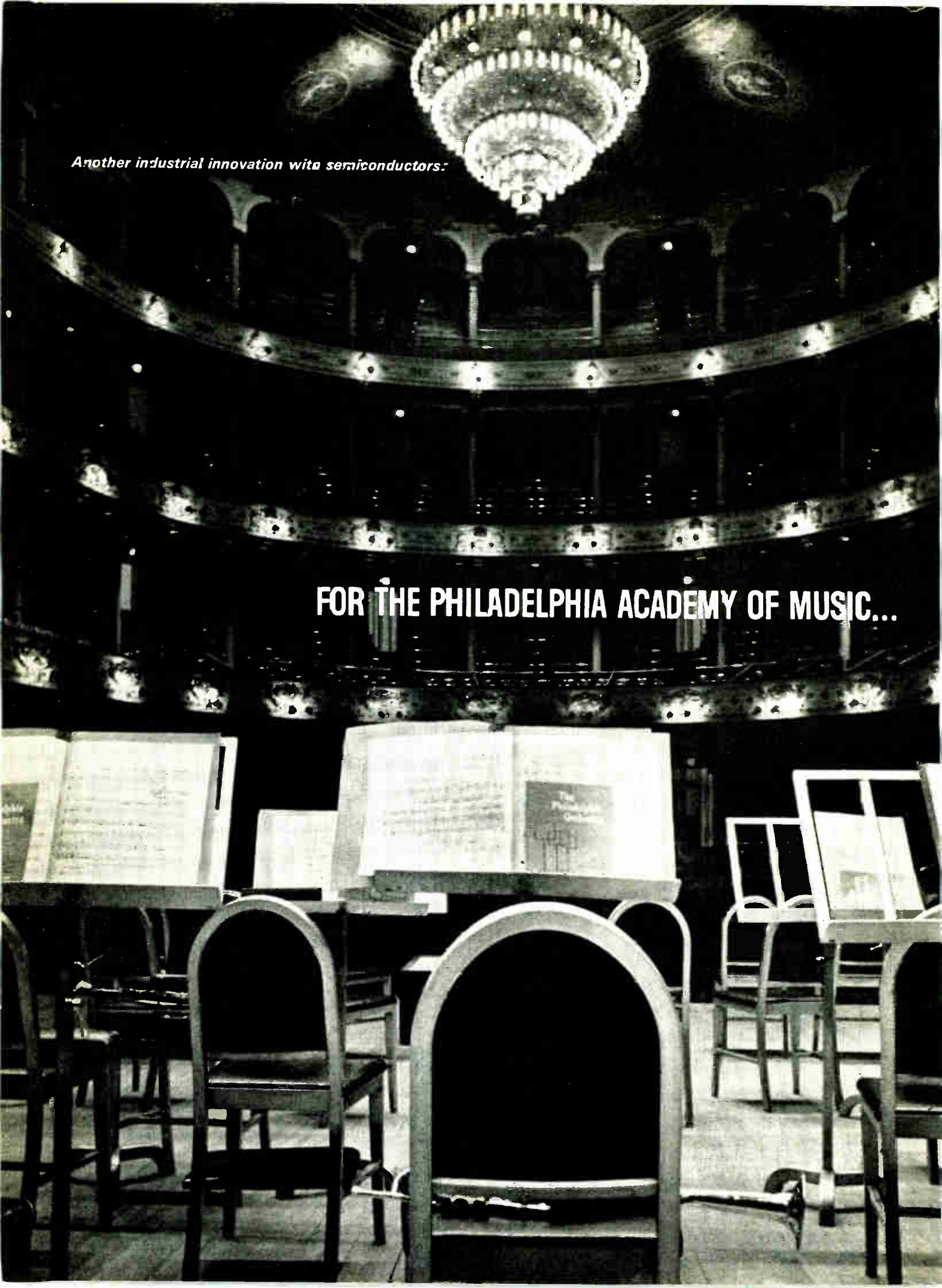
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This industrial innovation with a Westinghouse silicon semiconductor modernizes stage lighting controls and makes dramatic savings in crowded space area! Only 144 Westinghouse Trinistor controlled-rectifiers are required to control 72 six-kilowatt circuits . . . more than 400 kilowatts of power. The system is so compact and versatile that one operator at the control console can swiftly dim or switch any number of these circuits in any combination.

The Westinghouse Trinistor controlled-rectifier was chosen for this application because it combines the functions of a precision switch and a power-handling capacity of a high-power rectifier—all in a compact solid-state device with these characteristics: forward currents to 70 Amps. Switching times in the millimicrosecond range. Compact size and weight as low as 3 oz. Efficiencies up to 98%. Rise time; 200 volts per microsecond.

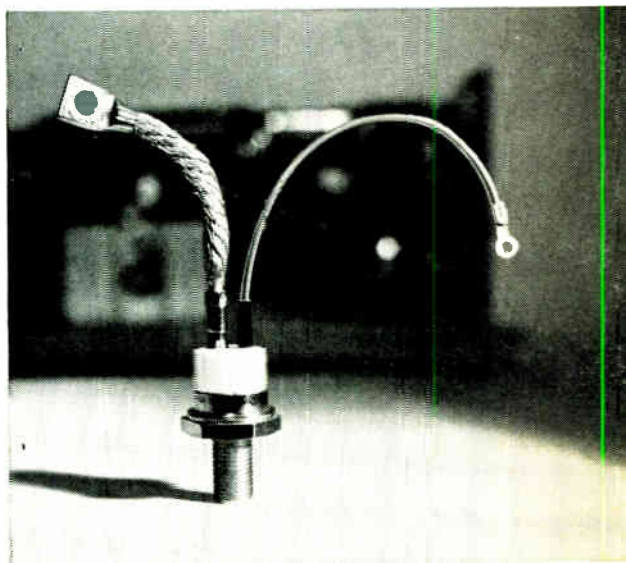
This device may enable you to achieve important product innovation, or gain valuable "lead time" over competition. It offers significant advantages in motor generator sets for static inverters, power supplies for high-speed induction motors, induction heating, fluorescent lighting, and many other applications. For complete information call your nearest Westinghouse distributor. Or write: Westinghouse Electric Corp., Semiconductor Dept., Youngwood, Penna.

You can be sure ... if it's **Westinghouse**

SC-1055

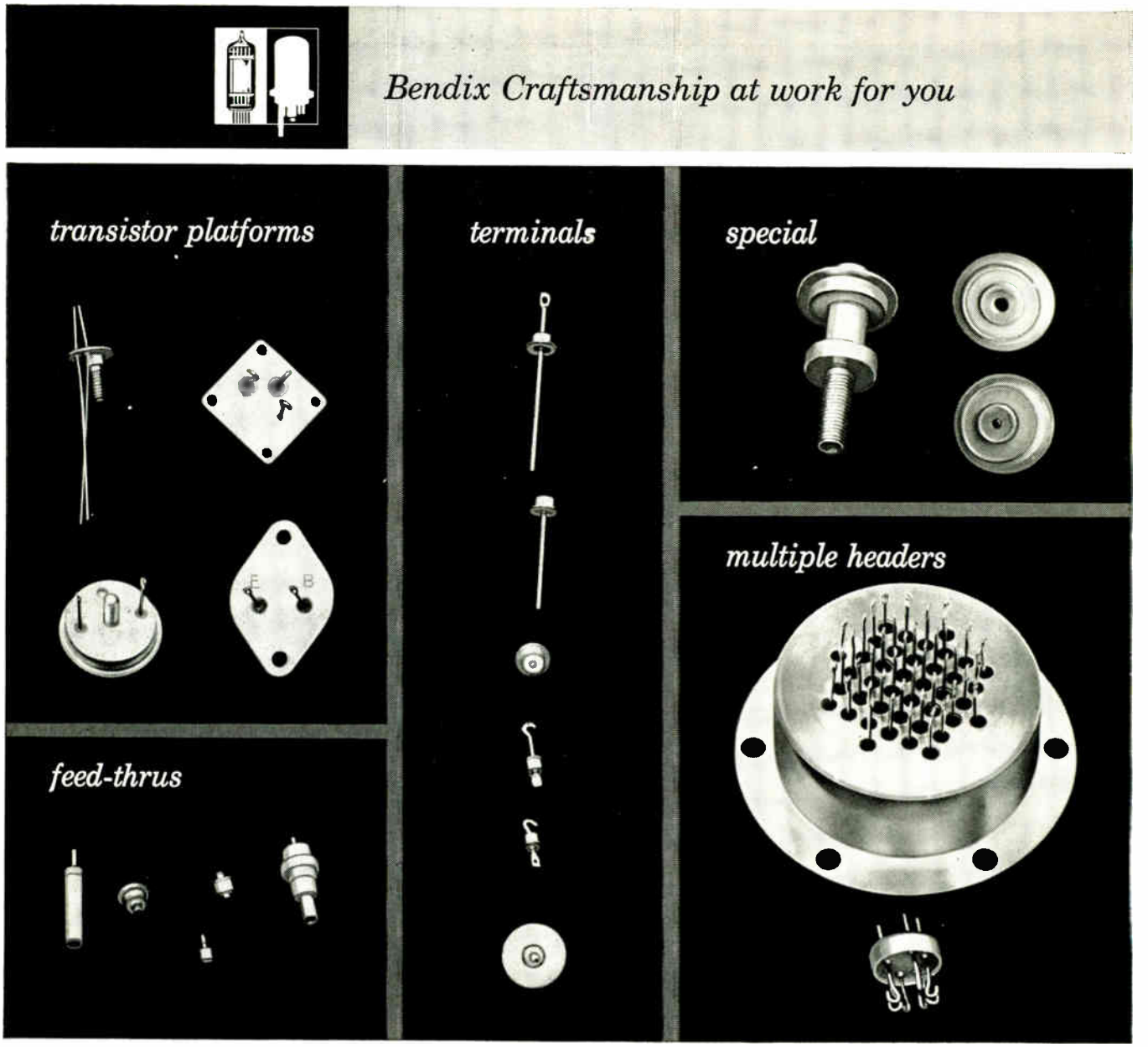
*TRINISTOR—Westinghouse trademark, pronounced TRY-NIS-TOR.

Compact console controls 72 six-kilowatt circuits. Herbert Kliegl, President of Kliegl Bros., Charles Roberts, Westinghouse Sales Engineer, and Stuart Louchheim, President of Philadelphia Academy of Music, inspect new lighting control system.



Each dimming "module" controls 6-KW load—with two 70-amp Trinistor controlled-rectifiers wired "back to back." Dimming units are controlled by signals from console. Rectifier-based control system has no moving parts, offers unlimited life.

Co-ordinated engineering at work. Herbert Kliegl (left), President of Kliegl Brothers, discusses design requirements with Charles Roberts, Westinghouse sales engineer. Such close cooperation helps equipment manufacturers to develop new products to meet customer specifications.



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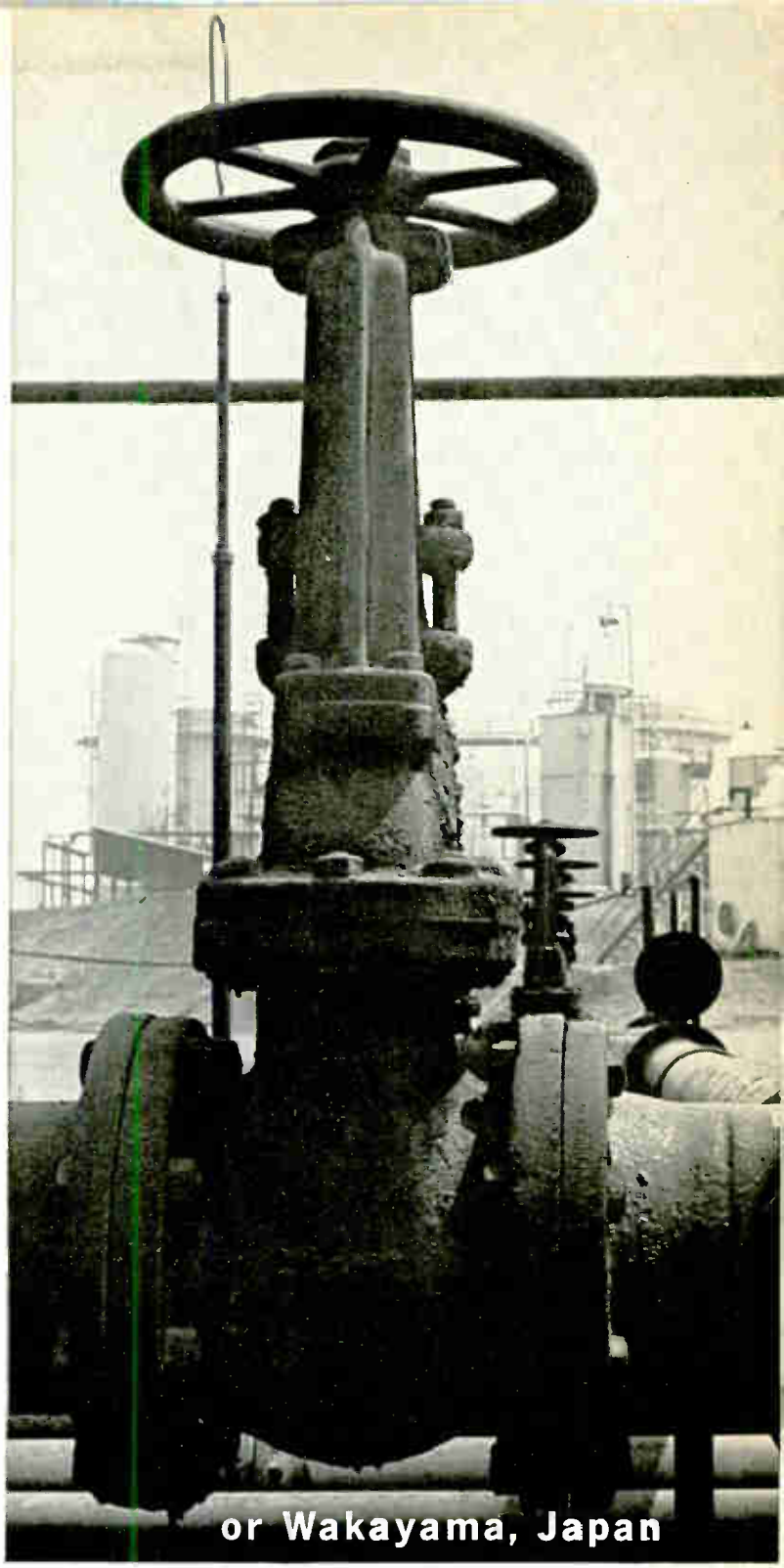
←CIRCLE 45 ON READER SERVICE CARD

CIRCLE 47 ON READER SERVICE CARD→



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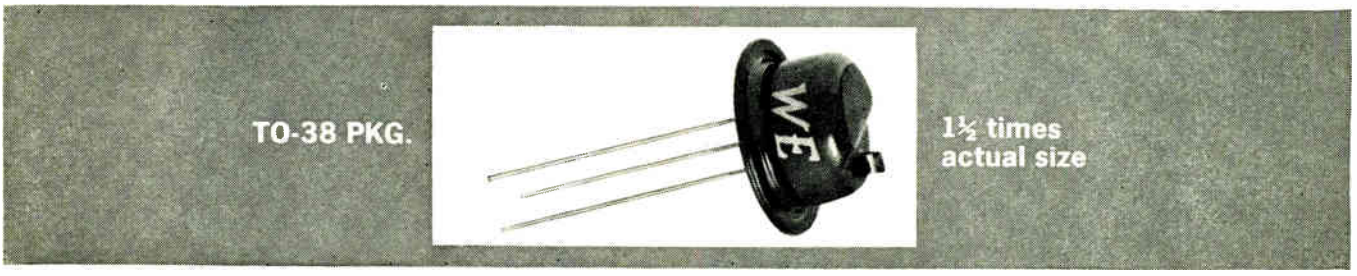
To Contractors and Subcontractors on U. S. Government Projects

HIGH CURRENT SWITCHING TRANSISTOR 2N1072



12.5 WATTS, 75 VOLTS, 2 AMPERES

Western Electric's 2N1072 is an NPN diffused silicon mesa transistor, designed by Bell Telephone Laboratories for high current switching and core driver applications. Typical turn-on time is 80 nanoseconds. Typical turn-off time is 200 nanoseconds. One ampere may be switched at rise and fall times of 50 nanoseconds. The maximum power dissipation at a case temperature of 100°C is 5 W.

ABSOLUTE MAXIMUM RATINGS (T_C=25°C)

P_C	V_{CES}	V_{EBO}	V_{CBO}	I_C &-I_E
12.5 W	75 Vdc	6.0 Vdc	75 Vdc	2.0 A

ELECTRICAL CHARACTERISTICS

	h_{FE}	V_{CE} (sat)	V_{BE} (sat)	$t_d + t_r$	$t_s + t_f$
	(V_{CE}=5 Vdc)	(I_C=750 mAdc)	(I_C=750 mAdc)	(V_{CC}=20 Vdc)	(R_C=25 ohms)
	(I_C=750 mAdc)	(I_B=75 mAdc)	(I_B=75 mAdc)	($I_{B\,(1)}$=75 ma)	
				($V_{BE(O)}$=0)	($I_{B(2)}$=–75 ma)
Min.	20	–	0.70 Vdc	–	–
Max.	–	2.0 Vdc	1.8 Vdc	100 nsec	300 nsec

The 2N1072 transistor may be purchased in quantity from Western Electric's Laureldale Plant. For technical information, price, and delivery, address your request to Sales Department, Room 102, Western Electric Company, Incorporated, Laureldale, Pa. Telephone — Area Code 215 — 929-5811.

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electronics
May 18, 1962

Automatic control panel for epitaxial furnace

Epitaxial Growth and Devices

Semiconductor crystals grown by vapor deposition on substrates can be closely controlled for thickness and resistivity, to make devices such as epitaxial mesa and field-effect transistors, and integrated circuits

By RAYMOND M. WARNER
Manager, Materials Research,
Motorola Semiconductor Products Inc.,
Phoenix, Arizona

THE SEMICONDUCTOR industry has progressed along a path marked by significant technique innovations which have appeared at remarkably regular intervals. These techniques have had to do mainly with junction formation. The most recent is epitaxial growth. It has been exploited seriously for about two years, although in point of origin it is considerably older.[1]

In the epitaxial process, a solid semiconductor crystal is grown from the vapor phase by deposition on a substrate. The substrate is usually a wafer or slice cut from a semiconductor crystal grown by more conventional means. It is customary to grow silicon layers on silicon substrates, germanium on germanium, although dissimilar materials can be mated by epitaxial growth if their properties match well enough. For example, gallium arsenide films can be grown on germanium substrates.

Through this process it is possible to produce layer upon layer, as shown in Fig. 1 (top), in a specimen which represents a radius of a wafer. These can be highly controlled in thickness and resistivity. This potentiality goes far beyond the capabilities of any previous technique. Device requirements presently make modest demands on the number of layers desired—perhaps four at most. But it certainly is reasonable to assume that future requirements will make fuller use of this capability. Integrated circuit developments will likely exert pressure in this direction.

Structures incorporating nonplanar layers can be achieved by using a contoured substrate. The result of such a procedure is shown in Fig. 1 (bottom). Pictures such as shown in Fig. 1 are made by polishing a facet on the specimen at a small angle to the top surface and then staining the facet chemically

to delineate n and p regions. This procedure geometrically magnifies vertical dimensions for clearer observation.

The epitaxial art has been employed first in improving familiar existing devices such as mesa transistors. But it is now being applied to devices that could be made only inefficiently, if at all, by previous techniques.

Of particular note at this laboratory have been the contributions to epitaxial work made by G. V. Russell, W. J. Corrigan, J. T. Law and R. R. Haney.

While silicon is but one of several materials currently being prepared successfully by the epitaxial process, it is the most important, and therefore will serve as an example.

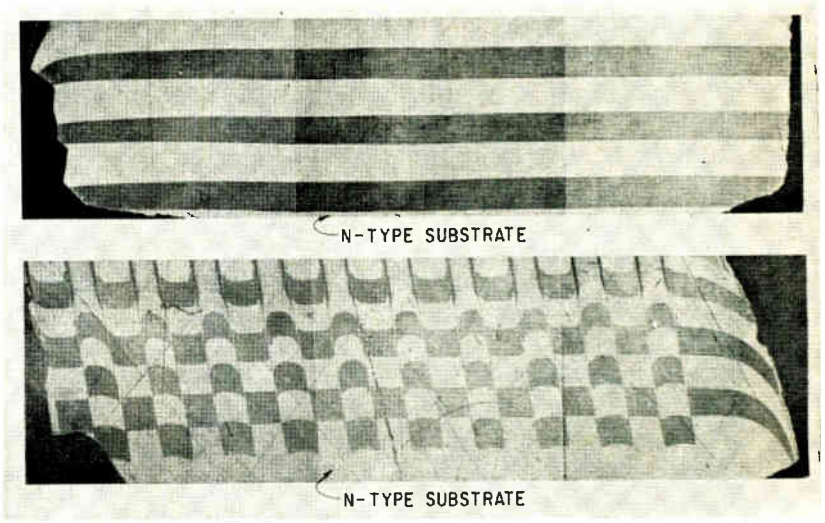

FIG. 1—Six epitaxial layers of alternating type (top); epitaxial checkerboard (bottom) formed by growth on contoured substrate

In one process, a mixture of hydrogen and silicon tetrachloride flows through a quartz tube into the reaction zone of the furnace. The flow path may be vertical or horizontal. The difference here is not as trivial as it might at first seem because the silicon slices or wafers on which growth is to occur are in general lying on a horizontal surface, and the flow conditions over them have an important bearing on growth uniformity. Significant claims can be made for either arrangement. To be specific again, consider the horizontal case. Here the reaction zone is simply a further length of quartz tube, as shown in Fig. 2A. Energy is delivered to the reaction zone by external r-f coils that couple to a graphite "susceptor." The wafers lie on top of a quartz sleeve which encases the susceptor, and they are thus protected from possible contamination by impurities from the graphite.

In the overall reaction that proceeds in the vicinity of the heated silicon wafers, hydrogen reduces silicon tetrachloride to form pure silicon and hydrogen chloride gas. Silicon evolved in the reaction deposits on the silicon wafer and has a strong tendency to continue the crystallographic pattern embodied in the wafer. This continuation of structure is "epitaxy." While this picture of the process is imperfect with respect to detailed mechanisms, it is reasonable to assume that to maintain the crystal pattern, a silicon atom on the growing surface must be given time to migrate to a "proper site" (crystallographically speaking) or to leave the surface before it is trapped by other atoms in a wrong position. This qualitative picture is supported by the observation that disordered growth occurs if the growth rate is pushed above a certain value at a given temperature. Raising temperature raises the tolerable growth rate. Since the rate of the deposition process can be controlled, and since it can be stopped at any time by shutting off the reactants, the thickness of the epitaxial layer can be controlled to within a few tenths of a micron.

It is also possible to adjust impurity doping precisely. Again, a number of methods can be used. An impurity compound may be mixed in a small quantity with the silicon tetrachloride; it too can then be reduced in the reaction zone and the impurity atoms will be included in the crystal. Alternatively, separate vessels can be provided for the main silicon tetrachloride supply, for a p-doped supply, and for an n-doped supply, giving separate n and p ports, as suggested in Fig. 2A. As in the main supply, a carrier gas can be sent through the doped vessels. Also, diffusion can be employed as the delivery mechanism. In the latter, it is possible to control vapor pressure by adjusting temperature. Still another approach employs gaseous impurity compounds diluted in a carrier gas. In general, control is more difficult as resistivity goes up, that is, as impurity control goes down. Practical control at present is about 10 percent at the one-ohm-centimeter level.

The epitaxial process lends itself to mechanization because such parameters as flow rate and flow time are keys to the control of layer resistivity and thickness. The lead photograph depicts an automatic control panel capable of controlling an epitaxial furnace that repeatedly produces layers with predetermined properties. The specimen shown in section in Fig. 1 (bottom) was produced with this apparatus. The panel embodies timers, flowmeters, valves and related equipment for controlling gas flow into the associated furnace.

The epitaxial mesa transistor[2, 3, 4] represents a first major application of the technique. Some of the principles and advantages embodied in such a structure were elucidated previously by Early.[5] The structure of the epitaxial silicon mesa transistor is sl.own schematically in Fig. 2C with that of a conventional silicon mesa (Fig. 2B) for comparison. In the conventional device, both junctions are formed by diffusion, producing a p-type base region about one micron thick. But the n-type collector region is typically 50 to 100 times thicker for mechanical strength.

In choosing the resistivity of this region, which is the starting

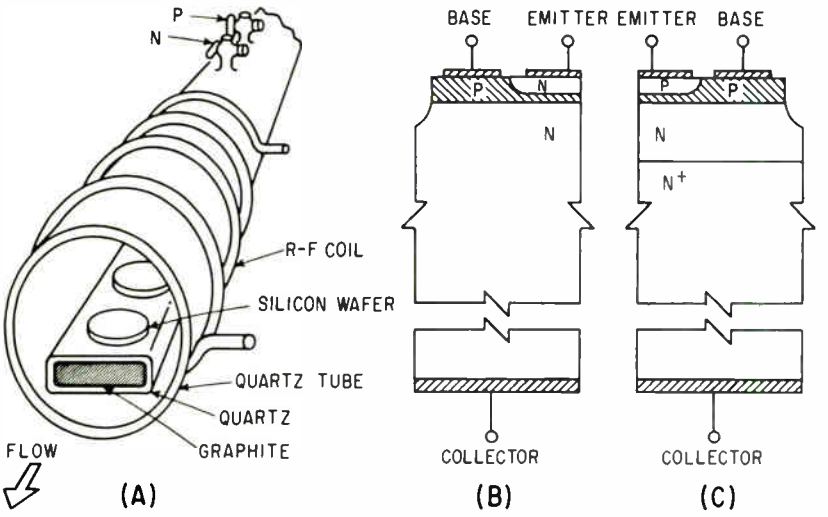

FIG. 2—Reaction zone of epitaxial furnace (A); conventional mesa transistor (B); epitaxial mesa transistor (C)

material, the designer notes that a high value favors high breakdown voltage for the collector junction and low parasitic capacitance. But all the output current from the transistor must flow through this region, and its nonnegligible resistance leads to losses, so that, from this point of view, low resistivity favors efficiency. A vexing compromise was therefore necessary until epitaxial growth gave the designer new freedom. He could now use low-resistivity starting material having a thin high-resistivity epitaxial layer on top, as shown in Fig. 2C. Another way of looking at this structure considers the n^+ region to be a "handle," or simply an extension of the collector ohmic contact.

Among the important advantages of the new design are a lower collector-to-emitter voltage when the transistor is conducting. This affects the efficiency of the transistor as a switch. It also affects its efficiency as a high-frequency oscillator or amplifier. Further, the lower parasitic collector resistance makes the epitaxial transistor a more linear amplifier under certain load conditions than a comparable conventional transistor.

The application of epitaxy to junction transistors has been carried further. Thousands of mesa devices have been made with base regions grown epitaxially as well as collector regions[6]. These have demonstrated unequivocally that epitaxial *p-n* junctions are at least as good as diffused junctions.

The field-effect transistor was proposed and analyzed by Shockley[7] over nine years ago. Even though it has properties of interest and utility to circuit designers, it has still not acquired any appreciable commercial significance. Its fabrication poses a difficult problem which has made it, in a sense, a device in search of a technique. Specifically, the field-effect transistor requires a thin semiconductor layer sandwiched between regions of opposite conductivity type within a single crystal. That is, it requires a thin *n* layer between two *p* regions, or the reverse. Alloying, diffusion, growing from the melt, etching and mechanical cutting have all been employed in making field-effect transistors. But these techniques generally lack the refined control necessary to make the device a practical entity.

Epitaxial growth is so well adapted to making micron-thin, uniform layers in a reproducible way that it promises to make the device a practical one at last. It is true that one-micron base layers are common in conventional diffused junction transistors, but they typically contain ten to one hundred times more impurity doping than can be tolerated in the field-effect transistor; light doping in a thin layer is the combination that is so difficult to control by previous methods.

In Fig. 3A is a schematic representation of the device. Consider that the gates and source are connected together as indicated by the dashed lines. When a positive voltage is applied to the drain, then the full applied voltage appears across the junctions bounding the drain region, while no applied voltage appears across those bounding the source region. The transition from zero to full applied voltage represents *IR* drop associated with a current flowing from right to left in the channel.

The junctions bounding the drain and channel are reverse-biased and only negligible leakage currents flow across them. But the region of depleted carrier concentration—the depletion layer—associated with the reverse-biased junction is fundamental to the transistor's operation. The junction acts as an insulator to transverse current such as channel current. Therefore, as the depletion layer grows thicker with increasing applied voltage, the channel's resistance increases. When the depletion layers meet at the right end of the channel, a condition known as pinch-off has been reached. Further increases in voltage thicken the depletion layers to the right of this point, but the current remains nearly constant. The thickening depletion layers are a sort of sponge that soaks up additional applied voltage, a limit to this process being imposed by avalanching, which ultimately will occur, causing a sharp increase in current through the device.

By reverse-biasing the gates with respect to the source, it is possible to thin down the channel electronically. Thus when drain voltage is applied as before, pinch-off occurs at a lower drain voltage and current. Thus it is possible to generate a set of characteristics like those shown in Fig. 3B, having gate voltage as a parameter. These transistors are usually used with gates common, but the gates can be employed independently if desired.

Like a pentode vacuum tube and like a junction transistor operated in the common base mode, the field-effect transistor exhibits high output impedance. But unlike the conventional transistor it also exhibits

high input impedance, mitigated only by parasitic junction capacitances. Its high input impedance is a property of interest to circuit designers. While it shares this property with the vacuum tube, it has the important transistor advantages of small size, simplicity and power economy, as well as the possibility of complementary pairing. That is, it is possible to make a device with a *p*-type channel and *n*-type gates. Its performance, in silicon, is somewhat inferior to that of the *n* channel unit because *p* carriers move three times slower in response to an electric field than *n* carriers. But this unit takes opposite bias polarity. With homologous pairs it is possible to open intriguing areas of application.

Closely related to the field-effect transistor is the field-effect diode, or current limiter.[8] It has a current-voltage characteristic which is essentially that of the transistor with $V_G = 0$, Fig. 3B.

The current limiter is the current analog of the zener diode. Its most obvious use is as a straightforward current regulator in a series circuit. Also, it can be used as a protective device. Less obvious is its application as a sort of choke, exploiting its high ratio of a-c to d-c resistance when biased in the constant current region of the characteristic. Thus as a coupling element it offers high impedance without requiring the excessive bias voltage that a resistor would require. The advantage here is twofold. First, the primary supply voltage requirement is diminished and second, the overall dissipation in the circuit (an increasingly important problem in integrated circuits) is diminished by eliminating the power otherwise thrown away in a resistor.

Numerous other applications have been suggested. A current limiter can be used to charge a capacitor at a constant rate, thus generating a ramp voltage. Placing current limiters of graduated current levels in series gives rise to an intriguing staircase *I-V* characteristic. Current limiters of weighted current levels make excellent input elements in a digital-to-analog encoder; the voltage developed across the output resistor will be proportional to digital input even though the voltage applied to the input terminals varies within wide limits. Specifically, the input voltage can vary between the current limiter's pinch-off voltage V_p and breakdown voltage V_B.

There is a reason to believe that the realm of application of this new nonlinear diode will approach the scope enjoyed by the zener diode.

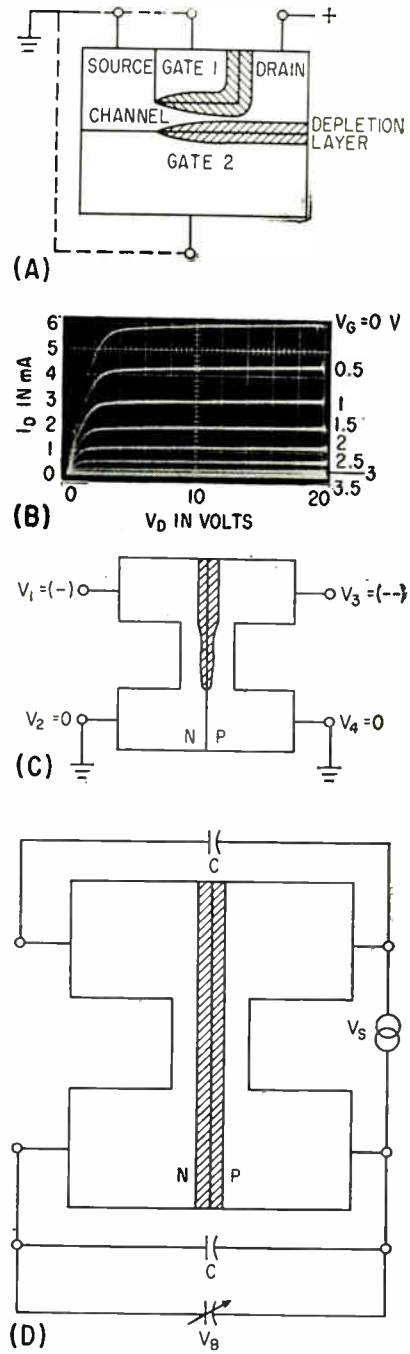

FIG. 3—Field-effect transistor (A) and its drain characteristics (B); field-effect tetrode (C); field-effect tetrode as a linear electronically variable resistor (D)

A future challenge to epitaxial technology is posed by the field-effect tetrode.[9, 10] Its structure, shown schematically in Fig. 3C, incorporates two thin channels side by side. Reverse bias is always maintained on the junction separating them, and thus each channel can be said to act as a gate for the other. The two adjacent channels pose more fabrication difficulties than the single channel required in each of the other field-effect devices. Nonetheless, this structure offers potentialities that make it worth pursuing. All these have already been demonstrated with nonepitaxial laboratory models which were made by laborious cut-and-try mechanical and chemical shaping methods.

Employed as a four-pole network, the tetrode exhibits gyrator properties[11] and is capable of inverting impedances. That is, a capacitor viewed through this network appears inductive. Considerable interest attaches to methods such as this for producing inductance without bulky wire-wound elements. The field-effect tetrode exhibits this special kind of nonreciprocity for a number of bias conditions, one of which is indicated in Fig. 3C. A positive voltage increment applied at the left port gives rise to an inward-flowing current increment at the right port, while a positive voltage increment at the right causes an outward-flowing current increment at the left. That is, the two transfer admittances of this network are opposite in sign.

A second unusual property of the tetrode can be observed by interconnecting terminals 2 and 3 and applying a voltage between 1 and 4, with terminal 1 positive. Beyond a certain voltage, the resistance of the two channels in series rises faster than the applied voltage, and therefore current decreases, resulting in a voltage-controlled negative resistance.

Probably the most interesting application of all for this new device is as an electronically variable yet truly linear resistor. Figure 3D illustrates the principle. Bias voltage V_B establishes a uniform depletion layer through the junction region. Capacitors *C*, with re-

actance small compared to channel resistance at the frequency of the signal voltage, V_s, insure that the signal voltage will not appear to any significant degree across the junction. Therefore the two channels in parallel constitute variable resistance totally unmodulated by the signal voltage. Signal voltage can exceed bias voltage and even junction breakdown voltage. Only dissipation considerations impose a limit.

It seems probable that epitaxial technology will find wide application in the integrated circuits area. At present there is an appearance of competition between diffusion and epitaxy in silicon integrated circuit work. But this is because requirements to date have not been nearly as bold as they will soon be in number of layers and profile control in them. When the number goes above two layers formed on one side of a crystal, epitaxy will enjoy a clear advantage. The two techniques will become, as they should be, complementary. Where heavy doping is desired at the surface, diffusion is a natural choice. This is usually the case where a metal-semiconductor contact is to be made. On the other hand, uniformly doped layers are not obtainable by diffusion.

O. P. Frazee of this laboratory has shown feasibility on an integrated circuit for performing the NOR function in a digital system. The embodiment he developed is truly monolithic in that it consists of a single semiconductor crystal. Schematically it consists of a transistor, three base-input resistors, and an output resistor, as shown in Fig. 4 (top). All interconnections in the circuit—as opposed to the connections to the header leads—are achieved by evaporated metal or by employing a common semiconductor region. Conventional wire-bonding methods are used for connections to the header leads, as shown in the photograph of the completed device, Fig. 4 (bottom).

The starting material consists of an n^+ substrate having three epitaxial layers grown on it. These are, in sequence, a 6-micron n layer to become the collector, a 1-micron p layer to become the base, and a 1-micron n^+ layer on top to become the emitter and the resistors. Through KMER (Kodak Metal Etch Resist) masking, mesas that form the emitter and the four resistors are etched completely through the n^+ layer but not through the p layer. In Fig. 4 (bottom), the emitter is a rectangle at right center, the three base input resistors are the serpentine mesas at the left, and the output resistor is the small mesa feature at the right.

Using KMER another time, a pattern is etched selectively in an evaporated metallic coating. This pattern provides metallized spots for wire bonding and also joins the input resistors to the base. The wire bonded at that point, left center in Fig. 4 (bottom), provides a test point in this exploratory model. Next, a deep moat is etched encircling the entire configuration to isolate it from its neighbors and from the edges of the chip. This moat defines the collector junction. Finally the integrated circuit is mounted on an eight-lead TO-5 header.

