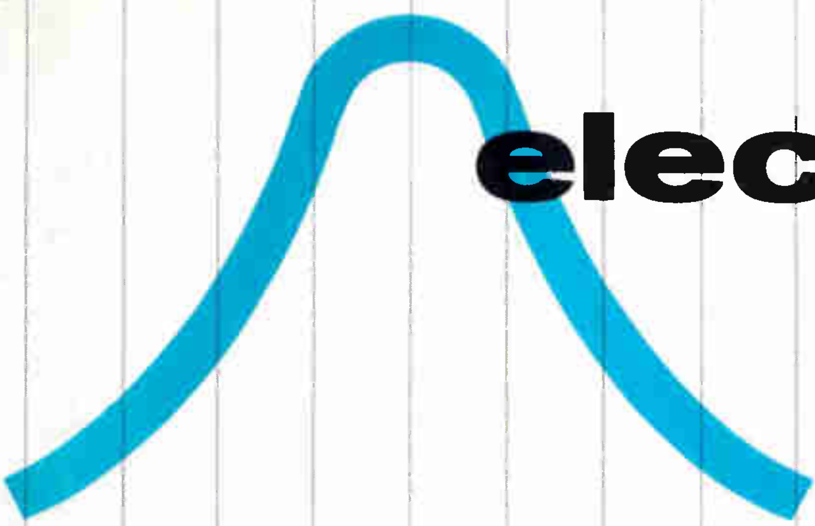
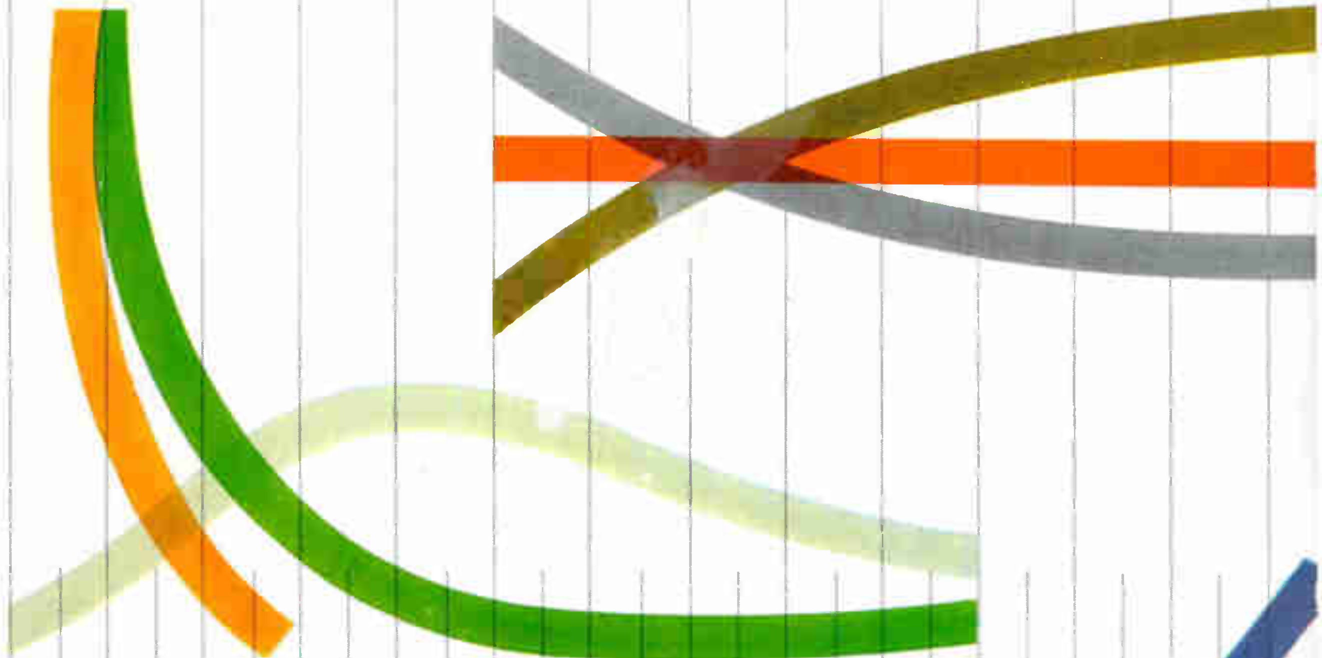
November 30, 1962

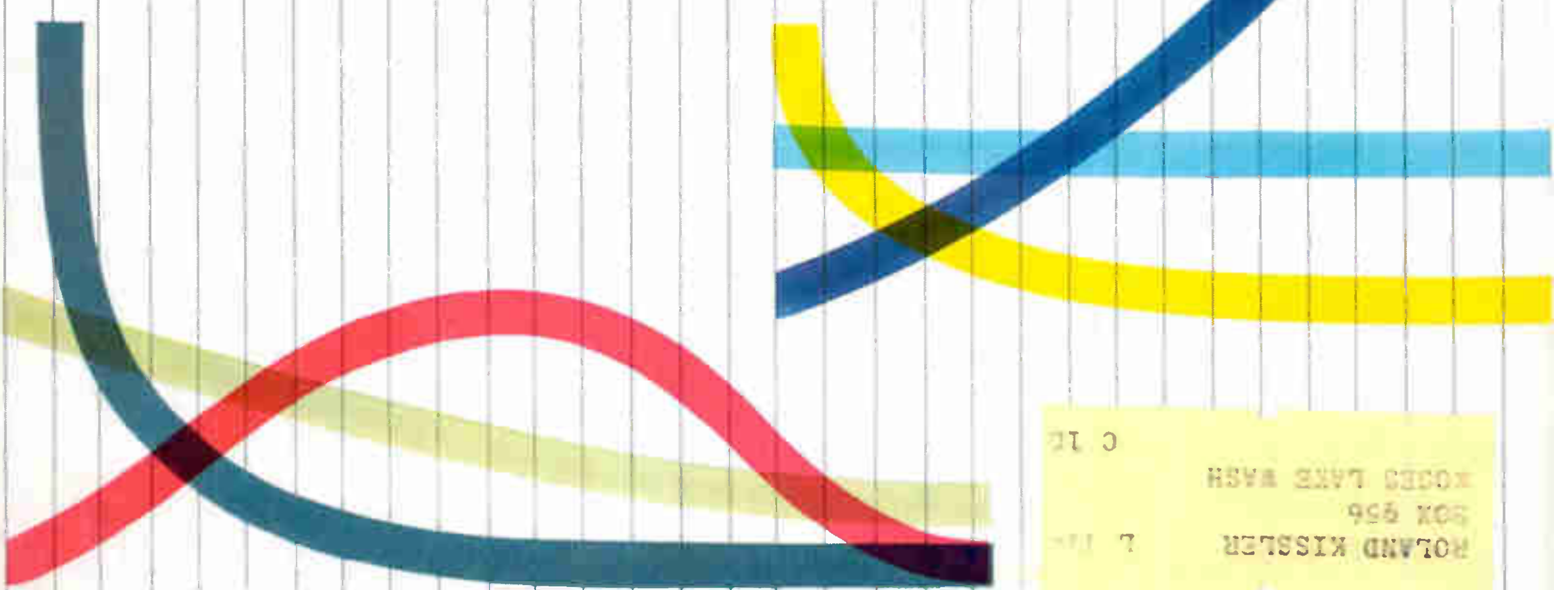
# electronics

A McGraw-Hill Publication 75 Cents





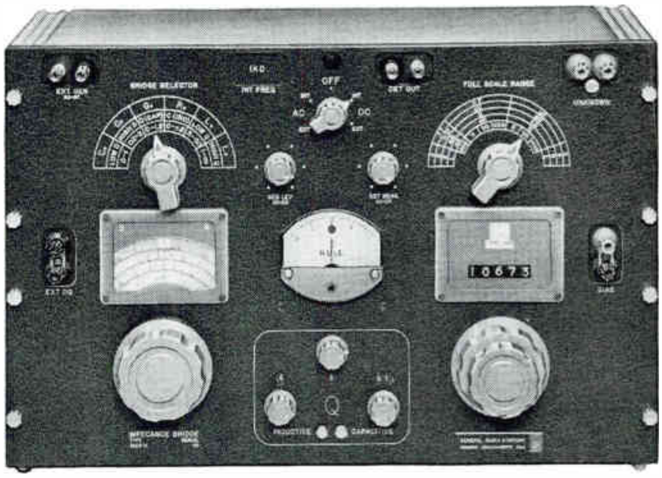
**SPECIAL REPORT** Reliability: 1962. *How modern engineering techniques can improve profits and may even insure our national survival*



# 2 Universal Bridges

## for Precise Measurements with 0.1% accuracy

### Type 1608-A Impedance Bridge ... $1175



- Digital readout of C,R,L, and G with automatic decimal-point location. Measures components having any D or Q.
- Appropriate D and Q scales illuminated automatically ... no multiplying factors to remember.
- Self-contained oscillator and selective null detector. Plug-in modular construction facilitates changing fixed frequency (1-kc unit supplied). Provision for external generator or detector.
- Three internal dc supplies allow standard EIA voltages to be set over most of the resistance range.
- Provision for applying external d-c bias to components under measurement.

## SPECIFICATIONS

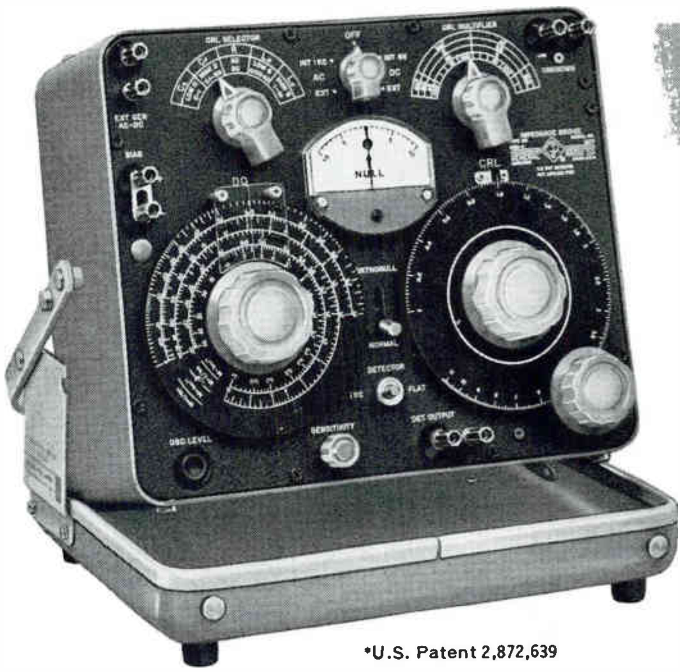
**Ranges:**
R: 0.05 mΩ to 1 MΩ in 7 ranges (ac or dc)
G: 0.05 n℧ to 1 ℧ in 7 ranges (ac or dc)
C: 0.05 pf to 1000 μf in 7 ranges (series or parallel)
L: 0.05 μh to 1000 h in 7 ranges (series or parallel)

**at 1 kc:**
D (series C): 0 to 1 — D (parallel C): 0.02 to 2
Q (series L): 0.5 to 50 — Q (parallel L): 1 to ∞
Q (series R): 0 to 1.2 Inductive — Q (parallel G): 0 to 1.2 Capacitive

**Accuracy (at 1 kc):** ±0.1% of reading ±0.005% of full scale except on lowest R and L ranges and highest G and C ranges where it is ±0.2% of reading ±0.005% of full scale. D and 1/Q accuracy are ±0.0005 ±5% at 1 kc for L and C; ±0.0005 ±2% in Q for R and G.

**Residual Terminal Impedance:** R ≈ 1 mΩ, C ≈ 0.25 pf, L ≈ 0.15 μh.

**Power Requirements:** 105-125 or 210-250 volts, 50-60 cycles.



*U.S. Patent 2,872,639

## for General-Purpose Measurements with 1% accuracy

### Type 1650-A Impedance Bridge ... $460

- Wide Range — 0.001 Ω to 10 MΩ, 1 pf to 1000 μf, 1 μh to 1000 h; 0.02 to 1000 for Q at 1 kc, 0.001 to 50 for D at 1 kc. Useful to 20 kc with external generator.
- Patented ORTHONULL* feature eliminates "sliding balance" — enables easy measurement of low-Q inductors and high-D capacitors.
- C, R, and L measurement accuracy within ±1% (±5% for D and Q); accuracy holds over all ranges — not reduced at range extremes.
- Unique "flip-tilt" cabinet serves as adjustable stand and doubles as protective carrying case.
- Panel controls designed for operator convenience — switching arrangement and panel engraving make bridge operation self-explanatory.
- Battery operated and portable — completely self-contained; built-in transistorized 1-kc oscillator and null detector; single null indicating meter for both a-c and d-c measurements.

*Write for Complete Information*

## GENERAL RADIO COMPANY

WEST CONCORD, MASSACHUSETTS

General Radio (Overseas) Zurich, Switzerland

NEW YORK, N. Y., 964-2722 Ridgefield, N. J., 943-3140 · CHICAGO (Oak Park) 848-9400 · PHILADELPHIA, 424-7419 Abington, 887-8486 · WASHINGTON, D.C. (Rockville, Md.) 946-1600 · SYRACUSE 454-9323 · DALLAS, 899-9065 · SAN FRANCISCO (Los Altos) 948-8233 · LOS ANGELES HO 9-6201 · ORLANDO, FLA. 425-4671 · IN CANADA (Toronto) 246-2171

CIRCLE 900 ON READER SERVICE CARD

November 30, 1962

# electronics

A McGraw-Hill Publication 75 Cents

W. W. MacDONALD, Editor

J. M. CARROLL, Managing Editor
SENIOR EDITORS: Samuel Weber, George W. Sideris. SENIOR ASSOCIATE EDITORS: Michael F. Wolff, John F. Mason. ASSOCIATE EDITORS: Michael F. Tomaino, Sylvester P. Carter, William P. O'Brien, Sy Vogel, Leslie Solomon, George J. Flynn, Laurence D. Shergalis. ASSISTANT EDITORS: Nilo Lindgren, Stanley Froud, Stephen B. Gray, Roy J. Bruun, George V. Novotny, Leon H. Dulberger. REGIONAL EDITORS: Harold C. Hood (Pacific Coast, Los Angeles), Thomas Maguire (New England, Boston), Cletus M. Wiley (Midwest, Chicago). ART DIRECTOR: Howard R. Berry. ASSISTANT ART DIRECTOR: John C. Wright, Jr. EDITORIAL ASSISTANTS: Gloria J. Meurer, Lorraine Rossi, Virginia T. Bastian, Lynn Emery, Ann Mella, Lorraine Werner, Alice M. O'Brien. FOREIGN NEWS BUREAU: Director, John Wilhelm: Alyne Elias, Betsy Wilson. LONDON—John Shinn, Derek Barlow, Nicholas Landon. BONN—Richard Mikton, Silke McQueen. BRUSSELS — Peter Forbath. PARIS—Robert Farrell, Arthur Erikson. MILAN—Marc A. Messina. MEXICO CITY—Bruce Bendow. RIO DE JANEIRO —Leslie Warren. MOSCOW—Stewart Ramsey. TOKYO—Richard Halloran, Charles Cohen, John Yamaguchi.

W. W. GAREY, Publisher



*Contents Continued*

**electronics**

November 30, 1962 Volume 35 No. 48

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).

Title ® registered U.S. Patent Office; © copyright 1962 by McGraw-Hill Publishing Co., Inc. All rights reserved, including the right to reproduce the contents of this publication, in whole or in part.

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. 212-640-4646. 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.

OFFICERS OF THE CORPORATION: Donald C. McGraw, President; Hugh J. Kelly, Harry L. Waddell, Executive Vice Presidents; L. Keith Goodrich, Executive Vice President and Treasurer; John J. Cooke, Vice President and Secretary.

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.

THE PUBLISHER, UPON WRITTEN REQUEST FROM ANY SUBSCRIBER TO OUR NEW YORK OFFICE, AGREES TO REFUND THAT PART OF THE SUBSCRIPTION PRICE APPLYING TO COPIES NOT YET MAILED.

Subscribers: Please address change of address notices, subscription orders or complaints to Fulfillment Manager, Electronics, at above address. Change of address notices should provide old as well as new address, including postal zone number if any. If possible, attach address label from recent issue. Allow one month for change to become effective.

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

Audited Paid Circulation

## CONTENTS continued



## DEPARTMENTS

# How Much Reliability?

NOBODY CAN SERIOUSLY DISPUTE that we must have more reliable electronic equipment. The need is most critical in military equipment, where the fate of the nation may hang in the balance. Reliability is also important in the industrial and consumer fields, although here the cost of unreliability is usually measured in dollars rather than lives.

But sometimes the cure can be worse than the disease. In the present state of knowledge there are only two bullet-proof ways to insure reliability: use simple tried-and-true equipment, or thoroughly life-test newly developed gear. There is nothing more reliable than a scrubboard, but what housewife would be content with that kind of reliability? The military could get a lot of reliability from a DC-3 and a Springfield rifle, but that kind of reliability can lose wars.

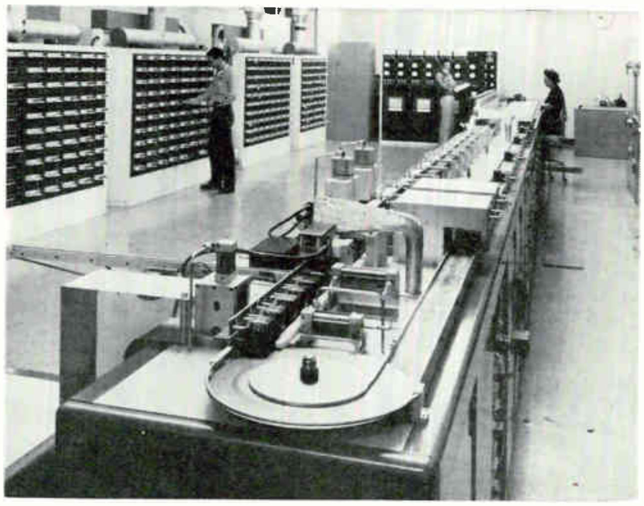
We must have new equipment, especially electronic equipment, that constantly pushes the state of the art. Right now the answer with respect to reliability is to run extensive life-tests on new equipment and components. This is expensive, both to the manufacturer and to the taxpayer. It also takes a lot of time; equipment may be obsolescent before the life-testing is finished.