Positive input signals are used. These reverse-bias the junction defining the resistors, which is of course a necessary condition. Thus, for the *npn* transistor an *n*-type layer is indicated for the input resistors. A bonus from using the n^+ emitter layer is that the resistors have a low temperature coefficient of resistance. A positive signal on any input terminal, or any combination of them, gives a negative output signal, which leads to the NOR designation of this circuit. The reason that output signal magnitude is independent of the number of simultaneous input signals is that the transistor is in saturation.

The circuit is designed for 6-volt input operation; the junction breakdown limitation at the input is greater than 9 volts.

The input resistors regularly agreed within 10 percent, and were very linear. Their resistance was about 6,000 ohms, while the output resistor value was 750 ohms.

This circuit illustrates the possibilities of epitaxial techniques in integrated circuits.

To sum up, epitaxial growth technology has given the device designer and the integrated circuit designer a freedom that they have only begun to appreciate, let alone to use fully. It is safe to predict that it will find rapidly increasing application over the next few years.

The author acknowledges the support of the Air Force in portions of the epitaxial development reported here through contract No. AF33(616)8276.

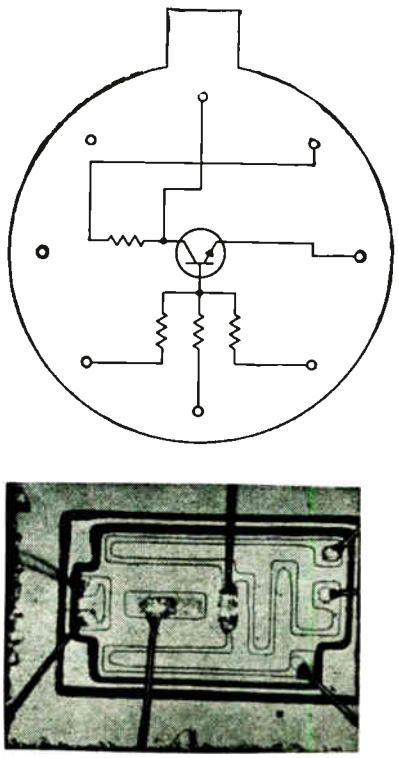

FIG. 4—All-epitaxial NOR circuit (top) and device (bottom)

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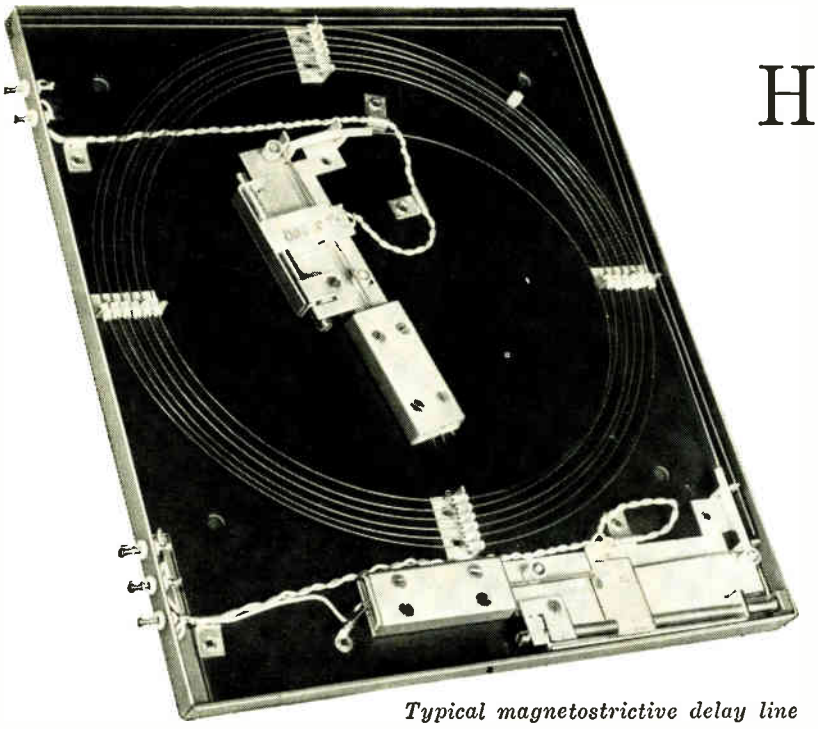

Typical magnetostrictive delay line

How to Specify

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INCREASING use of magnetostrictive delay lines in recirculating memories for digital computers emphasizes the need for practical specifications for these devices as electrical components. Unfortunately, when commercial delay lines were introduced a number of years ago, the prospective user was either unwilling or unable to determine specifications for the lines. He would submit circuit diagrams and models of his equipment to the delay-line manufacturer who would then tailor a line to fit. The only criterion for acceptance or rejection of the delay line was the overall system performance. System responsibility was shifted from the user to the manufacturer who then had to concern himself with circuit designs and other electrical components over which he had no control. There exists sufficient technical literature[1-6] on the theory, design, and application of this type of delay line to enable the user, in cooperation with the manufacturer, to determine reasonable electrical specifications for the line itself.

Particular attention will be paid to engineering principles by which the inductances of the input and output coils are designed as part of wideband electrical networks[3] which can pass the sharp rise times demanded in high-frequency digital operation.

In any type of magnetostrictive delay line, the conversion factor between electrical and mechanical energy is so small that the transducer impedances are primarily inductive. The delay line, which may be represented as in Fig. 1A, can be treated as a loosely coupled transformer with time delay between the input and output signal waveforms. As with other magnetic components, the delay line may be analyzed as a current input-voltage output device. Furthermore, such analysis may be accomplished under the circumstance where a step function of current is applied to the line under the linear conditions of small-signal operation. These conditions usually prevail.

Although the output voltage waveform may be expressed directly by a mathematical equation as a function of the input current, it is much easier to show this equation graphically.[3] The output response to an input current step in a properly constructed and operated delay line is the voltage doublet pulse shown in Fig. 1B. Ideally, the peaks of the doublet should be of equal amplitude with no overshoot beyond the second peak. Careful observation of the amplitude and shape of the doublet waveform serves as a basis for determining the delay-line specifications of time delay, resolution output pulse duration, delay variation and amplitude variation with temperature. The relationship of the amplitude of the doublet peaks to the peak amplitude of any extraneous signal outside of the doublet interval determines signal-to-noise ratio.

Time delay is usually measured from the 50-percent amplitude point of the input current step to the zero axis crossing of the output doublet.

An internal delay adjustment, built into most commercial lines, enables the manufacturer to set the nominal delay accurately in the center of the externally adjustable range, usually ± 4 μsec. The external adjustment permits the user to compensate for circuit delays.

Time spacing, t_R, between the peaks of the doublet, which is an indication of the delay-line resolution, is the minimum spacing between adjacent amplitude changes in the input current which the line can distinguish. For example, if t_R is 0.5 μsec, the line can store bits of information which are 0.5 μsec apart, thus permitting a maximum information rate of 2 Mc in a non-return-to-zero (nrz) mode. In a conventional return-to-zero (rz) application, the maximum information rate or pulse repetition frequency (prf) becomes 1 Mc for the same value of t_R.

Output pulse duration, t_D, which is measured between the 10-percent amplitude point of the rise of the first peak of the doublet to the 10-percent amplitude point of the fall of the second peak, should equal $2t_R$.

Magnetostrictive Delay Lines

Logical engineering concepts upon which to determine the minimum number of specifications for a magnetostrictive delay as an electrical component in digital applications

A practical tolerance for total delay variation in digital application is 0.2 of the digital period. For example, at a prf of 1 Mc, the delay variation is limited to 0.2 μsec. For a millisecond delay line operating at this prf over the normal industrial temperature range of 0 to 50 C, the average temperature coefficient of delay should not exceed 4 ppm/degree C.

The delay-line user can be guided by the following practical information when specifying a particular delay variation over a given temperature range:

For the usual longitudinal line, the temperature coefficient of delay is about 150 ppm/degree C. By sacrificing some output amplitude, transmission materials are available that can yield a coefficient as low as 1 ppm/degree C over a range from −10 to 60 C. The coefficient of the usual torsional line is less than 5 ppm/degree C over the same temperature range, and may be reduced to less than 1 ppm/degree C over a more limited range. Generally, the delay variation is not linear with respect to temperature for low-coefficient lines.

With increasing temperature, the output amplitude of a delay line will rise. Over a range from −50 to 100 C, the amplitude will change as much as 25 percent from its mean value at 25 C. However, this change will have no effect in digital operation if the output amplifier and shaper are properly designed.

Magnetostrictive delay line noise may be defined as any voltage response outside of the doublet interval. Noise may arise from capacitance feedthrough from the input coil to the output coil because of improper electrical grounds, pulse overshoot caused by insufficient electrical or mechanical bandwidth on the overall delay line with its electrical input and output networks, and reflected signals from the ends of the line, wire supports, or the mode converters in the torsional lines.

The three types of noise are illustrated in Fig. 1C. The signal-to-noise ratio, which may be defined as the ratio of the peak amplitude of the output doublet to the maximum peak of any noise response, should not be less than 20 to 1. This value, measured as a response to an input current step, is generally sufficient to provide satisfactory performance when the line is subjected to the random pulse patterns in digital operation.

In its digital application, the delay line must accept and store random pulse patterns. It is therefore necessary that the input coil be housed in a network that has the

DELAY LINE DEFINITIONS

These specifications are based on the output voltage doublet generated by an input current step. Where necessary, the definitions of these specifications will be repeated. All time measurements should be in microseconds.

TIME DELAY—*a measurement from the 50-percent amplitude point of the input current step to the zero axis crossing of the doublet.*

RESOLUTION—*the time spacing between the peaks of the doublet.*

OUTPUT PULSE DURATION—*time spacing between the 10-percent amplitude point of the rise of the first peak of the doublet to the 10-percent amplitude point of the fall of the second peak.*

DELAY VARIATION WITH TEMPERATURE—*change in time delay over a specific temperature range.*

AMPLITUDE VARIATION WITH TEMPERATURE—*relative change in peak doublet amplitude over a specific temperature range, a ratio.*

SIGNAL-TO-NOISE RATIO—*ratio of the peak amplitude of the output doublet to the maximum peak of any noise response outside of the doublet interval.*

INPUT AND OUTPUT COIL INDUCTANCES—*These should be expressed in microhenries.*

OUTPUT PULSE AMPLITUDE—*peak amplitude of the output doublet, in millivolts, which is obtained across the specified output load for a given amplitude of input current step, in milliamperes.*

OUTPUT TERMINATION—*a parallel resistance and capacitance which provides an output network, in combination with the output coil inductance, having the bandwidth to pass the output voltage doublet without distortion*

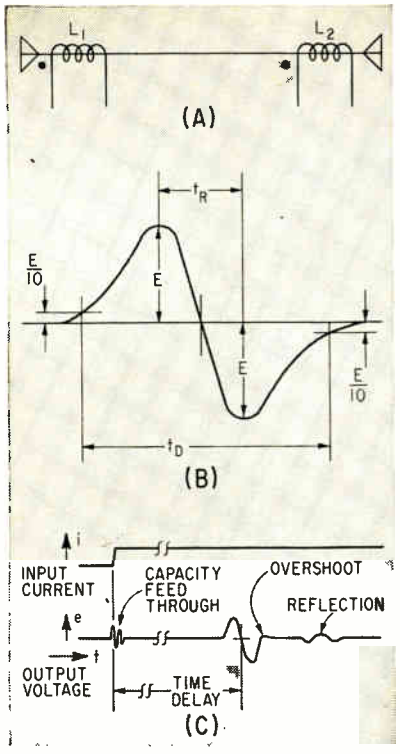

FIG. 1—Magnetostrictive delay line (A) with output voltage doublet (B) and typical delay line noise (C)

bandwidth to pass all the frequencies in these patterns. This bandwidth may be obtained by loading or damping the coil with a shunt resistor or diode.

A more suitable wideband network is the low-pass pi filter section[2] shown in Fig. 2A.

Select R_1 for proper loading of the driver circuit. Let $L_1 = R_1\, t_R/4$ and $C_1 = t_R/8R_1$. For example, if $R_1 = 200$ ohms (a value suitable for a transistor driver), and $t_R = 0.5$ μsec, then $L_1 = 25$ μh and $C_1 = 312.5$ pf.

The terminating network or load, into which a delay line operates may be considered to consist of a parallel resistance and capacitance. These parameters should form a wideband network (Fig. 2B)with the inductance of the output coil that has the bandwidth to pass the output voltage doublet without distortion.

These relationships[2] determine a suitable design

$$t_R = 8L_2/R_2 = 8R_2\, C_2$$

For example, if $t_R = 0.5$ μsec, $R_2 = 2{,}500$ ohms, and $C_2 = 25$ pf, then $L_2 = 156$ μh.

Attenuation in a magnetostrictive delay line depends on the losses in the transmission medium and the efficiency of the transducers. Transducer efficiency, which is the dominating influence, is a function of the coefficient of magnetic coupling between the transducer coil and the section of delay line underneath the coil and the conversion factor between magnetic and mechanical energy. Since the second factor is much less than unity[4] (0.02 for nickel, 0.04 for permendur), the transducer impedances are almost entirely reactive.

In narrow-band applications, the input transducer inductance may be resonated to achieve fairly efficient operation. However, the input inductance must be in a wideband network for digital application. The resistive loading, which is a necessary part of this network, will dissipate real power and so cause inefficient transducer operation.

As far as the output transducer is concerned, since only a small amount of the transmitted mechanical energy can be reconverted into electrical energy, efficient operation cannot be obtained for any application. However, this condition of loose coupling enables many output coils (taps) to be placed on a delay line without loading the line and causing reflections.

The delay-line user is generally more interested in the wideband transmission system of which the delay line is the major component than in the line itself. The concept of a wideband transmission system helps define attenuation[2]. The attenuation of a magnetostrictive delay line, with wideband input and output networks, is the ratio of the peak pulse power absorbed in the resistive termination of the output network to the peak pulse power dissipated in the resistive termination of the input network. If the input network is a pi section, the input power can be easily determined. However, where the input coil is damped either by a shunt resistor or a diode, the input power cannot be as readily calculated or measured.

There is another approach to the problem of specifying delay-line attenuation based upon the fact that the line is a current input-voltage output device. The peak amplitude in millivolts of the output voltage doublet across the rated load is measured as a function of the amplitude in milliamperes of the input current step. With this relationship between the input and output signals, the delay-line attenuation may be calculated for a given set of wideband networks if the resolution, t_R, and the coil inductances L_1 and L_2, are specified. If the input network is a pi section, then the input power $P_1 = I^2\, R_1\, 10^{-6}$ watt, where I is the amplitude of the input current step. Since $R_1 = 4\, L_1/t_R$, where L_1 is in microhenries and t_R is in microseconds, $P_1 = 4\, I^2\, L_1/t_R\, 10^{-6}$ watt.

Output power for a peak signal of E millivolts is $P_2 = E^2/R_2\, 10^{-6}$ watt. If L_2 has been determined according to the relationship, $t_R = 8L_2/R_2$, then $P_2 = E^2\, t_R/8L_2\, 10^{-6}$ watt. Delay-line attenuation is $P_2/P_1 = 1/32\ (E/I)^2\ (t_R^2/L_1\, L_2)$.

For a millisecond delay line with a value of t_R equal to 0.5 microsecond, $L_1 = 25$ μh, $L_2 = 100$ μh $I = 40$ ma and $E = 10$ mv are representative. For this line, attenuation, P_2/P_1 is equal to $0.2\ 10^{-6}$ or 67 db.

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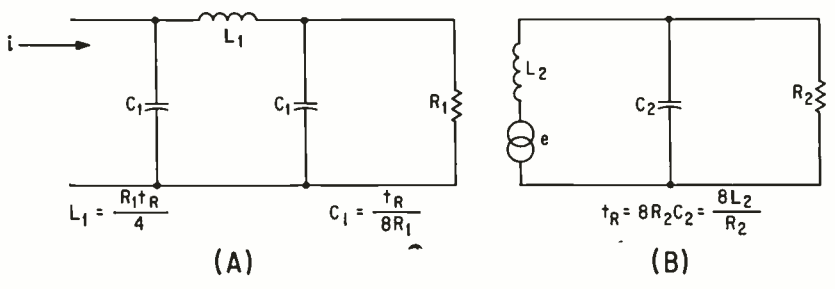

FIG. 2—Equivalent input pi network (A) and output network (B)

AMPLIFIER SPECIFICATIONS

Input: 0.4 volt rms/inch/second from a 200-ohm source impedance vibration detector

Output: 2.0 ma d-c full-scale proportional to peak-to-peak vibration displacement amplitude

Input for Full-Scale Output:
Model 1: 5 mils peak-to-peak (1 mil = 0.001 inch)
Model 2: 15 mils peak-to-peak (1 mil = 0.001 inch)

Input Impedance: 5,000 ohm minimum

Frequency Range: 6 cps to 200 cps, with a low-frequency voltage boost of 25 percent or more at 6 cps, dropping to zero boost at 20 cps and above

System Accuracy: ± 3 percent of full scale for lower 1/3 of scale and ± 10 percent of point for upper 2/3 of scale

Switching Requirement: During operation a new detector will be switched into the input each 5 seconds. The d-c output must reach 95 percent or more of its new level within 4 seconds over the entire output and frequency range

Ambient Temperature: −15 C to + 50 C

Supply Voltage: 120 volts rms ± 1 percent at 50 or 60 cps

Vibration Measurements With Peak-Reading Circuit

Has low-frequency boost to compensate for detector characteristics. Input is switched to a different detector every five seconds, so a special circuit is used in the peak-reader to insure accuracy on full-scale changes

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VIBRATION MEASURING equipment is important in the protection systems of large steam turbine installations in utility power stations. Although an available vacuum tube unit performs satisfactorily, a transistor unit with equal or better performance was designed for greater long-term reliability. Specifications for the amplifier section of the device are given in the table.

Since the output from the velocity-type vibration detectors used in turbine supervisory instrumentation is a voltage proportional to both displacement and frequency, an integrating action is required of the amplifier if the output is to be proportional to displacement only. Integration is usually achieved most satisfactorily by capacitance feedback around a high-gain amplifier stage, and this approach is used in this application.

Although some low frequency boost can be obtained with resistance and capacitance input and feedback circuits, inductance was added to increase boost and decrease rounding off at the break frequency. A damping ratio of 0.5 gave satisfactory operating characteristics. Not all models require low frequency boost, as Fig. 1 indicates.

The requirement for output current proportional to peak-to-peak displacement amplitude over the entire frequency range—when coupled with the switching requirement—proved to be more difficult with transistors than it is with vacuum tubes. However, a satisfactory circuit was worked out, based on a peak reading circuit invented by H. A. Harriman and J. L. Paine[1].

Figure 1 shows the schematic and the stages of the system that was developed. For input signals of 60 cps, the voltage amplification of the compensating amplifier is approximately 6.8, and that of the integrating amplifier is approximately 5.6. The peak-reading circuit is a dual diode-capacitor voltage doubler, while the d-c amplifier is a compound emitter follower with a large current amplification but no voltage amplification.

To achieve the required system input impedance without an input transformer, which would have complicated the low-frequency boost, it was necessary to make the input impedance of the first transistor relatively high. An emitter follower input stage is used, followed by a common-emitter voltage amplifying stage. An emitter follower output stage was also used to allow the high full-scale output voltage swing required when the input signal is at maximum frequency. All three transistors are silicon grown-junction devices.

Breakdown diode D_1 in the input amplifier allows d-c coupling between stages with minimum a-c degeneration. Overall d-c feedback through resistors R_2 and R_4 insures good d-c bias stability. Capacitor C_3 prevents any appreciable a-c feedback from occurring in this loop. Capacitor C_4 eliminates any high-frequency (greater than 200 cps) oscillation that might be present. This capacitor was found to be most effective when returned to B+.

The minimum open-loop voltage

*Now with Massachusetts Institute of Technology.

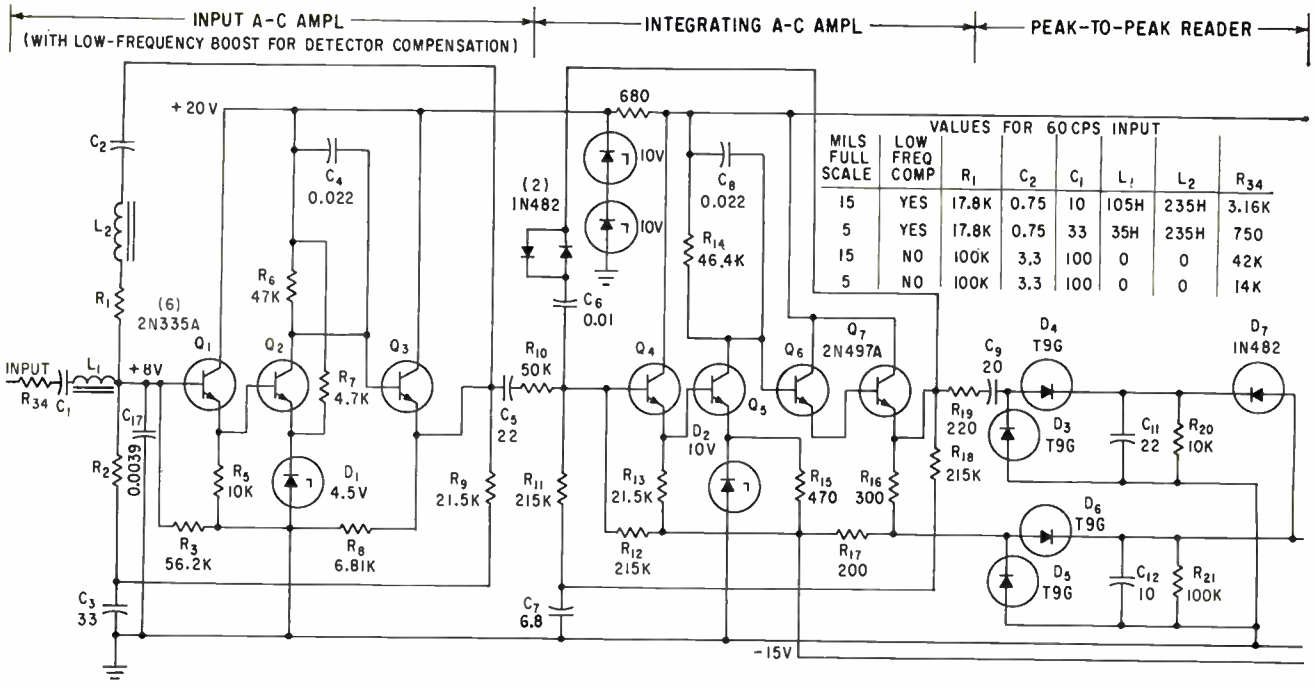


FIG. 1—Input amplifier has a low-frequency boost to compensate for the vibration detector, which develops a signal instrument is switched to a different detector every five seconds, GF circuit in the peak-reader makes sure it responds

amplification of the three-transistor combination is approximately 450, and the minimum input impedance is 90,000 ohms. These values are large enough to insure that the a-c performance of the compensating amplifier is almost completely determined by the input and feedback impedances.

The first three stages of the integrating amplifier are almost identical to those of the compensating input amplifier. However, the integrating amplifier must drive the peak-reading circuit, and the latter requires a high input voltage and a low driving impedance to furnish a d-c output that is proportional to the peak-to-peak displacement amplitude over the entire frequency range.

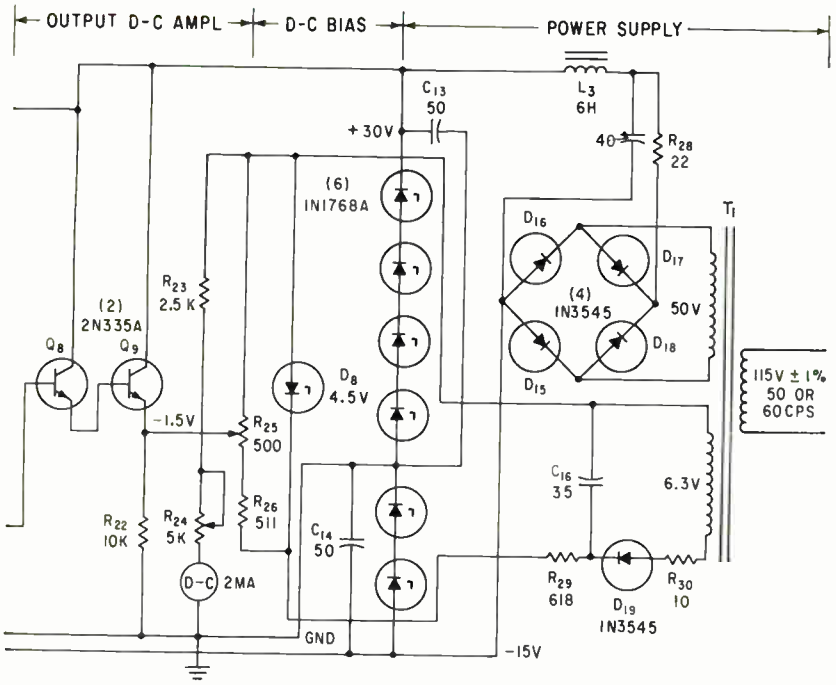
This requires the output stage of the integrating amplifier to operate at a higher current level and higher power level than is feasible with the 2N335A used for the first three stages. The 2N497A silicon diffused junction transistor was chosen for transistor Q_7, since it has uniform current amplification at current levels from 10 to 100 ma.

The minimum open-loop voltage amplification of the integrating amplifier is 200 and the minimum input impedance is 115,000 ohms. These values are large enough to insure that the a-c performance is almost completely determined by input resistor R_{10} and feedback capacitor C_8. The product of R_{10} and C_8 sets the integrating time constant of the amplifier and is dictated by system considerations. The choice of 0.01 microfarad for C_8 is a compromise between poorer performance (if C_8 were smaller) and unnecessarily high cost (if C_8 were larger). The diodes in series with C_8 prevent feedback until the output reaches about 0.6 volts. This off-set in the output compensates for the linearity error of the peak-reading circuit.

The operation of the peak-reading circuit is to convert the peak-to-peak voltage output of the integrating amplifier into a d-c voltage. However, it must also be capable of changing its d-c output level from full scale to zero at all input frequencies in less than five seconds to meet the switching requirement. To accomplish this, two separate diode-capacitor voltage-doubling networks interconnected by a silicon diode are used, one to provide the signal output and the other to provide the rapid change to a new level upon switching. This method requires a large amount of driving power from the integrating amplifier, but it is practical and meets the specifications.

Details of the peak-reading circuit are also shown in the schematic diagram. High-conductance germanium diodes are necessary for D_3 through D_6 to minimize the error due to the diode forward voltage drop. There are several time constants of importance. The product of R_{21} and C_{12} must be large enough so that there is no appreciable error for 6-cps inputs due to imperfect voltage doubling. The product of R_{20} and C_{11}, together with the ratio of R_{17} to the sum of R_{16} and R_{17}, must be such that silicon diode D_7 is reverse-biased for all steady-state conditions; however, resistor R_{20} must be small enough to allow capacitor C_{11} to almost completely discharge through diode D_7 in less than five seconds after the input is switched from a full-scale value to zero. It was necessary to add resistor R_{19} in series with capacitor C_9 to prevent distortion in the peak-to-peak signal into the peak-reading circuit for 200-cps full-scale inputs. The magnitudes of the capacitors and hence the resistors were set by the minimum input impedance of the d-c amplifier output circuit.

A d-c amplifier is required as the output circuit to furnish 2-ma full-scale output current. A peak-reading circuit furnishing more than about 100 μa of d-c current was not practical, but it was possible to ob-



that varies with vibration in both amplitude and frequency. Since the quickly enough

tain the full-scale voltage swing at the input to the d-c amplifier. Hence a two-transistor compound emitter follower is used for the output stage.

In the d-c amplifier transistors Q_6 and Q_7 give current amplification. The base of Q_6 normally operates at about −0.5 volt to draw a trickle current through diodes D_5 and D_6. With these diodes already conducting slightly, most of the normal nonlinearity of diodes is removed. To provide a zero adjustment for the output current, the network containing diode D_4, potentiometer R_{25} and resistor R_{24} is provided. Variable resistor R_{24} allows the overall gain of the amplifier to be calibrated and adjusted.

Because of the isolated power supply used for the zero adjusting network, the output of the amplifier can have one side connected to the common ground of the input and power supply.

The d-c power for the vibration amplifier consists of +30 volts at 90 ma and −15 volts at 95 ma. These voltages are obtained from the 115 volt, 50 or 60-cps line by connecting a series resistor and a string of ±5 percent silicon regulator diodes across the output of a transformer-rectifier-filter network, with the circuit ground connected one-third of the way up the string. By using six 7.5-volt regulators, a low dynamic impedance was achieved. The regulators are operated at approximately 65 ma, making the total average current through the rectifier diodes approximately 160 ma.

The complete amplifier was evaluated for accuracy at several frequencies and temperatures. Figure 2 shows some of the results.

A frequency response curve for 0.8 full-scale input is shown in Fig. 2A. This plot shows the low-frequency boost and no appreciable high-frequency falloff.

Data was taken at room temperature and at 50, 0, and −15 C. Figures 2B and 2C show linearity plots for three temperatures for input frequencies of 6 and 200 cps. A small zero shift occurs at both extremes of temperature for all models but the overall gain is not affected and the performance of the complete circuit is not degraded.

The effect of variations in h_{fe} among transistors was negligible, indicating adequate negative feedback.

The performance of the amplifier was checked at maximum and minimum values of power supply voltages. The only appreciable change observed was a slight drop in the full-scale output for a 200-cps input when the positive power supply voltage was lowered 5 percent.

All components in the amplifier are operated conservatively and long-term reliability should be excellent. Although there are several more transistors in this amplifier than vacuum tubes in the amplifier previously used for vibration measurements, the need for an expensive input transformer has been eliminated and the frequency response has been extended.

REFERENCES

(1) Patent No. 2,924,769 Peak Reading Circuit. Herbert A. Harriman and Joseph L. Paine.

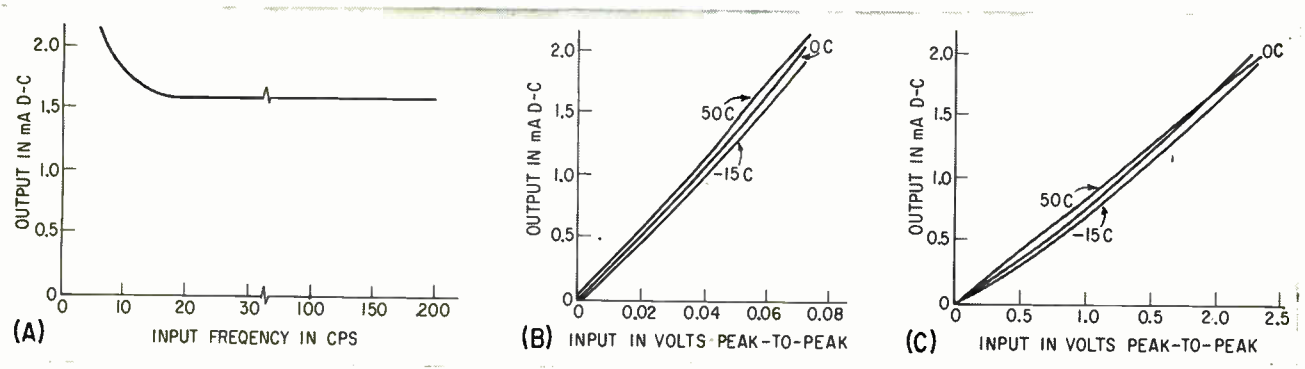
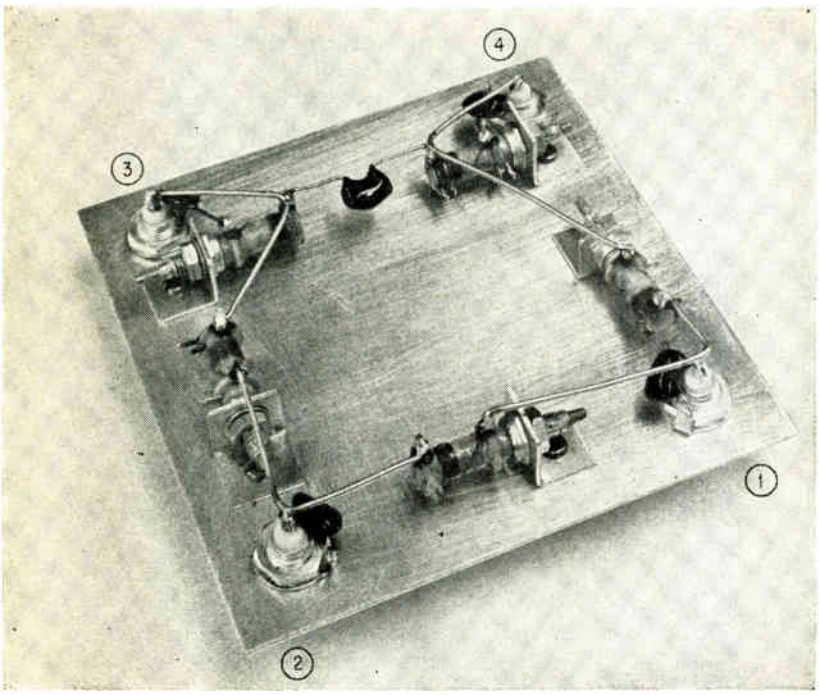


FIG. 2—Frequency response (A) for 80-percent full-scale input. Temperature effects for 6-cps input (B) and 200-cps input (C)



Design Technique

A 50-ohm hybrid ring with design center frequency of 6 Mc

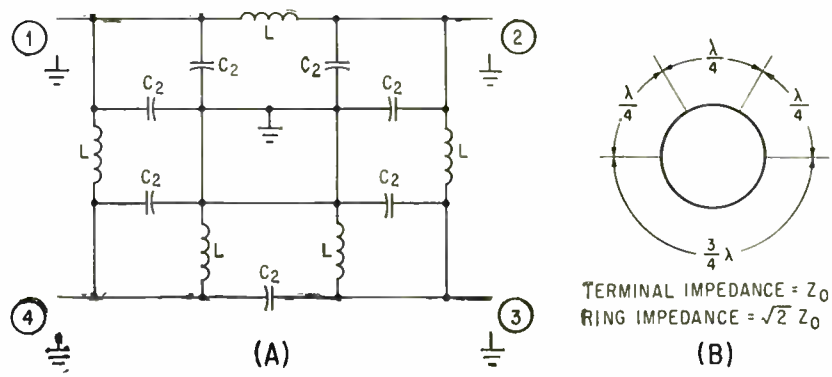


FIG. 1—Lumped-circuit element hybrid ring (A). In a practical version (see photo) capacitors C_2 at ports 1 and 2 can be combined into C_1. Equivalent distributed-circuit element hybrid ring (B)

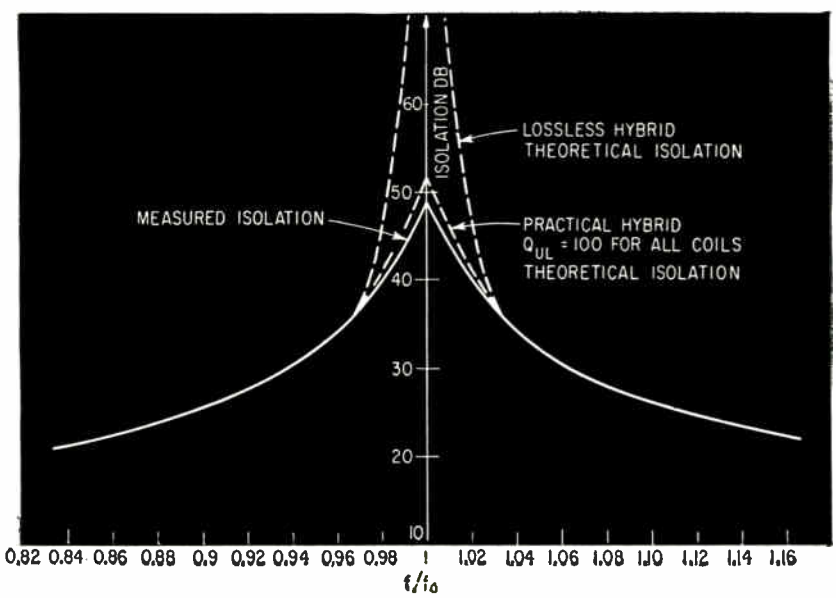


FIG. 2—Isolation plotted against normalized frequency for the lumped-circuit hybrid ring, showing theoretical and experimental figures

for Lumped-Circuit Hybrid Rings

At low power levels and below 100 Mc, lumped-circuit hybrid rings have advantages over their distributed-circuit counterparts

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LUMPED-CIRCUIT hybrids can be used in parametric amplifiers, balanced mixers, phase comparators, automatic frequency control circuits and null detectors. Lumped-circuit construction is generally applicable to frequencies below 100 Mc and average power levels below 10 watts. In the 100-Mc to 250-Mc band, it is a toss-up between lumped and distributed circuit hybrids. Above 250 Mc, the distributed-circuit hybrids are preferable. At average power levels substantially above 10 watts, particular attention should be directed towards minimizing dissipation losses and heat sinking, though high-power lumped-circuit hybrids are generally feasible.

The lumped-circuit hybrid is preferable to its distributed-circuit equivalent at frequencies below 100 Mc because the quarter-wave line lengths in transmission-line hybrids become intolerably large—29.5 in. in air or 20.9 in. in Teflon at 100 Mc.

A hybrid ring using lumped-circuit elements can be synthesized from a 3/2λ transmission line hybrid ring using distributed-circuit elements by replacing $\frac{1}{4}\lambda$ and $\frac{3}{4}\lambda$ transmission lines by their π equivalents, Fig. 1. This equivalency is exact only at the design center frequency at which the transmission lines are of resonant lengths.

The lumped-circuit elements can be computed from the equations

$$L = \frac{\sqrt{2}Z_o}{2\pi f_o}$$

$$C_2 = \frac{1}{2\pi f_o \sqrt{2}Z_o}$$

$$C_1 = 2C_2$$

where Z_o = impedance level at all ports of external loads, and f_o = design center frequency of the hybrid ring.

The isolation of the lumped-circuit hybrid is frequency sensitive. For a lossless lumped-circuit hybrid ring, the isolation between conjugate ports (that is, 1 and 3; 2 and 4) is

$$I \cong 20 \log \left| \frac{4}{\frac{f}{f_o} - \frac{f_o}{f}} \right|$$

where I = isolation in db, and f = frequency.

A lossy hybrid does not have infinite isolation at the design center frequency. Assuming ideal capacitors (negligible leakage) and a small resistive loss in series with each coil

$I_o \cong 20 \log (4Q_{rL})$ (where $Q_{rL} \geqq 10$)

where I_o = design center frequency isolation in db

Q_{rL} = unloaded Q of the coils (all coils assured to be identical)

The previous equations for isolation assume that the hybrid is terminated in Z_o, at all ports. For terminations not equal to Z_o, maximum isolation will not occur at the theoretical design center frequency and the theoretical maximum isolation then will not be achieved.

A 50-ohm hybrid ring with design center frequency of 6 Mc was designed and fabricated using the equations. Circuit elements were: L = 1.875 μh, Q_{rL} = 100, C_1 = 750 pf, C_2 = 375 pf, both mica capacitors.

The terminating resistors were within 2 percent of 50 ohms. Each coil was adjusted to resonate with 375 pf at 6 Mc. Measured isolation between ports 1 and 3 against normalized frequency is plotted in Fig. 2 and can be compared to the theoretical performance predicted for lossless and lossy hybrids. Satisfactory correlation was obtained between theory and experiment.

In design of a 6-Mc hybrid, the coils should be laid out physically at right angles, to prevent undesirable electromagnetic coupling. Shielding between coils is not recommended for such low frequencies. With coils at right angles, shielding is unnecessary. Slug-tuned coils must be trimmed using a Q-meter to compensate for their stray capacitance; the additional stray capacitance to ground due to shields can appreciably alter the electrical performance of the coils after they have been trimmed.

This technique of realizing a lumped-circuit element equivalent of a distributed-circuit element hybrid ring can be extended to other transmission line hybrid circuits.

Analog-To-Digital Converter Uses

Magnitude of analog current sets from one to 31 transfluxors, which in turn set a six-bit shift register in binary code

THIS ANALOG-TO-DIGITAL converter changes each of three analog signal inputs to a six-bit binary Gray code. Each analog is sampled at 5 Kc by a multiplexer, so that multiplexing is performed at a 15-Kc rate. The encoder uses magnetic elements to perform the conversion. Although the magnetic element may be a tape-wound core or a ferrite transfluxor, transfluxors are used since isolation of input from output is then less of a problem.

A block diagram of the input circuits to the analog-to-digital converter is shown in Fig. 1A. Each analog signal input channel includes input amplifier 1, a d-c to 2-Kc low-pass filter and a sampling switch multiplexer. The input signal at a maximum level of 5 volts peak-to-peak or ± 2.5 volts is fed into the input of buffer amplifier 1 whose input impedance is greater than 300,000 ohms. Input impedance of this order is required so that a transducer source impedance less than 1,000 ohms will not introduce signal variations greater than 0.3 percent. The amplifier has a stable gain of two, so that its maximum output voltage for the maximum signal input of 5 volts p-p is 10 volts p-p.

The output impedance of the amplifier is less than one ohm. Its output signal feeds the d-c to 2-Kc low-pass sampling filter, which removes frequencies greater than 2 Kc from the input signal to reduce quantizing errors due to sampling. The maximum signal level to the filter is 5 volts p-p and it is terminated at both ends in its characteristic impedance of 1,000 ohms. The filter attenuation is about 0.8 db. After filtering, the signal is sampled by the multiplexer at 5 Kc. The sampling pulse of -6 volts to ground and three-microsecond duration driving the multiplexer is controlled by the timing matrix and the three 50-μsec monostable multivibrators (MMV). The sampled analog output of the multiplexer is a 3-μsec pulse of either polarity with a maximum amplitude of 2.5 volts. This is fed to input amplifier 2 of the analog-to-digital converter.

The analog-to-digital converter block diagram is illustrated in Fig. 1B. The multiplexer output is amplified and phase-split in amplifier 2 before going through the diode folder that inverts any positive signals. Sufficient gain is needed ahead of the folder diodes to avoid low-level signal distortion caused by the characteristic response of the diode at low levels. Amplifier 2 thus provides a gain of four to the sampled signal of the multiplexer. The folder is a full-wave rectifier using germanium diodes. These characteristically distort or block signals less than 200 mv. Since the 3-μsec signal of the folder is inadequate to set the transfluxor, it is stretched approximately 22 μsec by a capacitor which charges through a small time constant and holds the charge with a long time constant. This capacitor is cleared by the clear pulse from the timing matrix. The stretched voltage from the voltage amplifier at a gain of 1.4 is converted to a current pulse by the current amplifier to set the transfluxor.

The set winding is wound through the large hole of the transfluxor and is driven by the stretched sampled analog signal current from the current amplifier. The pulse is made of sufficient width to set the transfluxor. The particular transfluxor set by a sampled analog signal current of specific magnitude is determined by the relation between the bias on the transfluxor as fixed by the bias winding current, and the magnitude of the signal current in the set winding, both of which pass through the large hole but in opposite directions. Thus a magnitude of signal current adequate to set the sixteenth transfluxor oversets transfluxors one through fifteen. As transfluxors one through fifteen pass through the set into the overset position, all fifteen present a back emf to the set-current driver. The 16th transfluxor is read out after this back emf reduces to zero. Thus the 3-μsec read pulse, and the worst case the switching time of thirty transfluxors, determine the width of the set current required.

Once a transfluxor is set, the read pulse that follows the sampling pulse in the conversion timing scheme produces an output on the sense winding to the sense amplifiers. Both the read and the sense windings are wound through the small hole. Until a transfluxor is set, however, no coupling occurs between these windings for readout to the sense amplifiers, since all unset transfluxors are magnetically saturated. The set transfluxor, when read out, produces outputs on all set or readout windings through its small hole. The number of readout windings is determined by the selected readout scheme which is the required winding scheme to produce a Gray code output.

The sense amplifiers amplify the sense winding outputs to a level sufficient to set the output register and also permit strobing of the output to prevent the setting of the register by unwanted or noise signals. The desired signal appears between two large noise voltages produced by the setting of the transfluxors. There are five sense amplifiers, one for each of the five

Transfluxors

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sense windings wound through the small holes of the transfluxors, in accordance with a winding scheme to produce a five-bit Gray-code binary output. The windings do not necessarily pass through all the transfluxors but only those indicated in the selected readout scheme. The shift register is set to digital value by sense amplifiers.

A sixth bit is obtained by polarity detection. The polarity detector circuit is set to respond only to negative signals above a 100-mv threshold. When a negative sample occurs, the detector output triggers the 22-μsec MMV. The polarity bit is set into the shift register by coincidence at the gated amplifier of the clear pulse and the MMV output.

Each a-c analog input channel has an input amplifier, a d-c amplifier with high input impedance. Figure 2A is a circuit diagram of the input amplifier 1 (Fig. 1A). Its input impedance is greater than 300,000 ohms and its output impedance is about one ohm. The amplifier dynamic range is such as to accept an input signal level to ±2.5 volts. It has a gain of approximately two and has operated satisfactorily to a temperature of +75 C with a drift of only 35 mv.

The input signal is fed to the base of transistor Q_1, which with transistor Q_2 forms a differential amplifier. The output of the differential amplifier is fed to transistors Q_3 and Q_4 to provide gain and phase inversion for feedback through complementary emitter follower transistors Q_5 and Q_6 to the base of Q_2 of the differential amplifier. Networks R_1-C_1 and R_2-C_2 provide phase adjustment to reduce oscillations due to feedback. The d-c drift is adjusted with the 200-ohm potentiometer in the emitters of Q_1 and

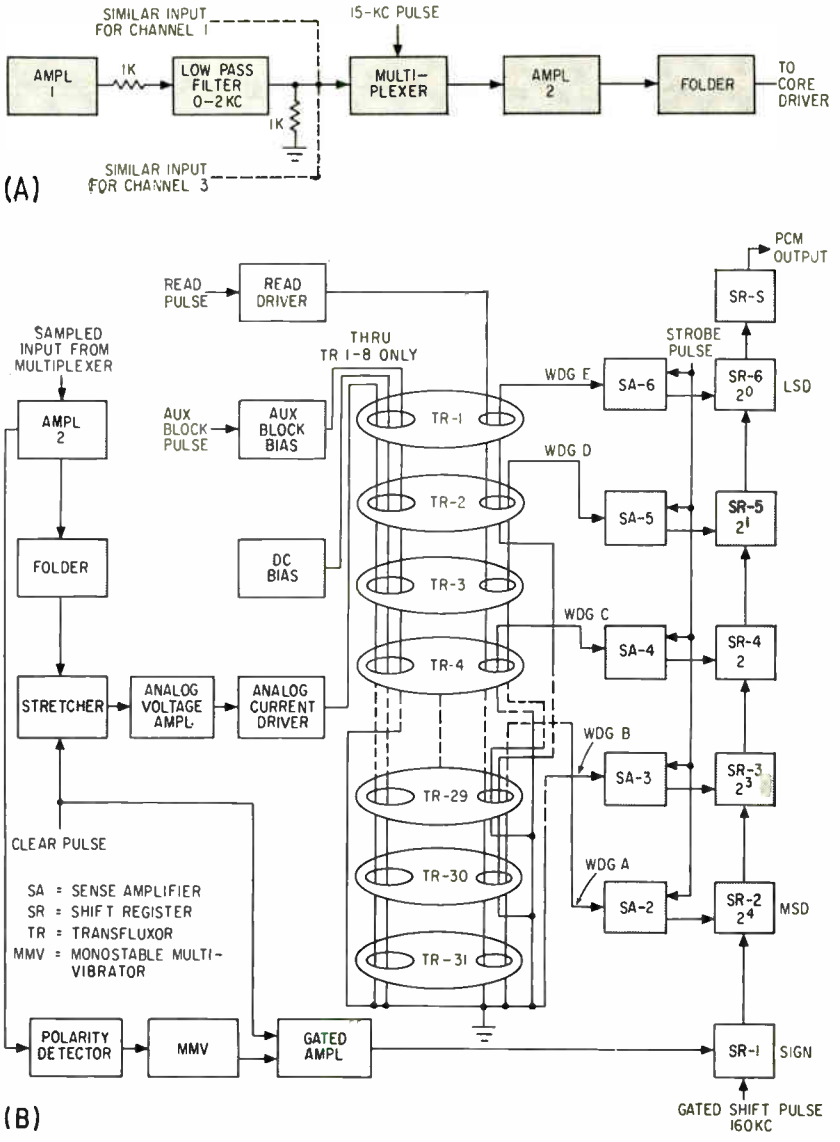


FIG. 1—Analog input channel (A) and analog-to-digital converter (B)

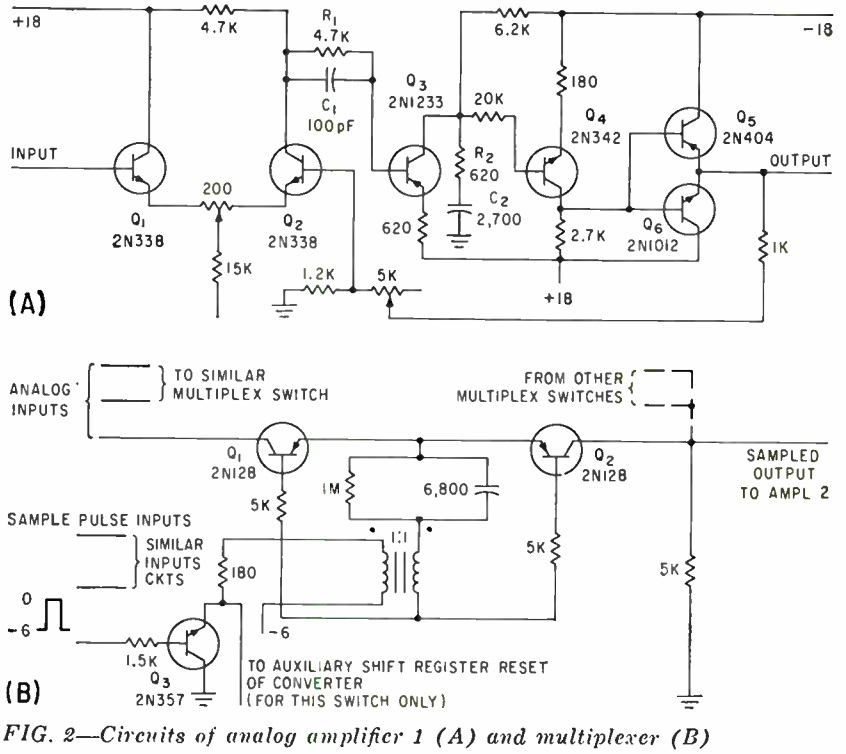


FIG. 2—Circuits of analog amplifier 1 (A) and multiplexer (B)

Q_2 and gain adjustment is provided by the 5,000-ohm potentiometer in the output feedback loop. The amplifier has a frequency response from d-c to more than 50 Kc. This is more than adequate for the signal input requirements, which are from d-c to 2 Kc.

Each analog channel has a 2-Kc low-pass sampling filter following the input amplifier. The filter has a characteristic impedance of 1,000 ohms and is therefore matched to 1,000 ohms on its input and terminated in 1,000 ohms on its output.

The analog signals are sampled and multiplexed in a floating transistor switch circuit shown in Fig. 2B. The switch is turned on and a sample of the signal input voltage is fed to the output when the sampling pulse from the digital timing matrix is applied to the primary of the pulse transformer. During the on time, the capacitor in the emitter leads charges to the polarity indicated. At the conclusion of the sampling pulse (about 3 μsec) the switch is turned off by the voltage on the capacitor. The discharge time constant is such that the switch will stay off until the next sampling pulse appears. Since the transistor switch suffers from minority carrier storage and is not suitable for high-speed operation into a high impedance load of 100,000 ohms, amplifier 2 following the multiplexer switch has an input impedance of 5,000 ohms. This reduces the long decay time when the switch is cut off. The drop across the switch and the zero offset voltage is a few millivolts and is negligible.

The circuit diagram of amplifier 2 and inverter is shown in Fig. 3, which includes the input circuit to the transfluxors. The buffer amplifier whose main stage consists of transistors Q_3 and Q_4 in a differential circuit presents a constant 5,000-ohm input to the multiplexer. The input signal to the differential stage is fed from the multiplexer to a complementary emitter follower including transistors Q_1 and Q_2. The differential stage must be balanced to maintain accuracy. Adjustment is made with potentiometers R_1, R_2 and R_3. Potentiometer R_1 equalizes the gain in the collector output of Q_3 and Q_4. Potentiometer R_2 sets the voltage level and potentiometer R_3 balances the collector voltages of Q_3 and Q_4 through the complementary emitter follower consisting of transistors Q_5 and Q_6.

Each side of the differential amplifier output is applied to a rectifying diode, D_1 and D_2 of the folder. These are forward biased at about 100 μa by the current through the 50,000-ohm resistor and the base of transistor Q_7. Sampled signals of either polarity appear at the input to Q_7 as negative-going pulses at a d-c level of -15.75 volts. These three-microsecond pulses charge capacitor C_1 to increase or stretch the sample pulse time for setting the transfluxor cores.

Grounded-collector stages Q_7 and Q_8 prevent the stretcher capacitor C_1 from loading the differential amplifier input stage. A sampled input pulse turns on transistor Q_9 and charges C_1 to the pulse peak during the three-microsecond interval. When the input is over, C_1 discharges through the back impedance of diode D_3 and the input impedance of transistor Q_{10}. The discharge time constant is approxi-

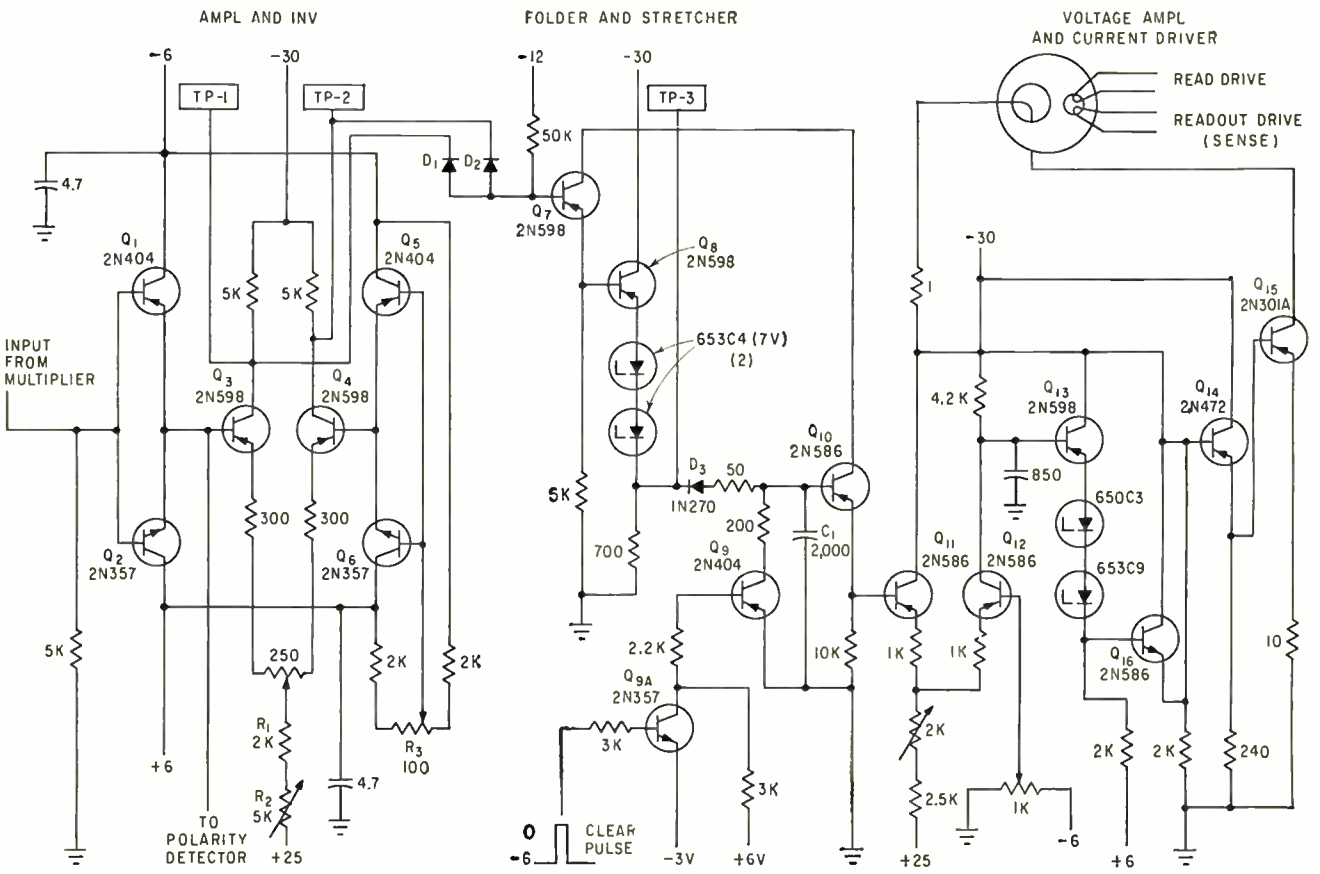


FIG. 3—Left portion of Fig. 1B: amplifier and inverter; folder and stretcher; voltage amplifier and current driver

mately 1,000 μsec and produces a nearly constant amplitude pulse out of the stretcher. The stretching is terminated by the clear pulse from the timing matrix which saturates transistor Q_9 to discharge C_1. When Q_9 saturates, the base of Q_{10} is brought to ground. As soon as Q_9 cuts off, the base of Q_{10} returns to the low negative voltage determined by that of test point TP_3. If TP_1 and TP_2 are more positive than −15.75 volts, D_3 may be biased off during the last half of the decay of the base of Q_{10} to the negative d-c level. As a result, the base may continue to discharge with a long time constant so as not to recover in time for the next conversion.

The stretched sample voltage is amplified by the voltage amplifier transistors Q_{11} and Q_{12}, which provide an additional gain of about 1.4. The voltage output of this amplifier feeds the current amplifier which sets the transfluxors. The current amplifier includes transistors Q_{13}, Q_{14}, Q_{15} and Q_{16}. The input at Q_{13} feeds successive emitter follower stages to produce sufficient current gain for driving the transfluxors. The inductance and stray capacity of the transfluxor set winding in the collector of Q_{15} appears as a tank circuit, the output of which feeds back to the base source impedance through the collector to base capacity. A transistor with too high an alpha cutoff frequency for Q_{15}, such as the 2N1046 originally tried, produced sustained oscillations. The lower frequency 2N301A limits the oscillatory condition to a slight overshoot.

It was found desirable to make the emitter resistors of Q_{13} and Q_{14} large enough to prevent overheating of the transistors should the +25 volt or the ±6 volt power supplies fail. This results in an increase in the base source resistance of Q_{15} which is corrected by the addition of stage Q_{16}. The 850-pf capacitor in the base of Q_{18} slows the rise time and also reduces oscillations in Q_{15}.

The transfluxors each have five windings, three through the large hole and two through the small hole. The large hole windings are the bias winding, the auxiliary block winding and the set or analog signal output winding. The bias winding provides the reference current that spaces the setting characteristics of adjacent transfluxors. The spacing is achieved by proportionately increasing the number of turns on succeeding transfluxors and passing the same d-c bias current through all of them. Thus a uniformly increasing ampere-turns of bias is provided for each succeeding transfluxor. With the set and bias windings both around the large hole of the transfluxor, coupling between these windings produces an increase in bias current since the induced voltage in the bias winding is in such a direction as to break down the transistor in the d-c bias circuit. This coupling becomes negligible if the bias source has a high impedance.

The auxiliary block winding is needed on the first eight transfluxors only, since these are disturbed by the set pulse and must be reblocked by 1.5 ampere-turns before the next set cycle begins. If these transfluxors are not reblocked, the setting characteristic will be unpredictable. In transfluxors 9 through 31, the block function is performed by the d-c reference

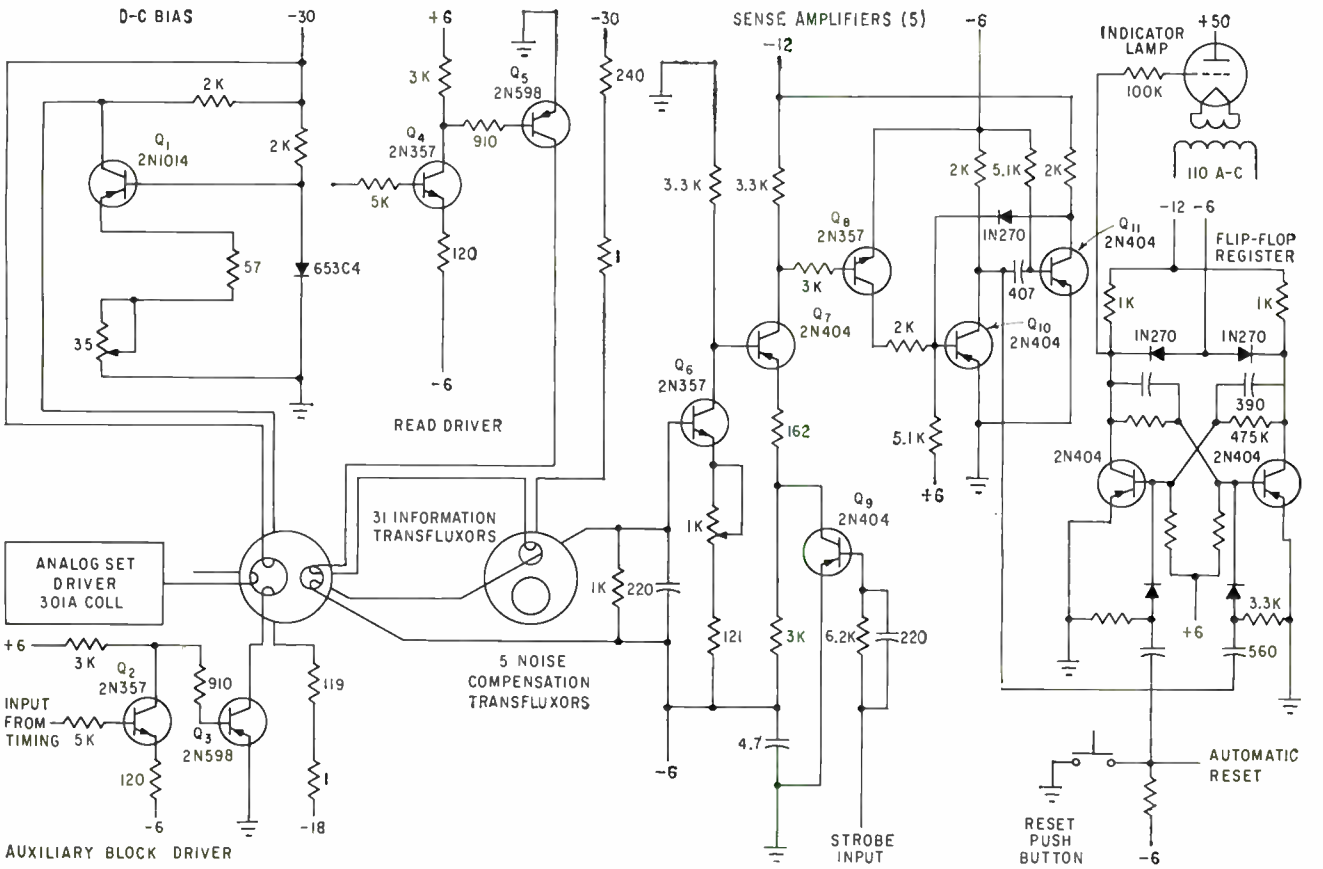


FIG. 4—Circuits of right portion of Fig. 1B: read driver, auxiliary block bias, d-c bias, sense amplifier and shift register

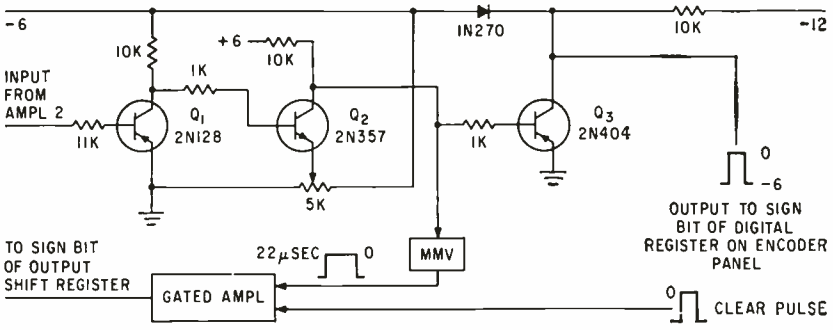


FIG. 5—Circuit of polarity detector

bias. However, in transfluxors one through eight, the mmf of the d-c bias windings is less than 1.5 ampere-turns and must be supplemented by the auxiliary bias pulse. The auxiliary block winding is driven by a driver that receives a timing pulse from the timing matrix in the digital circuits.

The windings through the small hole of the transfluxor include the read-drive winding and the read-output or sense winding. The read-drive winding is driven by the read driver, a circuit similar to that of the auxiliary block driver. It also receives a timing pulse, the read-timing pulse, from the timing matrix and produces a read-output voltage of 35 to 80 mv per turn on the read-output or sense winding. This voltage is selected to be of the same polarity from all sense windings and is fed to the sense amplifiers. The selection is made possible by wiring the five sense windings so that all produce outputs of the same polarity.

Since the read-current winding passes through the small hole along with the sense winding, during rise of the read current a small noise (undesired signal output) voltage is induced in the sense winding. This undesired signal is a cumulative voltage induced in the sense winding by the read driver coupling through the transfluxors that are not set for read-out. The noise from 16 transfluxors on each sense winding adds up, and could become large enough to be mistaken for a signal. A method of noise compensation applied successfully to improve the signal-to-noise ratio adds one additional transfluxor on each sense winding. It is driven by 6 turns of the read driver and contains a second winding through the small hole with 20 turns in series opposition to the sense turns in the 16 conversion transfluxors. The intentionally added noise cancels the noise normally present. A small reduction in a peak signal out results, but the improvement in signal-to-noise is several orders of magnitude.

Figure 4 illustrates the encoder output circuits from the transfluxor to the digital shift register. The d-c bias circuits and the auxiliary block and read drivers are also shown. The bias circuit provides a biasing current of 100 ma. The high impedance is obtained by placing the transfluxor bias winding in the collector of the transistor and biasing the base with a zener reference diode.

The circuits for providing the auxiliary block driving current and the read-drive current are similar except for the collector resistance in series with the associated transfluxor winding. The auxiliary block circuit is driven by the auxiliary block pulse from the timing matrix.

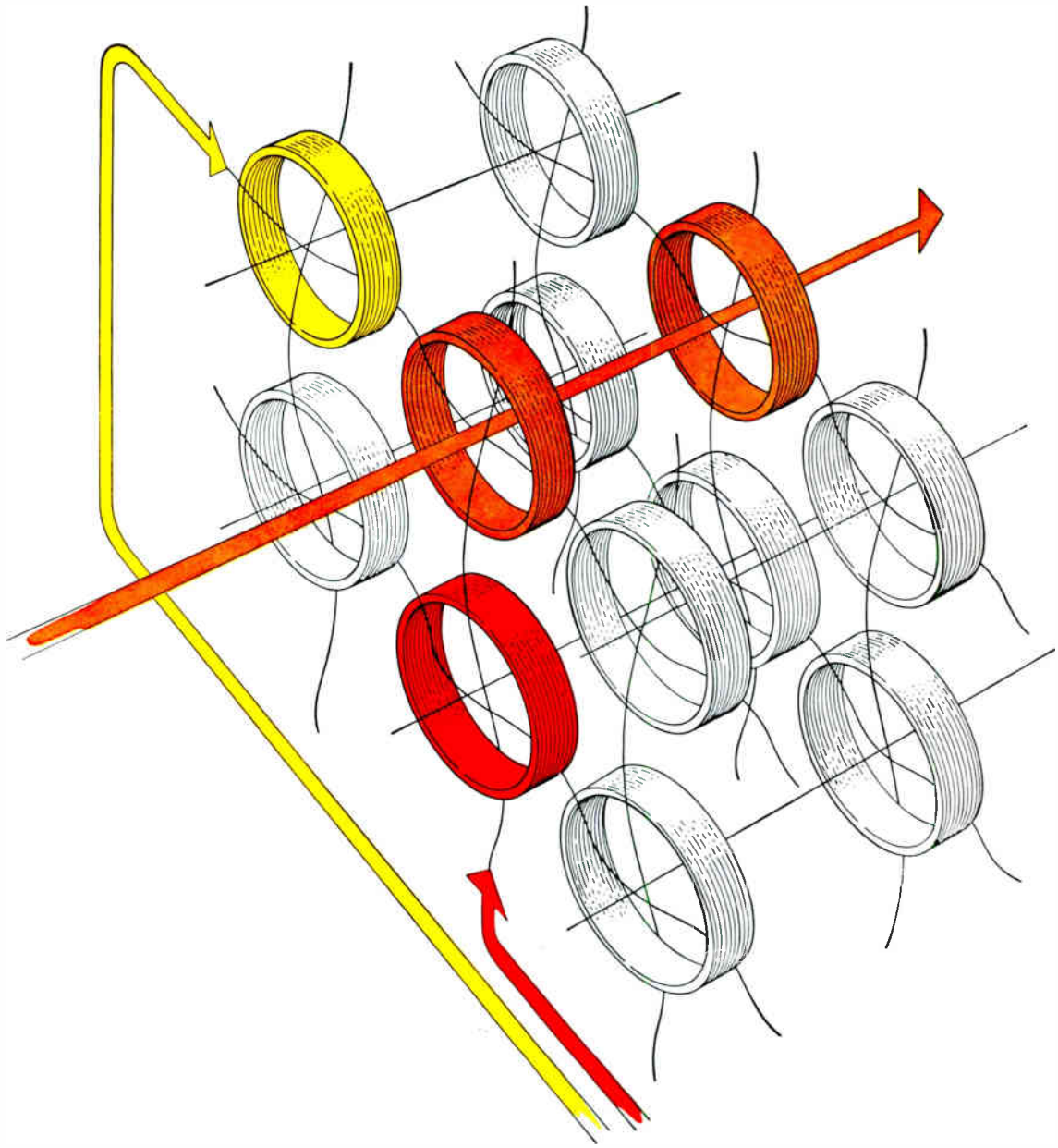
Normally, both stages of the drive circuit are off. They are turned on by the positive going input pulse. The second stage transistor (Q_3 for the auxiliary block and Q_5 for the read) is driven into saturation and the collector load resistor acts as a current source to switch the transfluxor.

There are five sense amplifiers one for each of the readout or sense windings. All the sense windings are wired to produce outputs of the same polarity to the sense amplifier. The first stage, Q_6, is biased class B. The second stage provides for both gain and strobing to select the signal between the two large noise voltages due to the rise and fall of set current. The third and fourth stages, transistors Q_8 and Q_{10} are for pulse shaping, and Q_{10} together with Q_{11} constitutes a monostable multivibrator. The use of the monostable circuit improves the threshold response and stabilizes the width of the sense amplifier output. Stabilization of output is required to reduce the indeterminate output level that may set the shift register. Signals below a certain level will not set the register at all while those above this value set it all the time. Noise riding on the signal, variations in the threshold value of Q_{10} and in the triggering threshold of the flip-flop register contribute to the indeterminate response region. This is materially improved by the monostable multivibrator. The 200-pf capacitor across the 6,200-ohm resistor in the strobe output speeds the rise time of the leading edge of the strobe pulse. The potentiometer in the first stage transistor permits adjustment of the rejection level on each sense amplifier. The 1,000-ohm resistor reduces the transfluxor loading, which is caused by the input impedance of the sense amplifiers. Because of the sense-winding arrangement, the number of sense windings on a transfluxor may vary from one to five. Thus, one transfluxor may be loaded with one sense amplifier while another may be loaded with five. The 1,000-ohm resistor is a compromise between a value which produces a damping effect and one that produces loading.

Figure 5 is a circuit diagram of the polarity detector. Negative analog samples from amplifier 2 (Fig. 1B) greater than 100 mv are amplified in transistor Q_1 to drive transistor Q_2. The amplification of the two stages provides a sharp pulse output to drive the 22-μsec monostable multivibrator MMV. The input signal threshold is adjusted by the 5,000-ohm potentiometer in the emitter of Q_2. Coincidence of the 3-μsec clear pulse from the timing matrix and the trailing portion of the 22-μsec output of the MMV at the gated amplifier input produces a pulse simultaneously with the conversion readout time to set the sign bit in the shift register.

The total encoder dissipation at maximum signal level is about 16 watts. It has a conversion accuracy of two percent.

This work was performed for the US Army Ordnance Corps, Picatinny Arsenal.