Is the answer to relax reliability requirements? In some cases it may be. A piece of equipment must be sufficiently reliable so that enough units survive to do their job when the chips are down. The number that must survive is a problem that concerns military strategy and tactics rather than engineering. But we must rely on the military to be realistic in its demands and not ask for more reliability than is needed. Reliability is an expensive commodity.

But sometimes a reliability spec must be high, and to handle these cases the engineer will have to come up with a better answer than life-testing equipment until it becomes obsolete or until his employer goes bankrupt.

Here are a few things engineers can do:

- Get to know basic materials and manufacturing processes better, to find out not just when equipment or parts will fail but why
- Try to relate obvious anomalies, such as high noise or excessive debugging failures to subsequent failure on life-test
- Take another long look at accelerated life-testing and see if valid relationships between stress-level and life can be established
- Study use of modern mathematical methods, such as Markoff chains, to predict reliability from smaller samples, shorter tests.


CART *(Central Automatic Reliability Tester) at Texas Instruments, Inc. life-tests 30,000 operating devices*

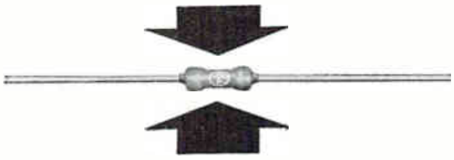
Finally, we can all work just a bit harder for reliability, from the research engineer to the girl on the production line. There are already a lot of good guidelines for more reliable design. We need a more general application of the original reliability specification: MIL-TFB-41—*Make It Like The Foolish Blueprint For Once.*

COLLISION COURSE. No one can sit in an airplane today without occasionally wondering if another plane isn't just behind that mountainous cloud off to the left. No one visiting a busy control center can leave without increased admiration for the job the controllers do, nor without worrying about the equipment they do it with.

FAA knows the nation's air traffic control system is rapidly becoming inadequate and has plans to carry the system through 1975. Implementing this plan will cost about $\$\frac{1}{2}$ billion. It will also strain the ingenuity of the electronics industry.

Details of the plan and a review of existing and proposed control equipment will be reported by Senior Associate Editor Mason in three articles beginning next week. The first covers data processing, display and radar. The others will report on navigation aids, communications and meteorological networks.

QUICK DELIVERY FROM SPRAGUE



THIS IS A ONE-WATT BLUE JACKET RESISTOR

P. S. *Big brothers available up to 11-watts power rating*

P. P. S. *For complete data, write for Engineering Bulletin 7410 D*

Axial-lead Blue Jackets, available in ratings from 1 through 11 watts are specially designed for use with point-to-point wiring or on printed boards in miniature electronic assemblies.

SPRAGUE ELECTRIC COMPANY
35 Marshall Street, North Adams, Mass.

SPRAGUE®
THE MARK OF RELIABILITY


## COMMENT

### Engineer Shortage

While your editorials in ELECTRONICS are certainly well-written, I don't agree with your November 2 editorial (p 3) on overcoming the "engineering shortage."

Your analysis is superficial. It completely neglects the system of writing armament contracts that places a greater stake in the *number* of engineers on a Government job so that a multiplying factor of 2 to 3 times the engineer's salary can be applied; against the order; to the *quality* and *productivity* of the engineer. Result: big, fat "ENGINEERING SHORTAGE"!

SAM LEVINE
Doylestown, Pennsylvania

### Further Logic

Your letter from Mr. Powell with the 10-minute problem from Bell Labs (p 4, Nov. 2) illustrates a symptom of much of our scientific and engineering thought, namely, the tendency to rely on cumbersome general approaches rather than to pick out what meaningful information is readily available, deduce the consequences and go on until we come to the end. In this way many problems can be unravelled, that could not be crushed.

To restate the problem, find the digits in the addition, given that $D = 5$

$$\begin{array}{r} d\ o\ n\ a\ l\ d \\ +\ g\ e\ r\ a\ l\ d \\ \hline r\ o\ b\ e\ r\ t \end{array} \quad \text{or} \quad \begin{array}{r} 5\ o\ n\ a\ l\ 5 \\ +\ g\ e\ r\ a\ l\ 5 \\ \hline r\ o\ b\ e\ r\ 0 \end{array}$$

Mr. Powell was led down the garden path because he did not know whether or not a carry should be applied to each column (except the next to last), and spent much time formulating this uncertainty in completely general terms.

However, take the first column. It is apparent that $r$ is 6, 7, 8 or 9, because $g$ must be at least 1 (0 is taken), and also, $g$ is 1, 2, 3 or 4, because $r$ can be no more than 9. This is quite a bit of information. Should there be a carry from the second column? Let's see now.

If $o + e = o$, then $e$ is zero, but this is wrong since zero is already taken. Therefore there must be a carry from column 3, and $n + r +$ (1 maybe) $= b + 10$.

If $o + e + 1 = o$, then $e$ is zero, which is impossible. Thus $o + e + 1 = o + 10$, and, aha, $e = 9$, no matter what $o$ is, and we must carry 1 into the first column.

Now we have $6 + g = r$, and $r$ can only be 7 or 8 (9 is taken). Which? Let's see now, where else does $r$ appear? Column 3 says $n + r +$ (1 maybe) $= 10 + b$. No help here. In column 5, we have a carry ($5 + 5 = 10$, in column 6) so, aha, $2l + 1 = r +$ (10 maybe). So $r$ is odd. Therefore $r = 7$, and $g = 1$. Now the problem looks like this:

$$\begin{array}{r} 5\ o\ n\ a\ l\ 5 \\ 1\ 9\ 7\ a\ l\ 5 \\ \hline 7\ o\ b\ 9\ 7\ 0 \end{array}$$

Now let's see, in column 2, $o$ can be anything, no help. In column 3, $n + 7 +$ (1 maybe) $= 10 + b$, and since $b$ must be at least 2 (1 is taken), $n$ must be 4, 6 or 8, but we can't tell which yet. How about column 4? Since $a + a$ can't equal 9, an odd number, there must be a carry from column 5 and, aha, $2l + 1 = 17$, since there is a carry from column 6, and $l = 8$. Immediately, $2a + 1 = 9$ or 19, but if 19, $a = 9$, which is taken, so $a = 4$.

From this, $n = 6$, $6 + 7 = b + 10$, $b = 3$ and $o = 2$, the only digit left.

STUART T. MARTIN
President
WCAX-TV
Mt. Mansfield Television, Inc.
Burlington, Vermont

### Wide, Not High

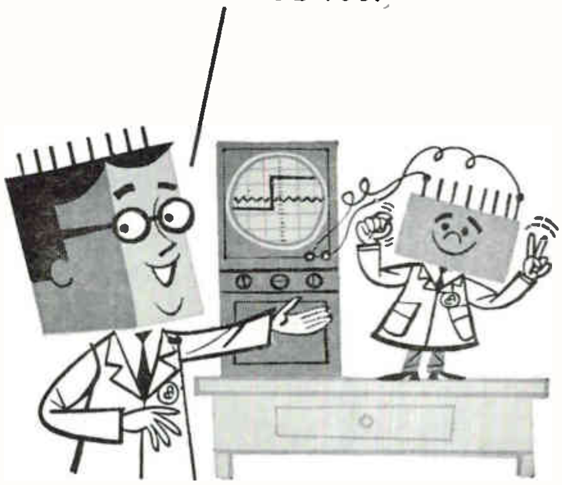
Much as we appreciate the publicity you gave us in the issue on Electronics In Canada (p 37, Sept. 28), I must point out that your statement regarding our speaker system was incorrect.

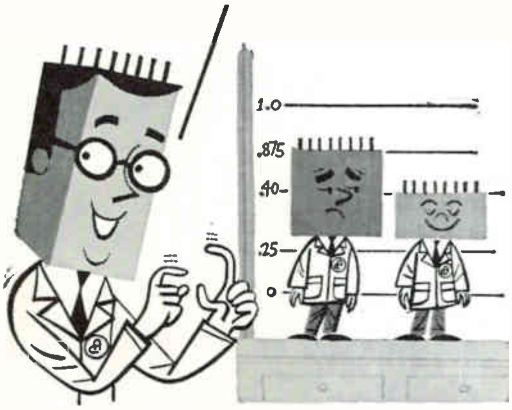
The main feature of this system is that it is the first *full range* modular electrostatic on the market; many other electrostatics reproduce high frequencies, but none the full range from a given number of *identical transducers*.

J. M. WALKER
Sigma Technical Associates Ltd.
City of Jacques Cartier, Quebec

**We said "reproduces high-frequency audio signals." We should have said "reproduces wide-frequency audio signals."**

# MR. RELAY *by Allied Control*



There's more news worth noting about Allied's new S relay. Flux contamination, for example, is a thing of the past. We use the latest heliarc welding techniques to seal the S relay within an inert atmosphere. Since there's no bobbin (the coil is wound *directly* on the magnetic core), Allied eliminates possible contamination here, too. And talk about immunity to shock and vibration! S is really rugged with its balanced rotary action armature. All S relays are calibrated for contact overtravel of the energized contacts *during* production, so they *stay and stay* on the job. Want complete application data? Write for Catalog Sheet S or call your nearest Allied representative.

©1962 BY ALLIED CONTROL COMPANY, INC.

| OPERATING CONDITIONS | |
|---|---|
| Contact Rating: (at nominal coil voltage) | 2 amperes resistive at 29 volts d-c Low level contacts available |
| Contact Arrangement: | Two pole double throw |
| Shock: | 50g operational |
| Vibration: | 5 to 55 cps at 0.125 inch D. A. 55 to 2000 cps at a constant 20g |
| Operate & Release Time: (at +25°C) | 4 milliseconds maximum at nominal coil voltage |
| Terminals: | Plug-in, printed circuit, hook type solder terminals and 3 inch leads |
| Weight: | 0.3 ounce maximum |

**ALLIED CONTROL COMPANY, INC.**

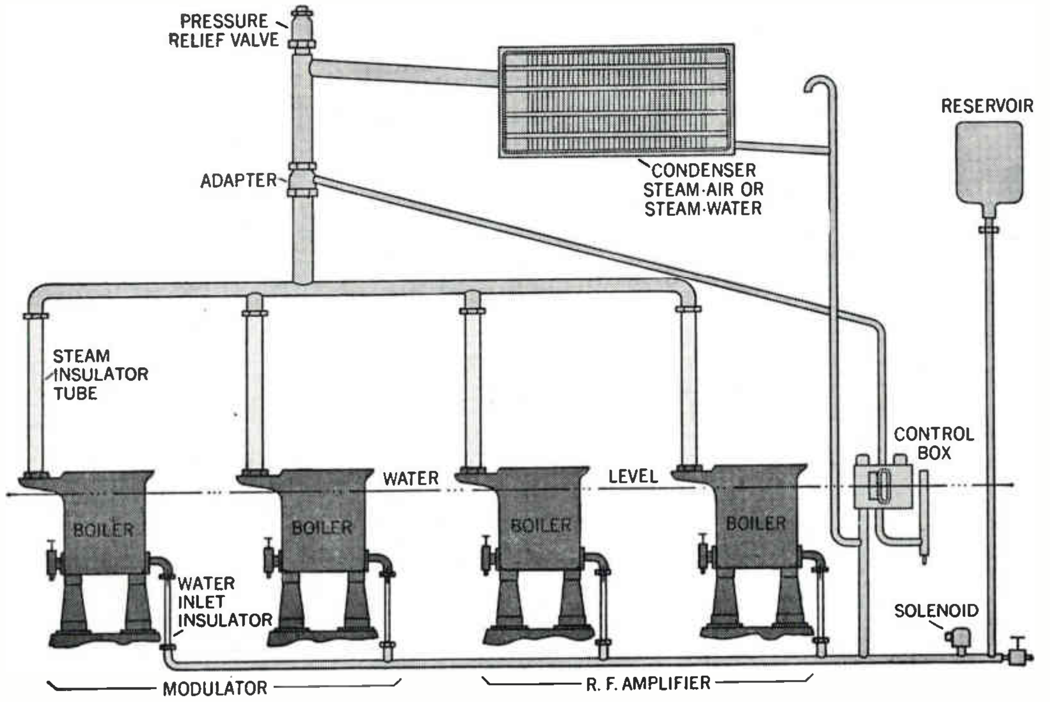
2 EAST END AVENUE, NEW YORK 21, N. Y.

AL-233-S

# VAPOR-PHASE COOLING?

## Eimac has the tubes

SCHEMATIC OF TYPICAL EIMAC MULTI-TUBE VAPOR COOLING INSTALLATION




## and all the components.

### EIMAC VAPOR-PHASE COOLING TUBES AND COMPONENTS

| Tube | Type | Typical Operation | Anode Dissipation | Vapor-Phase Cooling Components* Socket | Boiler | Control Box | Adaptor |
|---|---|---|---|---|---|---|---|
| 4CV8000A | Tetrode | Class $AB_1$ Power Output 10 Kw per tube | 8 Kw | SK1400 | BR100 | CB101 | AD100 |
| 4CV20,000A | Tetrode | Class $AB_1$ Power Output 17 Kw per tube<br>Class C, CW Power Output 17.5 Kw | 20 Kw | SK300A | BR200 | CB200 | AD200 |
| 3CV30,000A | Triode | Industrial Heater Service; Power Output, 30 Kw<br>Plate-Modulated AM Serv.; Power Output 17 Kw Carrier | 30 Kw | SK1300 | BR200 | CB200 | AD200 |
| 4CV35,000A | Tetrode | Class $AB_1$ Power Output 30 Kw per tube<br>Class C CW Power Output 40 Kw | 35 Kw | SK300A | BR200 | CB200 | AD200 |
| 4CV100,000C | Tetrode | Class $AB_1$ Power Output 130 Kw per tube<br>Plate-Modulated AM Power Output, 135 Kw Carrier<br>Class C Power Gain, 100 Times | 100 Kw | SK1500 | BR300 | CB200 | AD300 |

*Each tube in a system requires a socket, boiler, steam Pyrex tubing, water return Pyrex; Condensers of appropriate Kw rating and thermo-activated vent available. Reservoir and Solenoid valve optional.

Write for complete applications bulletin, Eitel-McCullough, Inc., San Carlos, California

# ELECTRONICS NEWSLETTER

## Superconductor Maser Has Low Pump Frequency

**MILLIMETER-WAVE MASER newly developed by Westinghouse Electric for the Air Force gets its applied field from a lightweight superconducting magnet and operates with a pump frequency considerably lower than the signal frequency.**

Once the magnet is started up, by a 12-v battery, the power can be disconnected and the magnet will continue to supply the field in a persistent-current mode. Field strength is 8,000 gauss.

Westinghouse says that a conventional electromagnet with an equivalent field would weigh 1,200 pounds and require continuous input of 3 Kw.

The maser operates at 96 Gc. Pump frequency is 65 Gc. The design incorporates a low-frequency, five-level pumping technique. Gains of more than 10 db have been achieved at noise levels near 2 db, the company reports. The maser can be tuned by varying the field value.

Both the magnet, made of niobium-zirconium wire, and the iron-doped titanium-oxide (rutile) maser operate at liquid-helium temperature (4.2 K).

## Organic Lasers May Go From R-F to Ultraviolet

LOS ANGELES—Hughes Aircraft is investigating the possibility of liquid lasers with emissions at submillimeter and ultraviolet wavelengths. So far, laser action at near-infrared through far-infrared has been achieved with benzene, nitrobenzene, deuterated benzene, toluene, bromonaphthalene, cyclohexane and pyridine. No limit is seen to the number of liquids that can be lased.

Company scientists have been working with a pulsed reflector using a ¼ by 3-inch pink ruby as the pulse source. The liquid is in ordinary glass absorption cells. Lasing results from a process known as two-quantum stimulated Raman scattering, rather than the single-quantum induced fluorescence of earlier lasers. An atom simultaneously absorbs and emits a single quantum instead of just emitting a single quantum of light.

The phenomenon was first observed in a nitrobenzene-filled Kerr cell. Stimulated emission at 7,670 angstroms accompanied the usual 6,943 emission, and its energy was about ⅓ that of the latter. Beam collimation at both wavelengths was about 6 milliradians.

## Computer Data Dialing System is Tried Out

BOSTON—Potentials for data communications in business were indicated this week by the linkup of a computer to Western Union's Telex dial telegraph network.

In a demonstration by Honeywell's Electronic Data Processing division, dialed Telex signals controlled and communicated with lab model of a Honeywell 400 located in nearby Newton.

The program is now experimental. But possibilities are seen for such commercial applications as dialing to get information from a central sales file in a computer.

## Japan Extending Radio Quotas Until Mid-1963

TOKYO—Japan Machinery Export Association said last week that the quota system for transistor radio exports to the U. S. would continue to mid-1963, subject to approval by the Ministry of International Trade and Industry. Quotas were to expire December 31.

MITI reportedly favors maintaining the quota system. The quota for the additional six months is expected either to level off or increase by 10 percent over the estimated 1962 exports of 7 million radios.

## Telstar's Communications Command Circuit Fails

TELSTAR'S communications command circuit has failed, Bell Telephone Laboratories reported this week. The cause, and whether the failure is permanent, had still not been determined. The satellite's communications system itself is apparently still operable, but it cannot be turned on or off. Telemetry is still functioning.

Bell Labs says that it had completed all of its scheduled experiments during the past four months. The communications system had been made available recently to other companies for demonstrations, such as the recent round of computer data transmission tests.

## Mulitifont Reader Sees Letters as Dot Patterns

MULTIFONT PRINT READER has been developed by IBM as a research tool to study and generalize methods of print recognition.

The programmable system can recognize in real time a variety of alphabets and type styles, including, for example, the Russian Cyrillic alphabet. Input characters are described by a relatively small number of measurements that are essentially independent spatial configurations of black and white

## Opposition Expected to $1.52 Minimum Wage

ELECTRONIC INDUSTRIES ASSOCIATION committee was to meet this week in San Francisco to consider the U. S. Labor Department's proposal to set a $1.52 minimum wage for the electronic equipment industry under the Walsh-Healey Act (p 10, Nov. 23).

Leonard Kane, of Raytheon, chairman of the EIA committee, said prior to the meeting that there is every reason to believe the electronics industry will file a statement of exceptions to the ruling. At the September hearings, EIA urged a $1.40 minimum points. The measurements are compared to a stored reference for identification.

Plug-in adjustments and programming changes can insert different recognition logics. The logic is such that the reader can identify fonts which were not considered in preparing the reference sets.

## All-Purpose Aircraft Work Gets Underway

FORT WORTH—Development contract for TFX, a supersonic jet fighter-bomber to be used by both the Air Force and Navy, has been awarded General Dynamics-Ft. Worth and Grumman Corp. of Bethpage, N. Y.