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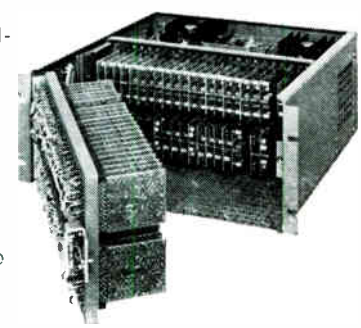

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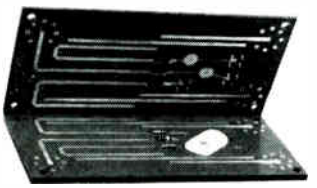

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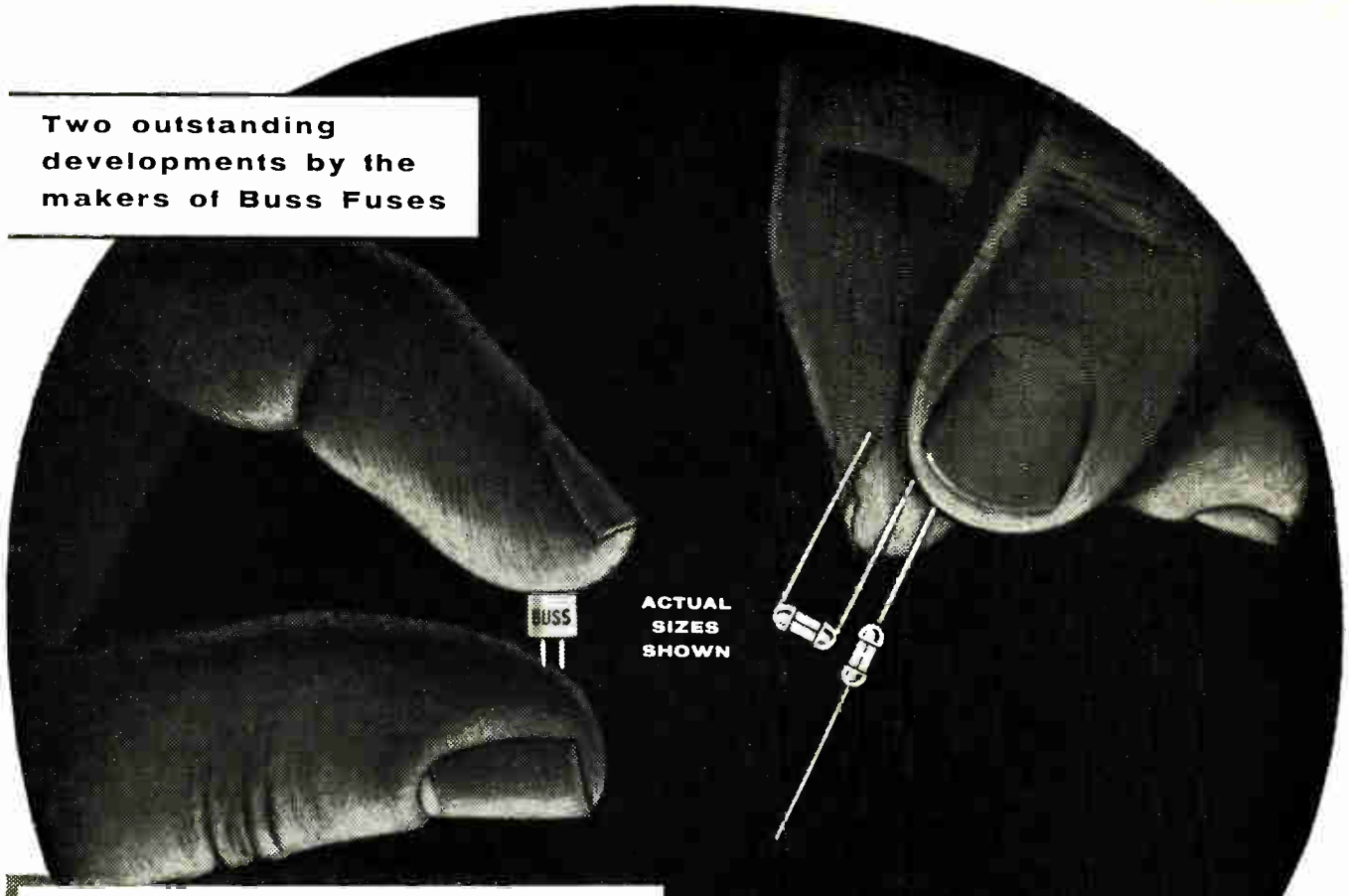

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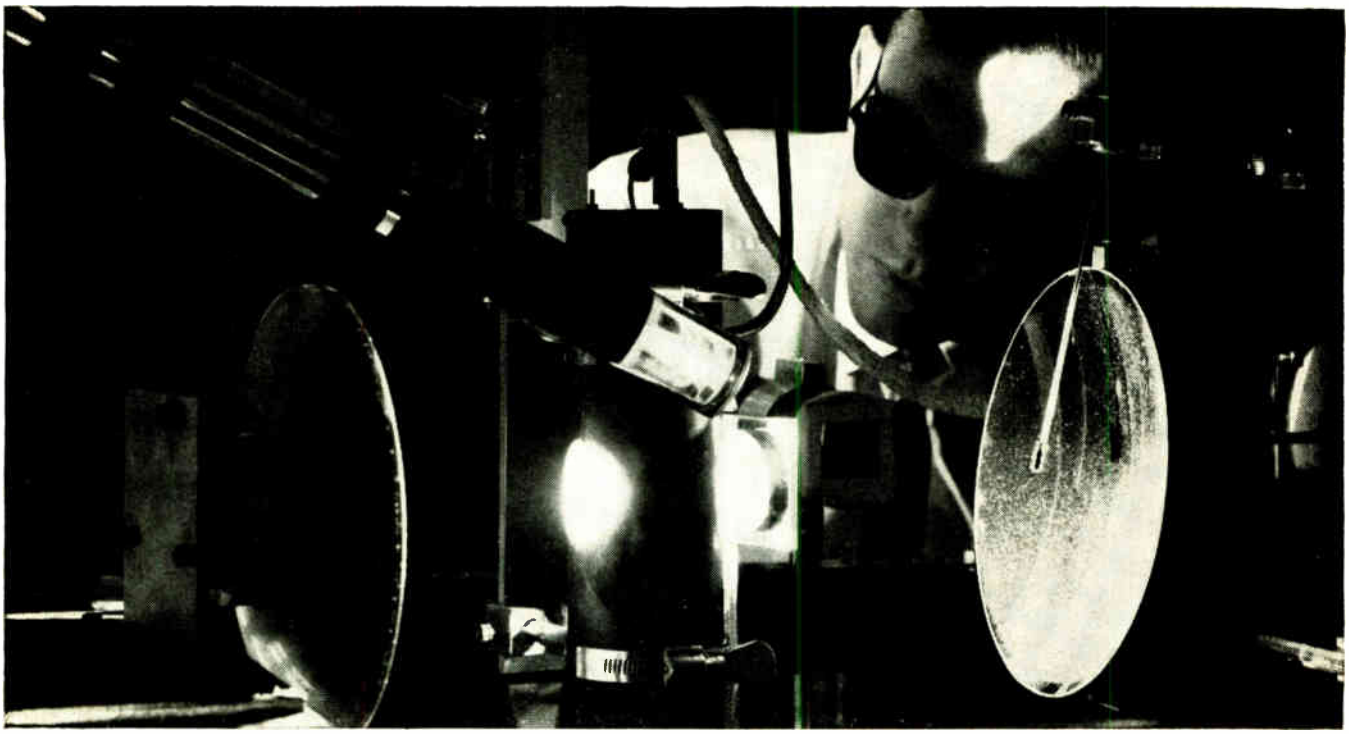


Exploring the possibilities in Coherent Light

At Bell Laboratories, Donald F. Nelson studies a beam of coherent red light produced by a continuously operating ruby optical maser. The heart of the device is a uniquely shaped ruby crystal immersed in liquid nitrogen in the tubular glass dewar extending from upper left to center. Light from the mercury arc lamp (lower center) is reflected by round mirror at left to mirror at right and then is focused on the ruby crystal to produce maser action. Coherent light emerging from end of dewar is picked up by a detector.

Is it feasible to take advantage of the enormous bandwidth available at optical frequencies? Could coherent light, for example, be sent through protecting pipes to provide high-capacity communication channels between cities?

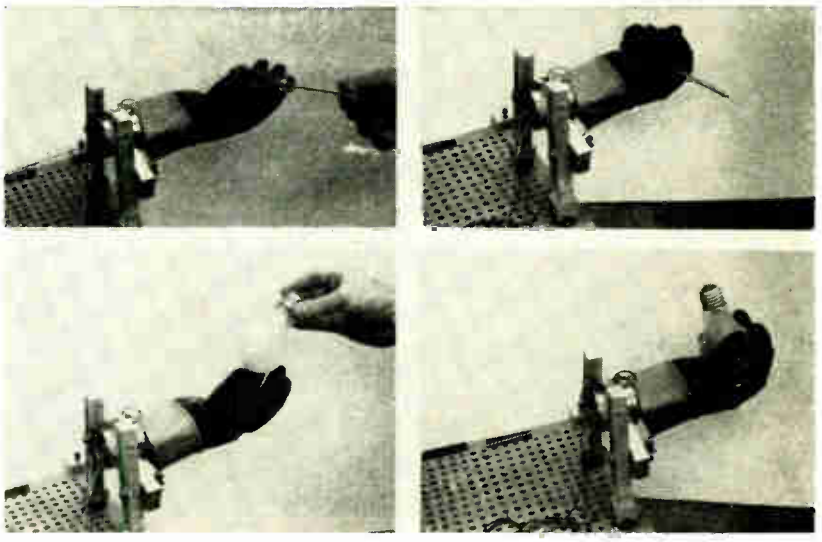
To study such possibilities it is, first of all, necessary to have a source of continuous coherent radiation at optical frequencies. Such a source was first produced when Bell Laboratories scientists developed the gaseous optical maser.

Recently, our scientists demonstrated the generation of continuous coherent light by solid materials. Using a crystal of neodymium-doped calcium tungstate, a material developed at Bell Laboratories, continuous optical maser action was obtained in the near infrared. It has also been attained with visible light, using a new optical "pumping" arrangement to excite a ruby crystal. (See illustration above.)

Multichannel light highways for communications are still far from realization. But with continuous sources of coherent light available, it becomes possible to explore the problems of modulating, transmitting, detecting, amplifying and, in general, controlling light for possible communications applications.

Artificial Hand Responds to Touch

By RAJKO TOMOVIC
Professor Electrical Engineering
Faculty Nuclear Institute,
Vincha, Yugoslavia



Artificial hand made at Biotechnology Laboratory of UCLA adapts to shape of object and exerts pressure proportional to weight of object

DESIGN APPROACH used in development of an experimental artificial hand could result in significant improvements in prosthetic devices. Principles used might also be applied in other fields, such as remote manipulation or remote operation of vehicles.

The artificial hand adapts to the shape of the object held and automatically adjusts pressure to the weight of the object. This characteristic is shown in the photographs provided by Gianni Boni, Biotechnology Laboratory, UCLA, where it was built during a 7-month period spent at this cooperative center for artificial limb research by the author. A model is presently being designed under the direction of the author at the Institute for Automatization and Telecommunications at Belgrade for amputees with both hands removed.

One fundamental requirement in any prosthesis design is a compact source of power for prosthesis action. Muscular effort of the amputee should be limited, particularly in hand prosthesis, where constant effort could be inconvenient. Externally powered hand prosthesises have been proposed using electrical, pneumatic and hydraulic units, but this problem has not been satisfactorily solved.

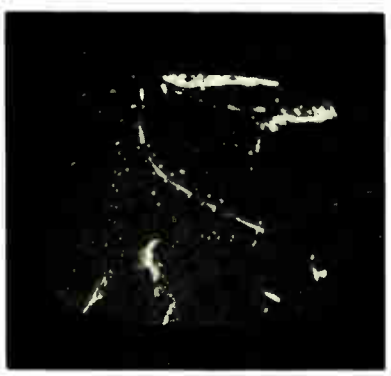
The second basic prosthesis design problem is providing adequate control signals to provide normal hand movements as far as possible. In some devices, controls signals have been reduced to a minimum, possibly to just one on-off signal. Movement of the amputee's shoulder or body initiates the signals. However, this approach severely limits performance of the artificial hand.

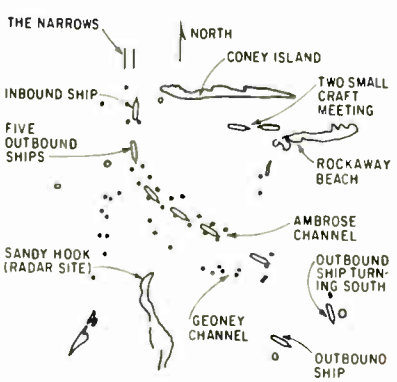
Another solution used for the signal control problem is so-called bioelectrical control. Use is made of the remaining muscles or nerves of the amputee, which when activated can produce the normal biological control signals in the form of electrical pulses. It has been demonstrated on an amputee that these pulses properly amplified can control a hand.[1] Despite its significance as an achievement in electronics, only an on-off bioelectrical control pulse was used. Because of the difficulty of amplifying bioelectrical currents and the variations among individuals in the level and location of pulses to be detected, a new approach was used.[2, 3]

Two factors taken into consideration are that reflexes account for a major part of normal activities and the sense of touch can be an important source of control signals. In fact, many reflexive hand movements depend partly or completely on the sensing of touch or pressure and heat.

Two types of control signals are used in the new hand. Actions like

Tv Displays Radar Image of Harbor





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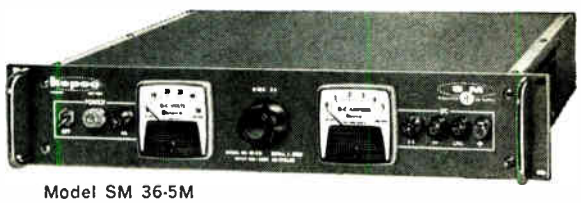

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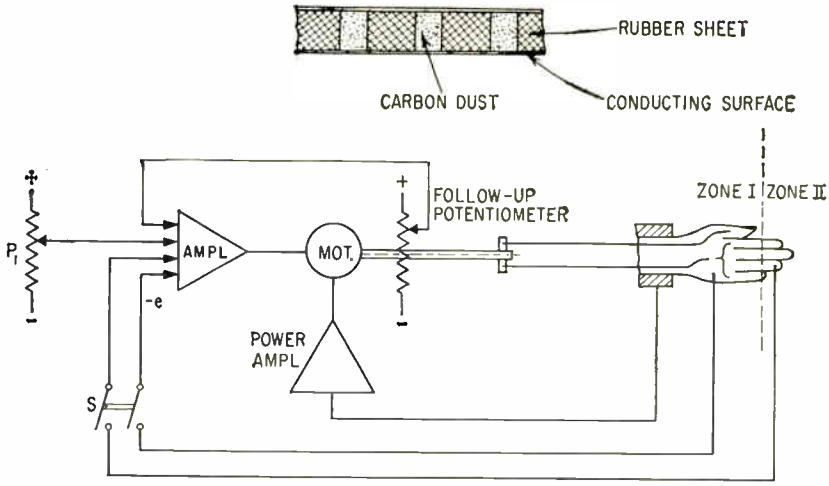


Carbon-filled holes in rubber sheet covered by conductive material function as pressure transducer. Servo permits variety of hand movements

opening the hand are controlled by an on-off signal initiated at will by the amputee. Activities like closing the hand or moving the fingers are initiated automatically by touching an object.

Pressure Sensitive

Basic design objectives for the hand included obtaining a prosthetic device similar anatomically to the human hand. All fingers and finger joints move except for lateral finger movements. The hand automatically adapts to the shape of the object to be held, and it automatically determines whether pinching or grasping actions are needed. Hand pressure adjusts automatically to the weight of an object.

The inner surface of the hand is made pressure sensitive. A 2-3 mm rubber sheet is perforated and the holes are filled with carbon dust like that used in microphones. A metallized layer on both sides covers the holes, as shown at the top of the figure. Output current of the elastic pressure-sensitive surface is proportional to applied pressure and activated surface area.

The surface serves as an on-off signal source, detecting that an object has touched the hand and triggering a closing reaction. For this function, elasticity of the rubber must be low for adequate sensitivity. The surface also produces a signal proportional to pressure, although strict linearity is not required.

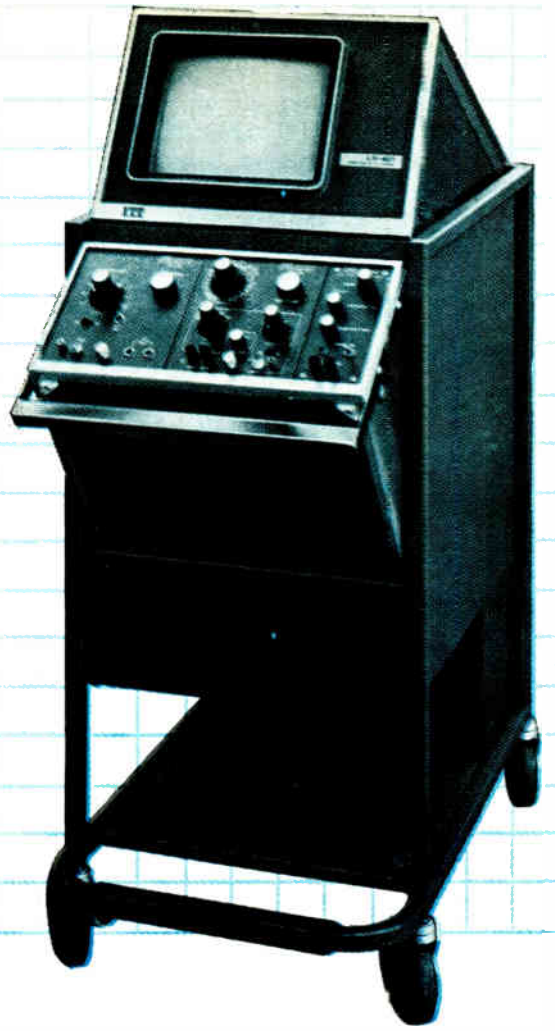
The pressure-sensitive surface is distributed on finger and corresponding palm locations, and the hand is covered by a glove. This source of control signals substantially increases capabilities of the hand by initiating many reactions locally, and the amputee is relieved of the burden of triggering them by an act of will. Although strain gages or other devices could be used, this pressure transducer is a simple, reliable current generator that presents no noise problems.

Feedback Loop

The thumb in the figure is controlled by one cable and all other fingers by a second cable. The servo amplifier has four inputs. With the hand open, the negative feedback loop from the follow-up potentiometer is completed and the closed-loop transfer function is $C_1(s) = G(s)/1 + G(s)$, where $G(s)$ is the open-loop characteristic. Initial conditions are set by P_1, which is placed on the lower arm so the amputee can control hand position by pressing it against his body. Although this control is not normally used, it provides an added central control channel.

When the hand is pressed against an object, the pressure-sensitive surface produces control signals. If they exceed a threshold level, the hand is closed through a positive feedback loop. If the hand is approximated by transfer function $H(s)$, the closed-loop transfer function is $C_2(s) = C_1(s)/1 - C_1(s)H(s) = G(s)/1 + G(s) - G(s)H(s)$, where $H(s)$ is greater than 1. These expressions indicate the difference in system behavior with

CIRCLE 79 ON READER SERVICE CARD→



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LARGE SCREEN
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and without external stimuli.

Dividing the hand into two zones enables determination of whether pinching or grasping action is required. Pressing the finger tips produces positive current while pressing the palm produces negative current, each causing servo motor rotation in the opposite direction. This arrangement permits introduction of a time delay in thumb action. The two cables (see p 79) are not attached at the same position relative to the motor axis so that either the fingers or the thumb start moving first, depending on the direction of rotation of the servo motor. This duplicates movement of the human hand, where thumb movement must be delayed to form a fist. The pinching reaction is always evoked by touching the finger tips, while holding is obtained by stimulating the palm.[3] The two zones are supplied with voltages of opposite polarity.

Because of the positive feedback loops, the hand would develop full power in all cases, which would crush many objects and also waste power. Provisions were therefore made to regulate hand pressure in accordance with the weight of the object held. Although this criterion is not satisfactory for all situations, it is in many cases. The hand is attached to the amputee's lower arm by a pressure-sensitive coupling of suitable elasticity. It is wrapped completely around the wrist so that the amount of stress when lifting an object or pressing the hand against a fixed surface controls servo motor power.

Finally, switch S is provided so that the amputee can use the hand as a conventional positioning servo at his option.

Standard Components Used

It is planned to attach the servomechanisms and circuits at the lower end of the arm with the power supply outside. Advances in miniaturization indicate that this arrangement is feasible. Since precision is not a problem, standard inexpensive components can be used.

Although the discussion was limited to the hand, the principle of localized stimulation could be valuable in other fields, such as remote manipulation and remote vehicle

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control and operation.

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Ruby Laser Makes Holes in Diamonds

COHERENT LIGHT beam has been used in recent experiments to cut holes in diamond. The narrow-beam light provided by a laser cut the holes in 200 microseconds, generating temperatures of 10,000 deg. F.

The experiments were conducted at the General Engineering Laboratory of General Electric using industrial diamonds. Results indicate the possibility of high-speed inexpensive techniques for machining a wide variety of very hard materials.

The diamond surface is vaporized almost instantly when it is exposed to the high-energy light. The light beam striking the diamond causes an explosive sound, and a blue-white jet similar to the flame of intensely hot gas is produced.

Diameter of the diamonds used is about one-quarter inch, and the laser-cut holes are about 0.002 inch in diameter. No structural defects resulting from the experiments appeared in diamond analyses.

Electron-beam techniques have also been used to cut diamonds. However, the laser method promises a number of advantages, including lower cost and higher speed. Also, an electron beam must be operated in a vacuum, which is not required for the laser.

The laser has also been used to make holes in stainless steel, tungsten and other hard metals that are difficult to machine using conventional methods.

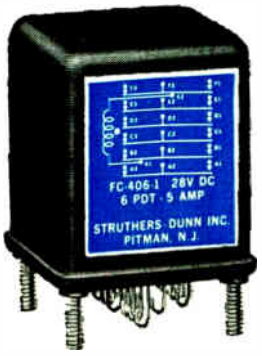
The ruby crystal used in the laser is a rod 8 inches long and slightly more than ½ inch in diameter. The laser was operated at room temperature, although higher energies could be achieved by cooling the ruby with liquid nitrogen.

Dunco

AIR FRAME RELAYS

TYPE FC-400
4P-DT
10 ampere contacts
for 28v DC or 115/200v,
400 cycles AC.

TYPE FC-404
4P-DT
5 ampere contacts
for 28v DC or 115v,
400 cycles AC.



TYPE FC-406
6P-DT
5 ampere contacts
for 28v DC or 115v,
400 cycles AC.

in 4- and 6-Pole Balanced Armature Types to MIL-R-6106C

Here's an entire series of Dunco relays built to standards which pace those of the missiles and aircraft for which they are designed. Their dual coil, balanced armature design combines low operating power with high resistance to shock and vibration.

Each unit is hermetically sealed under rigidly controlled atmospheres to assure long, fully dependable operation under minimum current, rated load, and severe overload conditions in either Class B8, A5 or A8 service. Non-gassing materials and bifurcated contacts further enhance the reliability of a fully proved basic design. Options available on all types include many terminal and mounting styles as well as self-contained rectifiers for AC operation of coils. Modifications for electronic applications complying with MIL-R-5757D also can be furnished.

Specifications on all three types are available by writing for Bulletin FC-400 to: *Struthers-Dunn, Inc., Pitman, N. J.*

STRUTHERS-DUNN

PIONEERS IN SPACE AGE RELAY RELIABILITY

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The new BR-5 is smallest of the precision relays that Babcock manufactures. Despite its small size, it features the same rugged dependability and operating versatility that distinguish all Babcock products.

Most airborne, undersea or ground support requirements can be satisfied by Babcock's standard line of relays, while other requirements are met by special variations. The following relay series show typical performance characteristics of Babcock's standard product line.

BR-5 MICRO/MICROMINIATURE DRY CIRCUIT TO 1 AMP SERIES

Contact Rating: 1 amp res. @ 32V DC, .050 Ω max. • **Contact Arrangement:** SPDT • **Vibration:** 30g, 40 to 3000 cps; 0.4" DA, 10-40 cps • **Shock:** 125g, 11 millisec. • **Life:** 100,000 operations min. @ 1 amp, 125°C. • **Military Specification:** meets MIL-R-5757D.

BR-5 SERIES

BR-7 SUBMINIATURE DRY CIRCUIT TO POWER SWITCHING SERIES

Contact Rating: 2, 5 and 10 amp res. @ 28V DC or 110V AC, 400 cps • **Contact Arrangement:** SPDT, DPDT • **Min. Pull-in Power:** 80 mw/pole, derated to 50 mw • **Header Styles:** plug-in terminals, solder hooks, 3" printed circuit leads.

BR-7 SERIES

BR-8 MICROMINIATURE CRYSTAL CAN SERIES

Contact Rating: 2 amp res. @ 32V DC or 115V AC, 400 cps; 1 amp inductive @ 32V DC • **Contact Arrangement:** SPDT or DPDT • **Dry Circuit:** 1μa @ 1 mv, 100 Ω max. contact resistance • **Size:** .360" x .790" x .870" high (current sensitive, 1.190" high).

BR-8 SERIES

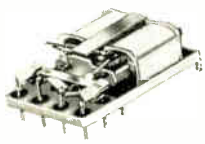
BR-9 SUBMINIATURE MAGNETIC LATCHING SERIES

Contact Rating: 5 and 10 amp res. @ 28V DC or 110V AC, 400 cps • **Contact Arrangement:** DPDT • **Header Styles:** 10 pin or 8 pin polarized • **Holding Coils:** separate or series operation.

BR-9 SERIES

BR-12 MICROMINIATURE ULTRASENSITIVE SERIES

Relay Types: standard, high sensitivity, max. sensitivity and centepede "lie down" printed circuit versions • **Contact Rating:** 2 and 3 amp res. @ 32V DC or 115V AC, 400 cps; 1 amp inductive @ 32V DC (max. sensitivity unit 2 amp res. @ 28V DC) • **Contact Arrangement:** SPDT or DPDT • **Coil Power** (max. sensitivity unit): 25 mw SPDT, 40 mw DPDT.

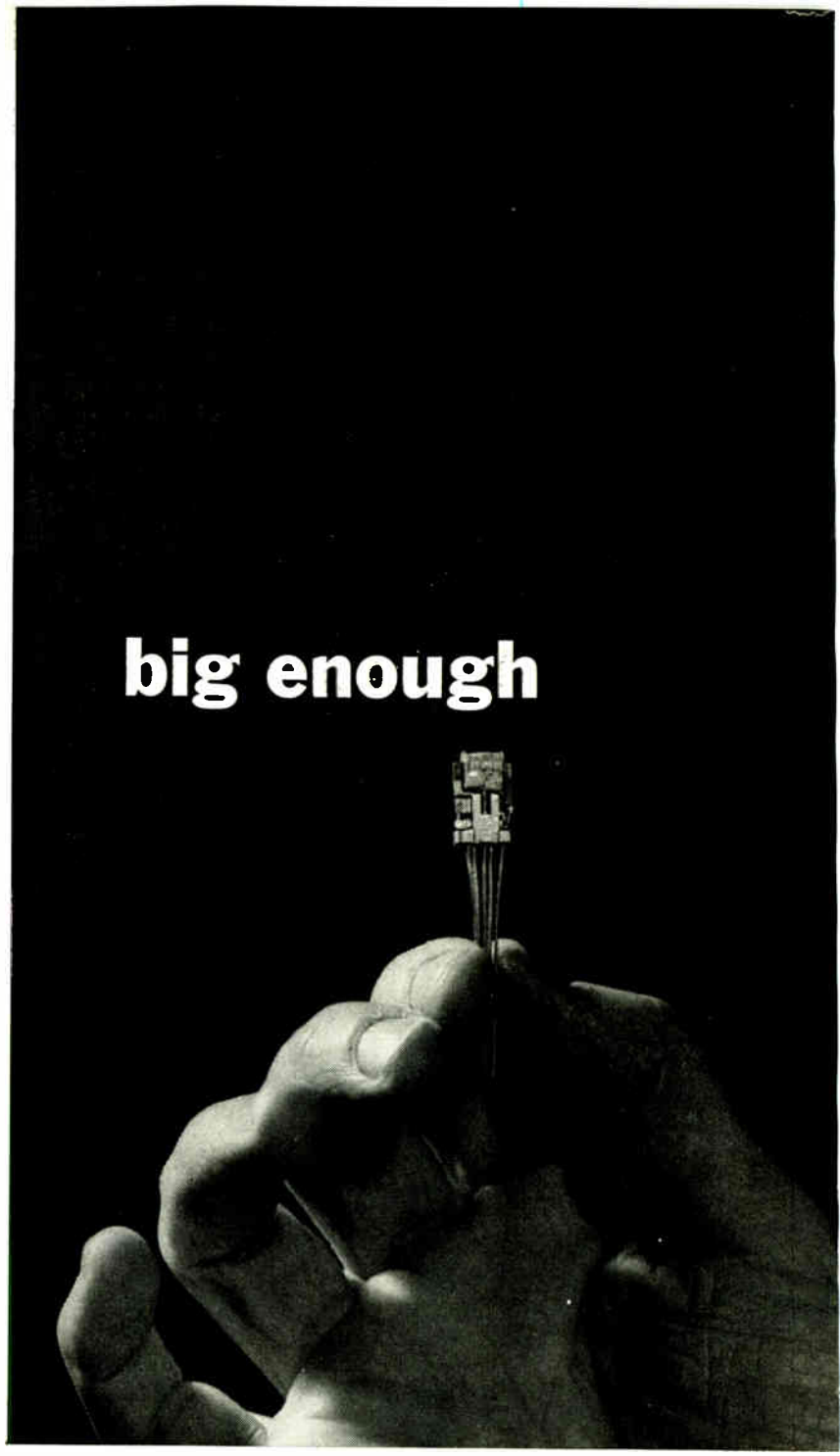


BR-12 SERIES
BR-12P SHOWN

BR-14 SUBMINIATURE FOUR POLE, DOUBLE THROW SERIES

Contact Rating: (@ 28V DC or 115V, 400 cps): 10 amp res., 3.5 amp inductive; 7.5 amp res., 2.5 amp inductive; 5 amp res., 2 amp inductive • **Contact Arrangement:** 4PDT (4 form C) • **Size:** 1.000" x 1.075" x 1.300" • **Weight:** 3.0 oz. max.

BR-14 SERIES



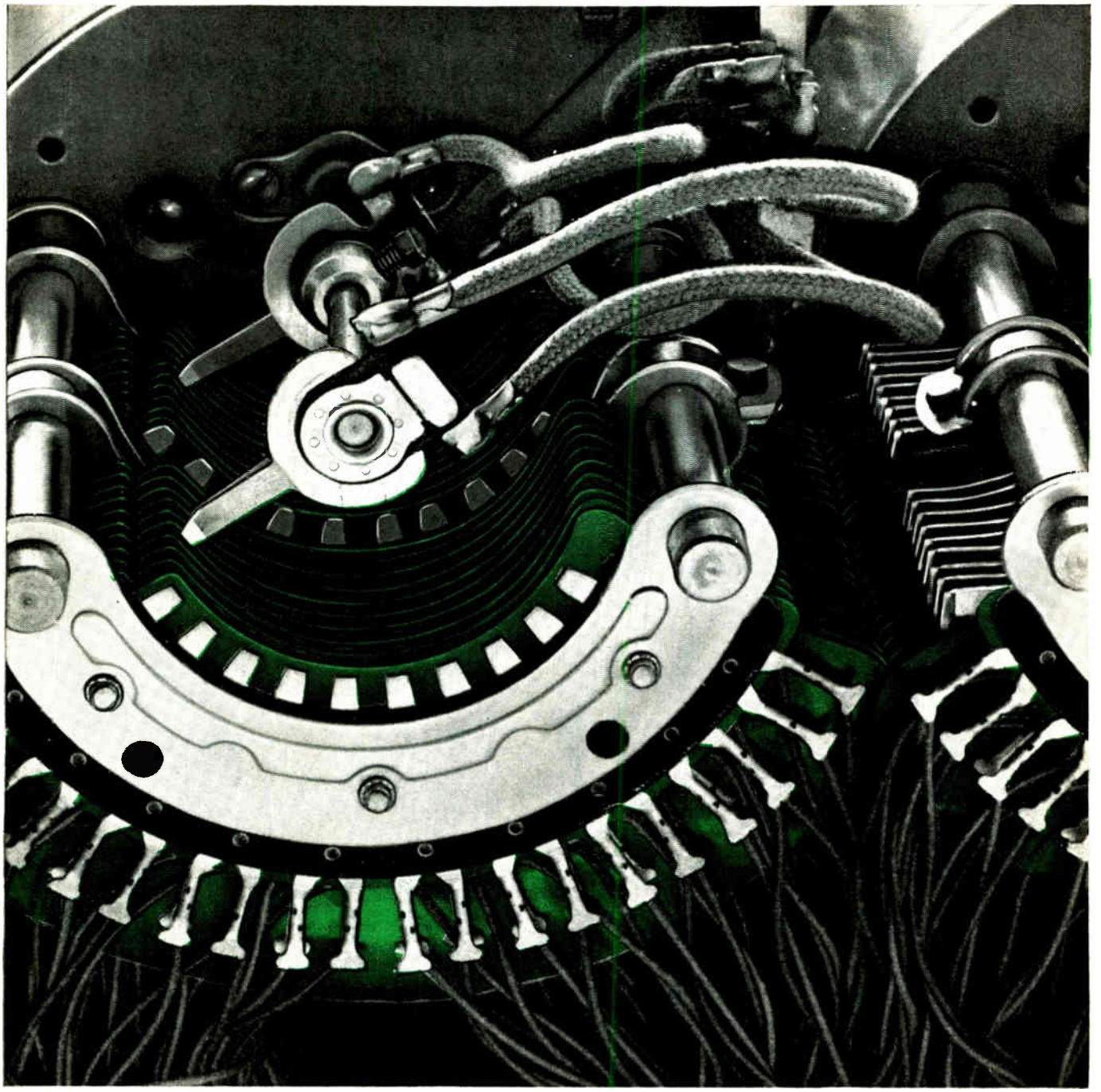
Dry circuit to 1 amp switching in a rugged 1/10th oz. hermetically sealed relay

Babcock's dependable new BR-5 SPDT relay easily handles any load to 1 full amp at 32V DC. The transistor can-sized package is only as large as it needs to be, measuring 0.2" x 0.4" x 0.6". A special magnetic circuit is responsible for its high sensitivity, generally a limiting factor in relay miniaturization. Exceptionally rugged, the BR-5 is built to withstand 125g shock and 30g vibration at 3000 cps. Selective utilization of materials enables −65°C to +125°C operation, ideal for missile and space probe environments. Available in various mounting styles with printed circuit leads. Interested designers should contact their Babcock representative or write direct for Bulletin BR 617.

Babcock Relays

A Division of Babcock Electronics Corporation
1645 Babcock Avenue, Costa Mesa, Calif.

CIRCLE 84 ON READER SERVICE CARD



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This step-by-step switch handles 300 trunk calls a day. A hundred thousand times a year the central contact wiper flashes between the tough spacers of Du Pont "Mylar" polyester film.

Western Electric Co. picked "Mylar" to replace stiff phenolic fiber. It reduced manufacturing costs, since separate insulators could be punched out automatically at high speeds from rolls of "Mylar". Phenolic fiber was available only in sheets, not adaptable to full automation. "Mylar" was tougher and more durable: resisted cracking when flexed or bent. It had a higher dielectric rating, allowing valuable space reductions.

"Mylar" today is the standard insulation in a wide variety of electrical/electronic applications. In motors, capacitors, switches and wiring, its superb dielectric, chemical and thermal properties guarantee years of trouble-free performance. The high performance of "Mylar" in thinner gauges frequently gives substantial savings—since you use less "Mylar" than conventional materials.

Additional cost reductions can come from design modifications and manufacturing economies. Why not investigate its unique properties in your application? Save time and money now by writing to: Du Pont Company, Film Dept., Wilmington 98, Delaware.

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DU PONT

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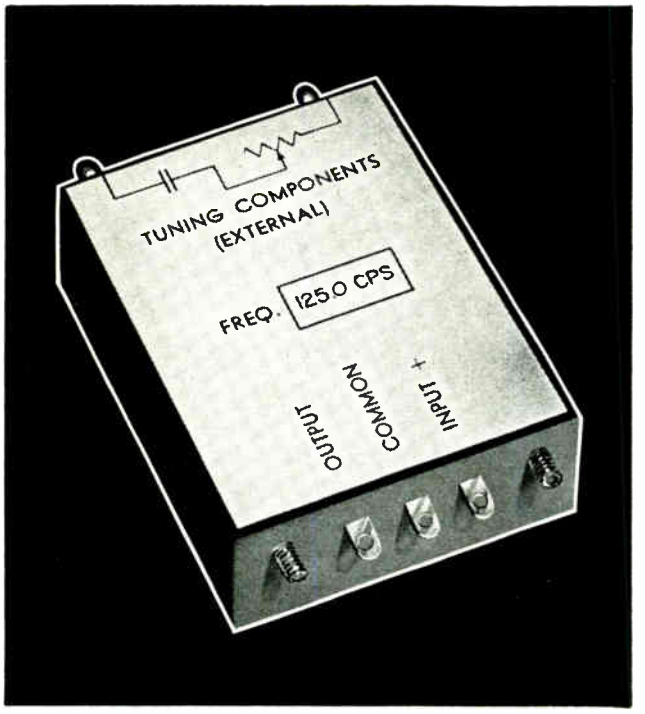

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FREQUENCY SOURCES
RANGE: 10 cps to 10 kcs

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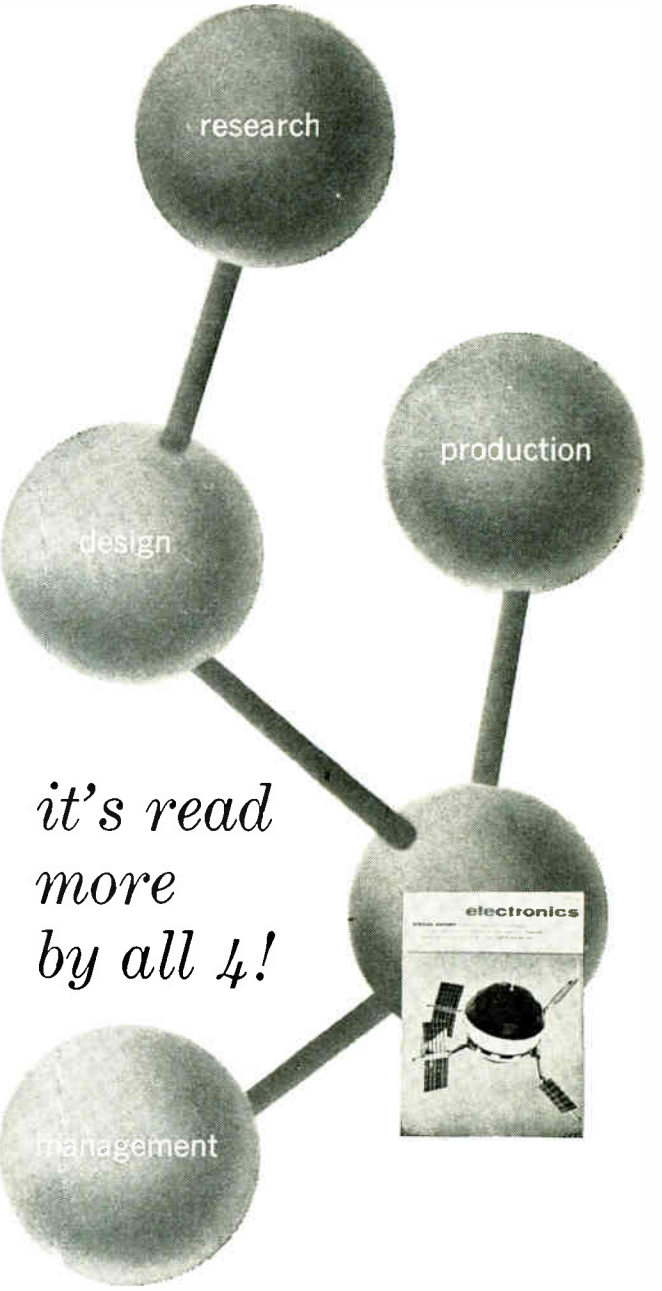

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NEW FROM BENDIX

42 RECTIFIERS 3-6-12 AMP SERIES

New Bendix® silicon rectifiers offer lower current leakage for greater circuit stability—as low as 10 microamps at 600 volts. They're 'Dynamically Tested', an exclusive Bendix quality control process that individually tests each unit to assure uniform reliability. The result: dependable, versatile units that offer a wide range of voltage capabilities (50 to 600 volts PRV). Designs conform to JEDEC DO-4 outlines—with welded case and glass-to-metal hermetic seal between case and anode lead. Ideally suited for applications including magnetic amplifiers, DC blocking units, and power rectification. Write Bendix Semiconductor Division for information.

MAXIMUM RATINGS

Type Number	Forward Current	Peak Reverse Voltage	Reverse Current at PRV		Forward Drop at 25°C
	Adc	Vdc	@150°C	@25°C	Vdc
1N1124-1N1128	3 @ 50°C	200-600	—	10 μAdc	1.1 @ 6 Adc
1N1199-1N1206	12 @ 150°C	50-600	10.0 mAdc	—	1.25 @ 12 Adc
1N1341-1N1348	6 @ 150°C	50-600	10.0	—	1.15 @ 6 Adc
1N1581-1N1587	3 @ 150°C	50-600	0.5	—	1.5 @ 6 Adc
1N1612-1N1616	5 @ 150°C	50-600	1.0	—	1.5 @ 10 Adc
1N2491-1N2497	6 @ 150°C	50-600	2.0	—	1.1 @ 6 Adc
B-443-B-449	12 @ 150°C	50-600	2.0	—	1.2 @ 12 Adc

Bendix Semiconductor Division

THE Bendix CORPORATION

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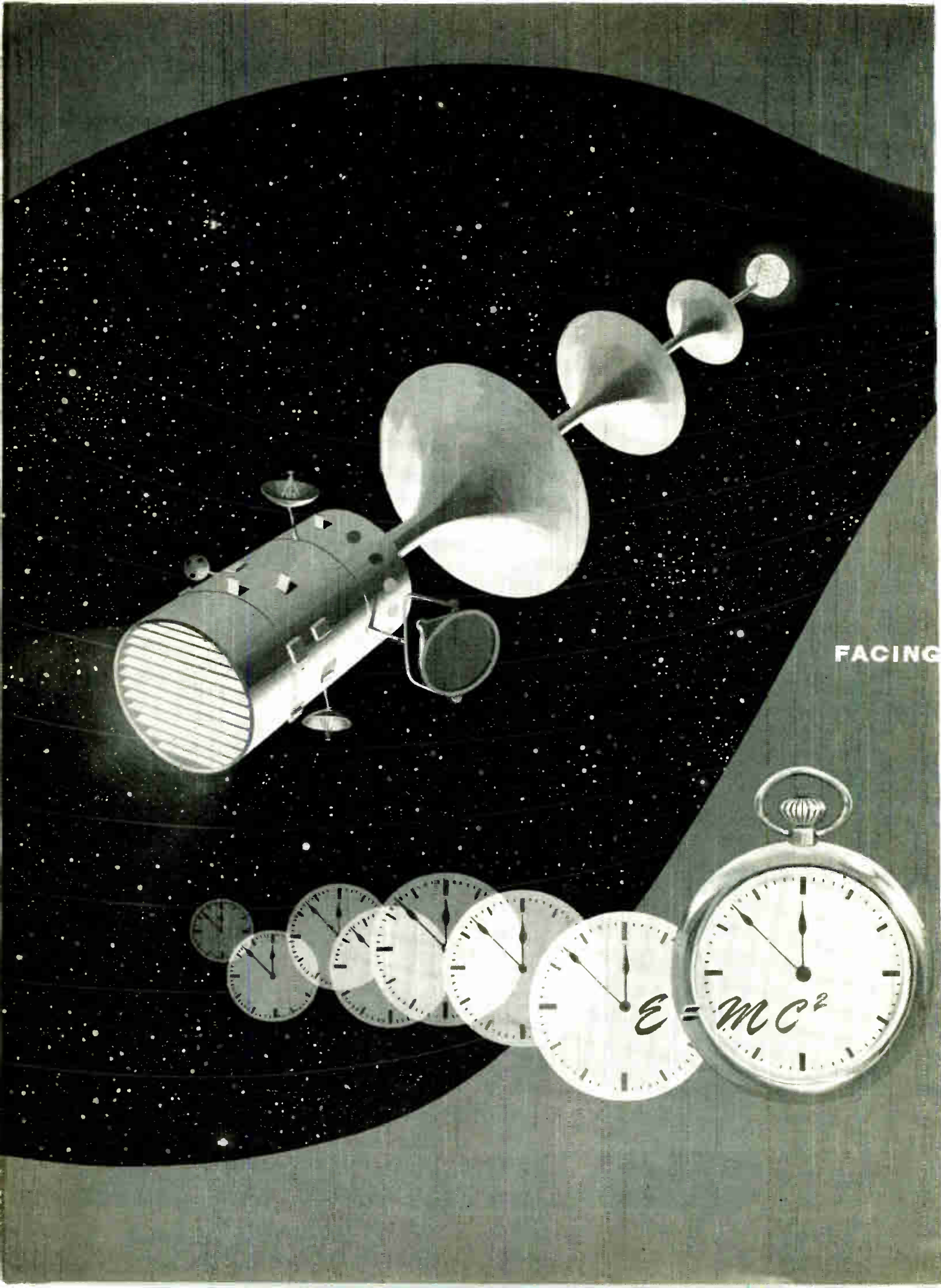
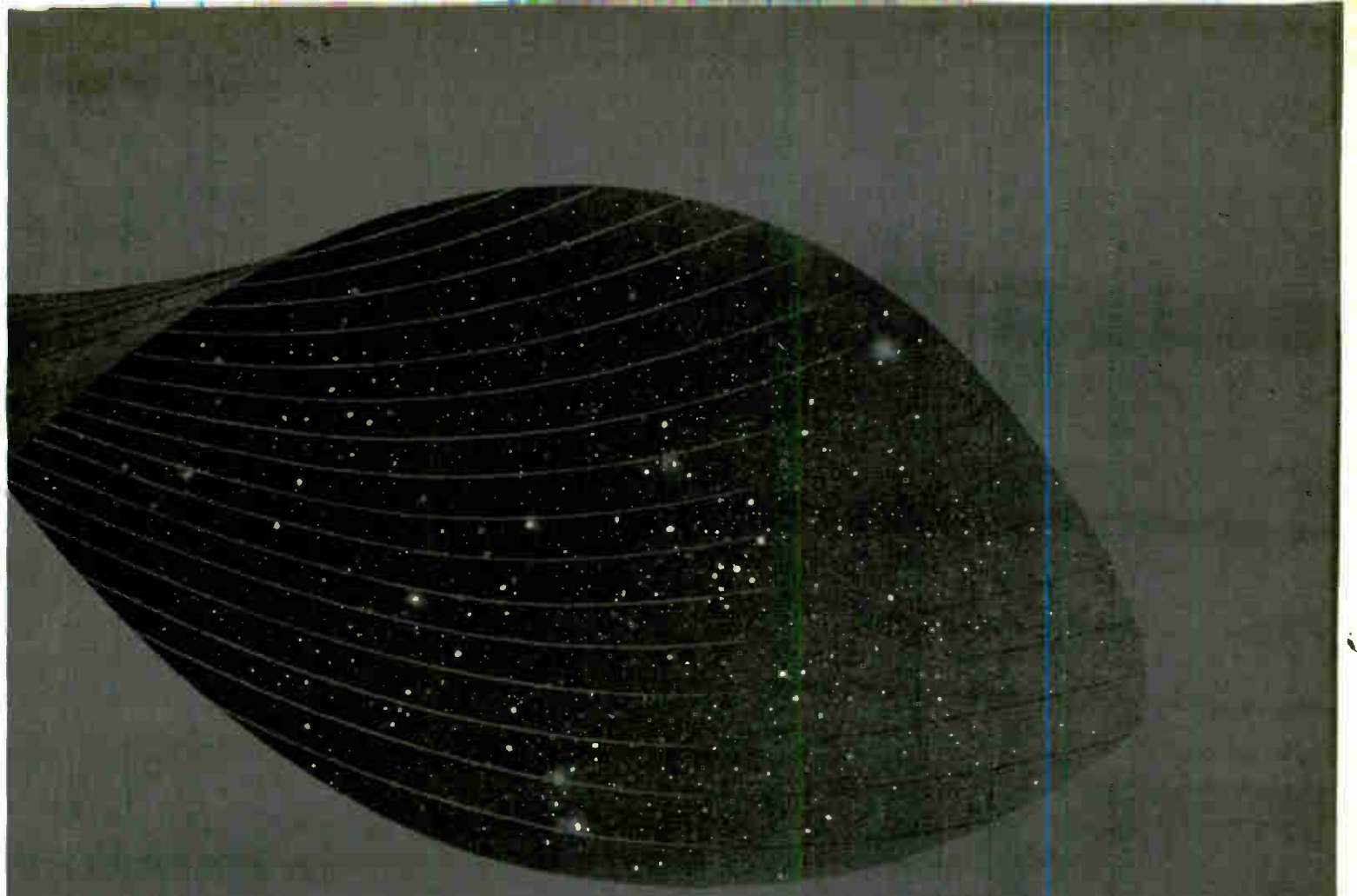

FACING
$E = mc^2$



HE FOURTH DIMENSION IN PROPULSION DEVELOPMENT

Whether the universe has a "saddle shape," or any shape at all, is a matter of interesting conjecture. The matter of space travel, however, is the subject of intense experimentation. A nuclear/thermionic/ionic propulsion system, currently being studied at Lockheed Missiles & Space Company, might well become the power source for space vehicles.

Its design incorporates a nuclear reactor only one foot in diameter, generating heat at a temperature of 1850°K. This is transmitted to banks of thermionic generators, converting the heat directly into electrical energy for the ion beam motor which uses cesium vapor as a fuel. The entire system is designed without any moving parts, minimizing the possibility of failure.

Lockheed's investigation of propulsion covers a number of potential systems. They include: plasma, ionic, nuclear, unique concepts in chemical systems involving high-energy solid and liquid propellents, combined solid-liquid chemical systems. The fundamentals of magnetohydrodynamics, as they might eventually apply to propulsion systems, are also being examined. Just as thoroughly, Lockheed probes all missile and space disciplines in depth. The extensive facilities of the research and development laboratories—together with the opportunity of working with men who are acknowledged leaders in their fields—make association with Lockheed truly rewarding and satisfy ng.

Lockheed Missiles and Space Company in Sunnyvale and Palo Alto, on the beautiful San Francisco Peninsula, is an exciting and challenging place to work. For further information, write Research and Development Staff, Department M-24D 599 North Mathilda Avenue, Sunnyvale, California. An Equal Opportunity Employer.

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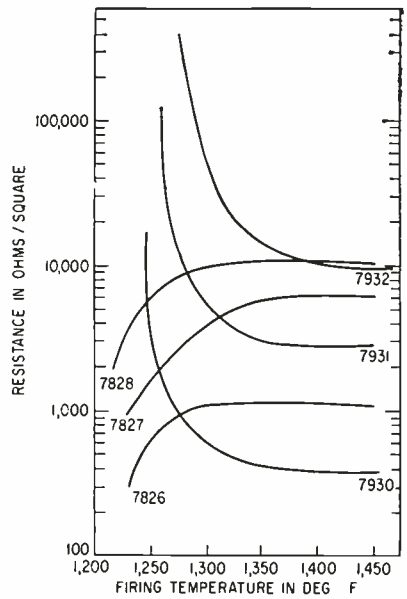
Process Variables for Fired-On Resistors



Effect of peak firing temperature of resistance, 3 in/min. belt travel for 45-min. cycles

IN 1960, Du Pont introduced a series of new resistor compositions for application of thin resistor films on various types of ceramic substrates by firing (ELECTRONICS, Oct. 28, 1960 p. 88). Many process variables must be considered when these thin film resistors are being prepared. A number of these variables are emphasized and helpful suggestions and precautions, based on Du Pont's experimental work, are given.

Of particular interest is a recent advance made by Du Pont in the firing technique. Simultaneous firing of the resistor film and terminal causes the two to form an alloy. The alloyed terminals give low temperature coefficient of resistance and low drift.

The base material has a marked effect on the properties of the resistor. The substrate must be flat, smooth, and free from camber to give the best possible reproducibility. The thermal expansion coefficient (TCR) affects the temperature coefficient of resistance by causing changes in particle-to-particle pressure when the resistor is heated. Although common ceramic substrates have given no evidence of chemical interaction with resistor compositions, this problem may arise with some unusual base materials. Excessive reduction, for example, has been encountered in the firing of resistors printed on graphite. Studies show that 95 per cent aluminum oxide has the best all-around properties for a resistor subtrate, according to Du Pont.

Equalizing Expansion

It is particularly important that the expansion of the terminals match that of the resistor film to obtain optimum TCR and low drift. In a new Du Pont-developed technique, the terminal print and resistor are co-fired so that they form an alloy. This eliminates the problems caused by unequal expansion or contraction. The Du Pont compositions found to give the best terminals are Silver 6320, Silver 6730, and Platinum-Gold 7553.

In the co-firing procedure, the terminal material is printed on the substrate and dried approximately 15 mins. 110-150 deg C. The resistor composition is then printed over the terminals so that the desired resistor path is between the terminals. When the two prints are fired simultaneously to 760 deg C they diffuse, and the line of contact between them becomes indefinite.

The metal in silver 6320 and silver 6730 reacts with the resistor composition during firing, and blisters or craters may form in the area of contact. While this results in a defective appearance, it has no effect on the electrical properties. Platinum-Gold 7553 produces smooth, defect-free terminals and, for this reason, is sometimes preferred. The platinum-gold composition requires a longer time in the solder bath than do the silvers, 10-20 seconds compared with 2-5 seconds, and does not accept solder quite so well as the silvers.

Silvers which fire at lower temperatures, such as Du Pont's silver 7095 and silver 7713, can also be used for terminals. When these are used, two firing cycles are required. First, the resistor is printed and fired at 760 C, then the terminal is printed and fired for 10 min at 540 C. The two-step application produces smooth prints which show a definite line of contact between the resistor and terminal. The chief disadvantage is that the resistors have higher TCR and drift than those with alloyed terminals.

The terminal composition is applied following the procedure given in Du Pont Bulletins CP 2 and CP 4. Procedures for preparing stencil screens are given in Bulletin V 8.

It is extremely important that the thickness of the resistor print be controlled since resistance varies with the volume of resistor composition applied. Differences in application thickness also lead to variations in texture of fired resistors which cause wide differences in resistance. In screen stenciling, the best control of print thickness which can be expected is ±10 per cent.

Viscosity Control

One important factor in obtaining constant print thickness is controlling the viscosity of the resistor composition. Best results are obtained by measuring the viscosity of the resistor composition periodically and making up solvent losses by adding butyl Carbitol acetate.

To minimize variation on print thickness, the screen should be set as far from the substrate as possible while still obtaining prints with a taut 4 × 4-in. screen—0.040 inch is optimum clearance. As the screen is moved closer to the substrate, the prints become thicker and the variation in thickness increases. The first one or two prints made from a stencil after it is charged with composition differ considerably in thickness from those which follow. These first prints should be discarded to maintain high standards of reproducibility. After printing, the resistors should be allowed to air dry for a

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controlled length of time before forced drying. Leveling of the print begins right after printing and has the effect of raising the resistance value. A 15-minute air-drying period, therefore, greatly improves the reproducibility. The forced drying which follows is not critical, providing the prints are thoroughly dry. It is suggested that the resistors be forced-dried for about 10-min. at 220 deg F.

Monitoring Thickness

Application thickness can be monitored by measuring the dried prints with a ten-thousandths micrometer. Thicknesses of 0.0009 in. to 0.0011 in. provide the best reproducibility, although thicknesses of 0.0007-in. to 0.0013 in. are commonly encountered. Weighing may also be used to measure thickness, but this requires a balance sensitive to the fourth decimal place. A 1/8 in. × 3/8 in. print, for example, weighs only 2.5 mg.

The terminal and resistor prints are co-fired to 1,400 deg F ± 25 deg F. The relationship between peak temperature for each firing cycle is shown in the graph, p 90.

Both series of resistors tend to reach a constant resistance value when the peak is sufficiently high. The 7,800 series approaches from low to high resistance, the 7,900 series from high to low resistance. Close control of firing temperatures must be maintained.

Control of firing time is not critical. Fast firing gives a slightly lower resistance with all of the compositions. A 10 per cent variation in resistance value was found when the firing rate varied from 2 inches to 4 in. min/belt speed.

The dried terminal and resistor prints are fired in a continuous belt furnace which has a preheat zone of 300-400 F at the entrance end. Deviation in firing temperature has deleterious effects on properties other than resistance. For best results, the firing temperature should be kept with 25 deg F of the specified 1,400 deg F.

The best method for attaching leads to resistor terminals is by soldering with a eutectic solder containing 62 per cent tin, 36 per cent lead, and 2 per cent silver at 210 deg C to 215 deg C. The resistor film is not affected by soldering, and either iron- or dip-soldering may be used.

Contacts to Terminals

Pressure contacts can be made to the resistor terminals if sufficient pressure is used and is spread out over a considerable area. The heterogeneous surface of the terminal makes sharp point contacts unreliable. When evaluating electrical properties, other than simple measurements of resistance, it is recommended that leads be soldered to the terminals.

Resistor composition specified for stencil screen applications have corresponding formulations suitable for the dip method of application as is used in making rod resistors. Rod resistors may be spiraled to obtain higher resistance values by using a diamond cutting wheel.

Thinner and Smaller Hall Devices

THE GROWING DEMAND for thinner and smaller devices prompted F. W. Bell to add two new Hall-Paks to their line of Hall-effect devices. Their Model BH-200 Transverse and Model BH-203 Axial Hall-Paks, released in July of 1961, now have received wide acceptance. The BH-200 is less than 0.019-in. thick and the BH-203 is 3/16-in. in diameter. Characteristics include low noise and high thermal stability. It is reported that the resistive and inductive null voltages are so low that no compensation is required for

Transverse field Hall device (top), and axial field sensor (bottom)

CAPTURING SOLAR STORMS WITH RADAR...

new data for man's exploration of space

Using the world's most powerful VHF radar system, MIT Lincoln Laboratory Solar Radar Site near El Campo, Texas is gathering new data on the sun's corona; measuring the origin and intensity of violent coronal activity which ejects high energy particles into the solar system . . . a serious hazard to space travel.

Heart of the radar is a 500,000 watt VHF transmitter designed and built by Continental Electronics, specialists in super power transmitters. Operating at frequencies near 38 megacycles per second with a continuous output power of 500,000 watts, this transmitter is ten times more powerful than the largest commercial broadcast transmitter in the United States.

Increasing our scientific knowledge of the factors affecting space travel, the El Campo project is jointly sponsored by the U. S. Army, Navy, and Air Force.

Partial view of the transmitter, console and control panel for the radar system.

Continental Electronics

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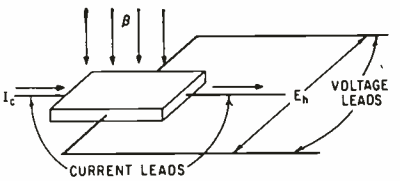
many applications. Several unique manufacturing techniques have resulted from these developments.

Bell has now developed a Transverse probe only 0.006-in. thick and an axial probe only 0.100-in. in diameter, designated Models BH-201 and BH-203. The semiconductor elements are wafers of indium arsenide approximately 0.030-in. by 0.060-in. by 0.0025-in. These units are available in small quantities.

The Hall effect was discovered in 1879 by E. D. Hall at Johns Hopkins University. Until recently it found little use except as a laboratory tool for evaluating material properties. The availability of high carrier mobility semiconductor ma-



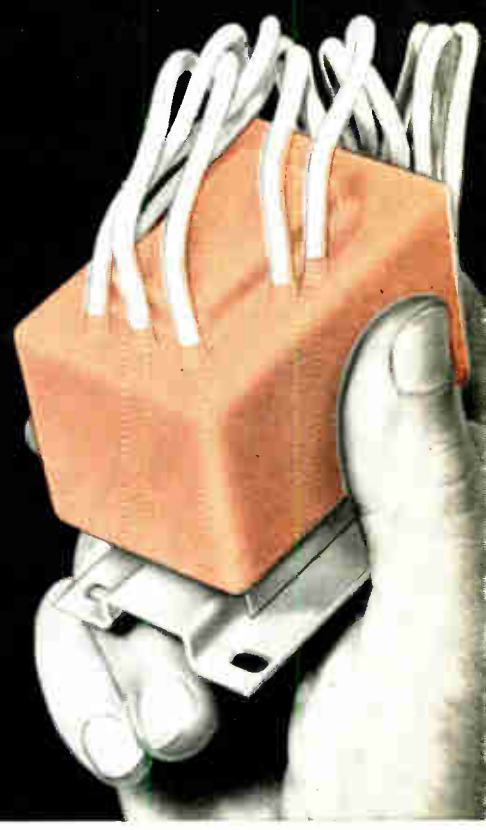
Principle of operation of Hall effect

terials, notably indium antimonide and indium arsenide, has made commercial devices practical.

The principal of operation of the Hall effect is illustrated in the drawing. The control current, I_c, passes through the long dimension of the semiconductor element. When a magnetic field is applied, some of the charge carriers are deflected to one side of the element and produce an output voltage, E_H. This voltage is directly proportional to the product of the control current and the magnetic flux density which is at right angles to the face of the crystal. Thus an output voltage is provided which is proportional to the product of the two inputs and to the sine of cosine function of an angular displacement. A few of the numerous applications for these devices are: gaussmeters, wattmeters, multipliers, modulators, linear and rotational transducers.

In addition to the Hall-device models, F. W. Bell, Inc offers a complete line of gaussmeters, including an instrument that has a 100 milligauss full scale and also an incremetal feature making it possible to resolve one part in 10,000 when measuring gradients or changes in fields of 10 gauss up to 10,000 gauss.

Different potting and encapsulating problems require different solutions. That's why General Electric offers a family of eight RTV and LTV silicones. LTV-602, for instance, is transparent, resilient and very easy to repair, curing in two hours. RTV liquid silicone rubber compounds offer good physical strength, resiliency and a selection of viscosities for impregnation, potting, conformal coatings or sealing.



8 fast cures for potting and encapsulating problems

General Electric Silicones protect against temperature, moisture, ozone, thermal and mechanical shock

Why are G-E silicones used? To protect against temperature extremes from −65° F to 600° F . . . to provide a resilient, shock-absorbing cushion for delicate parts . . . for outstanding electrical properties . . . for their very low (0.2%) shrinkage . . . for their resistance to moisture, ozone and thermal shock.

How are G-E silicones used? By dipping, pouring, spraying or buttering. Cure times can be varied from minutes to hours, depending on catalyst used and the heat applied (from room temperature to 125° C). They bond easily to properly primed surfaces, are easily removed from unprimed surfaces.

	COLOR	VISCOSITY POISES	CONSISTENCY
LTV-602	Clear	15	Easily Pourable
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RTV-20	Pink	300	Pourable
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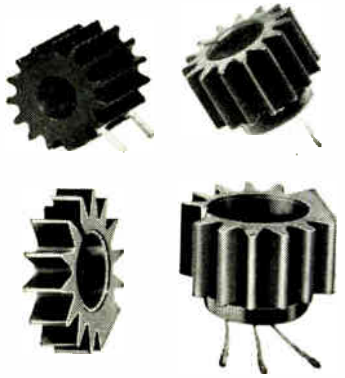

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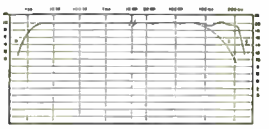
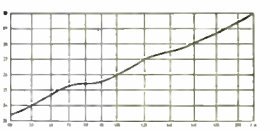
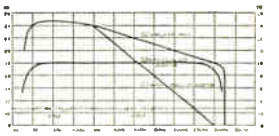


MODEL 222



MODEL 206



CHARACTERISTICS	MODEL 202D	MODEL 206	MODEL 211C	MODEL 222
Bandwidth	1kc - 210 mc	600 cps - 320 mc	15 mc - 100 mc	40 mc - 216 mc
Voltage Gain	20 db	18 db	33 db	28 db
Maximum Output	4 volts rms	6 volts rms	*4.2 volts peak	*4.2 volts peak
Impedance	200 ohms	200 ohms	75 ohms	75ohms

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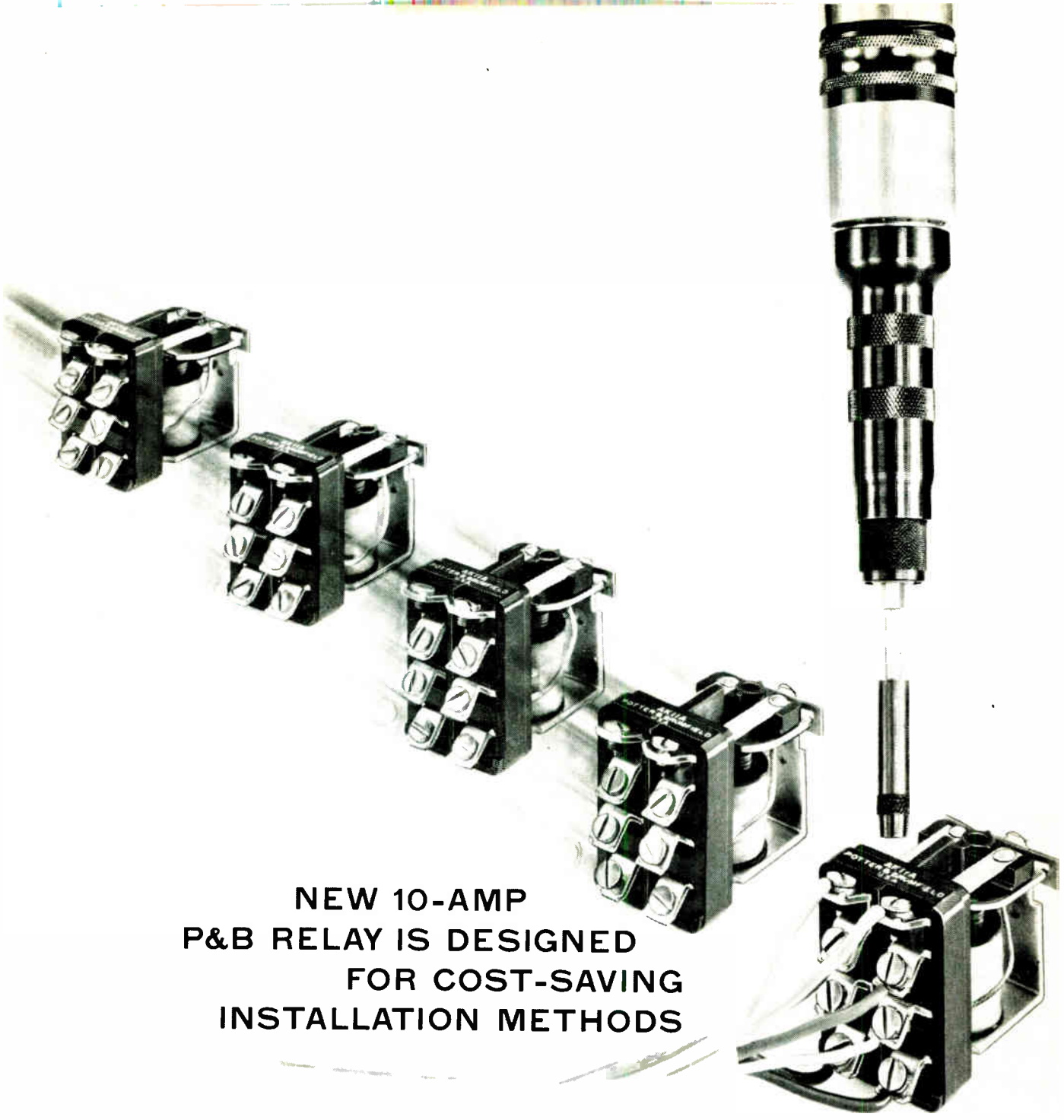

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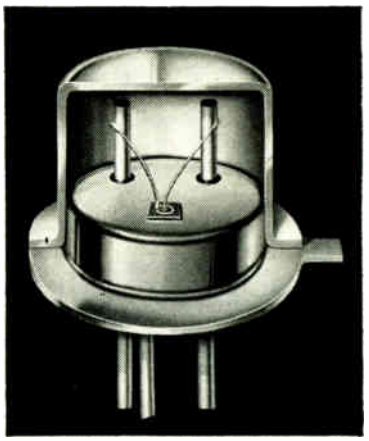
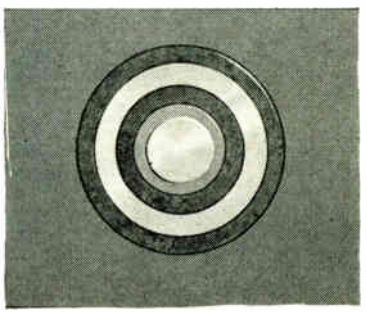
PLANAR EPITAXIAL PASSIVATED SILICON TRANSISTORS

HIGH SPEED WITH LOWEST V_{CE}(sat) RATINGS





The silicon oxide is thermally grown during the planar diffusion process. It forms a passivated surface over the junction that provides maximum protection against contamination and degradation of characteristics during the entire life of the transistor. The thin epitaxial layer on low resistivity substrate gives negligible body drop resulting in extremely low saturation resistance and increased uniformity from unit to unit.

PEP (PLANAR EPITAXIAL PASSIVATED) TRANSISTORS

Type No.	Description	Notable Advantage
2N2192	Similar to 2N1711 (see chart below)	V_{CE} (sat) = 0.35V max. V_{CEO} = 40 V min.
2N2192A	Similar to 2N1711 (see chart below)	V_{CE} (sat) = 0.16V Typ.; 0.25V max. V_{CEO} = 40 V min.
2N2193	Similar to 2N1613 (see chart below)	V_{CE} (sat) = 0.35V max. V_{CEO} = 50 V min.
2N2193A	Similar to 2N1613 (see chart below)	V_{CE} (sat) = 0.16V Typ.; 0.25V max. V_{CEO} = 50 V min.
2N2194	Similar to 2N696 (see chart below)	V_{CE} (sat) = 0.35V max. V_{CEO} = 40 V min.
2N2194A	Similar to 2N696 (see chart below)	V_{CE} (sat) = 0.16V Typ.; 0.25V max. V_{CEO} = 40 V min.
2N2195	General Purpose Industrial Type	V_{CE} (sat) = 0.35V max. V_{CEO} = 25 V min.
2N2195A	General Purpose Industrial Type	V_{CE} (sat) = 0.16V Typ.; 0.25V max. V_{CEO} = 25 V min.

(V_{CE} (sat) ratings @ I_C = 150 ma, I_B = 15 ma)

PLANAR PASSIVATED TRANSISTORS

Type Nos. TO-18 Package	Type Nos. TO-5 Package	h_{FE} @ I_C = 150 ma V_{CE} = 10 V	V_{CE} (sat) (max.) @ I_C = 150 ma I_B = 15 ma	V_{CER} (min.) @ I_C = 100 ma R_{BE} = 10	I_{CBO} (max.)
2N717	2N696	20-60	1.5V	40V	1 μa @ 30 V
2N718	2N697	40-120	1.5V	40V	1 μa @ 30 V
2N718A	2N1613	40-120†	1.5V	50V	10 mμa @ 60 V
2N719	2N698	20-60	5V	80V	2 mμa @ 60 V *
2N719A	2N698	20-60	5V	80V	
2N720	2N699	40-120	5V	80V	2 μa @ 60 V
——	2N1711	100-300†	1.5V	40V	10 mμa @ 60 V
2N720A	2N1893	40-120†	5V	100V	10 mμa @ 90 V

† plus guaranteed minimum h_{FE}'s at several other currents

* 2N719A and 2N698 are electrically equivalent except that on 2N719A, I_{CBO} @ 75V = 10 mμa max., on 2N698, I_{CBO} @ 75V = 5 mμa max.

The G-E 2192-2195 and "A" series combines three of the most advanced processes in semiconductor technology to bring you new standards of silicon transistor performance, reliability and stability. This series of PEP transistors can replace standard units without basic circuit changes.