The $750-million order calls for 22 test models. Production contract, expected after delivery of test models within the next two and one-half years, could run over $5 billion.

Design requirements call for a craft that can fly at 1,650 mph, and at supersonic speed at sea level, can be launched and recovered by aircraft carriers, and use conventional or nuclear weapons against ground and air targets.

## Central America Seeks Integrated Communications

INTEGRATED TELECOMMUNICATIONS system for Central America will be blueprinted by a year-long study beginning next month under United Nations sponsorship.

Five and 10-year programs will be developed for El Salvador, Guatemala, Honduras, Nicaragua and Panama, signers of agreements with the World Bank, and for Costa Rica, expected to sign soon.

A regional study will also be made. The UN pointed out that the systems in the six countries require expansion and modernization and are of different types. This, said the UN, offers an opportunity for regional integration as well as local improvements.

Cost of $770,000, including $75,200 from the six countries, will be paid by the UN Special Fund. Experts from the French Ministry of Posts and Telecommunications will make the study.

## Military Information Systems Need Debated

INFORMATION SCIENTISTS met in Hot Springs, Va., last week to hammer out guidelines for future development of automated military information systems. Among key questions being debated were how automated such systems can be, and how much of the command decision load can be shared by systems.

Brockway McMillan, Air Force assistant secretary, warned against bringing over-automation into military decisions.

Topics at the First Congress on the Information System Sciences included new communication and control theories, biological models for command automata, joint man-computer decision processes, self-organizing and self-adaptive systems. The congress was sponsored by the Air Force and Mitre Corp.

## Radars Double Up 30-Mw Transmitters

TWO DUAL-FREQUENCY pencil-beam radar systems will be installed next year at White Sands Missile Range by Ling-Temco-Vought. Both will have two 30-Mw transmitters and will operate with dual polarization as well as dual frequency. Pulse-forming lines will be triggered by ignitrons. One system will have a 30-foot parabolic antenna and the other an 84-footer. The Air Force contract can exceed $40 million.

## Space Tv Designers Get Versatile Scan Converter

NASA HAS ORDERED development of a scan converter that can handle incoming tv signals varying from 5 to 25 frames a second and from 100 to 525 lines a frame.

It will be used to evaluate displays at standard tv broadcast rates, as an aid in designing slow-scan tv systems for spacecraft.

Image Instruments will develop the converter under a $71,000 contract. The company says it will use three crt charge-storage tubes in a time-sharing fashion. This is expected to eliminate flicker and smear in the tv display.

# In Brief . . .

ALL-CHANNEL TV standards proposed by the industry last summer (p 8, Sept. 14) have been approved by FCC.

DEFENSE DEPARTMENT has released another $50 million for development of radar and other RS-70 aircraft equipment. Congress had voted an extra $200 million.

GE WILL SELL research samples of gallium-arsenide diode lasers for $1,300 each, 10 times cost on diodes with noncoherent emission.

NEMA ESTIMATES that total sales of the electrical industry will hit $25 billion in 1962 and 1963. R&D is estimated at $2½ billion for 1962. E. R. Perry was re-elected president of NEMA at its annual meeting.

VENUS-BOUND MARINER has broken Pioneer 5's communication's distance record of 18 million miles.

LITTON INDUSTRIES plans to buy Emertron, a subsidiary of Emerson Radio.

CORNING GLASS has purchased a substantial interest in Signetics Corp., manufacturer of integrated circuits.

PACKARD INSTRUMENT will develop two gamma-ray detectors for lunar spacecraft. The units will measure gamma-emitting elements on the surface of the moon.

SPERRY won radar contracts from the Air Force totaling $4 million. Major portion is for production of APN-59 radars, spare parts and ground support equipment.

UNITED CONTROL will supply temperature control units for Minuteman's guidance compartment cooling system, to be used while the missile is stored in its underground launch silo.

HALLICRAFTERS received an Air Force contract for airborne and ground electronic equipment that is expected to top $10 million.

# How Important *is* Experience?

**When you select a microwave spectrum analyzer,** remember that Polarad is the pioneer. In fact, we have had more experience in designing, building, and helping engineers apply microwave spectrum analyzers than all of our competitors combined . . . several times more. We wrote the only textbook in the field — in its fifth printing now. (Write for one — it's free.)

**So What?** Why should it matter to you that we have the most experience? Does experience really count? We think it does. In fact, we believe it is the **most important factor in your final decision.** Let us tell you why.

**Every circuit** in a Polarad spectrum analyzer is a second- or third-generation design. That means:

- **refinements** that make it more precise and stable.
- **sophistications** that make it more versatile and useful.
- **revisions** that make it more reliable and economical.
- **updating** that assures state-of-the-art capability.

**On the other side** of the coin is what experience **spares** you. You know the kind of thing we mean:

- subtle surprises . . . the mixer, or other circuit that isn't there, just when you need it. (All Polarad Spectrum Analyzers are furnished **complete.**)
- inconveniences . . . like the hard-to-read scale, the oversensitive control, or the awkward panel arrangement.
- weak links . . . the causes of sudden failure right in the middle of an important test.

Everyone is plagued by these things . . . and only experience — **properly applied to the evolution and elaboration of a design** — ever eliminates all of them.

*To sum up,* when you buy a Polarad spectrum analyzer, you benefit in two ways: you get the **most** instrument for your money; **and** you get the accumulated experience of thousands of engineers, in many hundreds of installations all over the world. No one else can offer you that much.

**Call** your Polarad Field Engineer for positive proof.

## Newest in a Distinguished Family — the Model SA-84 WA Extended-Range Spectrum Analyzer

Extended Frequency Range: 10 MC-63,680 MC in a single self-contained instrument! Extended Dispersion Range: 25 KC to well over 80 MC (to 100 MC on special order!) Highest Sensitivity ever offered in this class of spectrum analyzer!

Wide-Range Variable Resolution: 1 KC-80 KC! Many other features: 0.01% Crystal-controlled markers over entire frequency range . . . log-linear display . . . (up to 36 db calibrated log display) accurate IF attenuator . . . full 5" usable display.

**HAVE YOU MADE RESERVATIONS YET?**

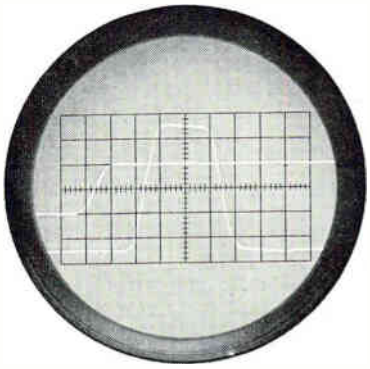

Polarad's new "Project Mohammed" is now bringing the "Mountain" (our new Mobile Microwave Calibration Laboratory) to "Mohammed" (your microwave instruments). Be sure to take advantage of this opportunity to have your gear checked — at your doorstep. Save weeks of delay and needless expense. Call your Polarad field engineer for details and schedules!

**POLARAD**

**Polarad Electronics Corporation**
*World Leader in Microwave Instrumentation*
43-20H 34th Street
Long Island City 1, New York

# TOTAL COVERAGE

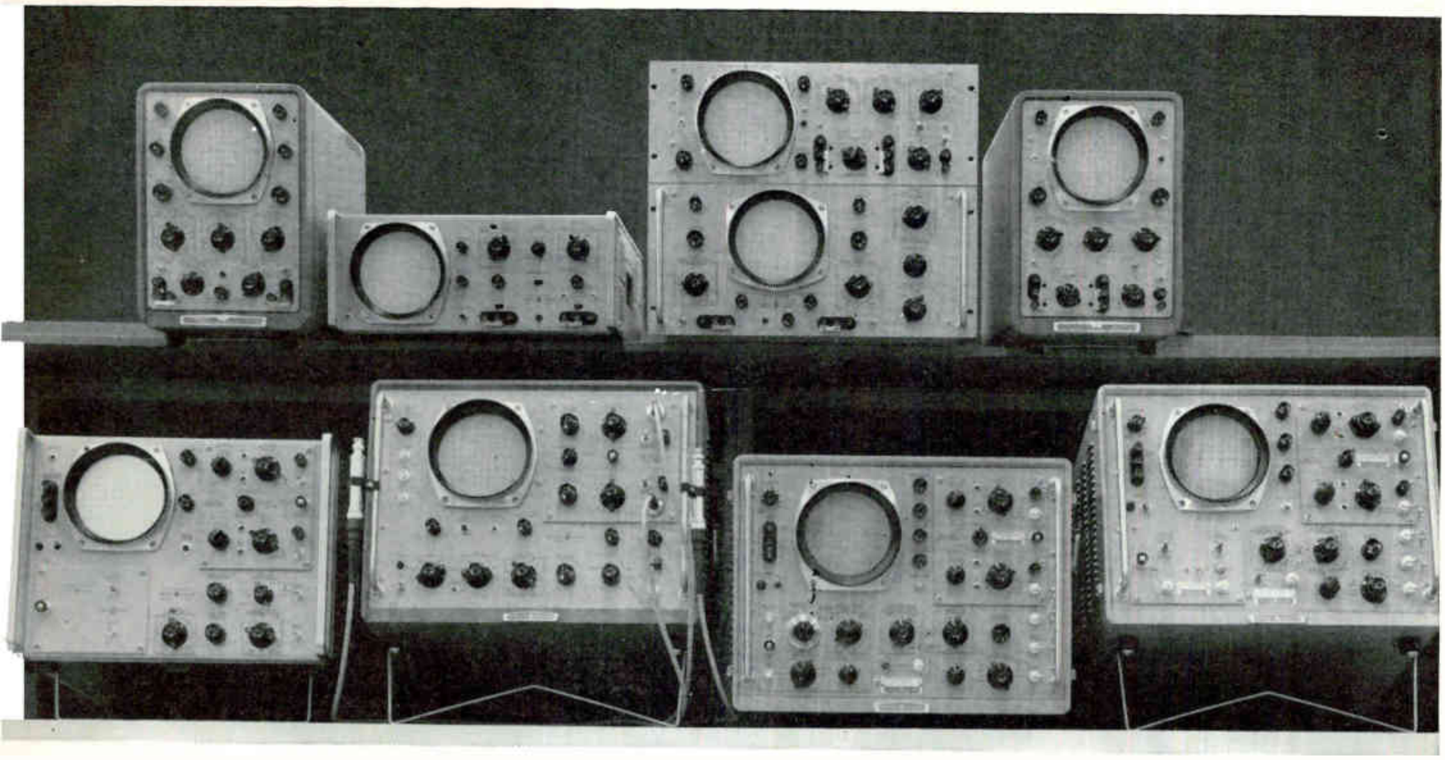
## in quality hp SCOPES



### *Easy, fast, accurate measurements*

## DC to 1000 MC

| OSCILLOSCOPE | Description | Features |
|---|---|---|
| hp 185B | High-speed sampling-type scope, dc to 1,000 MC, conventional convenience over entire range (3 db point beyond 800 MC). Dual trace presentation with hp 187B plug-in. hp 186A Switching Time Tester available. | High sensitivity, wide dynamic range, high impedance signal probes. Versatile signaling up to 1,000 MC. Rise time less than 0.5 nanosecond. X-Y recorder output; time, amplitude calibrators. Rack mount available. |
| hp 175A | Dual trace 50 MC universal scope. Horizontal and vertical plug-ins for dual trace to 40 MC; high gain, single channel viewing, sweep delay, display scanning for X-Y output, time markers. Modular packaging for bench or rack mount. | 12 Kv post-accelerator CRT with 6 x 10 cm display with internal graticule, no front panel astigmatism control; beam finder; simplified circuitry, no distributed amplifiers. |
| hp 160B, 170A | Militarized scopes, hp 160B, dc to 15 MC; hp 170A, dc to 30 MC. Plug-ins: dual trace, fast rise, high gain vertical amplifiers; marker generator, display scanner, sweep delay generator horizontal plug-ins. | Designed to withstand shock, vibration, humidity, temperature variations; beam finder; meet environmental requirements of MIL-E-16400. Rack mount available. |
| hp 120B | General purpose 450 KC scope. Human engineered front panel, simplified circuitry; no-parallax no-glare CRT; modular packaging for bench or rack mount. | Beam finder, automatic triggering, amplifier calibrator. |
| hp 122A, AR | Dual trace 200 KC scopes. Twin vertical amplifiers for either dual or single trace viewing. Bench or rack models. | Alternate, chopped presentation; differential input; automatic sync; x 5 sweep expansion. |
| hp 130B, BR | General purpose 300 KC scopes. 1 mv sensitivity. Similar vertical, horizontal amplifiers. Bench or rack models. | Minimum controls, easy operation, balanced inputs, high sensitivity. |



130B 120B 122AR 122A
175A 185B 130BR 170A 160B

There's a dependable, accurate Hewlett-Packard oscilloscope for your every measuring task from dc to 1,000 MC. In addition to conservative design and rugged construction, ⓗⓟ scopes offer such error-free operating features as human engineered front panels, beam finder and automatic preset triggering. ⓗⓟ scopes are easy to use and easy to maintain.

## ⓗⓟ CRTs eliminate scope parallax error!

Hewlett-Packard developed cathode ray tubes, standard on ⓗⓟ 175A, 185B, and 120B Oscilloscopes and optional for other ⓗⓟ scopes, use an interal graticule to eliminate parallax error! The graticule is *inside* the CRT so that trace and graticule are in exactly the same plane. These CRTs also have the exclusive ⓗⓟ no-glare, no-reflection faces. Select the scope for your job and call or write today for complete information.

**HEWLETT PACKARD COMPANY**

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., 54-54bis Route des Acacias, Geneva; Canada, Hewlett-Packard (Canada) Ltd., 8270 Mayrand Street, Montreal 7900

*Data subject to change without notice. Prices f.o.b. factory. *Prices do not incude plug-ins.*

| Vertical Sensitivity | Horizontal Sweep | Price, basic oscilloscope |
|---|---|---|
| 10 to 200 mv/cm, vernier to 4 mv/cm, with dual trace amplifier. | 0.1 nsec/cm calibrated (0.04 nsec with vernier) to 10 μsec/cm. | $2,300.00* |
| 5 mv/cm with high gain amplifier plug-in; 0.05 v/cm to 20 v/cm (50 v/cm with vernier) with dual trace amplifier. | 0.1 μsec/cm to 5 sec/cm, vernier to 12.5 sec/cm. x 10 magnifier increases max. sweep speed to 10 nsec/cm. | $1,325.00* |
| 5 mv/cm with high gain amplifier. 0.02 v/cm to 50 v/cm with dual trace amplifier; 0.05 v/cm to 50 v/cm with fast rise preamplifier. | 0.02 μsec/cm with expander to 15 sec/cm with vernier. | ⓗⓟ 160B, $1,850.00*<br>ⓗⓟ 170A, $2,150.00* |
| 10 mv/cm to 100 v/cm | 1 μsec/cm to 200 msec/cm, vernier to 0.5 sec/cm. | $475.00 |
| 10 mv/cm to 100 v/cm | 1 μsec/cm with expander to 0.5 sec/cm with vernier. | $675.00, cabinet (ⓗⓟ 122A) or rack mount (ⓗⓟ 122AR) |
| 1 mv/cm to 125 v/cm | 0.2 μsec/cm with expander to 12.5 sec/cm with vernier. | $650.00, cabinet (ⓗⓟ 130B) or rack mount (ⓗⓟ 130BR) |

CIRCLE 11 ON READER SERVICE CARD

# WASHINGTON OUTLOOK

### DEFENSE BILL GOING UP, NOT DOWN

INSTRUCTIONS TO CUT PROCUREMENT have been issued to all agencies by the White House, due to its commitment to cut taxes in the face of a mounting federal deficit. Even the Pentagon is involved.

But defense spending will still rise at least $2 billion next year. Gossip that existing production schedules will be stretched out to defer payments to help ease the deficit is untrue, officials say.

Economy moves are to affect only "marginal, postponable" projects (like administrative planes and vehicles, and replacement-type construction), not "combat power." Some officials fear that more of a damper will be put on programs now facing stiff administration opposition, like Nike Zeus. The economy drive may also offset any budget boosts prompted by the Cuban crisis.

### PENTAGON PUTS CLAMP ON COST-PLUS ENGINEERING

APPLIED ENGINEERING CONTRACTS will be limited from now on by the Pentagon to fixed-price or incentive awards. Applied engineering covers advanced hardware development of systems or components deemed technically feasible and approved for operational use. This year's budget provides over $3.5 billion for such projects.

The new policy is part of the effort to restrict severely cost-plus fixed-fee awards. In the past year, the Pentagon has cut this type of contracting from 38 percent of total procurement to 33.2 percent. Fixed-price incentive contracts are up from 9.7 to 12.5 percent of total procurement and cost-plus incentive contracts have risen from 2.7 to 3.5 percent of total procurement.

### INDUSTRY IS LUKEWARM TO INCENTIVES

MANY PENTAGON OFFICIALS are dismayed by what they consider to be industry's lukewarm reception to the stress on incentive contracts. Says Joseph M. Imirie, Air Force assistant secretary for materiel: "It seems to be one thing (for industry) to decry low profit and government control. It seems to be quite another to leave the sanctuary of guaranteed fee and cost recovery." In cost-plus incentive contracts, the fee can range from minus a few percentage points to the legal limit of 15 percent, depending on the contractor's performance.

### NEW MISSILE STILL IN AIR

MOBILE MID-RANGE BALLISTIC MISSILE'S future is still very much up in the air. But if it ever goes into full-bloom development and production, Hughes Aircraft would be a key contractor. Hughes has been picked to finish preliminary design and cost studies on the project's "integration, assembly and checkout" phase. Hughes is still competing against a Martin-Sylvania team for MMRBM's command and control system. General Precision has a $185-million contract for guidance and control, the only phase approved beyond program definition.

### FOREIGN TRADE BARS FALLING

ADMINISTRATION IS MOVING FAST on its program to ease foreign trade restrictions. The new presidential representative for trade negotiations, ex-Secretary of State Herter, wants to scale back tariffs rapidly so that the European Common Market and the U.S. can eventually be brought together in a virtual merger. He decries trade restriction efforts by "special interest industrial groups."