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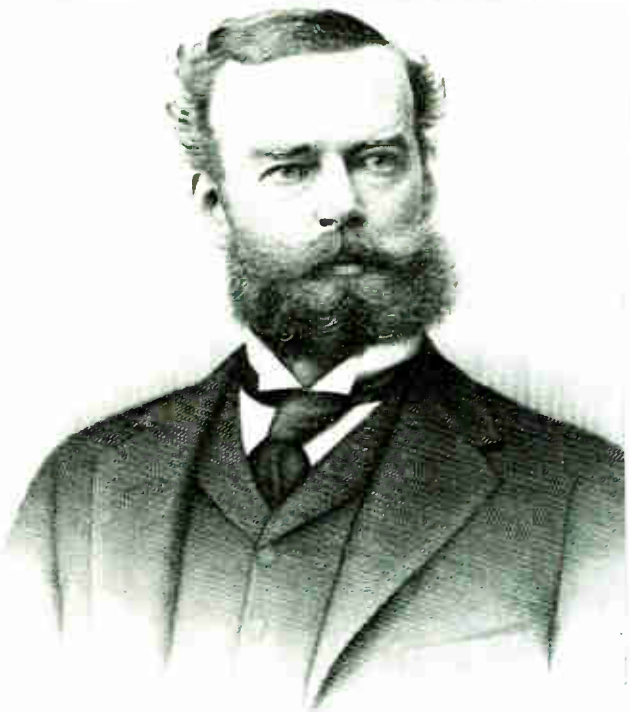
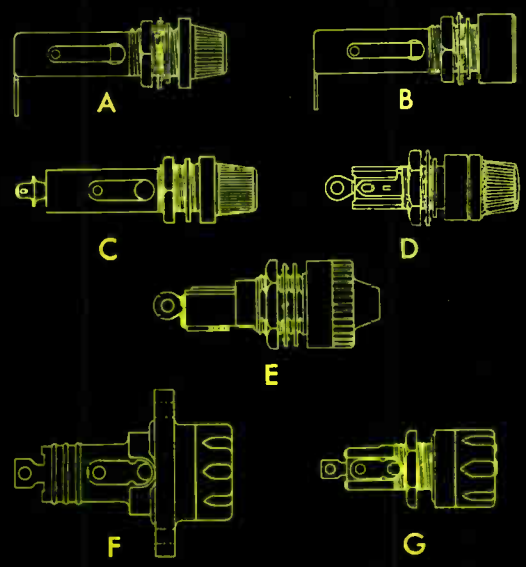
GENERAL ELECTRIC





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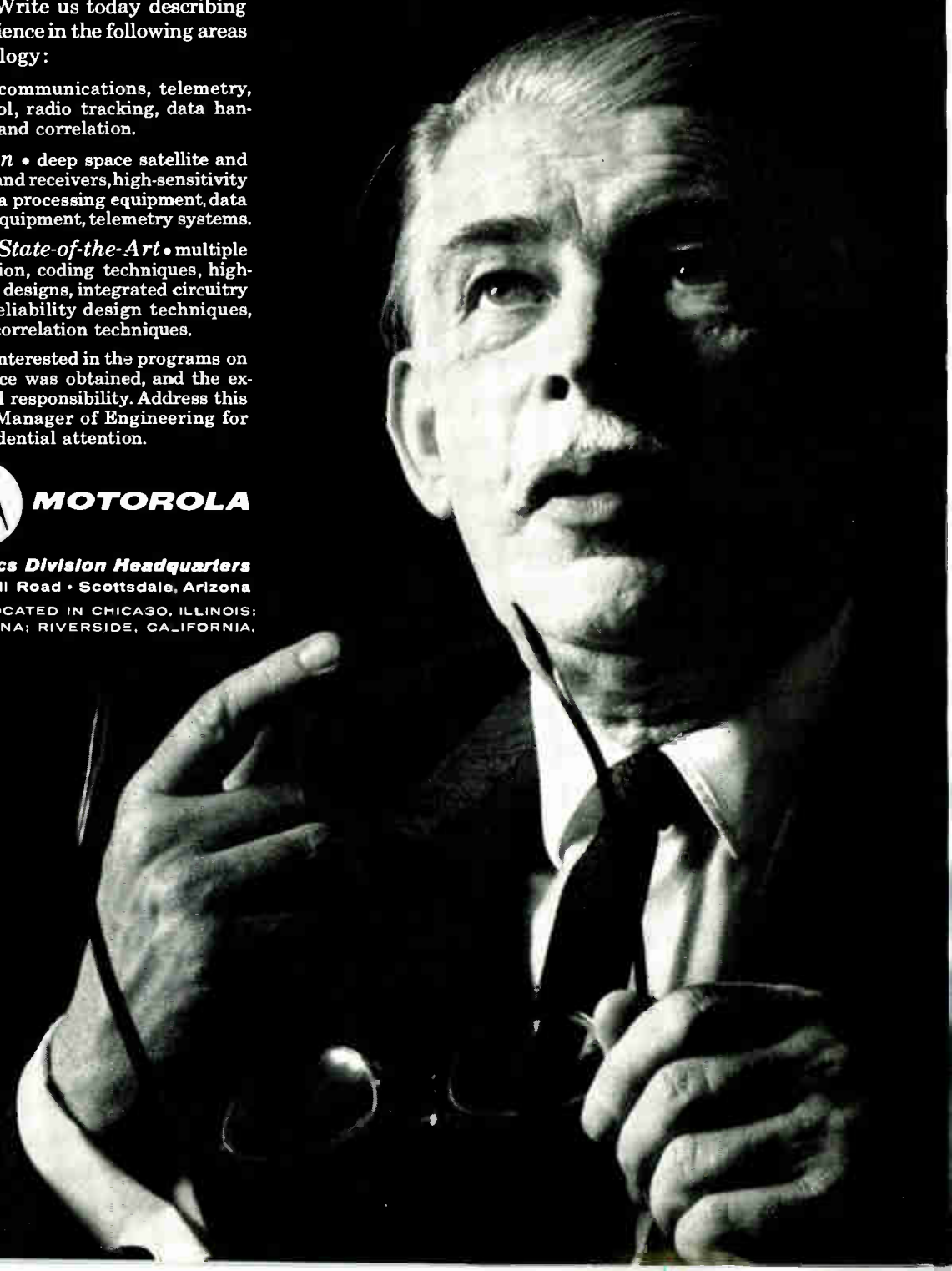

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Hitemp's Engineering Department will help us meet *special* requirements using modified Ceramatemp constructions. They've also got a new product—Ceramaglass—for potting and encapsulating. We oughta ask about that—I'm sending for their "Condensed Catalog" at the same time.

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Tungsten Needles for Semiconductor Tests

By FRANK G. PANY
Semiconductor Products Div.,
Motorola Inc., Phoenix, Ariz.

THE CENTER of the star planar transistor shown in the photographs has an area of approximately one-millionth of a square inch. To make electrical probes of semiconductor areas as small as this, tungsten needles with points having a radius on the order of 50-millionths of an inch are useful; a circle with a radius of 50-millionths of an inch, for example, has an area of about 7.8×10^{-6} square inch.

An electrolytic method for producing such fine probes has been developed by Semiconductor Products Div., Motorola, Phoenix, Arizona. The simple apparatus required is shown in Fig. 1.

A tungsten ground steel rod, 7.6×10^{-2} cm in diameter and 1.9 cm long, was adjusted to give a distance between cathode and rod of 72×10^{-3} cm. The solution (4 percent KOH, 96 percent water) level was set at 42×10^{-2} cm above the cathode. A current of 400 ma at 10 v was applied to the circuit and after 4 minutes and 30 seconds the immersed part of the rod fell off, leaving a point with a taper of about 30 degrees included angle.

The probe, still not fine enough for the application, is shown in Fig.

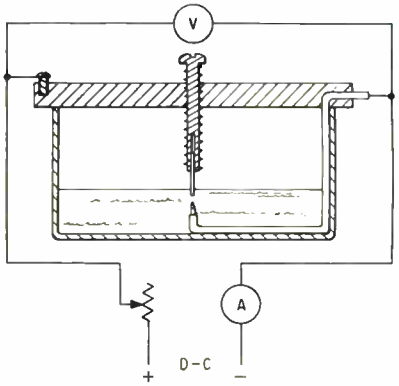
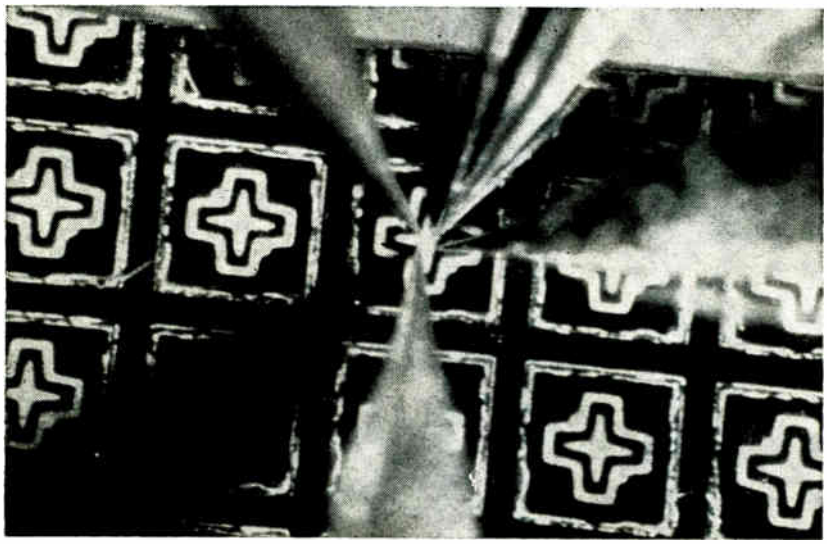
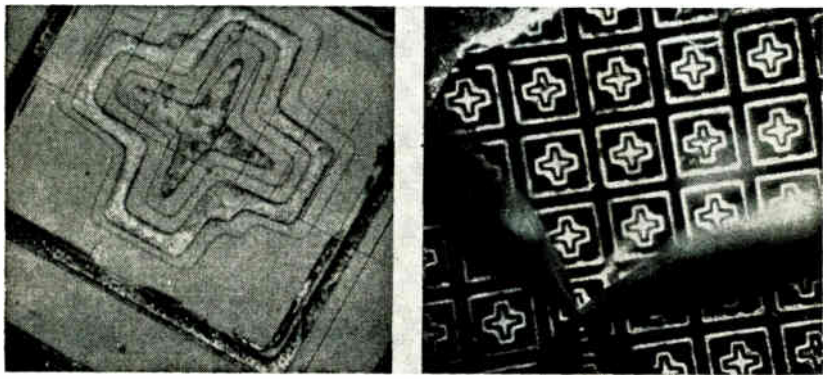


Fig. 1—Needle holder is stainless steel screw, drilled at its lower end to hold tungsten rod. Cathode is insulated stainless steel wire, stripped at both ends. The immersed end stands 1.6 cm high in the center of the tank and is ground to a truncated conical tip, 24 degress included angle, 63.5×10^{-4} cm tip diameter



Fine tungsten probes can make electrical tests on semiconductor areas as small as one-millionth square inch



Center area of star planar transistor (left) has an area of about one-millionth square inch. Ordinary probes (right) with tip radii of 150 to 300 millionths of an inch are not satisfactory for such small dimensions

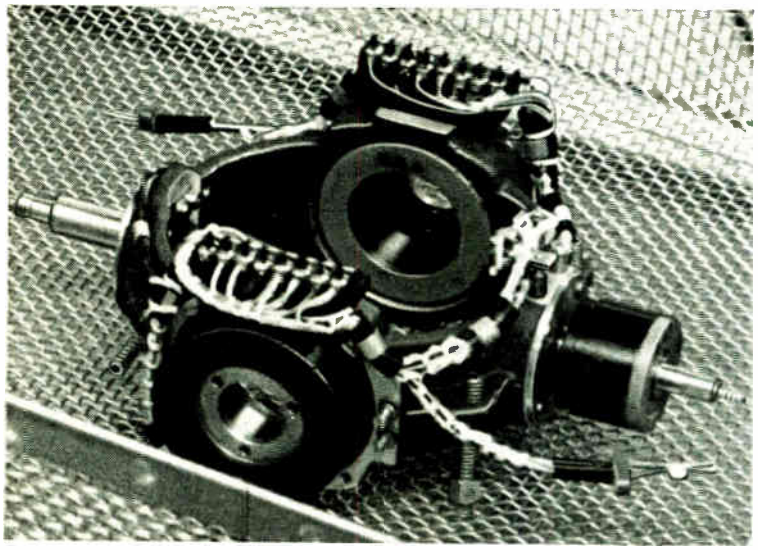
2. The addition of a detergent to the solution was indicated and eventually the following composition was selected: 4 gm KOH (solid pellets), 94 gm distilled water and 2 gm JOY liquid detergent. The detergent is added after the KOH has dissolved.

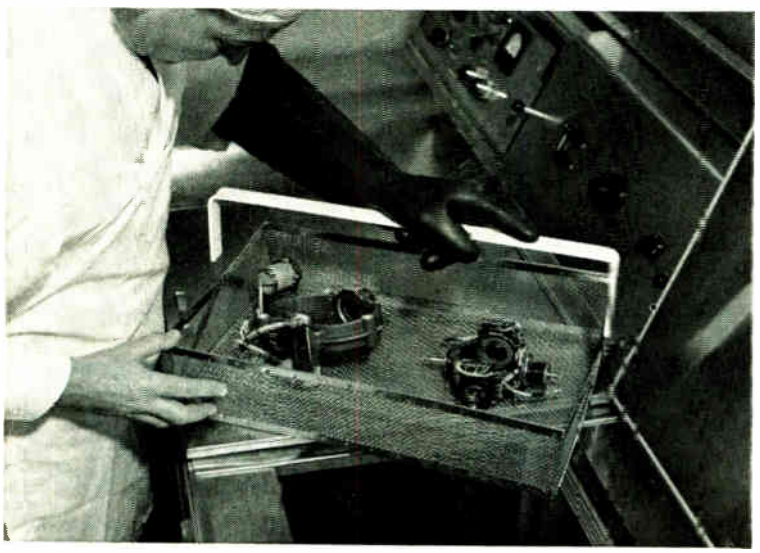
Enough fresh solution is prepared each morning to bring the level of the solution 42×10^{-2} cm above the conical end of the cathode. The level is checked after etching each needle and electrolyte losses are compensated for by adding distilled water. Temperature is kept between 23 and 27 C.

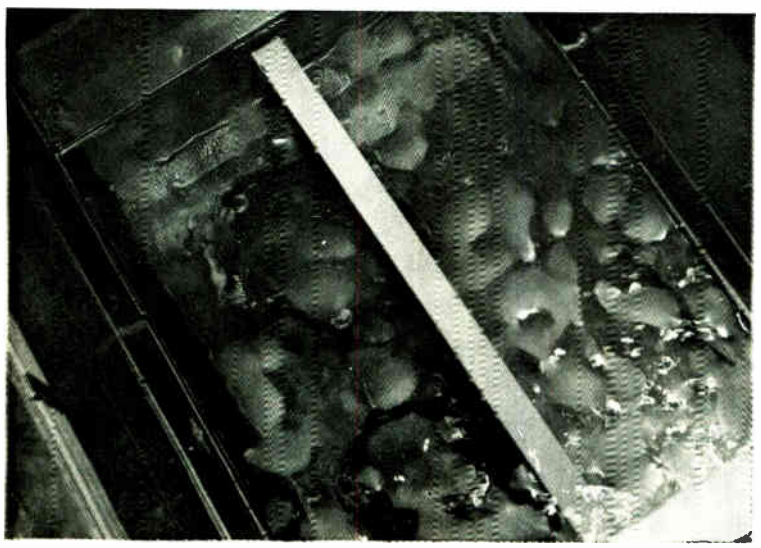
The tungsten ground steel rod, (supplied by Sylvania Electric Products Division, Towanda, Pa.) 7.6×10^{-2} cm diameter, 1.9 cm long, with flat ends, is first aligned with the cathode and the holder is then turned clockwise until the lower end of the rod touches the cathode. A half-turn counterclockwise will then set the rod at 72×10^{-3} cm from the cathode (when the holder has 18 threads to the inch); a separation distance less than 51×10^{-3} cm will cause sparking.

After about 4 minutes and 20 seconds of etching at 400 ma and 28 v, the current suddenly drops to 30 ma and should then be switched

How Bendix cleans critical subassemblies containing 13 different plastics and metals







PROBLEM: Eclipse-Pioneer Div., The Bendix Corp. needed reliable production-cleaning of vital subassemblies for aviation instruments. The subassembly had to be immersed *whole* in the cleaning agent, with no harm to 13 different materials of construction, paint and color coding—yet with thorough removal of contaminants.

SOLUTION: Du Pont Freon* solvent, a selective fluorocarbon cleaning agent. "Freon" penetrates the tiniest openings to remove contaminants, yet its inertness makes it compatible with all sorts of delicate plastic and metal surfaces. The photos also show how quick and easy the new process is—using a sonic-energy cleaner.

Here's how Bendix describes it: "Our objective is to remove any microscopic contaminants generated during production of these subassemblies for aircraft and missile gyros, instruments, flight control systems, etc. Contaminants could include air-borne dust, grease, oil films and particulate matter—and 'Freon' cleans 'em all out. Yet it doesn't harm any of 13 different materials we commonly use in our units —including diallyl phthalate, phenolic, epoxy, nylon, vinyl, melamine, alkyd, Teflon* and Mylar* plastics; aluminum, steel, brass and gold, and various types of paints, varnish and color coding. So now we get fast, thorough cleaning of subassemblies by immersing them *whole* in 'Freon'."

"Another point is that 'Freon' fits fine into our Clean Room operation. It's nonflammable, almost completely nontoxic, fast-drying without residue, and works well in our Bendix sonic-energy degreaser." (see photos) "This closed-cycle degreaser gives us sonic energy cleaning, a vapor rinse, and continuous solvent purification, all in one cabinet."

For cleaning and degreasing all kinds of delicate instruments, bearings, printed circuits and assemblies, it's hard to beat "Freon" solvents. Write us for complete technical data and/or the services of one of our technical men. Du Pont, N-2420E, Wilmington 98, Del.

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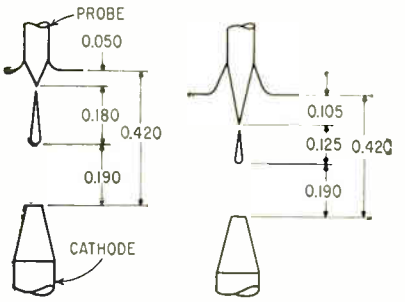


FIG. 2—Probe (left) after etching in 4 percent KOH, 96 percent water; dimensions are in cm. Probe (right) after etching in solution of 2 percent liquid detergent, 4 percent KOH, 94 percent water

Tip of tungsten needle (left), and tip of fine sewing needle (right), both magnified 128 times. Tungsten needle has 50-millionths inch tip radius and ten degree taper; sewing needle has 150-millionths tip radius and 45 degree taper

off. The sudden drop in current is due to the end of the rod etching through and dropping off. Delay in switching the current off at this time will result in a blunt point.

Typically, the tip of the needle will have a taper of 10 to 20 degrees included angle and a point with radius less than 13×10^{-5} cm. The needle will be 23×10^{-2} cm shorter than the original rod. In a few cases the bottom piece does not separate from the needle, and occasionally a whisker is left at the end of the needle.

In these cases a few additional seconds of etching with a current in the range of 50 to 200 ma will usually suffice. To increase the taper's included angle for additional mechanical strength, while keeping the sharp point, a final etching is required. This is done by re-setting the gap between cathode and needle at 72×10^{-3} cm and etching for 5 seconds at 400 ma. The final etching can be repeated to further increase the taper's included angle.

The technique has given consistently good results with expert operators.

The author wishes to thank Dr. H. daCosta and William Barlow for assistance.

Clean Room for Transistor Production

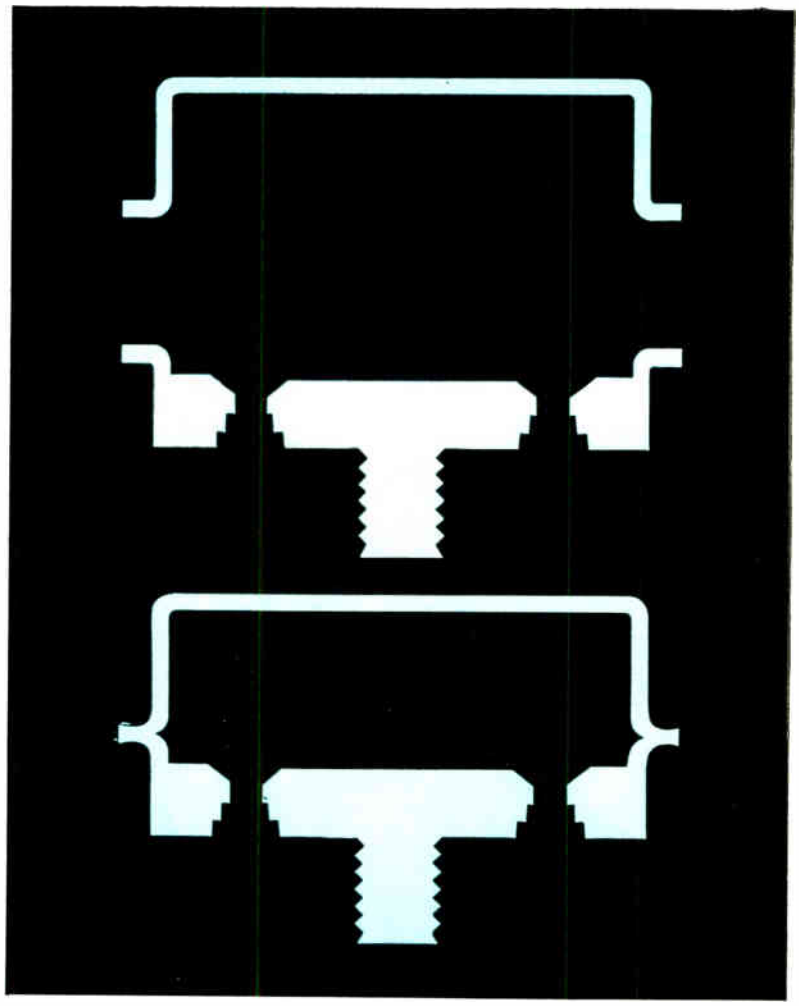
Transistor manufacturing line has stations for washing, rinsing, vacuum bakeout, filling, sealing, welding. Arm rests and built-in lighting are aids to production

WHITE ROOMS or clean rooms have been found to be of definite value in many areas of electronic production, particularly when reliability is of the kind demanded by our space and missile programs. Raytheon's transistor plant at Lewiston, Maine is itself essentially a huge clean room, but in addition, a system of dry boxes has been installed. Rela-

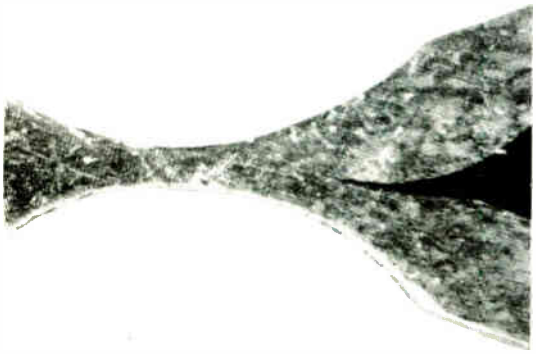
TUNG-SOL COLD WELDS OFHC* CASES

TO PRODUCE POWER TRANSISTORS THAT DELIVER FULL POWER

*Oxygen Free, High Conductivity



To be Cold-Welded, the flanges of the transistor can must be free of contaminants. The two surfaces are united under evenly distributed high pressure, causing copper molecules to flow together, producing an unbreakable, hermetic seal. Photomicrograph (45X) reveals absence of seam or interface. In addition to photomicrographs, Tung-Sol non-destructively tests weld quality with 100-psi water bomb immersion, mass spectrometer and radioactive tracer tests.



Cold-Welded germanium power transistors originated with Tung-Sol. The Cold-Weld process provides Tung-Sol transistors (in all case styles) with several significant advantages over transistors sealed by other techniques:

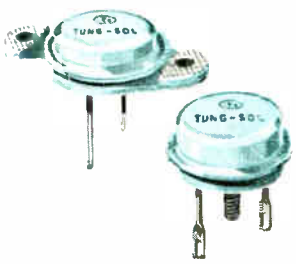
A seamless molecular bond between can and header improves thermal properties. Hot spots are eliminated, preventing reduction in power output or degradation of the semiconductor. The oxygen-free, high-conductivity copper provides superior heat conduction and is compatible with other device parts.

Cold-Welding prevents heat-caused damage during production, contributing to longer life and optimum performance. There are no "splash"-produced fragments, which, if undetected during factory tests, could short the transistor in operation.

Temperature fluctuations due to environmental changes, or on-off operations, cannot cause "breathing". The seam-free molecular bond excludes moisture and cannot be torn apart by mechanical stress.

Cold-Welding typifies the advanced design and production techniques employed by Tung-Sol in the manufacture of power transistors. Characteristics such as thermal resistance (K factor) are based upon the most meaningful combination of environmental and electrical tests. Design center ratings are given for junction temperatures of 110°C, 10 degrees above usual requirements. Saturation voltages are lower and breakdown voltages higher than in ordinary transistors. Mounting surfaces are flat-ground to provide full contact with heat sinks.

These features are present in all Tung-Sol TO-3 and TO-36 configurations. Write for design information. Tung-Sol Electric Inc., Newark 4, New Jersey. TWX:NK193.



TUNG-SOL® FULL POWER
POWER TRANSISTORS

tive humidity within the dry boxes can be controlled down to less than one percent, which is too severe for the production people who assemble the transistors, even if there were no problems of contamination from dust, oil, rust and other particles found even in the air of a clean room.

Dust Kept Out

The dry boxes themselves, custom engineered and manufactured by S. Blickman, Weehawken, N. J., have hard smooth surfaces of stainless steel, glass rather than plastic windows, die formed glove openings, and are designed to eliminate as many dust catching corners and mating surfaces as possible. Positive pressure, usually with an inert gas such as nitrogen, is maintained within the boxes to keep foreign particles from entering. Molecular seives or refrigeration is used to remove moisture and the dew point within the boxes is approximately −80 F.

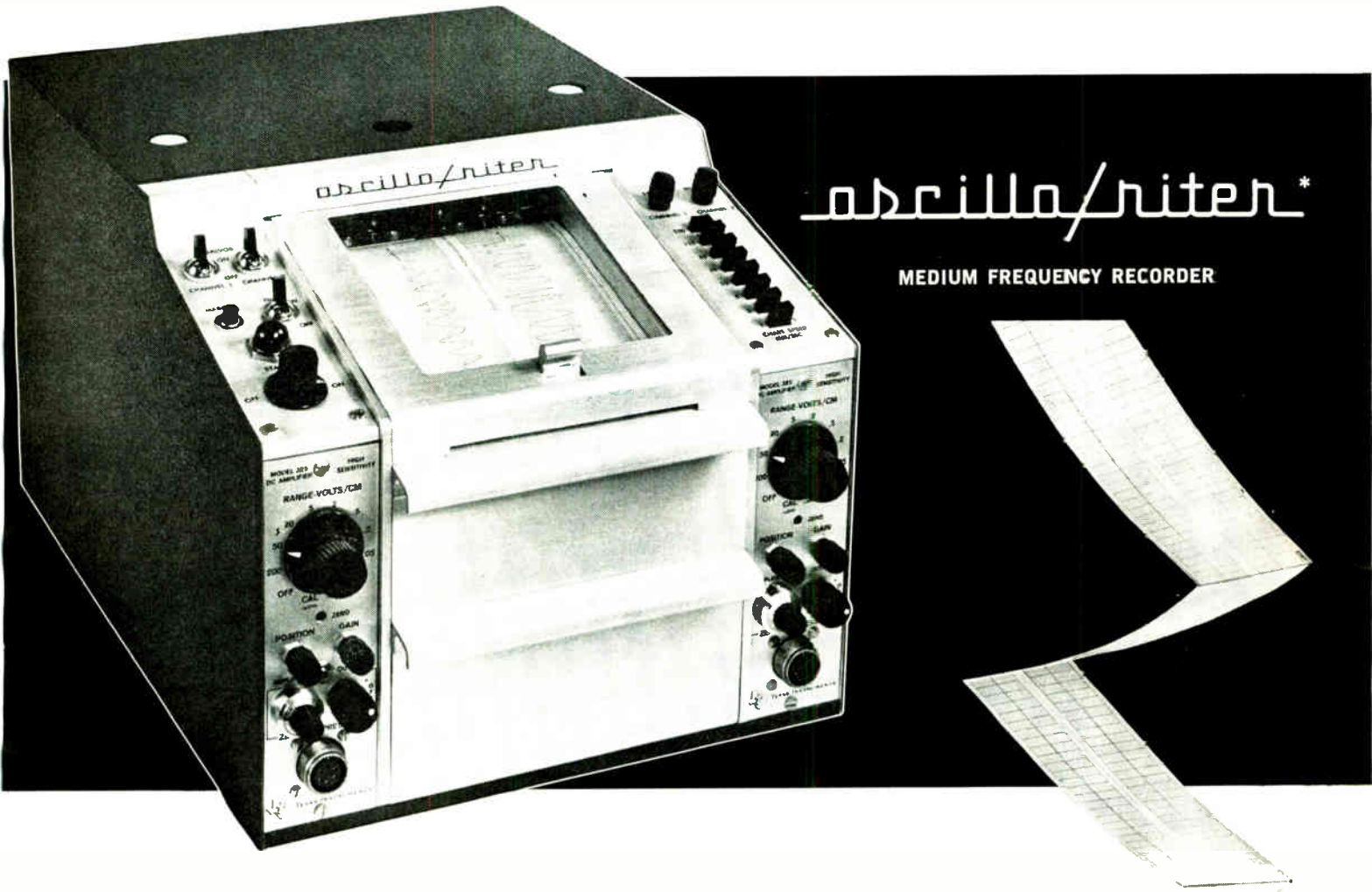
The dry boxes are built into a continuous line, with internal conveyors to transport the transistors between some stations, with air or vacuum locks for other transfer points, and with bakeout ovens, inspection stations, and other operations. Bakeout ovens are bottom mounted and operate from 100 to 250 C; vacuum chambers have low leak rates and can maintain a vacuum of 5×10^{-5} mm of Hg.

Battery-Powered Wire-Wrap Tool

RECHARGEABLE nickel-cadmium battery is used in a completely portable Wire-Wrap tool.

A permanent magnet electric motor drives the tool, which can make an estimated 4,000 connections with 24 gauge solid conductor wire before battery recharge is necessary. The battery recharges with 110 volt, 60 cps in approximately 14 to 16 hours, using a built in transformer and rectifier. The tool, manufactured by Gardner-Denver, Quincy, Ill., can be equipped for wrapping all wire sizes from 22 to 32 gauge. The low cost of parts replacement and the ease of replacing batteries should make the device particularly suitable for field repair work.

MORE OPERATING FEATURES THAN ANY OTHER MEDIUM FREQUENCY RECORDER



Here is the instrument that combines *all* the features found in other medium frequency recorders plus some TI exclusives. The *oscillo/riter* offers highest sensitivity, widest selection of ranges and chart speeds, rectilinear recording in either heat or ink, transistorized electronics, interchangeable plug-in amplifiers, and the convenience of Z-fold chart paper.

Broad Frequency Response. Flat to 200 cps within 1 db, 10 mm peak to peak with ink writing system.

High Sensitivity. Sensitivity range with high-gain amplifier is 0.5 mv/mm to 200 V/cm in 10 steps.

Push-Button Chart Speeds. Eight push buttons select 1, 2, 5, 10, 25, 50, 125, and 250 mm/sec.

Plug-In Amplifiers. Interchangeable amplifiers offer complete flexibility to economically handle more recording jobs. All electronics are fully transistorized for long-term reliability and convenience of no warm-up time.

Z-Fold Chart Paper. Provides random access to minutes, hours or days of recorded data by simply flipping pages of the chart as you would pages of a book. Roll chart paper optional.

Compare feature for feature, and you'll choose the *oscillo/riter* from industry's most complete line of strip chart recorders . . . made by Texas Instruments.

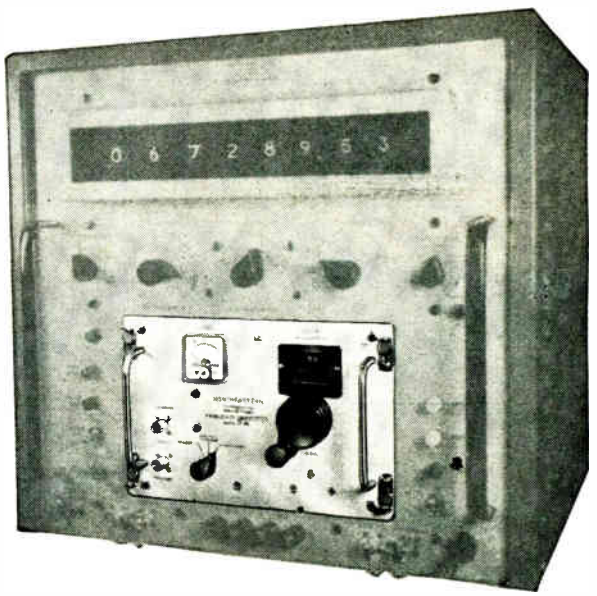
WRITE FOR COMPLETE INFORMATION

*A trademark of Texas Instruments Incorporated

TEXAS INSTRUMENTS
INCORPORATED
3609 BUFFALO SPEEDWAY
P. O. BOX 66027 HOUSTON 6, TEXAS

NOW – 1000MC MEASUREMENT WITH FREQUENCY COUNTERS

The model 14-26c, a 1 KMC Frequency Converter, is a plug-in unit for use with the Northeastern Engineering Model 14-20c Frequency Counter/Standard, and counters of other manufacturers.



Technical specifications:

- Frequency range ....200 MC to 1 KMC
- Input voltage (min.) .....100 millivolts RMS
- Input impedance ....50 ohms, approx.
- Accuracy .....±1 count, ± accuracy of counter
- Power requirements .....furnished by counter
- Weight .....5 pounds

$550.00

WESCON Booth #3245

NORTHEASTERN ENGINEERING INCORPORATED

DEPT. 1A, MANCHESTER, NEW HAMPSHIRE
AFFILIATE OF ATLANTIC RESEARCH CORP.

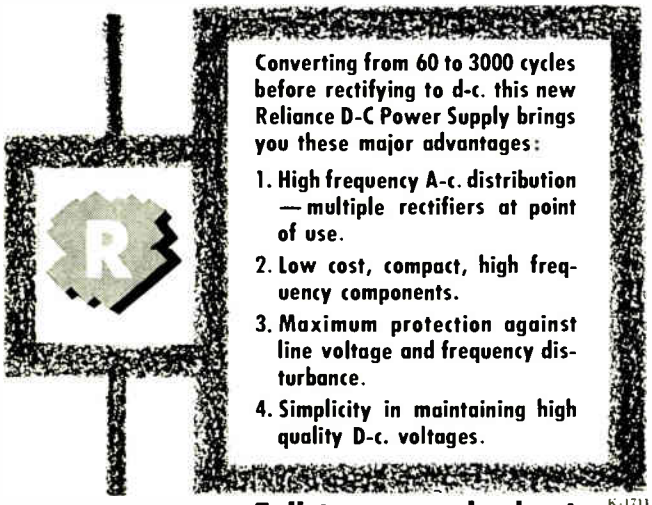
EMPLOYMENT OPPORTUNITIES OPEN AT ALL LEVELS

In Canada: Conway Electronic Enterprises Ltd., Toronto, Ontario, Canada

CIRCLE 208 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:

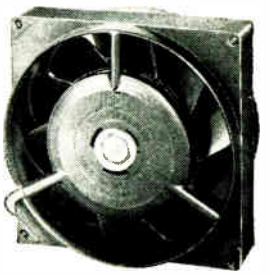
1. **High frequency A-c. distribution — multiple rectifiers at point of use.**
2. **Low cost, compact, high frequency components.**
3. **Maximum protection against line voltage and frequency disturbance.**
4. **Simplicity in maintaining high quality D-c. voltages.**

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. 83-5, Cleveland 17, Ohio. Canadian Division: Toronto, Ontario.

RELIANCE ELECTRIC AND ENGINEERING CO.

New! MINIATURE AXIAL FANS with up to 4 times greater cooling efficiency!



Characteristic	PAMOTOR Model 1000	Conventional Fan
Type of Motor	induction (capacitor-type squirrel cage)	shaded-pole
Housing	die cast warp-free Zymec	plastic
Output @ 60 cps (0 back pressure) (.25" back pressure) (.3" back pressure)	 125 cfm 75 cfm 50 cfm	 100 cfm 20 cfm 0
Output @ 50 cps (0 back pressure) (.25" back pressure)	 100 cfm 62.5 cfm	 75 cfm 5 cfm
Operating Temp. Range	−55°C to +85°C	−18°C to +44°C

The PAMOTOR Model 1000 Miniature Fan is completely interchangeable with conventional units now in use (4⅛" center-to-center mounting holes). But the similarity ends there.

check this comparison chart!

The Model 1000 Fan meets MIL-T-5422E, Class 2 Environmental specifications. Inside-outside rotating motor design gives flywheel effect, resulting in constant, quiet fan speed. Large surface sleeve bearings mean minimum maintenance, maximum reliability.

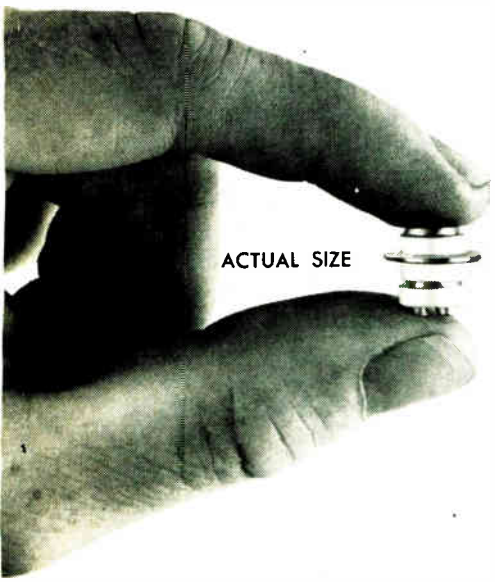
For complete specifications and name of nearest stocking distributor, write to: **PAMOTOR, Inc.** 312 Seventh Street • San Francisco 3, Calif.

CIRCLE 209 ON READER SERVICE CARD

CIRCLE 109 ON READER SERVICE CARD→

ELECTRONICS

*APPROXIMATE SIZE RANGE OF COMPETITIVE DEVICES



ACTUAL SIZE

NEW G-E CERAMIC TUBES REDUCE MICROWAVE COMPONENT SIZE* UP TO 40 TIMES

Detailed value-analysis chart shows how size, cost and performance advantages can be yours. Clip coupon, or circle reader service number, for free copy.

In many UHF applications, up to 10 Gc (KMC), microminiature G-E ceramic tubes can replace bulky TWT's, magnetrons, klystrons, and parametric amplifiers with no sacrifice in performance. G-E ceramic tubes are up to 40 times smaller and 20 times lighter than most UHF devices. Often, ceramic tubes can effect component cost reductions as high as $1,400.

To determine the specific reductions G-E ceramic tubes can make in your equipment, check these 6 size- and weight-saving features:

1. Microminiature size and weight range:
   Length: 0.315″ to 2.75″
   Diameter: 0.325″ to 1.25″
   Weight: 0.972 gram to 66.6 grams
2. High-gain, low-noise ceramic tubes eliminate components, require less complex circuitry. Useful to "C" and "X" band frequencies.
3. Ceramic tubes withstand strong spurious signals and switching transients; minimum protective circuits required.
4. Lower power requirements mean smaller, less elaborate power supplies.
5. High-temperature tolerance (400°C., max.) can eliminate cooling equipment.
6. Ceramic tubes are highly resistant to nuclear radiation; heavy shielding is eliminated. Ceramic planar structures tolerate high shock and vibration.

Most G-E ceramic tubes are on approved MIL-spec lists and are available "off-the-shelf" from your local General Electric Receiving Tube Sales Representative. Send today for your free value-analysis chart which lists all the size, cost and performance advantages that can be yours with G-E ceramic tubes.

Progress Is Our Most Important Product

GENERAL ELECTRIC

G-E TIPS (Technical Information and Product Service)
General Electric Receiving Tube Dept.
Room 1730
Owensboro, Kentucky

CERAMIC TUBE VALUE ANALYSIS DATA

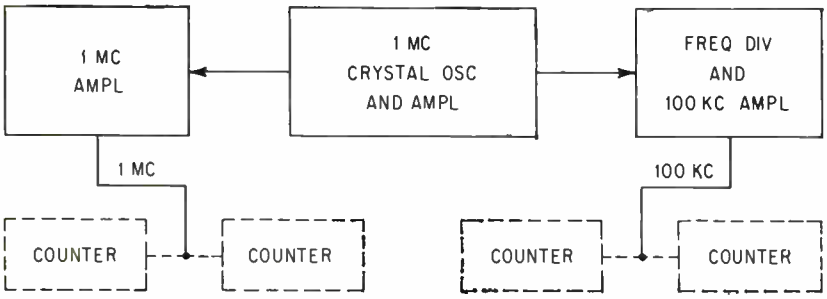
*Name*_____ *Title*_____

*Company*_____

*Address*_____

*City*_____ *Zone*____ *State*_____

DESIGN AND APPLICATION

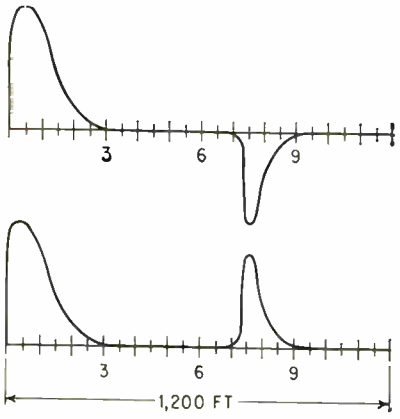


High Stability Oscillator

SUPPLIES 20 RELATED COUNTERS

ANNOUNCED by Hewlett-Packard Co., 1501 Page Mill Rd., Palo Alto, California, is the model 101A high stability oscillator that can provide up to 20 1 Mc and 100 Kc timing signals to related time interval counters thereby eliminating errors due to using different timing signals from different oscillators. Long-term stability is 5×10^{-8} per week while short-term stability is better than 3×10^{-10}. Ambient temperatures between −5 and +55 C do not degrade performance. To prevent transients from affecting the oscillator each time the oven thermostat cycles, oven heating resistors are bifilar wound so that winding inductance is cancelled out. The crystal operates at a very low and constant level and is followed by a high gain amplifier with a sensitive oscillator gain control system. The 100 Kc signal is provided from a free-running oscillator synchronized from the precision 1 Mc source. If the 1 Mc source fails, protective circuits cuts off the 100 Kc oscillator. All outputs are at least 1 v rms and isolated from each other.

CIRCLE 301 ON READER SERVICE CARD



Cable Fault Finder

UP TO 10,000 FT

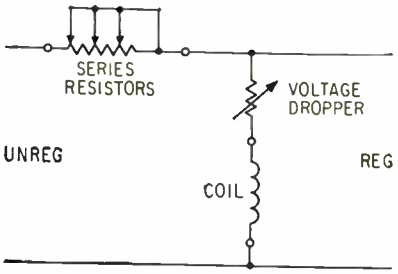
MANUFACTURED by Smith-Florence Inc., 4228 Twenty-third Avenue West, Seattle 99, Washington, the models 751 and 754 are designed to locate and determine faults in coaxial cables. The unit measures the elapsed time between a transmitted pulse and any resulting reflections due a change in cable construction. It can be used to determine the impedance of an unknown cable, for determining proper matching of attenuators and junctions of a cable system, for inventorying spools of cables without unreeling them, for checking cable connectors for intermittents and to determine relative attenuation of several cables by amplitude comparison. Basic difference between the two models is cable length testing. The model 751 measures between 75 and 1,200 ft of cable while the model 754 measures between 250 and 10,000 ft of cable. Time markers are provided on the trace to indicate distance. Pulse rate is up to 2 Kc, 300 v and approximately 0.075 μsec duration. Accuracy is better than 3 percent. The sketch shows a cable shorted at 725 ft (top) and an open cable at 725 ft (bottom).

CIRCLE 302 ON READER SERVICE CARD

Tracking System

SCIENTIFIC-ATLANTA, INC., 2162 Piedmont Road, N. E., Atlanta, Ga. An augmented manual tracking system, which permits the use of inexpensive motors for most antenna tracking applications, is now available.

CIRCLE 303 ON READER SERVICE CARD



Voltage Regulator

SEMIMECHANICAL

MANUFACTURED by Electric Regulator Corp., Norwalk, Connecticut, the Regohm voltage regulator can maintain its output level despite input frequency fluctuations. Two output levels are available, 90 v with input between 95 and 135 v and 100 v with inputs between 105 and 125 v. Regulation accuracy is within 2-percent for combined effects of line, load and frequency between 50 and 450 cps. One-percent units and units between 25 and 1,000 cps are also available. Response time is less than 3 cycles with 60 cps input and regulation ac-

CIRCLE 111 ON READER SERVICE CARD→

RAYTHEON DELIVERS 108 STANDARD DIODE QUADS

Raytheon now offers designers of ring and bridge modulators, discriminators, phase detectors, diode choppers and other balanced circuits the industry's most complete line of germanium and silicon diode quads.

Three PIV's and three forward match percentages in six package styles for both germanium and silicon provide maximum flexibility to meet a wide range of electrical and mechanical requirements.

Raytheon's long experience in circuit packaging techniques and quality diode manufacturing and matching assures you of proven reliability, extremely uniform electrical characteristics, and dependable mechanical stability. For details on the industry's most complete selection of high quality diode quads, plus off-the-shelf price and delivery information, please contact your Raytheon Distributor or Field Office.

ELECTRICAL DATA GERMANIUM QUADS

T = 25°C Each diode		
Io — Average Rectified Current		65 mA
Peak Rectified Current		150 mA
Surge Current for 1 Second		500 mA
Ambient Temperature Range	−60 to +90	°C
Power Dissipation		80 mW
Maximum Forward Voltage @ 100 mA		1 V

Electrical Rating Code (ordering)	Degree of Forward Match @ 4 mA	PIV each Diode	Maximum Inverse Current @ −10 V
1	1%	35 V	20 μa
2	1%	75 V	10 μa
3	1%	100 V	10 μa
4	2.5%	35 V	20 μa
5	2.5%	75 V	10 μa
6	2.5%	100 V	10 μa
7	5%	35 V	20 μa
8	5%	75 V	10 μa
9	5%	100 V	10 μa

HOW TO ORDER: C707 PAK STYLE ⌐ ⌐ RATING CODE

ELECTRICAL DATA SILICON QUADS

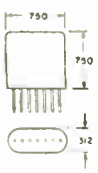
T = 25°C Each diode		
Io — Average Rectified Current		200 mA
Surge Current for 1 Second		1.5 A
Ambient Temperature Range	−60 to +150	°C
Power Dissipation		250 mW
Maximum Forward Voltage @ 100 mA		1 V
Maximum Reverse Current @ PIV		.025 μa
Maximum Reverse Current @ PIV (150°C)		5.0 μa

Electrical Rating Code (ordering)	Degree of Forward Match @ 4 mA	PIV each Diode
1	.5%	25 V
2	.5%	125 V
3	.5%	180 V
4	1.0%	25 V
5	1.0%	125 V
6	1.0%	180 V
7	2.5%	25 V
8	2.5%	125 V
9	2.5%	180 V

HOW TO ORDER: C708 PAK STYLE ⌐ ⌐ RATING CODE

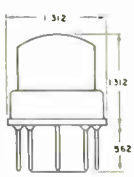
OUTLINE DIAGRAMS

PAK STYLE 1 — RS



- 7 pin in-line basing
- Non polarized connected
- All welded connections
- Epoxy encapsulated with metal case
- Mates with socket — Elco type 790 BC or Cinch type 2H7 or equal

PAK STYLE 2 — MV

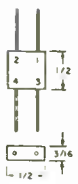


- Type MT-8 shell
- Soldered connections
- Plugs into standard 8 pin octal socket

PAK STYLE 3 — MP

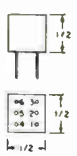
- All welded construction
- Epoxy resin encapsulant
- Basing shown bottom view
- Plugs into standard 7 pin miniature socket

PAK STYLE 4 — TK



- Pigtail leads
- Epoxy resin encapsulant
- Welded construction
- Leads 1.0" minimum length, .019" − .021" diam.

PAK STYLE 5 — TL



- Printed circuit pins
- Pin spacing on .100" grid
- Epoxy resin encapsulant
- Universal connections
- Welded connections

PAK STYLE 6 — TM

- Epoxy resin encapsulant
- All welded construction
- Each diode individually terminated
- Plugs into standard 9 pin miniature socket

SEMICONDUCTOR DIVISION

LOWELL, MASSACHUSETTS

RAYTHEON

curacy is not affected by power factors loads from unity to 0.7 lagging. It can also be used as a current regulator. Current capabilities are between 10 ma and 100 amperes but units are available down to 50 mw. The device occupies 30.5 cubic inches and weighs ¾ lb.

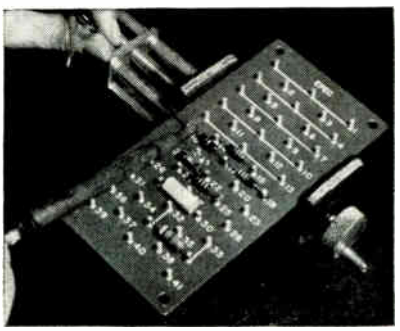
CIRCLE 304 ON READER SERVICE CARD

Metal Film Resistors

ULTRARELIABLE

PYROFILM RESISTOR CO., INC., U. S. Highway 46, Parsippany, N. J. Use of special formulated metal alloys on a high purity alumina substrate, through controlled vacuum evaporation produces a stable, firmly bonded film with low temperature coefficient. Units exceed requirements of MIL-R-10509D and are available in ¼, ½ and 1 w sizes with standard temperature coefficient of ±25 ppm and 50 ppm at 1 percent and 0.5 percent tolerance. Price is $1.50 to $3.00 each.

CIRCLE 305 ON READER SERVICE CARD



Terminal Board

HIGH TEMPERATURE

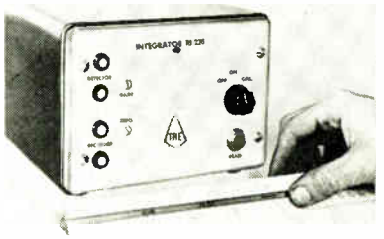
ELECTRALAB PRINTED ELECTRONICS CORP., Needham Heights, Mass., announces an aluminum terminal board for high-temperature (up to 600 F) application. It is insulated by a dielectric ceramic hardcoat using the Dielox process. Tests show that the average breakdown voltage of the boards between terminals is 5,100 v, and between a terminal and a ground, 3,800 v. Insulation resistance is 28,700 megohms; average surface resistivity, 343,000 megohms; volume resistivity, 4,440 megohms. Dielectric constant at 1 Mc is 2.51.

CIRCLE 306 ON READER SERVICE CARD

Oscilloscopes

LAVOIE LABORATORIES, INC., Morganville, N. J. Model LA-275 standardized general purpose oscilloscopes feature a vertical frequency response of dc to better than 60 Mc, using the LA-275-S plug-in preamplifier head.

CIRCLE 307 ON READER SERVICE CARD

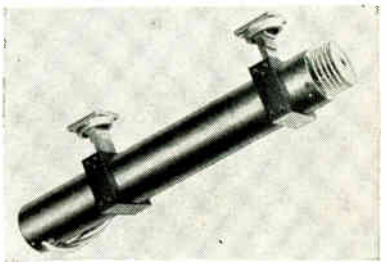


Recorder Integrator

COMPACT, INEXPENSIVE

TEXAS RESEARCH AND ELECTRONIC CORP., 6612 Denton Drive, Dallas 35, Texas. The RI220, for the integration of chart recorder signals, utilizes a solion tetrode as the integrating element and is designed for use with the widest selection of recorders. It can be used with any servo recorder having a 500 to 5,000 ohm retransmitting potentiometer and an event marker. List price is $440.

CIRCLE 308 ON READER SERVICE CARD



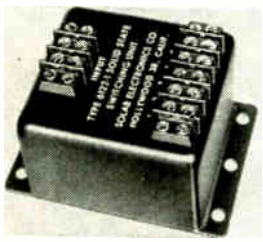
T-W Tube

200-WATT

MICROWAVE ELECTRONICS CORP., 4061 Transport St., Palo Alto, Calif., has introduced a small and lightweight ppm focused twt which delivers 200 w pulsed power at 1 percent duty at the 30 db gain level. Operating

in X-band from 7.5 to 11.0 Gc, it weighs 8 lb and is 16 in. long. It features high-mu grid, oxide coated cathode and a conservatively rated 4 w heater.

CIRCLE 309 ON READER SERVICE CARD



Solid State Switch

PHASE-CONTROLLED

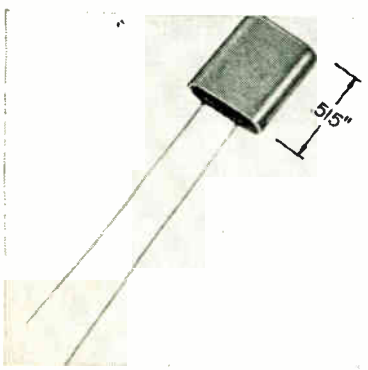
SOLAR ELECTRONICS CO., 5909 Melrose Ave., Hollywood 38, Calif. Type 6122-1 functions as a 3-position polar relay that responds to 0.1 μw excitation, at 60 cps. Operating as an spdt switch, with an adjustable dead-zone, it provides 50 v d-c at 3 amp to inductive or resistive loads. Input impedance is greater than 50,000 ohms; phase of input signal determines which load is energized.

CIRCLE 310 ON READER SERVICE CARD

Terminal

AMP INC., Harrisburg, Pa. The Termi-Foil terminal is designed to reduce costs and improve performance for manufacturers of electrical equipment using aluminum foil and strips.

CIRCLE 311 ON READER SERVICE CARD



L-F Crystals

SUBMINIATURE

MONITOR PRODUCTS CO., INC., 815 Fremont Ave., South Pasadena, Calif., announces its MC-18 crystals with frequencies from 250 Kc to 800 Kc. Frequency tolerance is

±0.01 percent over temperature range −40 C to 70 C. Standard leads are 1½ in., ¼ in. and flattened and pierced pins. Dimensions are 0.515 in. by 0.171 in. by 0.421 in. Prices from $22 to $33 each in small quantities.

CIRCLE 312 ON READER SERVICE CARD

Square Law Detector

IN TWO PACKAGES

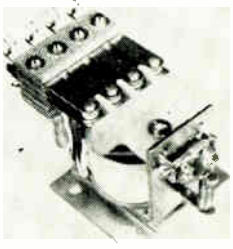
MSI ELECTRONICS INC., 116-06 Myrtle Ave., Richmond Hill 18, N. Y. The Bolomistor square law detector is available in 1N26 and 1N53 packages for use in the K_u and K_a band regions. These types are available in 40 db dynamic square law range versions with sensitivities in excess of −40 dbm. The C-120 and E-120 detectors go from 0.01 mw up to 100 mw.

CIRCLE 313 ON READER SERVICE CARD

Coaxial Connectors

TRU-CONNECTOR CORP., 245 Lynnfield St., Peabody, Mass., has developed crimp-type coaxial connectors to replace standard clamping type, and permits mass production of cable assemblies.

CIRCLE 314 ON READER SERVICE CARD



Glass Reed Relay

FOR P-C APPLICATION

WHEELOCK SIGNALS, INC., Long Branch, N. J. Series 260 is a 1 mil-

lisec switching device capable of billions of operations. Designed for p-c application, the precisely pre-sized, pre-positioned leads mean fast, easy mounting. Costly reed breakage is practically eliminated through the use of a patented protective resilient molded frame that absorbs shipping and mounting shocks.

CIRCLE 315 ON READER SERVICE CARD

Polyurethane Coating

COLUMBIA TECHNICAL CORP., Woodside, N. Y. An insulating and protective coating on a polyurethane base, HumiSeal 2A56 was designed for electronic components and assemblies used in aircraft applications. It features excellent solderability.

CIRCLE 316 ON READER SERVICE CARD

Counter-Timer

35 MC, SOLID STATE

COMPUTER MEASUREMENTS CO., 12970 Bradley Ave., San Fernando, Calif. Model 729B is an all transistor 20 cps to 35 Mc universal counter-timer. Power consumption is 130 w and weight is 30 lb. Dimensions are 5¼ in. high by 17 in. wide by 12 in. deep. Unit combines the functions of a counter, time interval meter, and frequency/period meter.

CIRCLE 317 ON READER SERVICE CARD

Pulse Generator

PHOTOELECTRIC

CLIFTON PRECISION PRODUCTS CO., INC., 5050 State Road, Drexel Hill, Pa. Size 8 pulse generator affords a means for accurate rpm measurements of rotating shafts at speeds from less than 1 to greater than

15,000 rpm. It is designed to operate with an electronic counter employing a 1 sec time base or a frequency meter calibrated for cps. The output from either instrument, when so connected, will then be an accurate representation in rpm of the shaft speed.

CIRCLE 318 ON READER SERVICE CARD

D-C Motor

GLOBE INDUSTRIES, INC., 1784 Stanley Ave., Dayton 4, O. Type SD ¾ in. permanent magnet type motor operates on 3 to 50 v d-c, and develops 0.3 oz-in. of torque at 10,000 rpm continuous duty.

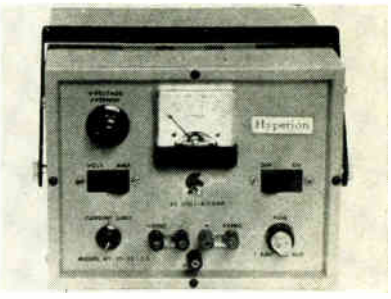
CIRCLE 319 ON READER SERVICE CARD

DPDT Choppers

MINIATURIZED

CAMBRIDGE SCIENTIFIC INDUSTRIES, INC., 18 Poplar St., Cambridge, Md., announces two miniature dpdt choppers, 255D for 60 cps operation, and 454D for 400 cps usage. Both are hermetically sealed in ¾ in. by 1⅞ in. cans, and feature 9 pin headers.

CIRCLE 320 ON READER SERVICE CARD



D-C Power Supply

ALL-SOLID-STATE

HYPERION INDUSTRIES, INC., Watertown, Mass. Model HY-Z1-32-2.5 has a variable output voltage of 0-32 v d-c at a load of 0-2.5 amp. Unit features remote sensing, re-

mote programming, vernier voltage adjustment, current and voltage metering, floating output adjustable current limiting and is short circuit proof. Ripple is less than 1 mv rms. Response time is 50 millisec.

CIRCLE 321 ON READER SERVICE CARD

Pressure Transducer

PIEZOELECTRIC

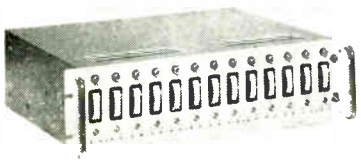
COLUMBIA RESEARCH LABORATORIES, MacDade Blvd. & Bullens Lane, Woodlyn, Pa. Model 100-P has a sensitivity of 200 mv/psi, permitting pressure measurements as low as 0.005 psi and as high as 4,000 psi. The transducer has a natural frequency of 60 Kc which makes possible a fast rise time of 5 μsec and a high frequency response of up to 12 Kc. Pressure overload tolerance without damage to the device is 50 percent.

CIRCLE 322 ON READER SERVICE CARD

Subminiature Relay

BOURNS, INC., 1200 Columbia Ave., Riverside, Calif. Model 3100 subminiature spdt relay meets environmental requirements of MIL-R-5757D with a predicted operating life of well over 100,000 cycles.

CIRCLE 323 ON READER SERVICE CARD



Tape Recorder Monitor

MULTICHANNEL

DYNAMICS INSTRUMENTATION CO., 583 Monterey Pass Road, Monterey Park, Calif. Model 4995 permits simultaneous voltage metering of 13 data channels. The meters are peak reading rms indicating 1 v full scale. Signals above 1.414 v peak cause a neon lamp to glow on each channel, indicating an overscale condition. Operating frequency

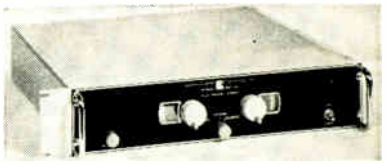
range is 1.7 cps to 30 Kc. Input impedance to each voltmeter is 900,000 ohms. Price is $2,170.

CIRCLE 324 ON READER SERVICE CARD

Impedance Bridge

GENERAL RADIO CO., West Concord, Mass. Type 1608-A is a universal impedance bridge with in-line readout and a nominal accuracy of 0.1 percent.

CIRCLE 325 ON READER SERVICE CARD



Frequency Extender

SMALL SIZE

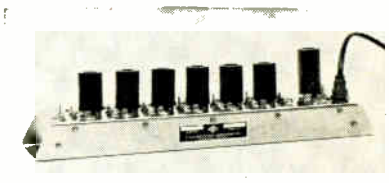
COMMUNICATION ELECTRONICS, INC., 4900 Hampden Lane, Bethesda 14, Md. Designed for use with any receiver tuning to 60 Mc, the type FE-25-1 provides additional coverage of the complete uhf spectrum from 235 Mc to 1 Gc. Featured are very low oscillator radiation, lower power consumption, small size (3½ in. panel height), and light weight (18 lb).

CIRCLE 326 ON READER SERVICE CARD

Tantalum Capacitors

ELECTRA MFG. CO., 4051 Broadway, Kansas City 11, Mo. A line of hermetically sealed solid slug tantalum capacitors are designed to meet or exceed MIL-C-26655A/2B specifications.

CIRCLE 327 ON READER SERVICE CARD



Log I-F Amplifier

100 MEGACYCLE

RHG ELECTRONICS LABORATORY, INC., 94 Milbar Blvd., Farmingdale, L. I., N. Y. Providing state-of-the-art performance at off-the-shelf prices,

model L10020 features 20 Mc bandwidth at 100 Mc center frequency, greater than 70 db dynamic range, accuracies to ±1 db and capability of handling pulses of 50 nsec risetimes.

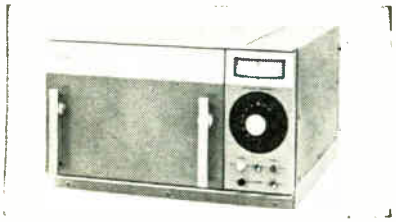
CIRCLE 328 ON READER SERVICE CARD

Urethane Foam Tape

SELF-ADHESIVE

UNITED MINERAL & CHEMICAL CORP., 16 Hudson St., New York 13, N. Y., announces Tesa Foam Stik Tape, a self-adhesive urethane foam which cushions electronic products or components against shock and vibration. A poly-vinyl chloride film 0.0015-0.0016 in. thick, with a tensile strength of 22-30 lb/in. of width, is permanently laminated to the foam and forms the carrier for the pressure-sensitive or adhesive mass.

CIRCLE 329 ON READER SERVICE CARD



Test Chamber

SOLID-STATE CONTROL

STATHAM INSTRUMENTS, INC., 12401 W. Olympic Blvd., Los Angeles 64, Calif. Model 3D-6 temperature test chamber features 24 lineal inches of calibrated set-point scale, true proportional control of heater power by all solid-state control circuitry, and temperature readout by means of a deviation meter calibrated in 1-deg increments referenced against set-point.

CIRCLE 330 ON READER SERVICE CARD

Coaxial Mismatches

FOR D-C TO 3 GC

COAX DEVICES, Box V, Chelsea 50, Mass. These coaxial mismatches consist of film resistors contained

in a matched housing. Present models are conservatively rated at ½ w. Standard mismatch values are 1.3; 1.6; 2.0; 2.5; 3.0; 5.0. Over the d-c to 3 Gc range, the deviation is less than ±6 percent. They can be used at higher frequencies if some greater deviation is tolerable. They are available in N type connectors. Price is $20.

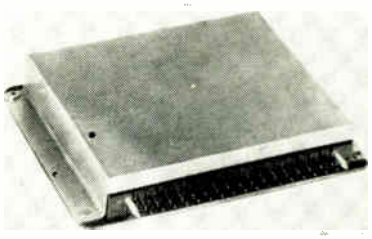
CIRCLE 331 ON READER SERVICE CARD

Bridge Rectifiers

HIGH VOLTAGE

TEXAS INSTRUMENTS INC., 13500 North Central Expressway, Dallas, Texas. The 1N3183 series bridge modules, all rated at 0.5 amp average rectified current and up to 2,000 v reverse voltage, offer a compact and versatile full wave bridge that can save hours of assembly time in the lab or on the production line.

CIRCLE 332 ON READER SERVICE CARD

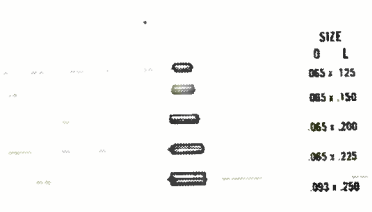


Flip-Flops

PACKAGE OF FOUR

DIGITAL DESIGN CORP., Box 21, Clay, N. Y. Model FF-151-DC is a package of four independent flip-flops. All are of the set-reset and trigger type, and feature a gated input trigger. They may be used in counters, shift registers, for storage, and for logic operations in computing systems. Switching rates to 1 Mc are accommodated. Price is $99.

CIRCLE 333 ON READER SERVICE CARD



Tantalum Capacitors

MICROMINIATURE

GLP DIVISION, Burnell & Co., White Plains, N. Y., announces micro-

miniature solid tantalum capacitors. Specifications: temperature range from −55 C to 85 C; tolerance is −20 percent +50 percent; d-c voltage ratings are max operating voltages at any point over the temperature range; capable of withstanding a 1,000 hr life test at max temperature with rated voltage applied.

CIRCLE 334 ON READER SERVICE CARD

Microwave Amplifiers

LOW-NOISE

INTERNATIONAL MICROWAVE CORP., 1 Seneca Place, Greenwich, Conn., offers a line of microwave tunnel diode amplifiers that operate in the 2 to 12 Gc range. They provide between 4.5 and 5.5 db noise figure, depending on frequency, with bandwidths to 1,000 Mc. They range in size from 20 to 50 cu. in., and gains from 10 to 20 db are available.

CIRCLE 335 ON READER SERVICE CARD

Time Delay Relay

AUTOMATIC TIMING & CONTROLS, INC., King of Prussia, Pa., has available a transistorized, hermetically sealed time delay relay with 30 sec range for operation from external power supply of nominal 27 v d-c for military, industrial, electronic and production needs.

CIRCLE 336 ON READER SERVICE CARD

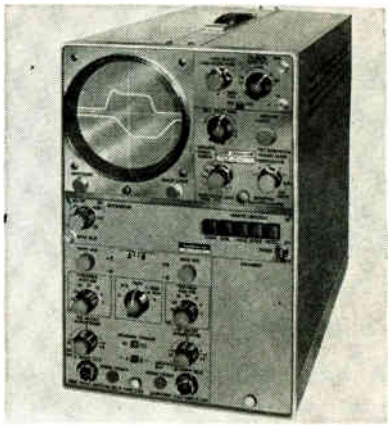
Octave Amplifiers

PACKAGED UNITS

LEL, INC., 75 Akron St., Copiague, N. Y. Low noise, broadband r-f amplifiers cover from 40 Mc to 640 Mc. Model OMP-5-160 has a gain

of 30 db minimum, ±0.5 db ripple and a linear output of greater than 1 v over the range of 160 to 320 Mc. It is available as a self-contained rack mounted unit as shown or as an amplifier only, model OMX-5-160. Rack mounted units employ a solid state power supply.

CIRCLE 337 ON READER SERVICE CARD

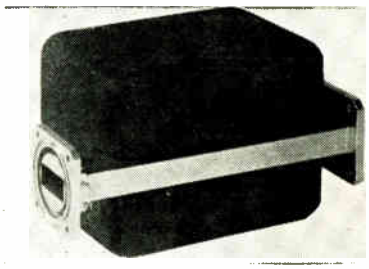


Sampling Scope

COMPACT UNIT

LUMATRON ELECTRONICS, INC., 116 County Courthouse Road, New Hyde Park, L. I., N. Y. A 1,000 Mc bandpass (approximately 0.35 nsec risetime), dual channel display, millivolts to volts input range, sensitive internal triggering to 1 Gc and compact size are features of the model 120 sampling oscilloscope.

CIRCLE 338 ON READER SERVICE CARD



Ferrite Isolators

HIGH POWER

CONSOLIDATED MICROWAVE CORP., 850 Shepherd Ave., Brooklyn 8, N. Y., offers two high power X-band ferrite isolators. Model X210-1 covers 8.4 to 10.0 Gc and X210-2 covers 10.0 to 12.4 Gc. The isolation over the band is greater than 20 db and the insertion loss is less than 0.5 db. Units can handle

250 w average power and peak power of 250 Kw. Input vswr is less than 1.15. Price is $130. delivery 4 weeks.

CIRCLE 339 ON READER SERVICE CARD

Universal Photometer

ELDORADO ELECTRONICS, 2821 Tenth St., Berkeley 10, Calif. Model 201, designed to operate with any photomultiplier tube or phototube, will indicate directly, percent transmittance from 0.001 to 100, and density from 0 to 6.

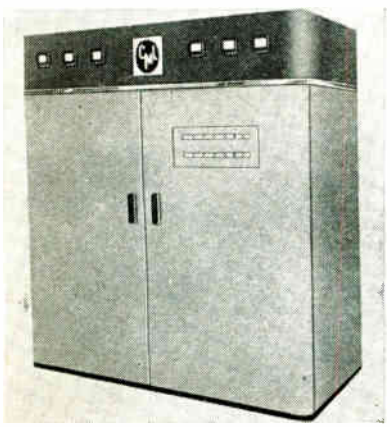
CIRCLE 340 ON READER SERVICE CARD

Tunable Oscillator

0 C TO + 80 C

SOLID STATE ELECTRONICS CO., 15321 Rayen St., Sepulveda, Calif. Model S-300 tunable silicon transistor sinusoidal oscillator is an epoxy encapsulated unit designed to create a stable sine wave signal source. Stability as a function of supply voltage and temperature have been emphasized together with reliability.

CIRCLE 341 ON READER SERVICE CARD



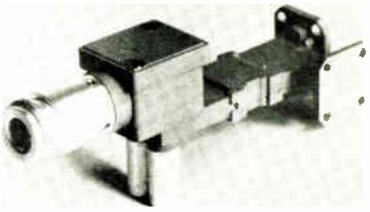
Power Amplifier

MODULAR CONSTRUCTION

COMMUNICATION MEASUREMENTS LABORATORY, INC., 350 Leland Ave.,

Plainfield, N. J., has developed a power amplifier rated at 10 Kw output. Model A10K is equipped with output taps to match selected vibration exciters, sonar and acoustic test transducers, and industrial ultrasonic devices. Standard frequency ranges between 10 cps and 150 Kc are available .

CIRCLE 342 ON READER SERVICE CARD



I-F Balanced Mixer

VSWR = 1.30 MAX

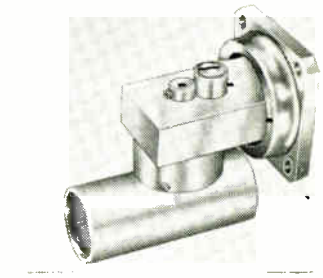
MICROWAVE DEVELOPMENT LABORATORIES, INC., 15 Strathmore Rd., Natick, Mass. Sidewall balanced mixer has a microwave i-f output of 2.9 Gc with input frequencies of 34.0-36.0 Gc. The i-f output utilizes a type N connector and has a vswr of 1.20. Unit measures less than 4.00 in length and utilizes 1N53 crystals. Vswr is 1.30 max and isolation, 12 db min.

CIRCLE 343 ON READER SERVICE CARD

Signal Converter

ROCHESTER INSTRUMENT SYSTEMS, INC., 275 North Union St., Rochester 5, N. Y., has available the SC-300 signal converter for making most standard process control instruments compatible with each other.

CIRCLE 344 ON READER SERVICE CARD



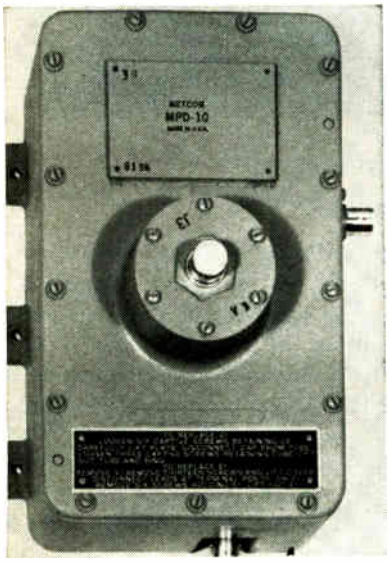
Harmonic Generator

FOR X-BAND

TRAK MICROWAVE CORP., Tampa, Fla. Type 2969X3 is a self-contained energy source and requires

only 150 to 175 v d-c at less than 12 ma and 6.3 v at 240 ma. Unit is suited to X-band l-o applications where klystrons were previously used, and provides the convenience of a single adjustment to cover the range of 8,800 to 9,000 Mc with a minimum of 5 mw output power. Frequency drift over 0 C to +100 C is nominally less than ±5 Mc at 8,900 Mc; characteristics of as little as ±1.5 Mc can be provided on request.

CIRCLE 345 ON READER SERVICE CARD

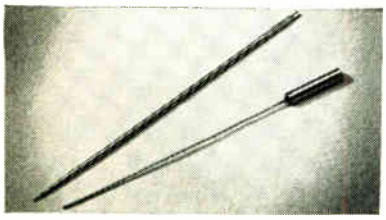


Strip Line Duplexer

COVERS 200-230 MC

METCOM, INC., 76 Lafayette St., Salem, Mass., offers complete strip line duplexing using gaseous-solid state techniques in the same package. The MPD-10 covers the frequency range of 200-230 Mc handling 10 Kw peak, 200 w average.

CIRCLE 346 ON READER SERVICE CARD



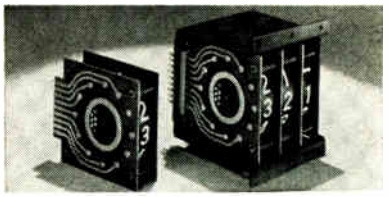
Photoelectric Cells

GERMANIUM JUNCTION

INTERNATIONAL TELEPHONE AND TELEGRAPH CORP., Clifton, N. J. Type PG40B features excellent sensitivity and small size (0.08-in. diameter), permitting close packing of the cells for punched-tape

and punched-card readers. Average sensitivity is 30 ma per lumen. Spectral response peaks at 1.7 microns and cuts off at 2.0 microns. Minimum and maximum bias voltages are 1 and 50 v, respectively, dark current is 200 μa max, and dissipation is 15 mw. Type PG50A is larger (⅜ in. diameter), has 100 v max bias rating and 50 mw dissipation rating.

CIRCLE 347 ON READER SERVICE CARD

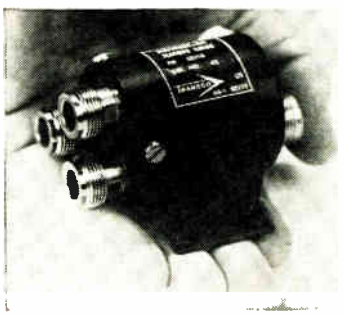


Indicator

12-POSITION

THE PATENT BUTTON CO., Waterbury 20, Conn. Series 10300 Magneline indicator has p-c contacts for quick mounting in panel displays. Other features include large numerical size (15/32 in.) and rapid positioning (½ sec for full rotation). The 12-position indicator meets MIL-E-5272-C and MIL-E-5400D, Class 2 requirements, and operates at 125 ma, 24 v.