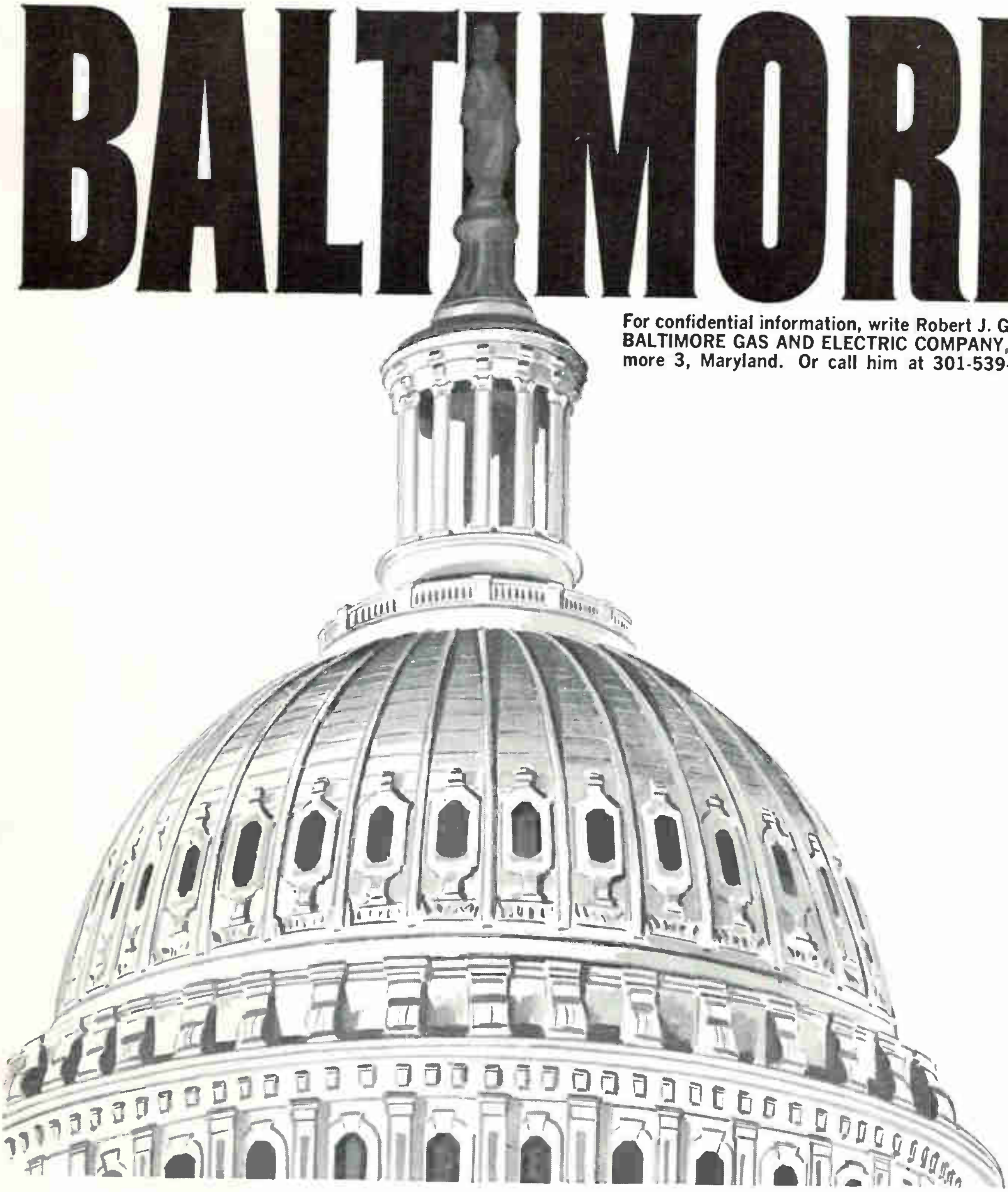
# NEXT DOOR TO THE CAPITAL AND CAPITOL

The more, the merrier. That's how Maryland feels about its many **kinds** of commerce and industry. 30,000 separate businesses . . . nearly 3,500 industrial establishments . . . products and services so varied that the region's economy never depends on one or two. Result: **stability** that encourages sound planning, steady growth, prosperity.

Baltimore and its neighboring counties make just about everything . . . adding up to over 80% of the major industrial categories in the U.S. census of manufacturers. They're suppliers of what you need, buyers of what you sell. And this bustling world-port location is closest to the rich markets of the Northeast, South and Midwest. When you really want to think **big**, think BALTIMORE.

## PUT YOUR PLANT IN

# BALTIMORE



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

CIRCLE 13 ON READER SERVICE CARD

CIRCLE 14 ON READER SERVICE CARD→

# LAND MOBILE RADIO Seeks End to

*EIA calls for more space, urges FCC to reevaluate allocations*

**FAST-GROWING SERVICE**

*In 1959, predictions were that land mobile radio services would have 1¼ million operational transmitters by the end of 1962, 2.4 million by 1967.*

*EIA now figures there will be 1.7 million transmitters by the end of this year and that the number will climb to 5 million by 1977—if there are enough channels.*

*In 1959, total bandwidth available for land mobile was 38 Mc. This provided 761 channels. Subsequent channel splitting expanded the possible number of channels to 1,376.*

*If the EIA request for an increase in total bandwidth to 40.8 Mc is granted, the number of possible split channels would increase to 2,576*

MOBILE RADIO USERS face a serious frequency congestion problem—a problem that will continue to grow unless the FCC does something about it, said an Electronic Industries Association spokesman during a recent visit to New York.

EIA is petitioning FCC to reallocate the frequencies now assigned to uhf-tv channels 14 and 15 (ELECTRONICS, p 7, Oct. 12) to land mobile services. This would be a move in the right direction, but overall spectrum-use reevaluation is the only long-range solution, said William Weisz, a Motorola vice-president, who heads EIA's Land Mobile Communications Section.

The problem, EIA feels, won't be solved by further technical sophistication. Weisz said that no other service has gone as far as land mobile in pushing the state of the art to get more users onto available channels.

Weisz added that the demand for space is so rapidly exceeding the supply that unless FCC acts quickly to ease the situation, land mobile will come to the end of the line.

CHANNEL SPLITTING—During the past 20 years, land mobile users have split the original 120-Kc channels to 60 Kc, then 30 Kc and even to 15 Kc in some cases.

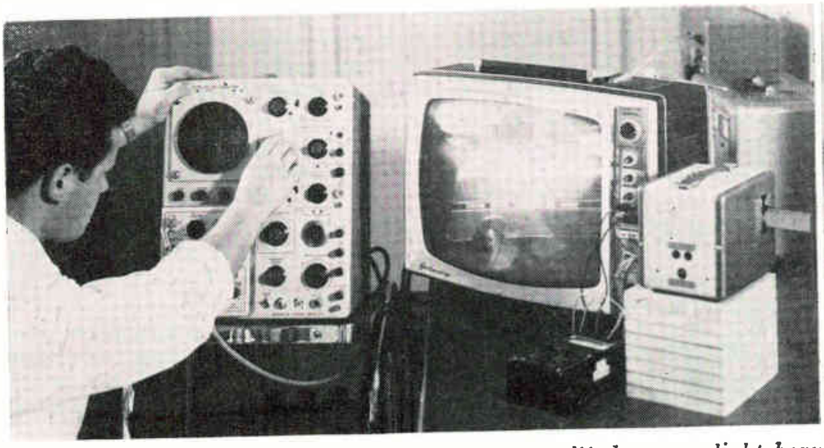
This has cost land mobile service users millions of dollars in equipment changeovers as well as substantially degraded service, Weisz said.

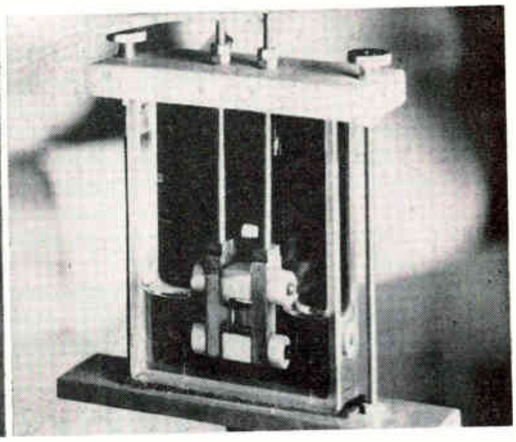
He expects the situation to get worse. The number of users has far outstripped the number anticipated when allocations were originally made and is increasing more rapidly than had been predicted even a few years ago.

Unlike public safety licensees, business users are promised no protection against interference by other users. A man who invests $500 and $800 per vehicle in radio equipment wants some assurance he can use it, Weisz pointed out. The businessman doesn't mind sharing a frequency with a few other users, but when he must share it with 20 or 30 other companies, each with as many as 15 or more mobile units, communications becomes unreliable and hardly justifies the expense, Weisz said.

EIA PETITION—There are several reasons why EIA is now requesting reallocation of channels 14 and 15. Among these are: There are now only a few stations in rural areas on these channels; these bands would provide immediate relief to land mobile services in areas

# Light Beam Transmits Television Signals





TV PICTURE AND AUDIO *signals are transmitted over a light beam at Grundig Research Labs, Bonn, Germany. Kerr cells polarize and split light from a mercury lamp into two components, then modulate brightness of the beam's components. Signals are received by multiplier phototube. Prototype's bandwidth is 100 Mc. Grundig expects development of commercial and space applications. Smaller photo shows modulator construction*

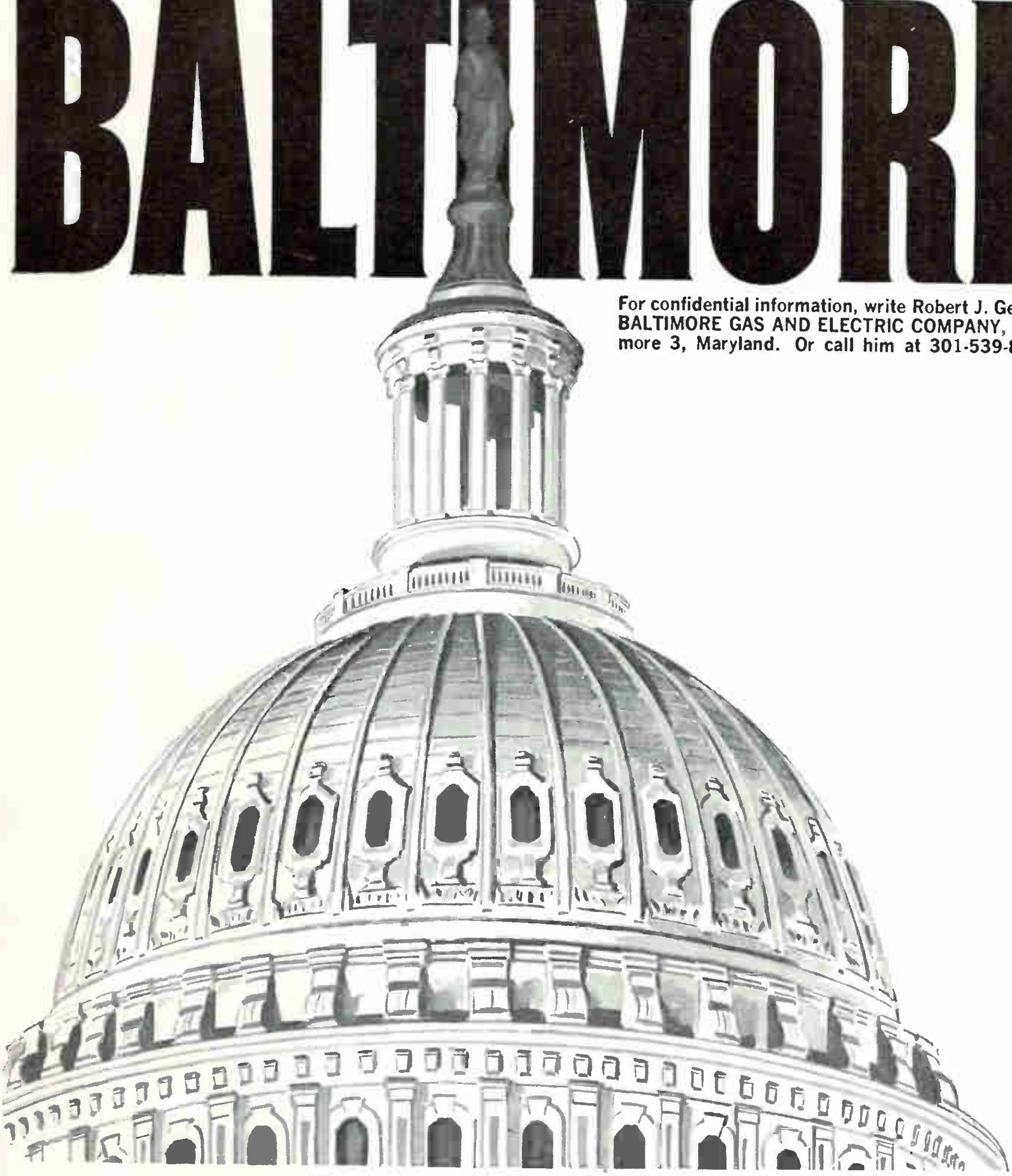
# NEXT DOOR TO THE CAPITAL AND CAPITOL

The more, the merrier. That's how Maryland feels about its many **kinds** of commerce and industry. 30,000 separate businesses . . . nearly 3,500 industrial establishments . . . products and services so varied that the region's economy never depends on one or two. Result: **stability** that encourages sound planning, steady growth, prosperity.

Baltimore and its neighboring counties make just about everything . . . adding up to over 80% of the major industrial categories in the U.S. census of manufacturers. They're suppliers of what you need, buyers of what you sell. And this bustling world-port location is closest to the rich markets of the North-east, South and Midwest. When you really want to think **big**, think BALTIMORE.