CIRCLE 348 ON READER SERVICE CARD



Coaxial Switch

SMALL, LIGHT

TRANSCO PRODUCTS, INC., 12210 Nebraska Ave., Los Angeles 25, Calif., announces a 50 ohm coaxial switch capable of 5 million life cycles. The 2 independent solenoid design can be fail-safe on one position and the wiping contacts are self cleaning and make possible the long life. Solenoid voltage is 28 v d-c; connector types are N, BNC and TNC. R-F characteristics are excellent to 2 Gc.

CIRCLE 349 ON READER SERVICE CARD

PRODUCT BRIEFS

FIXED VACUUM CAPACITORS 10 $\mu\mu$f through 100 $\mu\mu$f. Resitron Laboratories, Inc., 2908 Nebraska Ave., Santa Monica, Calif. (350)

PRECISION RATIO TRANSFORMER direct digital readout. Arnold Magnetics Corp., 6050 W. Jefferson Blvd., Los Angeles, Calif. (351)

STATIC PROPORTIONAL TEMPERATURE CONTROLLER highly sensitive. Metals & Controls Inc., 34 Forest St., Attleboro, Mass. (352)

PERMALLOY POWDER CORE with 200 permeability. Magnetics, Inc., Butler, Pa. (353)

BIDIRECTIONAL POWER MONITOR compact, versatile. Douglas Microwave Co., Inc., 252 E. Third St., Mt. Vernon, N. Y. (354)

TRANSFER STANDARD precision resistance. General Resistance, Inc., 430 Southern Blvd., New York 55, N. Y. (355)

ULTRASONIC DEGREASER uses high purity Freon. Harris ASW Div., of General Instrument Corp., Woodbury, Conn. (356)

TAPE TRANSPORT in kit and wired form. Electronic Instrument Co., Inc., 3300 Northern Blvd., Long Island City 1, N. Y. (357)

OSCILLOSCOPE CAMERA for high writing speeds. Cossor Instruments Ltd., Highbury Grove, London, N.5, England. (358)

R-F CHOKES range from 150 μh to 15 mh. Cambridge Thermionic Corp., 445 Concord Ave., Cambridge 38, Mass. (359)

INDUSTRIAL LOGIC MODULE Or-Gates. Digital Design Corp., Box 21, Clay, N. Y. (360)

PORTABLE TV CONSOLE for closed-circuit systems. Blonder-Tongue Laboratories, Inc., 9 Alling St., Newark 2, N. J. (361)

SELF-LOCKING COUPLING NUTS vibration proof. General RF Fittings, Inc., 702 Beacon St., Boston 15, Mass. (362)

FLANGELESS SILICON RECTIFIERS low-current. Electronic Devices, Inc.,

50 Webster Ave., New Rochelle, N. Y. **(363)**

TEST FACILITY high altitude. High Vacuum Equipment Corp., Hingham, Mass. **(364)**

DIFFERENTIAL PRESSURE SYSTEM mv output. H. E. Sostman & Co., P. O. Box 60, Cranford, N. J. **(365)**

MAGNETIC CIRCUIT BREAKER trips in millisec. Wood Electric Corp., 244 Broad St., Lynn, Mass. **(366)**

FLEXIBLE COAXIAL CABLE air dielectric. Andrew Corp., P. O. Box 807, Chicago 42, Ill. **(367)**

SILICON CONTROLLED RECTIFIER all-diffused version. Texas Instruments Inc., P. O. Box 5012, Dallas 22, Texas. **(368)**

INERTIA SWITCHES with controlled reset point. Inertia Switch Inc., 311 W. 43rd St., New York 36, N. Y. **(369)**

PATCHCORD features double-detent retaining action. AMP Inc., Harrisburg, Pa. **(370)**

DIGITAL COMPUTER with input/output equipment. Computer Control Co., Inc., 2251 Barry Ave., Los Angeles 64, Calif. **(371)**

MESA TRANSISTORS high quality switching. Motorola Semiconductor Products Inc., 5005 E. McDowell Road, Phoenix, Ariz. **(372)**

BUFFER STORAGE random/sequential access type. Di/An Controls, Inc., 944 Dorchester Ave., Boston 25, Mass. **(373)**

VOLTAGE CONVERTER frequency to analog. Pioneer Magnetics Inc., 850 Pico Boulevard, Santa Monica, Calif. **(374)**

PRESSURE TRANSDUCER operates at 50 g. Giannini Controls Corp., 1600 South Mountain Ave., Duarte, Calif. **(375)**

COAXIAL CONNECTOR closed entry contacts are featured. The Deutsch Co., Municipal Airport, Banning, Calif. **(376)**

READER/REELER bidirectional, high-speed instrument. Omnitronics, Inc., 511 N. Broad St., Philadelphia 23, Pa. **(377)**

Literature of the Week

POWER TRANSISTOR TESTER RD Instruments Division Hickok Electrical Instrument Co., 10514 Dupont Ave., Cleveland 8, O. An 8-page technical brochure covers the model 1885 dynamic beta power transistor tester. (378)

INSTRUMENTS Lavoie Laboratories, Inc., Morganville, N. J., offers an engineers' product handbook on counters, oscilloscopes, frequency meters and spectrum analyzers and other instruments. (379)

FERRITE FILTER INDUCTORS Indiana General Corp., Electronics Div., Keasby, N. J. A 10-page bulletin covers Ferramic TC core assemblies for filter networks. (380)

CAPACITOR TESTING Sprague Electric Co., Marshall St., North Adams, Mass. Technical paper 62-4, entitled "Accelerated Tests and Predicted Capacitor Life", is available upon letterhead request.

COMPUTER Computer Control Co., Inc., 2251 Barry Ave., Los Angeles 64, Calif. Six-page brochure describes the DDP-19 digital data processor. (381)

DUST-FREE CABINETS Torit Mfg. Co., 1133 Rankin St., St. Paul 16, Minn., has published a 6-page folder on the Specialaire dust-free cabinet. (382)

ULTRA HIGH BETA TRANSISTOR Solid State Electronics Co., 15321 Rayen St., Sepulveda, Calif., offers literature on model SST610 ultra high beta transistor in a TO-5 package electrostatically shielded. (383)

SYNCHROS Kearfott Div., General Precision, Inc., 1150 McBride Ave., Little Falls, N. J., has available a condensed catalog describing more than 65 synchros used in a variety of applications. (384)

ELECTRONIC PYROMETER Metronix Div. of Assembly Products, Inc., 75 Wilson Mills Road, Chesterland, O. Data sheet covers model 600 d-c electronic pyrometer for remote measurement. (385)

Blonder & Tongue: Complementaries

A DOZEN YEARS AGO, lights burning in a ramshackle Yonkers, N. Y., building excited the curiosity of police who once kept the spot under surveillance as a center for illegal off-track betting. Upon entering, the officers found two engineers, Isaac Blonder and Ben Tongue, (L).

Tongue still grins when he recalls that early start in May of 1950. He and Blonder had pooled $5,000 to rent a 20 by 60-ft area and founded what is now a thriving electronics company, Blonder-Tongue Laboratories, Inc., Newark, N. J.

Now president of the company, Tongue has been interested in radio since he was eight years old. He worked his way through Northeastern University and in 1945 earned a BEE degree with honors after 2½ years. Next came a master's degree from Polytechnic Institute of Brooklyn in 1948. During those years he worked at Panoramic Radio, starting as an engineer in 1945 and becoming chief engineer by 1947. He personally designed many of Panoramic's products, among them a miniature airborne transmitter and a variety of analyzers.

Still playing a major role in product development—in his own company, now—his present interests center about community and closed-circuit tv systems, and new developments in uhf equipment.

Blonder, who is chairman of the board, describes himself as being raised in a garage: his father was a blacksmith and later a general repair man. Blonder says he fixed his first radio at the age of ten and remained interested in the field ever since. He won a BS in physics with honors from the University of Connecticut in 1938 and received a master's degree from Cornell two years later.

Teaching physics at City College gave him some firm ideas on educating engineers. He feels that the main job of an educator is to instill and develop creativity, not teach only facts and formulas.

Following an active career in electronics during the war, Blonder met Tongue at Panoramic Radio. In 1948, he joined the TeleKing Television Corp. and two years later formed the partnership.

Tongue's nature is deliberate, while Blonder is more exuberant. Blonder approaches problems with a quick dynamism that often covers the broad general aspects which are then tended to in detail by Tongue.

Despite the apparent differences between the two men, they often seem to think with the same mind. Both emphasize high-quality engineering and are impatient with anything less. By mutual accord, they have avoided any pursuit of military contracts and have confined their efforts over the past twelve years to commercial developments. One friend, asked if they share any recreational activities, said "Yes, they work together as a matter of business and do the same for relaxation."

Philco Names Herzog Laboratory Director

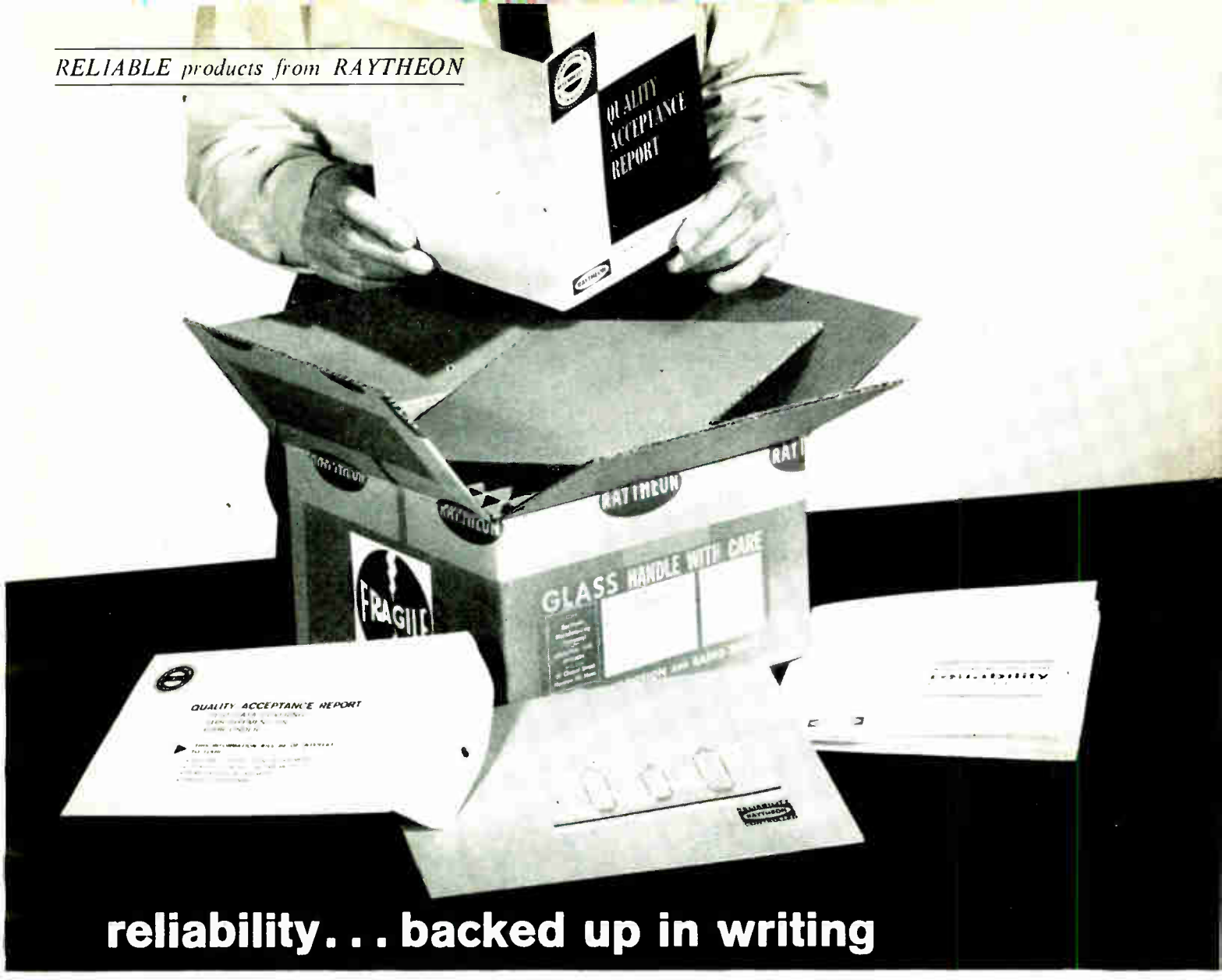
APPOINTMENT of Bernard Herzog as director of the Space Sciences Laboratory of the Western Development Laboratories of Philco Corp. in Palo Alto, Calif., has been announced. He will direct studies in physical phenomena and techniques relating to space technology.

Prior to joining Philco in 1958, Herzog was a research associate in the Physics Department of Stanford University.

Sealomatic Forms Ultrasonic Division

SEALOMATIC ELECTRONICS CORP., Brooklyn, N. Y., manufacturer of heat sealing, blister packaging machinery and high frequency generators, announces the formation of

RELIABLE products from RAYTHEON



reliability... backed up in writing

RAYTHEON Reports Give Customers Accurate Performance Data Before Tubes Are Used

Detailed life data on a typical group of industrial and military tube types is now available to you through Raytheon's *Reliability Report*. Total production failure rates in % per 1000 hours are published in this semi-annual report which provides accurate before-purchase performance data.

Further evidence of quality is presented by Raytheon's *Quality Acceptance Report* which is comprehensive data from actual lot acceptance records. *Quality Acceptance Reports* on a large number of tube types are available on lots of 100 or more tubes to assure compliance with customer and military specifications.

Use the coupon at right, or the reader service number, to obtain a copy of the latest *Reliability Report*. A sample of the *Quality Acceptance Report* may be obtained by checking the coupon. Raytheon Industrial Components Division, 55 Chapel St., Newton 58, Massachusetts.

Raytheon Industrial Components Division
55 Chapel St., Newton 58, Mass.
Dept. 2640-2
Please send a copy of:
__Reliability Report
__Quality Acceptance Report
__10,000 Hour Life Program
Name _____
Title _____
Company _____
Address _____
City _____ State _____

INDUSTRIAL COMPONENTS DIVISION

NEWTON 58, MASSACHUSETTS

RAYTHEON

CIRCLE 131 ON READER SERVICE CARD

its new Aquasonic division. This division at present will use the parent company facilities. A complete line of ultrasonic cleaning systems including its new transistorized units will be among its first products.

Lyle Taylor Joins Hopkins Engineering

LYLE G. TAYLOR has been named director of quality control for Hopkins Engineering Co., San Fernando, Calif., manufacturer of capacitors and filters.

He was formerly assistant quality control manager for Acoustica Associates.

Microwave Electronics Names Buchmiller

LYLE D. BUCHMILLER has been named senior research engineer at Microwave Electronics Corp., Palo Alto, Calif.

He was previously affiliated with the Stanford Electronics Laboratory, Stanford U., Calif.

Weinschel Appoints Ebert a V-P

JOHN E. EBERT has been appointed vice president in charge of re-

search, development and engineering of Weinschel Engineering Co., Inc., Kensington, Md.

Ebert comes to Weinschel with twenty years' experience in the microwave field. For the last nine years he was with FXR, Inc., where he was vice president and chief microwave engineer.

Magnin Accepts New Post at EMR

J. P. MAGNIN has been appointed director of research and engineering for the Sarasota Products division of Electro-Mechanical Research, Inc. In his new position he will direct R&D engineering on new telemetry products.

Magnin joined EMR as a section head from the research laboratory of the Schlumberger Well Surveying Corp.

Carrol Lund Joins Mesa Scientific

CARROL E. LUND, formerly a senior research engineer with North American Aviation, has joined Mesa Scientific Corp., computer consultants in Hawthorne, Calif.

At Mesa Scientific, Lund will be responsible for consulting assignments on the application and installation of analog computers,

digital differential analyzers, and general-purpose digital computers.

Burroughs Building Experimental Center

BURROUGHS CORP., Detroit, Mich., has started construction on a $500,000 two-story experimental center at Colorado Springs, Colo.

The new facility, operated for the USAF 425 L system program office of the Electronic System division, will include 50,000 sq ft of floor space. The building, designed to accommodate approximately 170 persons, is expected to be completed by mid-summer.

PEOPLE IN BRIEF

Warren D. Paley promoted to v-p and elected a director of Vector Associates, Inc. **Edgar R. Brastow** advances to asst. chief engineer of Giannini Controls' Gyro div. **Richard K. Mosher** moves up to president of LFE Electronics. Mitre Corp. ups **Alan J. Roberts** to head of the Strategic Systems dept., and **James J. Croke** to head of the SAGE System Design and Test dept. **Jay Tol Thomas,** formerly with M-H Regulator Co., appointed director of Siegler Research Laboratories. **J. R. Ballinger,** from Aeronutronic div. of Ford Motor Co. to Packard Bell Computer as mgr. of the Industrial Systems dept. Consolidated Electrodynamics elevates **Henry S. Black** to v-p and g-m of its Data Recorders div. **Richard Berman,** g-m of Telemedics Inc., appointed v-p in addition. **Joseph Oppenheim** of Raytheon Co. named to new post of director of international and interdivisional services. **Edward Gray** leaves AVCO-Everett to join Magnion, Inc., as mgr. of engineering and manufacturing. **Philip Diamond,** ex-Perkin Electronics, has started his own firm, Philip Diamond Enterprises. **E. R. Wagner,** previously with Datronics Engineers, Inc., now v-p and asst. to the president of Emertron, Inc., Babcock Electronics promotes **Moody Besancon** to v-p, administration, eastern region, and **Lester R. Russ** to asst. v-p.

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	180*	1
DOUGLAS AIRCRAFT CO. Missile and Space Systems Division Santa Monica, California	119*	2
ESQUIRE PERSONNEL SERVICE INC. Chicago, Illinois	180*	3
GENERAL DYNAMICS/ASTRONAUTICS San Diego, California	69-72	4
GENERAL DYNAMICS/ELECTRONICS A Div. of General Dynamics Corp. Rochester, New York	178*	5
GENERAL ELECTRIC CO. Defense Systems Dept. Syracuse, New York	179*	6
INTERNATIONAL BUSINESS MACHINES CORP. Owego, New York	180*	7
LOCKHEED CALIFORNIA CO. A Div. of Lockheed Aircraft Corp. Burbank, California	22*	8
LOCKHEED-GEORGIA CO. Div. of Lockheed Aircraft Corp. Atlanta, Georgia	113*	9
LOCKHEED MISSILES & SPACE CO. Div. of Lockheed Aircraft Corp. Sunnyvale, California	88, 89	10
MARTIN ORLANDO Div. of Martin Marietta Orlando, Florida	180*	11
McDONNELL AIRCRAFT St. Louis, Missouri	177*	12
McGRAW-HILL BOOK CO. Dayton, Ohio	137	13
MICROWAVE SERVICES INTERNATIONAL, INC. Denville, New Jersey	136	14
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION Washington, D. C.	181*	15

CONTINUED ON PAGE 137

(cut here) (cut here)

electronics WEEKLY QUALIFICATION FORM FOR POSITIONS AVAILABLE

Personal Background

NAME .....

HOME ADDRESS .....

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

HOME TELEPHONE .....

Education

PROFESSIONAL DEGREE(S) .....

MAJOR(S) .....

UNIVERSITY .....

DATE(S) .....

FIELDS OF EXPERIENCE (Please Check)

51862

☐ 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

TO R&D MEN WHO SEEK A CHALLENGE . . . RAYTHEON OFFERS THIS!

Right now, Raytheon's Bedford R&D Lab has openings for experienced personnel who relish the opportunity to imaginate, create, innovate in the many varied fields of electronics. You'll be working — exploring — in such challenging and virtually uncharted areas as advanced missile systems for aircraft . . . space rendezvous guidance . . . advanced command and control techniques for missile and space applications . . . penetration systems . . . stellar and inertial and re-entry guidance systems.

Positions offering unlimited professional development are available now at the Bedford R&D Lab as a result of expansion in long-range programs.

Radar Digital Data Processing
Bandwidth Compression for Digital TV
Pattern Recognition and Advanced Digital Techniques
Test Equipment Design
Heat Transfer
Aerophysics Engineering
Space Technology
Control Systems
Structures Engineering
Product Design Engineering (Senior Level Openings)
Aerodynamics
Circuit Design Engineering
Radar Transmitter
Microwave Engineering
Operations Research (Weapons Systems Requirements)
Reliability Engineering
Communications Engineering

If you would enjoy working with experienced pioneers and innovaters — whose successes already include the HAWK and SPARROW Missile Systems, breakthroughs in decoy sorting radar techniques and AICBM and tactical ballistic missile defenses, please send your resume or phone collect to Mr. William O'Melia, CRestview 4-7100, Ext. 2138, Raytheon Company, Missile & Space Division, Bedford, Massachusetts (suburban Boston).

RAYTHEON

MISSILE & SPACE DIVISION

BEDFORD, MASSACHUSETTS

An Equal Opportunity Employer

EMPLOYMENT OPPORTUNITIES

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.

— RATES —

DISPLAYED: The advertising rate is $40.17 per inch for all advertising appearing on other than a contract basis. Contract rates quoted on request.

An advertising inch is measured ⅞" vertically on a column—3 columns—30 inches to a page.

Subject to Agency Commission.

UNDISPLAYED: $2.70 per line, minimum 3 lines. To figure advance payment count 5 average words as a line.

Box numbers—count as 1 line.

Discount of 10% if full payment is made in advance for 4 consecutive insertions.

Not subject to Agency Commission.

ELECTRONIC ENGINEERS

Opportunities for graduate Electrical Engineers desiring careers with a highly respected, prosperous manufacturer of industrial process instruments.

Development Engineers. Requires extensive background in development of electronic instruments.

Process and Methods Engineers. Broad experience required in processing methods in manufacture of electronic instruments or components.

Application Engineer—with experience in electronic circuits in process industry; knowledge of vacuum tube and transistor circuitry. Location, Rochester, N. Y. Travel 15-30% of the time.

Field Sales Engineers. Previous sales experience and knowledge of process control instrumentation needed. Training course in Rochester prior to territorial assignment.

Qualified applicants should send resume* to Personnel Manager. All qualified applicants will receive consideration for employment without regard to race, creed, color, or national origin.

Taylor Instrument Companies

95 Ames Street Rochester 1, N. Y.

*All applications will be treated confidentially.

COMMUNICATIONS APPLICATION ENGINEER

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.

SR. DEVELOPMENT ENGINEER

ELECTROMAGNETICS

Electromagnetics specialist sought by Mid-west electronic instrument firm with record of profitability, quality products, professional and managerial competence, employment stability. Will be responsible for development of new electronic instrument recording techniques. Considerable autonomy and responsibility involved. Degree in physical sciences required. Experience in servo motors, oscillograph penmotors, galvanometers, torque motors, magnetic recording heads, synchros, instrument transducers and pick offs desirable. Working atmosphere pleasant; plant well equipped; basic research support readily available. All inquiries handled in confidence by established professional New York executive recruiting firm.

P-8934, Electronics
Class. Adv. Div., P. O. Box 12, N. Y. 36, N. Y.

WANTED: RUSSIAN-ENGLISH TECHNICAL TRANSLATORS

To fill out an elite staff of specialists in the following fields: Electronics, Physical Chemistry, Astrophysics, Space Medicine, Math.

Salary Commensurate With Experience

Location: **Dayton, Ohio (Full-Time Only)**
Relocation Expenses Paid

Requirements

- **B.S. Degree or Equivalent Experience in one of the Above Fields**
- **Native Command of English**
- **Reading Knowledge of Russian**

Send Resume To:

Translation Director
McGraw-Hill Book Co.
P. O. Box 3057
Overlook Branch Dayton 31, Ohio

An Equal Opportunity Employer

electronics

WEEKLY QUALIFICATIONS FORM FOR POSITIONS AVAILABLE

(Continued from page 135)

NATIONAL CASH REGISTER CO. Dayton, Ohio	178*	16
RAYTHEON CO. Missile & Space Div. Bedford, Mass.	136	17
SCOPE PROFESSIONAL PLACEMENT CENTER Waltham, Mass.	137	18
SPACE TECHNOLOGY LABORATORIES, INC. Sub. of Thompson Ramo Wooldridge Inc. Redondo Beach, California	13*	19
TAYLOR INSTRUMENTS COMPANIES Rochester, N. Y.	136	20
P 8934	137	21

*These advertisements appeared in the 5/11/62 issue.

SCIENTISTS/ENGINEERS

Career opportunities in:

- DESIGN
- RESEARCH
- DEVELOPMENT
- SALES
- MARKETING
- APPLICATION

Submit resume in confidence to:

- Alan Glou .....Technical/Scientific
- Sid Hopner .....Sales/Marketing

Specialists in the personalized placement of Electronic Engineers and Scientists, on a national basis, who have a BS or advanced degree. Client companies assume fee and relocation costs.

SCOPE
PROFESSIONAL PLACEMENT CENTER
1277 MAIN ST. WALTHAM, MASS.

MANUFACTURERS' REPRESENTATIVES

IN THE ELECTRONIC INDUSTRY

23 Years of Sales Success in Electronics Products
NEW YORK • NEW JERSEY
PENNSYLVANIA
KENNETH E. HUGHES Co., Inc.
4808 Bergenline Ave., Union City, N. J.

FOR MORE INFORMATION about Classified Advertising

contact the McGraw-Hill office nearest you.

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1375 Peachtree St., N.E. TRinity 5-0523
BOSTON, 16 M. Shouvlin
Copley Square COngress 2-1160
CHICAGO, 11 W. J. Higgins, D. Beran
645 No. Michigan Ave. MOhawk 4-5800
CLEVELAND, 13 I. C. Hill
1164 Illuminating Bldg. SUperior 1-7000
DALLAS, 7 F. LeBeau
1712 Commerce St., Vaughn Bldg.
RIverside 7-9721
DENVER, 2 J. Patten
1700 Broadway—Tower Bldg.
ALpine 5-2981
DETROIT, 26 Wm. H. Ginder, Jr.
856 Penobscot Bldg. WOodward 2-1793
HOUSTON, 25 J. Page
Prudential Bldg., Holcombe Blvd.
JAckson 6-1281
LOS ANGELES, 17 Wm. C. Gries
1125 W. 6th Street HUntley 2-5450
NEW YORK, 36 H. T. Buchanan-T. W. Bender
500 Fifth Avenue LOngacre 4-3000
PHILADELPHIA, 3 Wm. B. Sullivan-F. W. McCarthy
Six Penn Center Plaza LOcust 8-4330
PITTSBURGH, 22 J. Williams
4 Gateway Center EXpress 1-1314
ST. LOUIS, 8
7751 Carondelet Ave. PArkview 5-7285
SAN FRANCISCO, 11 J. A. Hartley
255 California Street DOuglas 2-4600

SEARCHLIGHT SECTION

(Classified Advertising)

BUSINESS OPPORTUNITIES

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 RESEARCH— DEVELOPMENT & EXPERIMENTAL WORK

Over 10,000 different electronic parts: waveguide, radar components and parts, test sets, pulsers, antennas, pulse xmfrs, magnetrons, IF and pulse amplifiers, dynamotors, 400 cycle xmfrs, 584 ant. pedestals, etc.

PRICES AT A FRACTION OF ORIGINAL COST!

Visit or Phone—

COMMUNICATIONS EQUIP CO.
343 CANAL ST., N. Y. 13, N. Y.
(Formerly at 131 Liberty St.)
CHAS. ROSEN, WOrth 6-4045

CIRCLE 460 ON READER SERVICE CARD

OUR BUSINESS IS CUTTING COSTS

Manufacturers of small electrical or mechanical units, however intricate, with high labor content will find our cost-cutting services interesting.

Our complete overseas facilities in Japan, Hong Kong, etc., provide unlimited services by skilled workers, under trained supervision, for the manufacture of complete units or sub-assemblies to your most rigid specifications. All transactions held in strictest confidence.

Submit sample or blueprint for firm quotation. Get the facts about our cost-cutting services — save dollars and build profits!

OVER 25 YEARS EXPERIENCE IN ELECTRONICS

INTERCONTINENTAL INDUSTRIES, INC.
555 W. Adams Street Chicago 6, Illinois
Established 1938

CIRCLE 461 ON READER SERVICE CARD

LOOKING FOR

USED/SURPLUS ELECTRONIC EQUIPMENT/COMPONENTS?

For an up-to-date listing of such equipment see Searchlight Section of May 11th.

INDEX TO ADVERTISERS

Audited Paid Circulation

• See advertisement in the July 20, 1961 issue of Electronics Buyers' Guide for complete line of products or services.

■

MANUFACTURERS' REPRESENTATIVES

CLASSIFIED ADVERTISING

F. J. Eberle, Business Mgr.

INDEX TO CLASSIFIED ADVERTISERS

■

• See advertisement in the July 20, 1961 issue of Electronics Buyers' Guide for complete line of products or services.

This Index and our Reader Service Numbers are published as a service. Every precaution is taken to make them accurate, but ELECTRONICS assumes no responsibilities for errors or omissions.

electronics

Audit Bureau of Circulations — Associated Business Publications

Audited Paid Circulation

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Assistant Publisher Buyers' Guide and Business Manager
FRED STEWART:
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Market Services Manager

RICHARD J. TOMLINSON:
Production Manager
GEORGE E. POMEROY:
Classified Manager
HUGH J. QUINN:
Circulation Manager

ADVERTISING REPRESENTATIVES

NEW YORK (36):
Donald H. Miller, Henry M. Shaw, George F. Werner
500 Fifth Avenue, LO-4-3000 (area code 212)

BOSTON (16):
William S. Hodgkinson, Donald R. Furth
McGraw-Hill Building, Copley Square, Congress 2-1160 (area code 617)

PHILADELPHIA (3):
Warren H. Gardner, William J. Boyle
6 Penn Center Plaza, LOcust 8-4330 (area code 215)

CHICAGO (11):
Harvey W. Wernecke, Robert M. Denmead
645 North Michigan Avenue, Mohawk 4-5800 (area code 312)

CLEVELAND (13):
Paul T. Fegley
55 Public Square, Superior 1-7000 (area code 216)

SAN FRANCISCO (11):
R. C. Alcorn
255 California Street, Douglas 2-4600 (area code 415)

LOS ANGELES (17):
Peter S. Carberry, Ashley P. Hartman
1125 W. 6th St., Huntley 2-5450 (area code 213)

DENVER (2):
J. W. Patten
Tower Bldg., 1700 Broadway, Alpine 5-2981 (area code 303)

ATLANTA (9):
Michael H. Miller, Robert C. Johnson
1375 Peachtree St. N.E., Trinity 5-0523 (area code 404)

HOUSTON (25):
Joseph C. Page, Jr.
Prudential Bldg., Holcomb Blvd., Jackson 6-1281 (area code 713)

DALLAS (1):
Frank Le Beau
The Vaughn Bldg., 1712 Commerce St. Riverside 7-9721 (area code 214)

LONDON W1:
Dennis McDonald
34 Dover St.

FRANKFURT/Main:
Matthee Herfurth
85 Westendstrasse

GENEVA:
Michael R. Zeynel
2 Place du Port

SPERRY microwave memo

ACTUAL SIZE

Now . . . SPERRY packs 10 W output, 60 db gain into a 10 cu. in. TWT

Because of the space age demand for smaller, more rugged components with outstanding performance characteristics, the new STX-186 is now available on 60-day delivery from Sperry Electronic Tube Division.

This new X band traveling wave tube is ideally suited to the rigors of aerospace application. It delivers a minimum 10 watts of CW output across X band, at gain levels up to 60 db. Yet it is only 10½ inches long, weighs only 12 ounces, and occupies only 10 cubic inches of payload space. Rugged metal-ceramic construction enables the PPM focused STX-186 to withstand the shock, vibration, and altitude extremes of the most demanding aerospace environments.

Designers can realize maximum benefit from the tube's small size by adapting mounting and cooling arrangements to meet specific environmental demands. Cooling may be air, heat sink, or liquid.

BROAD APPLICATION POSSIBILITIES

In addition to its small size and physical ruggedness, the STX-186 boasts performance characteristics that open a broad range of application possibilities.

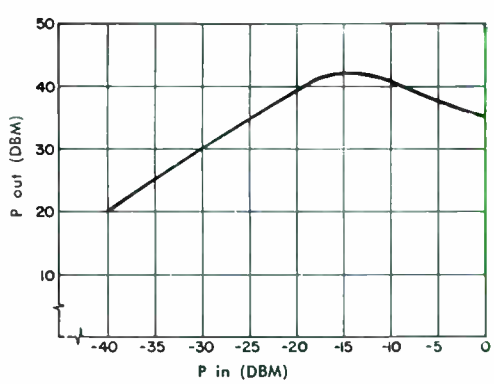
Across the entire band of 7 to 11 Gc, this new TWT delivers a minimum 10 watts CW at up to 60 db gain. The dynamic range of broadband signal amplification extends 25 db below saturation. These characteristics make the STX-186 eminently suitable for rocket, drone, and aircraft application in radar augmenter, ECM, or comunications systems.

IMMEDIATE AVAILABILITY

Sperry is now producing the STX-186 in quantity, and limited numbers are available within 60 days of receipt of order.

A NEW TECHNICAL BROCHURE, WHICH DESCRIBES THE CHARACTERISTICS OF THE STX-186 IN DETAIL, IS NOW AVAILABLE. FOR YOUR FREE COPY, WRITE TO SPERRY ELECTRONIC TUBE DIVISION, SEC. 120, GAINESVILLE, FLORIDA.

To avail yourself of the outstanding performance of this new tube, place your order now. Your Cain & Co. salesman, who represents Sperry Electronic Tube Division, will be happy to provide application assistance and quotation. Or you may communicate directly with us at Great Neck, N. Y.



Typical drive curve STX-186 at 9 Gc

SPERRY ELECTRONIC TUBE DIVISION

GAINESVILLE, FLA. / GREAT NECK, N. Y.
SPERRY RAND CORPORATION

CIRCLE 200 ON READER SERVICE CARD

RCA VIDICONS

choose the one that is exactly right for you

The Industry's broadest line of Vidicons—from RCA—offers high resolution capability for broadcast-quality pictures in any television pickup function: live, closed-circuit, or film. In each RCA type the unmatched tube-after-tube uniformity and quality is built-in by RCA's unique photosurface processes.

Tested to assure long-life reliability, these RCA Vidicon Camera Tubes are strengthened with all-glass beaded mounts. They are the Industry's leaders, offering highest sensitivity—lowest lag. And with these benefits each RCA type provides for its intended application an outstanding balance in performance characteristics.

RCA Vidicons are a superior answer to designer specifications in new compact camera designs. For special applications, RCA Vidicons can be adapted to your needs in other portions of the spectrum. They can also be custom-designed with fiber optic or radiation resistant faceplates. In addition to its wide choice of Vidicons, of course, RCA offers a complete line of Image Orthicons and Display Tubes.

For information on RCA Vidicons and other camera tubes, write: Section E-19-Q-3, Commercial Engineering, RCA Electron Tube Division, Harrison, N. J.

RCA Vidicons—for any Television Function

Type	Photosurface	Recommended Usage	Max. Length	Approx. Diameter	Focus	Deflection
8051	Good Sensitivity High Resolution Low Lag	Film Pickup Data Transmission	8"	1½"	Magnetic	Magnetic
7038	Ultra-Uniform Photoconductor	Film Pickup	6½"	1"	Magnetic	Magnetic
7735A	High Sensitivity Low Lag	Industrial	6½"	1"	Magnetic	Magnetic
7262A	High Sensitivity Low Heater Power Low Lag	Industrial	5⅛"	1"	Magnetic	Magnetic
7263A	High Sensitivity Low Heater Power Low Lag	(Ruggedized) Military	5⅛"	1"	Magnetic	Magnetic
4427	High Sensitivity Low Lag	Industrial	3⅜"	½"	Magnetic	Magnetic
C74015	High Sensitivity Low Lag	Industrial	6½"	1"	Electrostatic	Magnetic
C74016	High Sensitivity Low Lag	Industrial	6½"	1"	Electrostatic	Electrostatic

INDUSTRIAL TUBE PRODUCTS FIELD OFFICES . . . **OEM SALES:** Newark 2, N. J., 744 Broad St., HU 5-3900 • Chicago 54, Ill., Suite 1154, Merchandise Mart Plaza, WH 4-2900 • Los Angeles 22, Calif., 6801 E. Washington Blvd., RA 3-8161 • Burlingame, Calif., 1838 El Camino Real, OX 7-1620. **GOVERNMENT LIAISON:** Harrison, N. J., 415 South Fifth Street, HU 5-3900 • Dayton 2, Ohio, 224 N. Wilkinson Street, BA 6-2366 • Washington 7, D. C., 1725 "K" Street, N.W., FE 7-8500

RCA

The Most Trusted Name in Television