## PUT YOUR PLANT IN

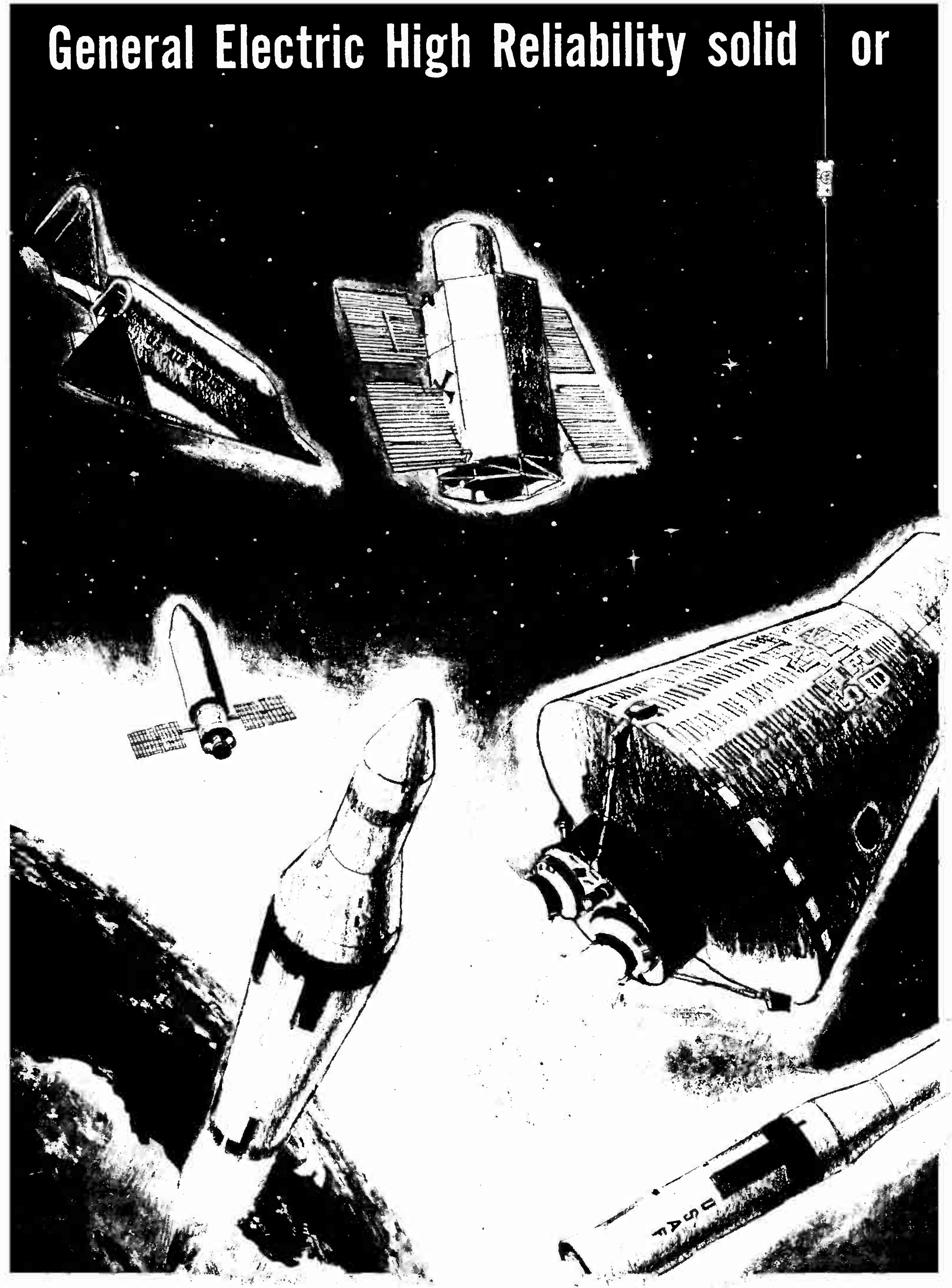
# BALTIMORE



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

CIRCLE 13 ON READER SERVICE CARD

CIRCLE 14 ON READER SERVICE CARD →


General Electric High Reliability solid or
USAF

# NEXT DOOR TO THE CAPITAL AND CAPITOL

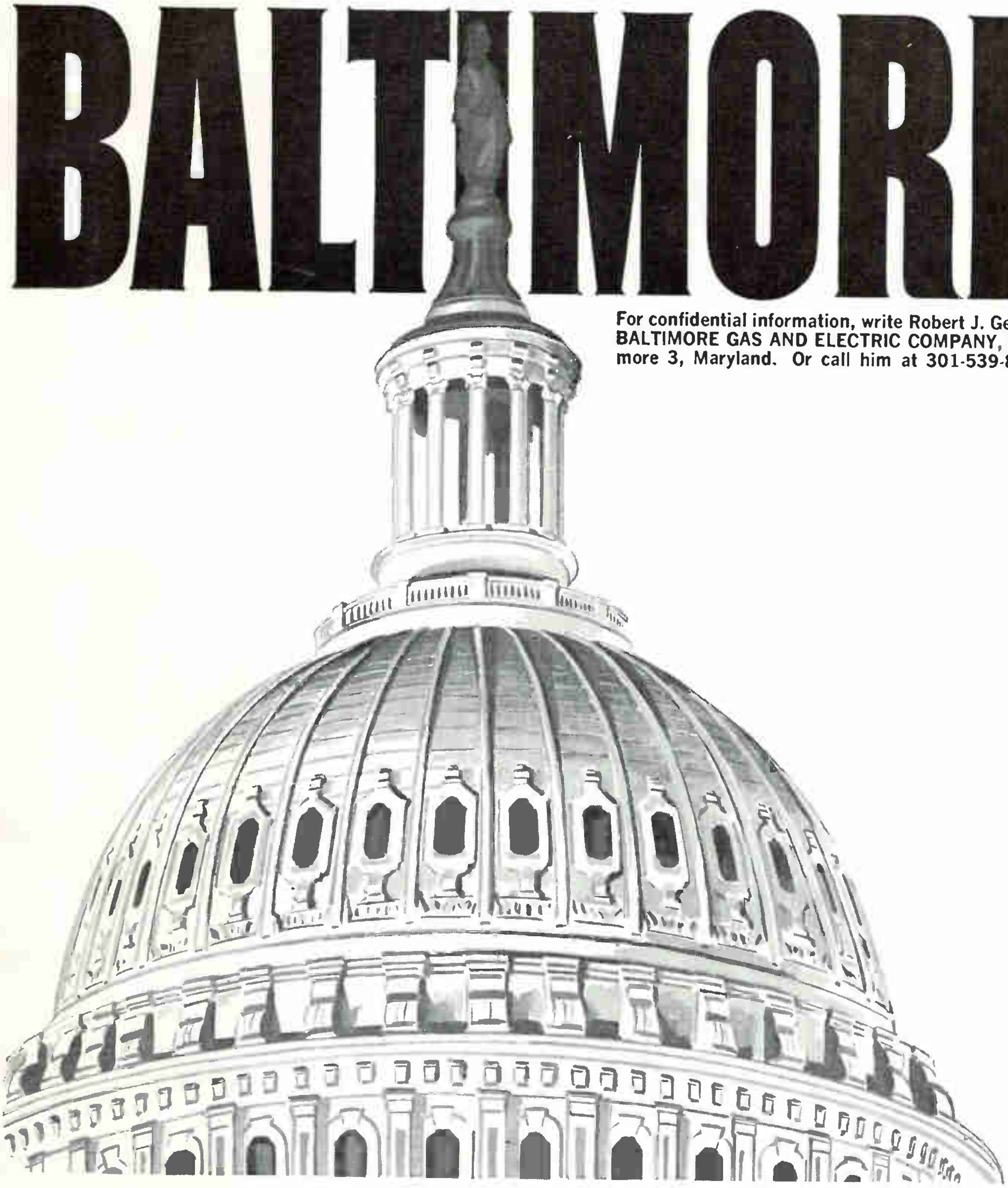
The more, the merrier. That's how Maryland feels about its many **kinds** of commerce and industry. 30,000 separate businesses . . . nearly 3,500 industrial establishments . . . products and services so varied that the region's economy never depends on one or two. Result: **stability** that encourages sound planning, steady growth, prosperity.

Baltimore and its neighboring counties make just about everything . . . adding up to over 80% of the major industrial categories in the U.S. census of manufacturers. They're suppliers of what you need, buyers of what you sell. And this bustling world-port location is closest to the rich markets of the Northeast, South and Midwest. When you really want to think **big**, think BALTIMORE.

## PUT YOUR PLANT IN

# BALTIMORE

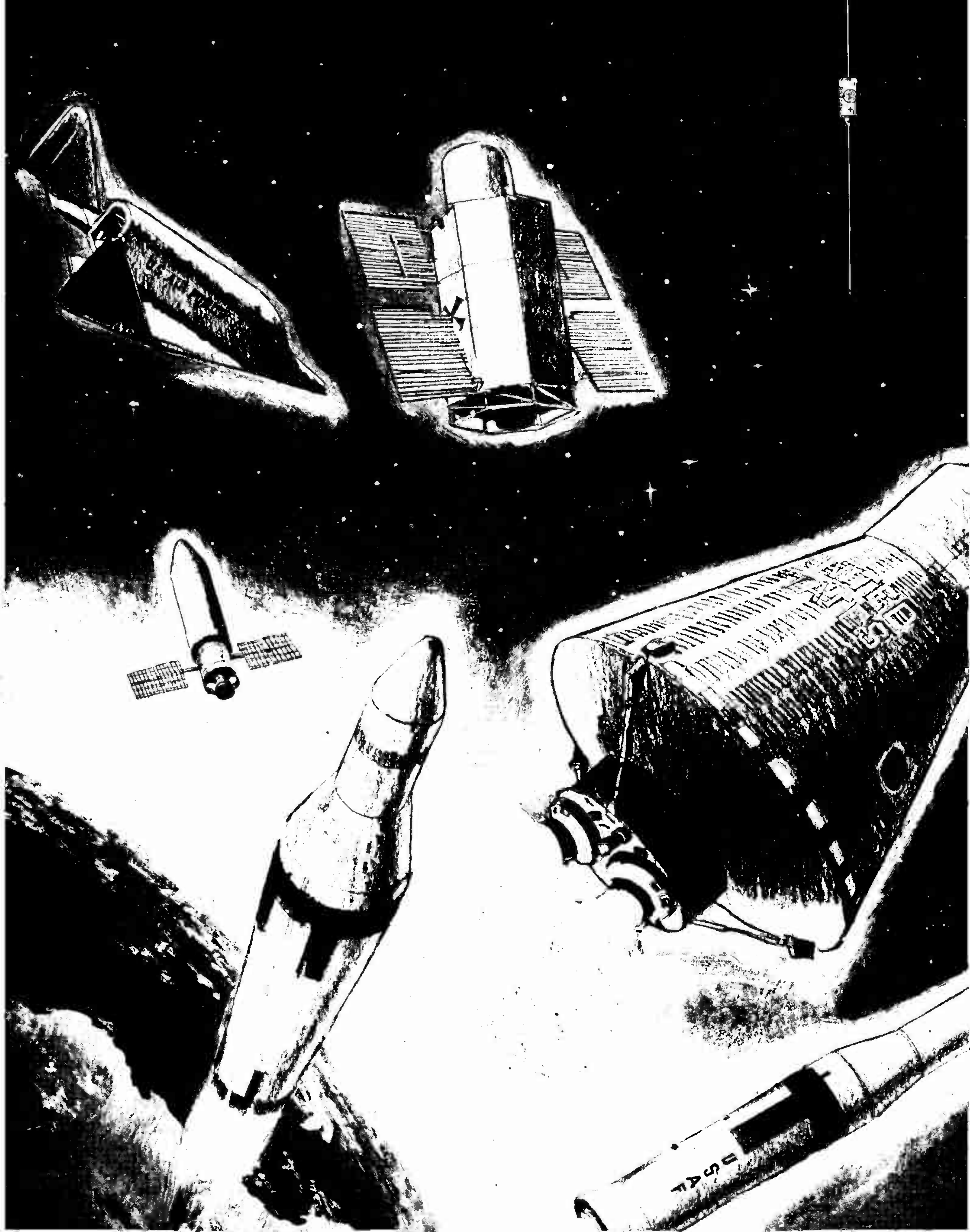
**For confidential information, write Robert J. George, BALTIMORE GAS AND ELECTRIC COMPANY, Baltimore 3, Maryland. Or call him at 301-539-8000.**



CIRCLE 13 ON READER SERVICE CARD

CIRCLE 14 ON READER SERVICE CARD→

# General Electric High Reliability solid or



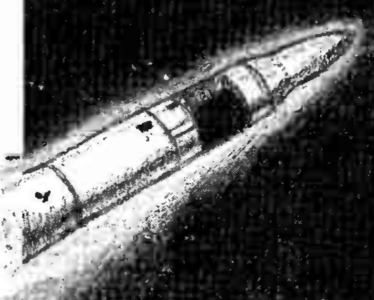

# foil | Tantalytic* capacitors qualified for:

## ATLAS-MERCURY
## MINUTEMAN
## NIMBUS
## OAO
## TITAN
## POLARIS
## DYNA-SOAR

# NEXT?

Your program can be the next to benefit from the unprecedented dependability of General Electric High Reliability solid and foil Tantalytic capacitors—products of a major breakthrough in capacitor reliability. What made the High Reliability line possible? A completely separate management group, a separate white room facility, and constant testing of capacitor designs (250,000 unit test hours weekly); then, in-process computer control of unit manufacture to assure adherence to test results. Now, our unit failure rate goal of .001% per thousand hours on foil has been achieved. Foil ratings available from 10V (.25uf) through 150V (300uf), 85C or 125C—solid ratings from 6V (.033uf) through 35V (120uf), all 85C. Join the seven programs which have already qualified these capacitors. Build General Electric High Reliability capacitor dependability into your present or future programs. See your G-E Sales Engineer, or write Section 430-09, General Electric Co., Schenectady 5, N.Y. *Capacitor Department, Irmo, South Carolina.*

*Reg. Trade-mark of General Electric Company.



*Progress Is Our Most Important Product*

**GENERAL ELECTRIC**

# NEW RCA MEMORY SYSTEM OPERATES FULL CYCLE IN 375 NANOSECONDS

## *Utilizes New Microferrite Arrays For Superior Performance At Lower Cost*

**RCA's new Microferrite memory system achieves ultra-high speed and high reliability in a compact, plug-in package. This new RCA memory system uses standard RCA Microferrite cores and advanced assembly techniques. Here are some of the outstanding advantages of this new, complete memory system:**

- **Broad Application**... Can be used for scratchpad or buffer memory applications ...available in capacity ranges from 32 to 1024 words, 1 to 72 bits.
- **High Efficiency**... At drive current levels below 350 ma the new RCA memory system delivers outputs to 50 mv per bit and has superior noise discrimination.
- **Inherent Reliability and Ruggedness**... Mechanized production techniques permit more precise control of each fabrication step...produce a rugged, high-reliability structure designed to meet military mechanical and environmental specifications.
- **Important Economy**... Use of Microferrite cores and mechanized production techniques keep Microferrite memory system prices lower than other systems of comparable speed.
- **Immediate Adaptability**... Standard components and circuits used in the new RCA Microferrite Memory System make it compatible with existing systems.
- **Plug-in Design**... Each stack, all associated circuitry and entire memory system are "plug-in-designed" for fast, easy installation—minimum down-time.
- **Quick Delivery**... RCA can deliver the standard Microferrite memory system in short delivery cycles.
- **Custom Systems**... RCA Memory Specialists are ready now to custom design systems of ½ usec or less to meet your requirements. Whatever your requirements, custom or RCA standard, your local RCA Semiconductor and Materials Division Field Representative is prepared to provide a completely coordinated application service for all RCA Computer Memory Products. Call him today at your nearby RCA Field Office.

For technical information on new RCA Microferrite Memory Products and Systems, write RCA Semiconductor and Materials Division, Commercial Engineering, Section **FN 11-5**, Somerville, N. J.

**RCA SEMICONDUCTOR & MATERIALS DIVISION FIELD OFFICES... EAST:** Newark, N. J., 744 Broad St., HU 5-3900 • (Camden-Philadelphia Area) Erlton, N. J., 605 Marlton Pike, HA 8-4802 • Syracuse, N. Y., 731 James St., Rm. 402, GR 4-5591 • Baltimore, Md., EN 9-1850 • **NORTHEAST:** Needham Heights 94, Mass., 64 "A" St., HI 4-7200 • **SOUTHEAST:** Orlando, Fla., 1520 Edgewater Dr., Suite #1, GA 4-4768 • **EAST CENTRAL:** Detroit 2, Mich., 714 New Center Bldg., TR 5-5600 • **CENTRAL:** Chicago, Ill., Suite 1154, Merchandise Mart Plaza, WH 4-2900 • Indianapolis 5, Ind., 2132 East 52nd St., CL 1-1405 • Minneapolis 16, Minn., 5805 Excelsior Blvd., WE 9-0676 • Denver 11, Colorado, Continental Terrace Bldg., Suite 301, 2785 N. Speer Blvd., 477-1688 • **WEST:** Los Angeles 22, Calif., 6801 E. Washington Blvd., RA 3-8361 • (San Francisco Area) Burlingame, Calif., 1838 El Camino Real, OX 7-1620 • Seattle 4, Wash., 2250 First Ave. S., MA 2-8816 • **SOUTHWEST:** Dallas 7, Texas, 7905 Carpenter Freeway, ME 1-9720 • **GOV'T:** Dayton, Ohio, 224 N. Wilkinson St., BA 6-2366 • Washington, D. C., 1725 "K" St., N.W., FE 7-8500 • **RCA INTERNATIONAL DIVISION,** 30 Rockefeller Plaza, New York 20, N. Y. Cable Address: RADIOINTER, N. Y.

RCA® **THE MOST TRUSTED NAME IN ELECTRONICS**

# MINUTEMAN TRIGGERS A PRODUCTION REVOLUTION

In 1960, our decision to produce 10 sophisticated types of Minuteman semiconductors on a regular production basis, on established production lines, triggered the intensive Transitron Total Reliability Program.

Because the production of these ultra-reliable devices — for North American Aviation's Autonetics Division — cut across the entire Transitron family of transistors, diodes, rectifiers and special products, the Program has resulted in a steep upgrading of the already high quality and reliability of every product we make.

To meet Minuteman's uncompromising demands, the Program was carefully developed through two extensive phases. First, we created an entirely new philosophy of manufacture and testing. Then, we developed the unique equipment and procedures that fulfilled this philosophy. From initial lot control at crystal formation to final intensive life and environmental tests, we imposed rigid in-process controls and checks upon ourselves.

Today, every Transitron customer enjoys the benefits of our extensive Total Reliability Program. Thorough product improvement documentation, continuous lot control, comprehensive failure analysis and complete visibility of change assure you of unmatched quality and dependability whether you order one or 10,000 Transitron semiconductors.

Today, more than ever before, wherever there's electronics — in medicine, industry, defense, business, space exploration — there's Transitron, continuing to lead the way toward greater semiconductor reliability.

For further information regarding the products and philosophy of Transitron's Total Reliability Program, write our Wakefield installation.

**Transitron** 1952 10 YEARS 1962

electronic corporation

wakefield, melrose, boston, mass.

SALES OFFICES IN PRINCIPAL CITIES THROUGHOUT THE U.S.A. AND EUROPE. CABLE ADDRESS: TRELCO

CIRCLE 17 ON READER SERVICE CARD

# LAND MOBILE RADIO Seeks End to

*EIA calls for more space, urges FCC to reevaluate allocations*

**FAST-GROWING SERVICE**

*In 1959, predictions were that land mobile radio services would have 1¼ million operational transmitters by the end of 1962, 2.4 million by 1967.*

*EIA now figures there will be 1.7 million transmitters by the end of this year and that the number will climb to 5 million by 1977—if there are enough channels.*

*In 1959, total bandwidth available for land mobile was 38 Mc. This provided 761 channels. Subsequent channel splitting expanded the possible number of channels to 1,376.*

*If the EIA request for an increase in total bandwidth to 40.8 Mc is granted, the number of possible split channels would increase to 2,576*

MOBILE RADIO USERS face a serious frequency congestion problem—a problem that will continue to grow unless the FCC does something about it, said an Electronic Industries Association spokesman during a recent visit to New York.

EIA is petitioning FCC to reallocate the frequencies now assigned to uhf-tv channels 14 and 15 (ELECTRONICS, p 7, Oct. 12) to land mobile services. This would be a move in the right direction, but overall spectrum-use reevaluation is the only long-range solution, said William Weisz, a Motorola vice-president, who heads EIA's Land Mobile Communications Section.

The problem, EIA feels, won't be solved by further technical sophistication. Weisz said that no other service has gone as far as land mobile in pushing the state of the art to get more users onto available channels.

Weisz added that the demand for space is so rapidly exceeding the supply that unless FCC acts quickly to ease the situation, land mobile will come to the end of the line.

CHANNEL SPLITTING—During the past 20 years, land mobile users have split the original 120-Kc channels to 60 Kc, then 30 Kc and even to 15 Kc in some cases.

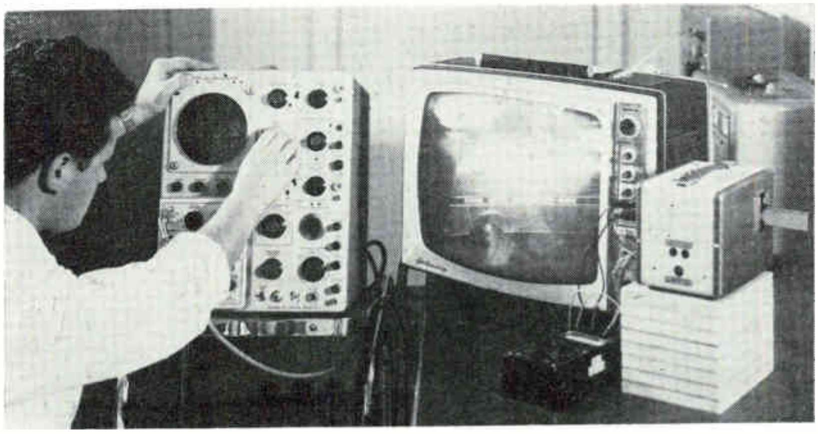
This has cost land mobile service users millions of dollars in equipment changeovers as well as substantially degraded service, Weisz said.

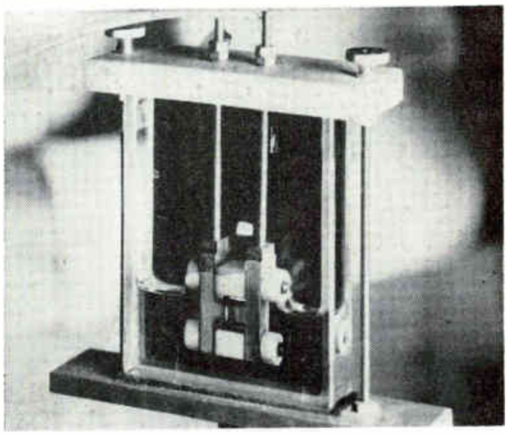
He expects the situation to get worse. The number of users has far outstripped the number anticipated when allocations were originally made and is increasing more rapidly than had been predicted even a few years ago.

Unlike public safety licensees, business users are promised no protection against interference by other users. A man who invests $500 and $800 per vehicle in radio equipment wants some assurance he can use it, Weisz pointed out. The businessman doesn't mind sharing a frequency with a few other users, but when he must share it with 20 or 30 other companies, each with as many as 15 or more mobile units, communications becomes unreliable and hardly justifies the expense, Weisz said.

EIA PETITION—There are several reasons why EIA is now requesting reallocation of channels 14 and 15. Among these are: There are now only a few stations in rural areas on these channels; these bands would provide immediate relief to land mobile services in areas

# Light Beam Transmits Television Signals





TV PICTURE AND AUDIO *signals are transmitted over a light beam at Grundig Research Labs, Bonn, Germany. Kerr cells polarize and split light from a mercury lamp into two components, then modulate brightness of the beam's components. Signals are received by multiplier phototube. Prototype's bandwidth is 100 Mc. Grundig expects development of commercial and space applications. Smaller photo shows modulator construction*

# Frequency Squeeze

of high population density; mobile equipment designed for use at 450 to 470 Mc is readily adaptable to use at uhf-tv's lower frequencies.

Weisz stressed that the reallocation would have to be made soon, before the introduction of all-channel tv sets in 1964.

BANDWIDTH NEEDS — Weisz said that EIA considers the minimum space requirements of the land mobile services to be a total of 40.8 Mc in three bands, instead of the total bandwidth of some 38 Mc now allocated.

Here's how he adds up the 40.8 Mc total:

- 4.8 Mc at frequencies below 100 Mc. These are considered best for rural or long-haul service. They have lower space attenuation, but are more susceptible to degradation by urban noise and interference.
- 18 Mc at frequencies between 100 and 300 Mc. These frequencies seem ideal for suburban use. Increased space attenuation is offset by reduced susceptibility to noise and increased tendency to reflect into difficult propagation areas.
- 18 Mc at frequencies above 300 Mc. These are well suited to urban use because they can penetrate buildings, are less susceptible to noise from neon signs, motors and other types of interference that bother lower frequencies.

# Why Aren't Sets Smaller?

*Microcircuits are available, but not outputs and display*

By LESLIE SOLOMON
Associate Editor

TORONTO — Consumer electronic products will have to wait for the development of microminiature display and output devices, and smaller, longer-lived portable power sources, before they can take full advantage of microelectronics.

That was how a majority of a six-man panel at the 1962 Radio Fall Meeting sized up the future role of microelectronics in consumer sets.

SIZE LIMITERS—Such items as loudspeakers, batteries, tuning and volume control devices at present limit physical size of radio receivers and audio equipment, the panelists agreed. In television sets, cathode-ray tubes, deflection transformers, yokes and power supplies take up most space and weight.

Even when miniature power consuming items are used, they present a serious heat problem if too densely packed. Although miniature tv sets are on the market now, they do not use microelectronics but skillfully packaged printed circuits.

One panelist thought that some manufacturers are holding back because only a few companies have the facilities to make microelectronic units. There are fears that some competitive advantage will be lost because the same subsystem would be available to all manufacturers and that manufacturers will be dependent on few suppliers.

With the introduction of microelectronic subsystems, radical changes may be needed in production techniques. Some circuit designers will have to be reeducated to using microelectronics.

All agreed, however, that the future is definitely towards increased use of microelectronics, that future consumer devices will be smaller and lighter.

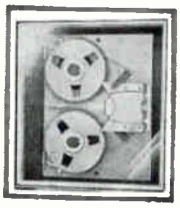
The six man panel consisted of Norman Parker, of Motorola, Edward White, of Warwick, and B. Miller of Zenith, representing set manufacturers, and Leo Lehner, of Motorola, Robert Cohen, of RCA, and E. A. Sack, of Westinghouse, representing device makers.


"Nothing is impossible to diligence and skill"
Samuel Johnson

These are the trademarks of some of our customers—each an important contributor to a dramatically growing industry. We at Potter pledge our diligence and skills to this growth through a constantly expanding program of research and development.

POTTER

M906 II Tape Transport couples high-performance and reliability . . .



with the lowest price in the industry. The unique design of this versatile transport provides compatibility for a variety of applications in digital data processing and computer systems.

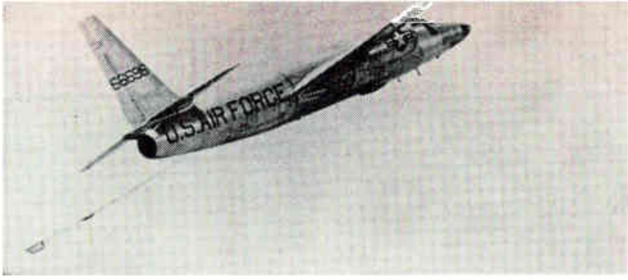
Five tape widths up to 1¼" may be accommodated at speeds up to 120 IPS. In addition, data transfer rates of 62,500 BCD digits per second are readily obtained using conventional recording techniques. When used in high-density recording applications, transfer rates of over 450,000 BCD digits per second with drop-outs fewer than 1 bit in 100,000,000 are provided.

*Complete specifications for this highly reliable system are available on request.*

*Manufacturers of:*
- Digital Magnetic Tape Systems
- Perforated Tape Readers
- High Speed Printers
- Data Storage Systems

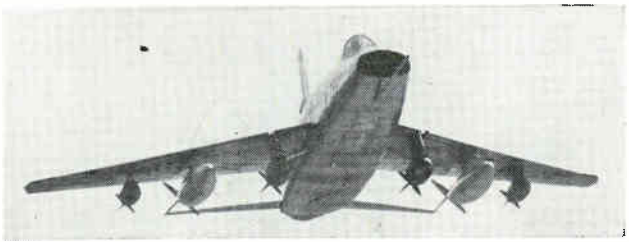
POTTER INSTRUMENT CO., INC.
*Sunnyside Boulevard • Plainview, New York*

NAVY'S F4H *Phantom II is equipped with electronic detection gear, an all-altitude bombing system, and once set a speed record (1,390.31 mph) for the tight, circular 100 Km closed course*



U-2 PICKS *up and records radio signals, photographs with visual light and infrared techniques. These high-flying, unprotected planes did first recon work over Cuba*

F-105 *carries bombs, napalm, or the accurate and reliable Bullpup missile*



F100C-6 *Super Sabre flies at 1,000 mph, and is seen carrying six bombs*

BULLPUP *arms USAF's F-105 and several Navy planes*

# Electronically-Controlled Cameras

*With hopes for on-site inspection fading, recon planes are vital*

By JOHN F. MASON
Senior Associate Editor

THE VALUABLE ROLE that remote reconnaissance played in uncovering the Soviet missile plot in the Caribbean will play an equally important role for some time to come. The stalemate on arrangements for on-site inspection appears to be hardening, rather than easing up.

Khrushchev's "word" is being accepted, while the mounting reports by Cuban refugees of missiles and aircraft hidden in caves are being ignored—at least, officially.

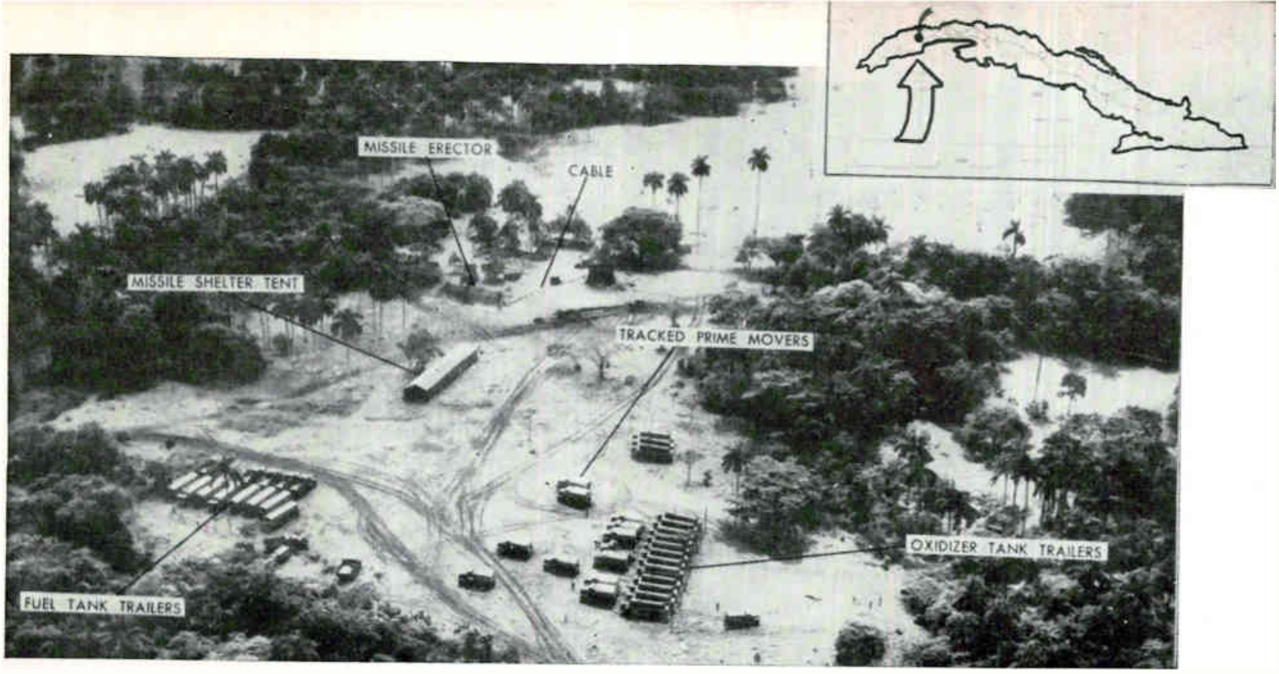
To protect the security of the Western hemisphere against these unpropitious conditions, reconnaissance by every means at our disposal will continue. The U. S. capability for this operation is excellent. Our capability for knocking out concealed sites, if this should ever become necessary, is just as good.

RECONNAISSANCE—First knowledge of missiles in Cuba may have come from detection of electromagnetic radiation from missile support equipment. This clue might well have preceded visual proof obtained by aerial photographs. While the actual sequence of events will probably never be revealed, the tools available are well known.

The U-2's ferreting gear could have picked up test signals from Soviet antiaircraft radar before flights over the island began. This would have tipped off the fact that something more important than sugar cane was being protected. Missile site communications could also have been recorded. These signals could have been received by U-2, ground receivers at Guantanamo, Navy ships and planes, or even by sensitive receivers in Florida.

After the fatal downing of the American U-2 on Oct. 27 and Castro's threat to shoot down further reconnaissance planes, the Defense Department announced openly that surveillance would continue. The high-flying, unprotected U-2 flights directly over Cuba were abandoned, and low-flying supersonic photo-reconnaissance planes were put into service.

One plane that is probably being used is the RF-101 Voodoo—the Tactical Air Command's top-ranking photo reconnaissance plane. The Voodoo, built by McDonnell, can fly at 50,000 ft or just above the trees. It can fly at twice the speed of sound, and is equipped with six electronically-controlled cameras. It once flew from Los Angeles to New York in 3 hours, 7 minutes, photographing a 16-mile-wide strip across the U.S. One KA-2 camera (12″ focal length) is in the forward position, three KA-2 (6″ focal length) cameras are in tri-camera stations, and two KA-1 (36″ focal




THIS SOVIET *missile site in Cuba was photographed by low-flying photo-recon plane. Pictures taken by obliquely-positioned cameras can be processed to show vertical perspective if desired*

RF-101A *Voodoo carries 6 electronically controlled cameras, can appear and disappear at tree top level before radar or troops know what has happened*


# Watch Cuba

length) cameras are positioned aft vertical. At night, flare ejectors are carried, and the tri-camera station is equipped with three K-46 (7″ focal length) cameras.

Cameras for the RF-101 were built by Fairchild Camera and Instrument. USAF's Aeronautical Systems div. designed and assembled the camera's electronic controls. Component suppliers were Bill Jack Co., Chicago Aerial Industries and DuMont Labs div. of Fairchild.

The Voodoo recon plane probably takes off from Florida and skims over the white caps of the Florida straits. It is blanketed from Cuban-based radar by the horizon, and blends into the water on airborne radar scopes. On reaching the Cuban coast, the Voodoo might climb to 300 feet. A combination viewfinder provides the pilot with a clear view of the terrain below and ahead of the aircraft. Using cockpit controls, the pilot feeds basic instructions into the camera system. The photo procedure then becomes completely automatic.

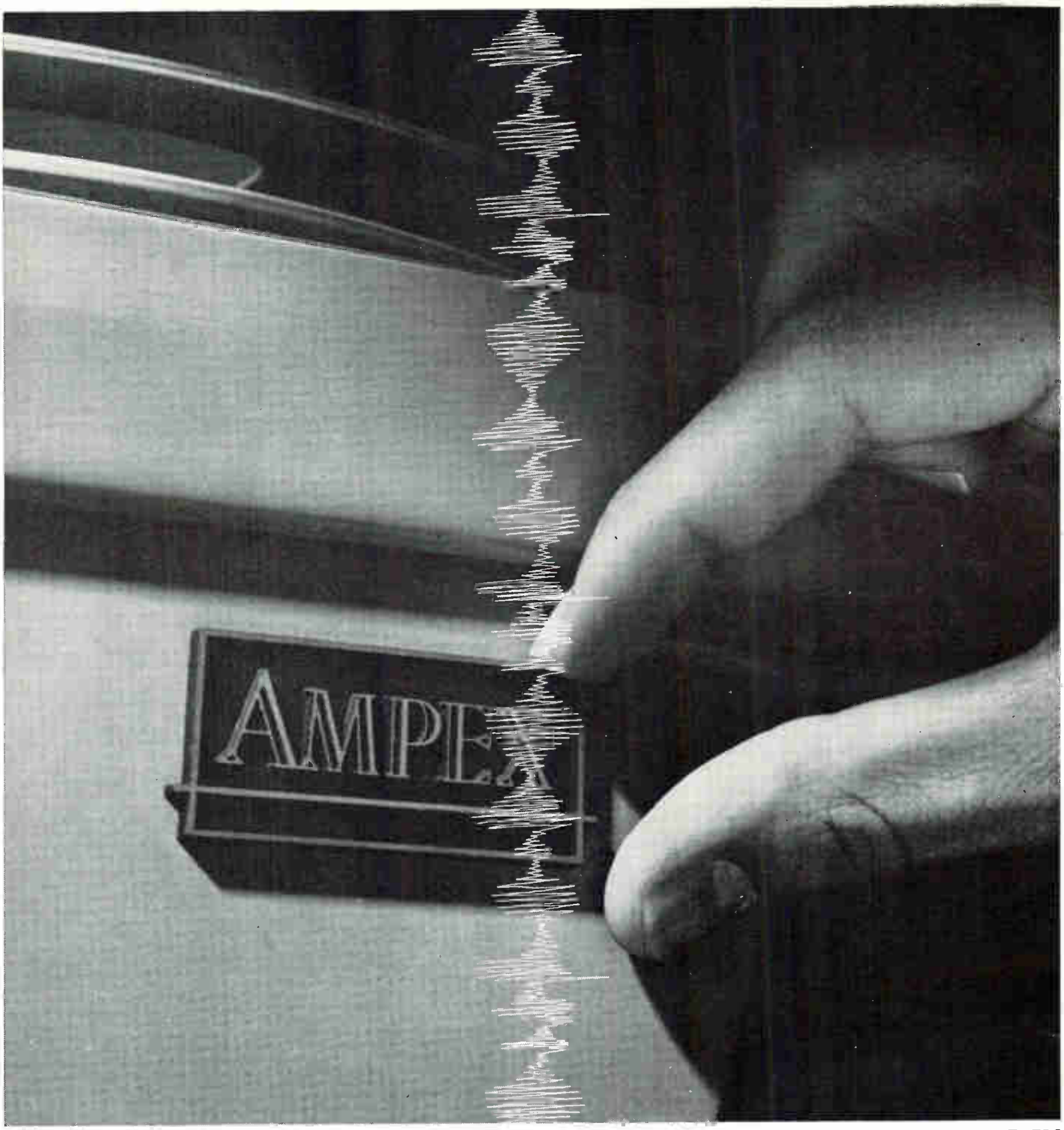
Flying at 850 knots, the Voodoo can cover a 12-mile stretch in 51 seconds; his six cameras recording the entire strip. He is relatively immune from enemy fire. Manual artillery would be useless, and radar has hardly had time to detect him before he has gone.

Similar procedures can be used by carrier-based Navy planes. The F8U-1P Crusader is a photo-recon plane (Ling-Temco-Vought) probably used. The F8U-1P Crusader (now designated RF-8A) is one of Navy's mainstays for photo-recon work. The A3D-2P Skywarrior (RA-3B) is another.

IF FORCE IS NEEDED—Striking capability, if that should be called upon, is swift and efficient. The northern most base in Florida is Jacksonville, 240 miles from Cuba. A fighter version of Voodoo, the F-101, flying at 850 knots, could reach its target in 17 minutes. The Tactical Air Command has other bases in Florida, southern Georgia and Alabama. Besides the Voodoo, there are F-101s and F-105s ready to go. All three can carry conventional bombs—these can be dropped from 300 ft altitude if time delays are used; and napalm—low altitude again is no problem, since the plane gets away before the conflagration begins. The F-105 can carry the very reliable Bullpup air-to-ground missile. This moves out from the plane so fast that the damage is done before the plane gets to the target.

The Navy has an impressive inventory of carrier-based planes that could swoop into Cuba, knock out a few carefully camouflaged missiles the Soviets somehow hadn't noticed, and be back on their carrier in minutes. The A3D Skywarrior series, the A4D, the AD-5 (A1E), A3J (A5A), F4H, F8U-2N (F8D).

These planes carry HVAR rockets and Bullpup guided missiles.




**What name is on the first 1.5 Mc recorder?**

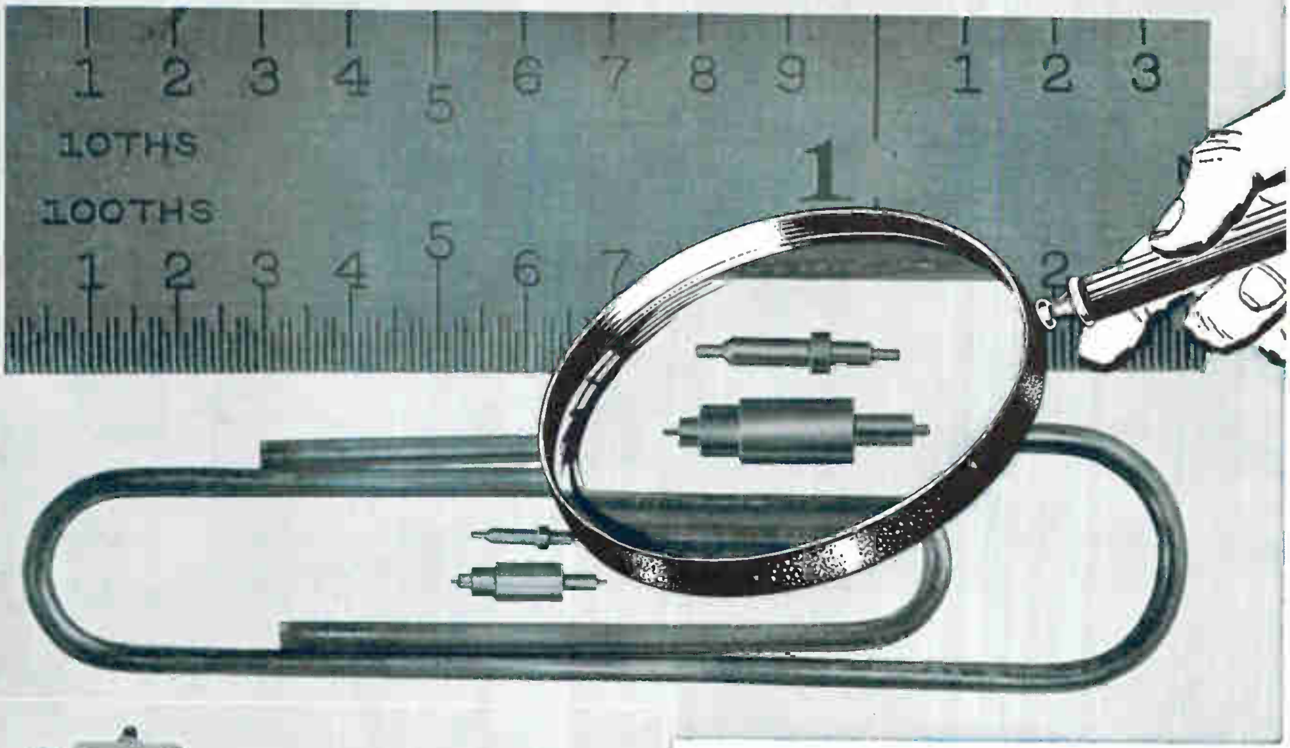
**AMPEX**

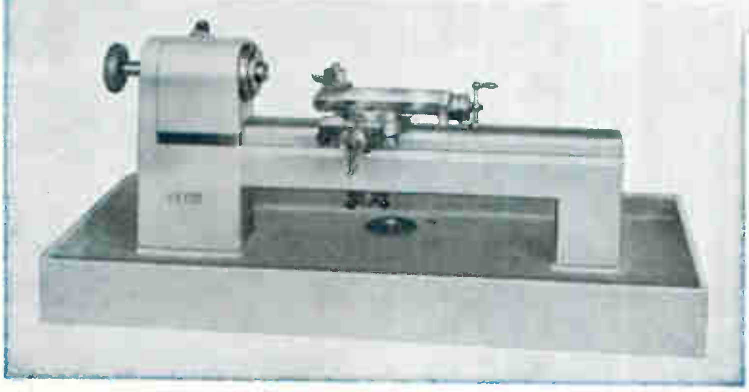
Here it is: a 1.5 Mc per track, multi-track recorder! And Ampex is the first to have it. It's called the FR-1400. It will give you the broadest bandwidth yet in longitudinal recording. What's more, it utilizes solid state electronics throughout—all in one rack. It has four speeds, each electrically switchable with no adjustments needed. And it comes with tape search and shuttle to provide quick data location and permit any portion of the tape to run repeatedly without operator attention. What about per-

formance? Outstanding! It offers better rise time and minimum ringing on square waves, low intermodulation distortion, and improved flutter. Ampex also brings you a new 1.5 Mc tape. In both you'll find the same engineering precision, the same superior quality, that has made Ampex first in the field of magnetic recording. Write the only company providing recorders and tape for every application: Ampex Corp., 934 Charter St., Redwood City, Calif. Worldwide sales and service.

AMPEX

# MICRO-MACHINED PARTS MADE BETTER



*LEVIN* instrument lathes are specifically designed for the production of small parts. Due to their high degree of precision, these lathes easily operate in the microrange of measurements on size, concentricity, and finish.

Larger and more costly lathes can often be relieved of the burden of microrange production with the installation of the proper *LEVIN* lathe. In addition, the speed and ease of operation of *LEVIN* instrument lathes generally surpasses that attainable on larger machines. With 41 standard models to select from, there is a proper *LEVIN* lathe for your application. Available in 3/16″, 5/16″, and 1/2″ collect capacities.

**SEND FOR COMPLETE CATALOG**

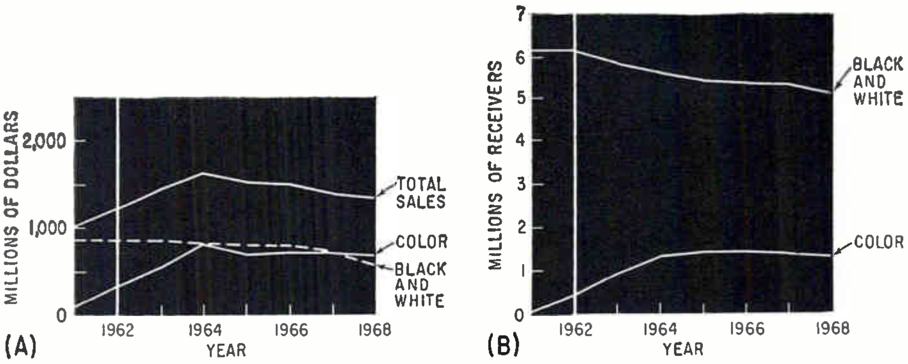
# LEVIN® INSTRUMENT LATHES

**LOUIS LEVIN & SON, INC.**
3573 Hayden Ave., Culver City, California

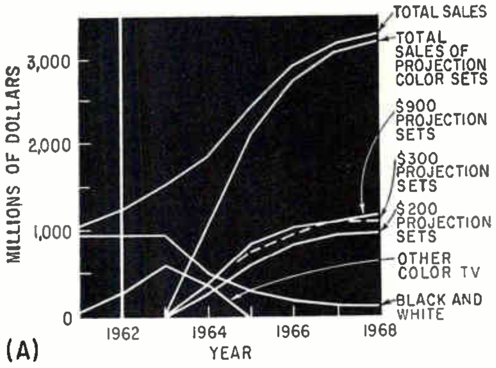
New York Representative and Showroom
**RUSSELL-HOLBROOK & HENDERSON, INC.**
292 Madison Ave., New York 17, N.Y.



CIRCLE 23 ON READER SERVICE CARD




CONVENTIONAL *black-and-white and color-tv set sales are said to face declines in both annual dollar volume (A) and in unit sales (B)*




SALES FORECAST *by Harries based on $300 and $900: (A) is prediction of annual*

# Will New Projection System Sharply Boost

*Developer claims it will increase not only sales, but profits too*

MASS PRODUCTION of his new projection-type color television sets would result in a sharp upturn in tv set sales in the U. S. and provide manufacturers with higher profit margins, says J. H. Owen Harries, president of Harries Electronics Corp. Ltd., Bermuda.

Projection color sets, he thinks, could push total set sales beyond the $3-billion mark by 1968. The increase in sales—a net rise of almost $2 billion over 1962 sales—would be accomplished despite a decline in conventional color and black-and-white set sales.

Harries predicts that without a spur to sales, such as the new system would provide, manufacturers of black-and-white sets will soon be faced with shrinking sales and profit margins. He also expects that sales of conventional color sets would soon reach the saturation point, after which their profit margins would also decline.

SALES PREDICTIONS—The accompanying graphs show the size and shape of the television market as Harries sees it.

The first set of graphs is his prediction if there is early production of projection color-tv sets in three price classes, $200, $300 and $900. The second set of graphs is how the market will look, according to Harries, if only conventional color and black-and-white sets are made.

The first graphs assume that the new type of receiver will replace 75 percent of the existing black-and-white sets in five years.

PROFIT MARGINS—The introduction of projection color-tv sets in several price ranges would make tv manufacturing more profitable, according to Harries.

Most black-and-white sets now sell at an average price of $160 and profit margins are low, he says. The reason that profits are low, he contends, is that purchasers tend to buy the cheapest set.

Buyers are aware, he says, that the difference in cost between a manufacturer's low-priced set and more expensive models is primarily cabinetry, not picture quality.

Profit on color-tv sets is good now, with set cost averaging around $600, he says. But he predicts that the market for such sets will become saturated in a few years, after which profit margins will also decline.

PRICE SCALES—The way to get better profit margins is to scale price to performance as the auto industry does, Harries believes.

This can be achieved by the projection system, he says, since value can be improved by increasing the number of picture tubes in a set. He proposes three price ranges as a starter:

- $200—an economy color receiver with three picture tubes, a 19-inch screen and picture luminance of 25 foot-lamberts.
- $300—four picture tubes, 23-inch picture and luminance of 60 to 70 foot-lamberts.
- $900—five picture tubes, 33-

---

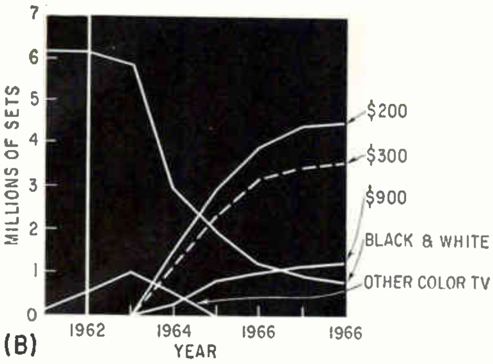
### LOW-COST SYSTEM

In its issue of December 14 ELECTRONICS will publish technical details on Harries' projection color-tv receiver.

As reported last week (p 7, Nov. 23), the new system is compatible with NTSC transmission, uses low-cost, molded-plastic optical elements and provides a bright picture.

Small picture tubes used in the system can be made on compact, high-speed, rotary machines, Harries says. Because the tubes will be inexpensive, extra tubes can be used to make the picture still brighter

---




*production of projection sets costing $200, dollar volume and (B) is unit sales*

# Color-Tv Sales?

inch screen and luminance of 60 to 70 foot-lamberts, or a 23-inch screen and luminance of 120 foot-lamberts.

The difference in performance of three such sets would be immediately obvious in a dealer's showroom, he adds, providing the purchaser with an incentive to buy the higher-priced set.

## Aircraft Inertial System Gets Radar Map Display

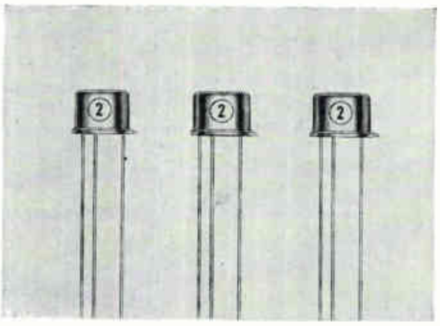
GENERAL DYNAMICS reports delivery of the first of the radars being built for Autonetics' radar-equipped inertial navigation system. The system is being produced for the Navy's A3J attack bomber.

The radar displays a pitch and roll-stabilized ground map, provides navigational fixes and, on bombing runs, target coordinates. Antenna tilt can be controlled to spotlight targets and provide uniform illumination from any altitude. Slant range information is obtained by manually positioning a range cursor over a selected target. Then the range cursor automatically tracks the target.

General Dynamics / Electronics has so far received an estimated $27 million in contracts for the radar and its development.

ADVERTISEMENT

## Wide Selection of Silicon Chopper Transistors Now Available in Production Quantities



High speed Silicon Precision Alloy Transistors specifically designed for use as low-level choppers and developed by the Sprague Electric Company are now available in a broad range of types and performance characteristics.

Sprague Silicon Chopper Transistor specifications have been tailored to meet specific circuit requirements. Superior in performance to ordinary alloy devices, they offer low offset voltage, low dynamic resistance, low output capacitance, low $I_{CBO}$, and high frequency response. The wide selection of types includes a variety of matched pairs.

| | |
|---|---|
| 2N2162<br>2N2165 | Guaranteed 30 volt rating. Typical $f_T$ of 20 Mc and low offset voltage make these transistors ideal where high voltage is required |
| 2N2163<br>2N2166 | Have 15 volt rating and same high frequency performance and low offset voltage as 2N2162 |
| 2N2164<br>2N2167 | Highest frequency P-N-P Silicon Choppers available as standard types |
| 2N2185 | Extremely low leakage current of 1 nanoampere at 10 volts. Has 30 volt rating |
| 2N2274 | Similar to 2N2185 but has lower inverted dynamic saturation resistance |
| 2N2276 | Low-cost version of 2N2274 |
| 2N2278 | Very low offset voltage of 1.75 mV at $I_B =$ 1 mA |
| 2N2187 | Matched pair of 2N2185 with $\Delta V_{OFF} =$ 50μV max. from +25 C to +85 C |
| 2N2275 | Matched pair of 2N2274 with $\Delta V_{OFF} =$ 100μV max. from +25 C to +65 C |
| 2N2277 | Matched pair of 2N2276 with $\Delta V_{OFF} =$ 100μV max. from +25 C to +65 C |
| 2N2279 | Matched pair of 2N2278 with $\Delta V_{OFF} =$ 50μV max. from +25 C to +85 C |

These transistors are inherently stable. Every Sprague Chopper undergoes a rigid production conditioning of 40 temperature cycles from −55 C to +140 C, a 200 hour bake at +140 C, and a two hour 125 mW operational burn-in!

For application engineering assistance without obligation, write Product Marketing Section, Transistor Division, Sprague Electric Company, Concord, New Hampshire. For complete technical data write Technical Literature Service, Sprague Electric Company, 35 Marshall Street, North Adams, Massachusetts.

4S-469

CIRCLE 200 ON READER SERVICE CARD

## CYLINDRICAL INTERFERENCE FILTERS

## the Smallest, Lightest, Most Efficient Designs Available!

- **Basic cylindrical design follows natural shape of rolled capacitor sections and toroidal inductors.**
- **Threaded-neck bulkhead mountings assure proper isolation between input and output terminals as well as firm peripheral mounting with minimum impedance to ground.**
- **Popular low pass design, intended for use as 3-terminal networks connected in series with circuits to be filtered.**
- **Excellent interference attenuation characteristics reflect the use of Thrupass® capacitor sections.**
- **Designs to meet the requirements of Military Specifications MIL-I-6181, MIL-I-26600, MIL-I-16910, and MIL-I-11748.**

**For additional information, write for Engineering Bulletin 8100A to Technical Literature Service, Sprague Electric Company, 35 Marshall St., North Adams, Massachusetts.**

**SPRAGUE®**
**THE MARK OF RELIABILITY**

4S-468

CIRCLE 25 ON READER SERVICE CARD

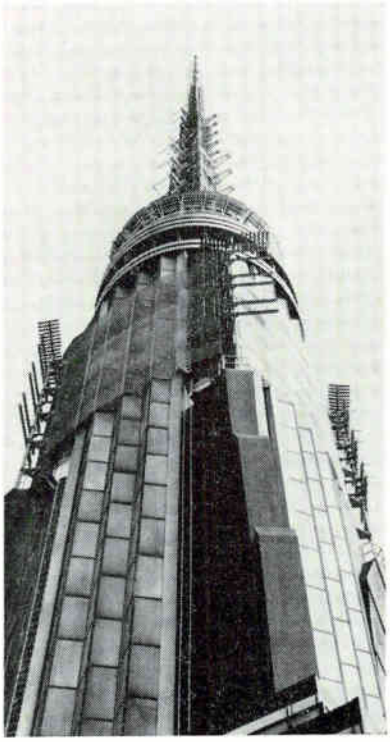
# UHF Tv Gets Set for Boom

*FCC tests show uhf tv has no major technical problems*

By GEORGE J. FLYNN
Associate Editor

WITH OPERATING TESTS favorable in New York City, and with all-channel sets required by law beginning April 30, 1964, the fuse is set and lighted for the expected boom in uhf tv. Applications for station licenses started to increase even before the FCC's report was released (ELECTRONICS, p 12, Nov. 9, and p 10, Nov. 23).

TEST RESULTS—The New York City tests were designed to test actual receiver operation in what is regarded as one of the worst uhf locations. Manhattan's tall buildings and concrete canyons cause reflections and shielding that lead to ghosting and loss of picture. The premise was that if uhf works in NYC it will work anywhere.



TRANSMITTING *antennas atop Empire State Building*

Standardized receiving sets were installed at 768 locations within 25 miles of the transmitting antenna on the Empire State Building.

Approximately 10 percent of the locations showed better reception of vhf than uhf when only indoor antennas were used. When outdoor antennas were installed at sites with inferior reception, vhf was still better than uhf but only at one or two percent of the sites. Inferior reception of uhf with indoor antennas was blamed primarily on poorer penetration of uhf signals.

In general, if vhf reception is good, so is uhf reception.

ANTENNAS—When outdoor antennas were found necessary, simple types were generally adequate.

In Manhattan itself, and within four miles of the transmitter, 56.8 percent of the sites had satisfactory uhf reception with inside antennas, while 60 percent of the sites received vhf adequately. When outside antennas were used, uhf reception was satisfactory at 94.6 percent of the sites and vhf was satisfactory at 93.6 percent.

Channels 2 and 7 were used to compare 31 for black and white and channel 4 used for color.

Viewers of the test installations did not always understand the purposes of the tests and often confused picture quality with program quality. Trained observers (Jerrold Electronics installation crews) also checked on picture quality.

UHF PROSPECTS—Uhf receivers are still not considered quite as good as vhf receivers. What uhf most needs now is a cheap, low-noise diode mixer or converter, say industry sources. Also, the r-f tube circuits in vhf receivers have better noise performance than similar uhf circuits.

Uhf requires 10 to 20 times as much transmitting power as vhf to give the same reception. Installation and operating costs will be higher.

There are now slightly more than 100 uhf stations in the U. S. Another 1,500 to 2,000 may be activated eventually.

where x = RELIABILITY

Though the missions were different, the Mercury Capsule and Telstar traveled some of the same "roads." There's something else alike in these vehicles — the electrical wire.

An essential property of an insulated wire is as much its performance during the process of installation as its reliability in use. If stripping, potting or marking become a problem, so may ultimate reliability.

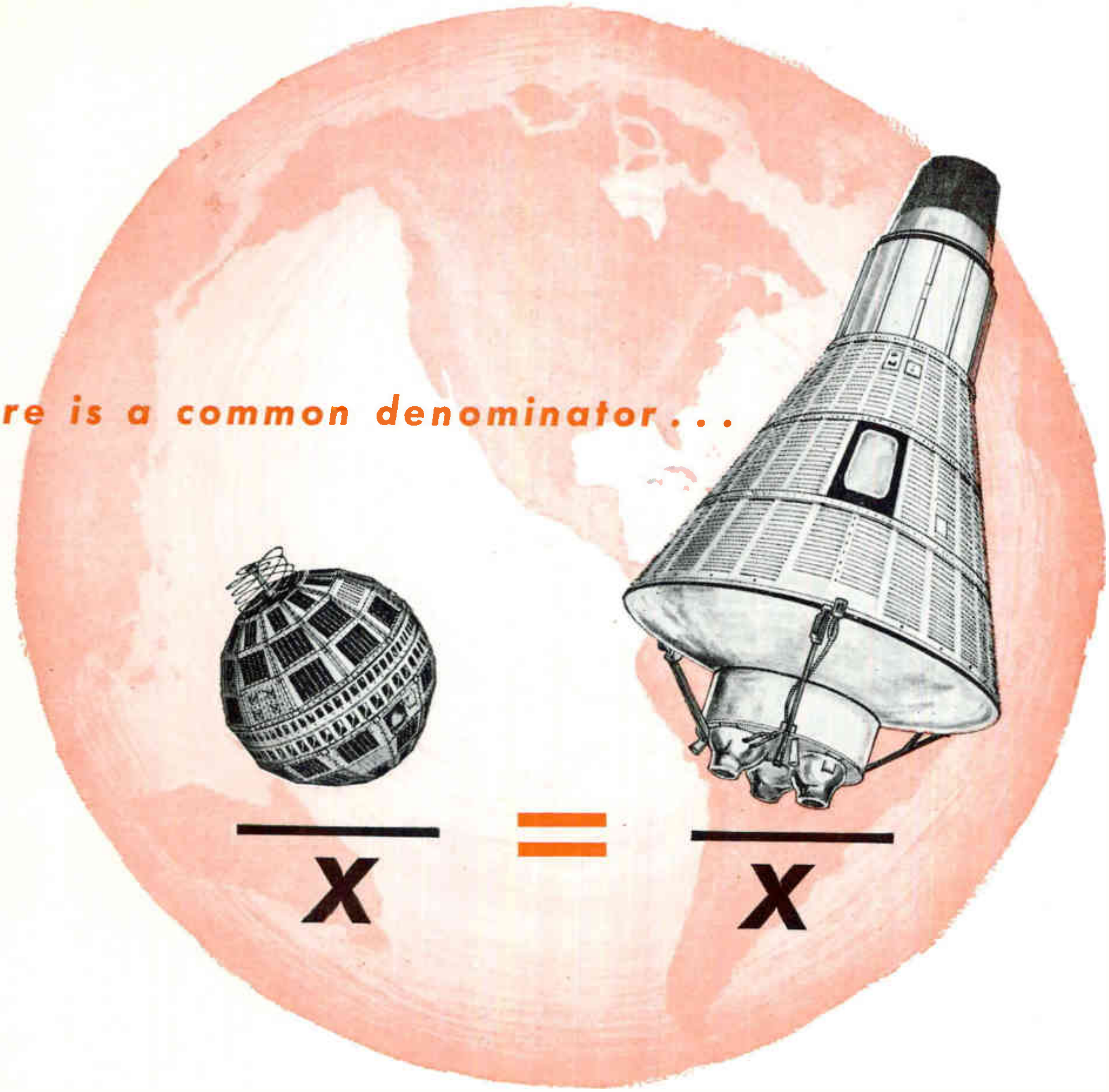
Raychem Corporation irradiated modified polyolefin insulated products are non-melting and therefore have excellent resistance to solder iron cut-through. They are easily potted with commonly used elastomeric or rigid sealants with no prior surface etching. Printing is accomplished as routinely as with the common vinyls or nylon.

These characteristics can be an important advantage in your use of high temperature wire and cable products.

RAYCHEM
CORPORATION
REDWOOD CITY, CALIFORNIA

CIRCLE 27 ON READER SERVICE CARD

there is a common denominator . . .




## where X = reliability

Though Telstar and Mercury differ in function, they have a common denominator. The reliability and performance in vacuum and space of RAYCHEM wire and cable was vital in their success.

**LEADER IN RADIATION CHEMISTRY FOR ELECTRONIC WIRE AND CABLE**

RAYCHEM® CORPORATION



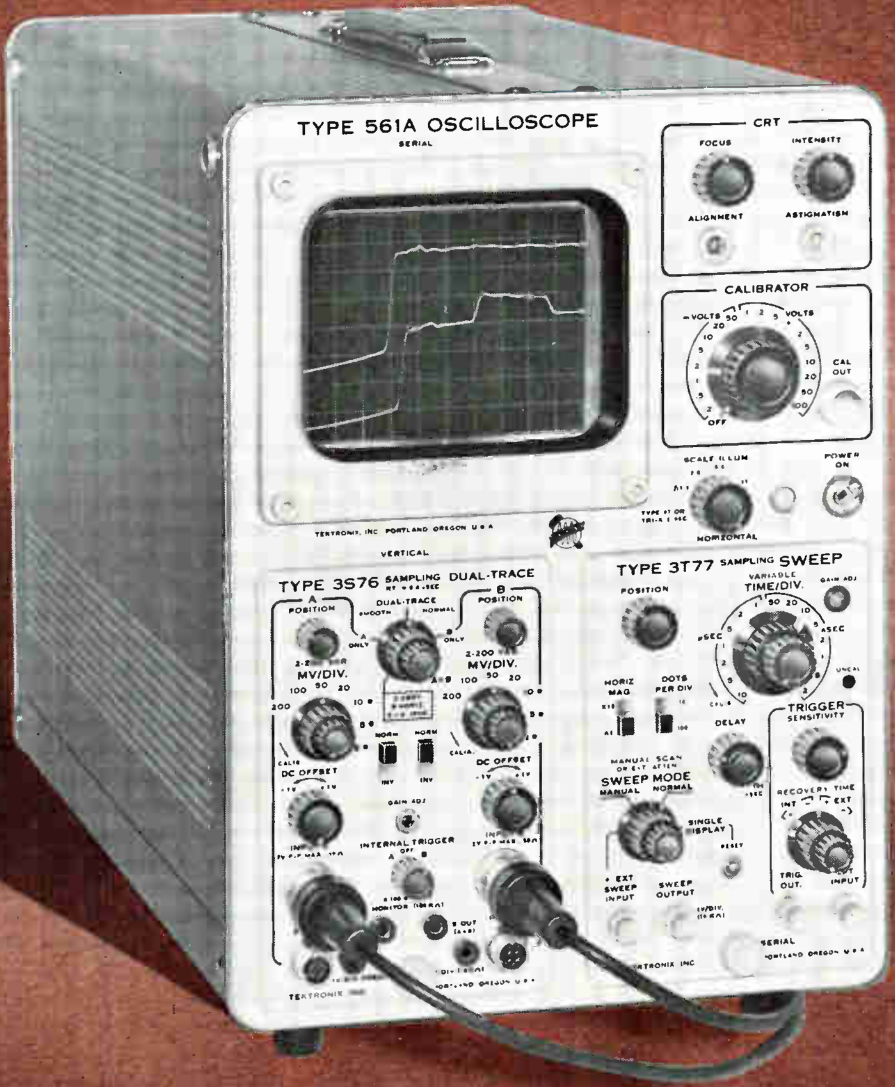
CIRCLE 27 ON READER SERVICE CARD

# New Value Package

## *Sampling sweep and sampling dual-trace plug-in units*

**WITH THE TEKTRONIX TYPE 561A OSCILLOSCOPE**

- *illuminated internal graticule*
- *rectangular ceramic crt*



Tektronix Type 561A Oscilloscope

# *This new low-drift sampling system is as easy to operate as a conventional oscilloscope—but with sensitivity and bandwidth possible only through sampling.*

## HERE'S WHAT YOU CAN DO WITH THIS SAMPLING SYSTEM:

**1** Measure millivolt wide-band signals with either 0.4-nsec risetime sampling channel. Time-measurement range extends to 100 microseconds.

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

**3** Display repetitive signals on 15 calibrated equivalent sweep rates from 0.2 nsec/cm to 10 μsec/cm, accurate within 3%. Magnifier provides 10X sweep expansion . . . time per dot remains the same for digital readout (with auxiliary equipment).

**4** Measure millivolt signals in the presence of a ±1-volt dc component by means of a dc-offset voltage, monitorable at the front panel.

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

**6** Show X-Y (lissajous) patterns, observe single or dual-trace displays, add signals algebraically.

**7** Change the signal-source impedance without affecting the dot transient response.

**8** Vary sweep delay through 100 nanoseconds.

**9** Drive X-Y plotters or similar readout accessories.

**10** Select calibrated vertical sensitivities from 2 to 200 mv/div.

**11** Choose signal probes for higher input impedances, various attenuations.

### WIDE OPERATING VERSATILITY, AVAILABLE THROUGH OTHER 2-SERIES AND 3-SERIES PLUG-INS

| AMPLIFIER UNITS TYPE | PASSBAND (3-db down) | SENSITIVITY | PRICE |
|---|---|---|---|
| 2A60 | dc—1 Mc. | 50 mv/cm—50 v/cm 4 decade steps with variable control. | $105 |
| 2A63—Differential (50:1 rejection ratio) | dc—300 kc. | 1 mv/cm—20 v/cm 1-2-5 sequence with variable control. | $130 |
| 3A72—Dual Trace (Identical Channels) | dc—650 kc. (each channel). | 10 mv/cm—20 v/cm, 1-2-5 sequence, with variable control. | $250 |
| 3A74—Four Trace (Identical Channels) | dc—2 Mc (each channel). | 20 mv/cm—10 v/cm, 1-2-5 sequence, with variable control. | $550 |
| 3A75—Wide Band | dc—4 Mc. | 50 mv/cm—20 v/cm, 1-2-5 sequence, with variable control. | $175 |
| 3A1—Dual-Trace (Identical Channels) | dc—10 Mc. (each channel). | 10 mv/cm—10 v/cm 1-2-5 sequence with variable control. | $410 |

| TIME-BASE UNITS TYPE | SWEEP FEATURES | TRIGGERING | PRICE |
|---|---|---|---|
| 2B67 | 1 μsec/cm to 5 sec/cm, 1-2-5 sequence, variable between rates. 5X Magnifier. Single Sweep. | Internal, External, Line; Amplitude-Level Selection; AC or DC-Coupling; Automatic or Free-Run; ± Slope. | $175 |
| 3B1 | Normal and Delayed Sweeps—0.5 μsec/cm to 1 sec/cm, 1-2-5 sequence 18 calibrated delay settings, 0.5 μsec to 10 sec, variable between rates uncalibrated. | Internal or External; AC or DC Coupling; Automatic; ± Slope Same features for Normal and Delayed Sweep Modes, except automatic. | $475 |
| 3B3 | Normal and Delayed Sweeps—0.5 μsec/cm to 1 sec/cm, 1-2-5 sequence. Continuously variable calibrated delay from 0.5 μsec to 10 sec. Single Sweep for main sweep. | Internal or External; Line; AC or DC-Coupling; Automatic; ± Slope; for Normal Sweep Mode; Same features (except no Line or Automatic) for Delayed-Sweep Mode. | $525 |

### *TYPE 561A CHARACTERISTICS*

#### UNIQUE CRT

- 5-inch rectangular ceramic-envelope tube
- Illuminated no-parallax internal graticule on high quality parallel-ground plate-glass face
- Controllable graticule lighting—for convenient trace photography
- Monaccelerator design and 3.5-KV accelerating potential,—for a bright, sharply-defined trace of small spot size

### OTHER FEATURES

Improved regulated power supplies • Regulated dc heater supply • Z-axis input • Amplitude calibrator with 18 steps from 0.2 mv to 100 v • Operation from 105 v to 125 v or 210 v to 250 v, 50 to 400 cps.

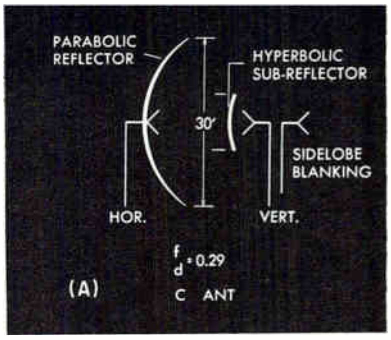
TYPE 561A Oscilloscope . . . . . . $ 470
(without plug-ins)
TYPE 3S76 Dual-Trace Sampling Unit $1100
TYPE 3T77 Sampling Sweep Unit . . $ 650
Probes:
Type P6032 Cathode-Follower Probe . $ 160
Type P6034 Miniature Passive Probe . $ 35
(10X Attenuation)
Type P6035 Miniature Passive Probe . $ 35
(100X Attenuation)

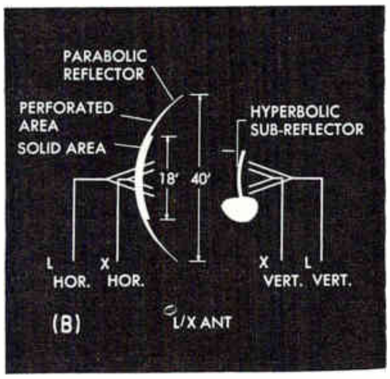
U. S. Sales Prices, f.o.b. Beaverton, Oregon

For more information on a Type 561A Oscilloscope and plug-in combinations, please call your Tektronix Field Engineer.

**Tektronix, Inc.** *P. O. BOX 500 • BEAVERTON, OREGON / Mitchell 4-0161 • TWX—503-291-6805 • Cable: TEKTRONIX*

*Tektronix Field Offices are located in principal cities throughout the United States. Please consult your Telephone Directory.*
*Tektronix Canada Ltd: Field Offices in Montreal, Quebec • Toronto (Willowdale) Ontario.*
*Tektronix International A. G., Terrassenweg 1A, Zug, Switzerland • Overseas Distributors are located in 27 countries and Honolulu, Hawaii.*




C-BAND ANTENNA (A) *and L/X-band antenna (B) comprise an integrated radar system that can track three targets simultaneously, get 36 pieces of real-time data*

---

**PROGRAM GETS NEW NAME, NEW MONEY**

*Advance Range Instrumentation Ship program carries on with developments begun under the Mobile Atlantic Range Station program* (ELECTRONICS, *p 22, July 28, 1961).*

*The first two Aris ships are being outfitted by Sperry in a $50-million program. Contract awards are expected soon for conversion of two more ships and plans are hardened for at least a fifth ship.*

*Ships 3 and 4 will get $65 million from the Air Force's 1963 Research, Development, Test and Evaluation funds. Ship 5 will get $36 million for long-leadtime instrumentation. More funds for ship 5 will come from 1964 money* (ELECTRONICS, *p 30, April 27)*

---

# Six-in-One Radar Will Track Nose Cones

*Three radars, each with two polarizations, integrated on ship*

NEW RADAR for the first Advance Range Instrumentation Ship (Aris)—formerly called Mobile Atlantic Range Station (Mars)—is significant for the design problems solved, and for its position as forerunner of a long line of missile and space tracking equipment to be installed aboard ships.

Main purpose of this ship and its successor, Aris 2, is to extend the Atlantic Missile Range to over 9,000 miles. Operating in the Indian Ocean, these floating stations will gather terminal and reentry phenomena data on ballistic missiles launched from Cape Canaveral.

THREE-BAND DESIGN—The design problem was to build radar that would get as much data on missile reentry as possible, and yet not take up too much room on the weather deck of the ship.

To acquire comprehensive data, three frequency bands are used—C-band for signature and tracking, and L- and X-band for signature.

To cut down on space, the L-band and X-band radars share one 40-ft transmitting and receiving antenna (see diagram B)—the center 18 feet for X-band, with the remainder of the dish perforated to provide reflection at L-band. Power output is 10 Mw for L-band and 1 Mw for X-band. Each can transmit with pulse compression modulation.

The X/L-band and telemetry antennas and the cameras are all slaved to the 30-ft C-band antenna by a 120-horsepower servo train.

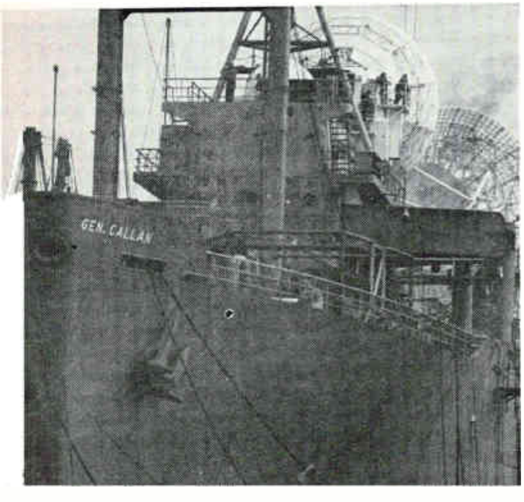
For better control and economy of space, one console handles the whole system, including other instrumentation subsystems. The combined radars are called the Integrated Instrumentation Radar (IIR).

Below decks, there are separate transmitter rooms for each band, an IIR room that is master control for the system, and the central data conversion equipment room where radar outputs are translated into computer language.

All radars will transmit with alternately vertical and horizontal polarization so that the IIR is not one radar but six integrated radars.

C-BAND—The C-band radar uses a Cassegrainian system with a two-horn feed at the paraboloid vertex for horizontal polarization. Cas-

C-BAND ANTENNA, *30 feet in diameter on truck (left) waits for shipment as the 40-foot L/X-band antenna is hoisted to turntable at radar test range*




THIS SHIP WILL *go to Indian Ocean to track terminal trajectories of missiles launched from Cape Canaveral. The C-band radar is in foreground, X/L band radar in background* segrainian subreflector is polarized so that it is transparent to vertical polarization and reflects horizontally polarized energy.

The receivers accept four pieces of precision trajectory and signature data: vertical-vertical, vertical-horizontal, horizontal-horizontal, and horizontal-vertical. The three bands together provide 12 pieces of information on one target. Three simultaneous targets provide 36 pieces of real-time data.

C-band radar operators have the choice of simultaneous skin and beacon tracking, or they can switch from one to the other. In general practice, tracking will be beacon first, then simultaneous beacon-skin tracking, then skin tracking until the target plunges into the sea.

Heart of the pulse compression technique used in the C-band radar is a filter using a staggered triplet of bridged-T time-delay sections. This provides a linear time delay vs. frequency characteristic. To achieve adequate compressed sidelobe reduction, modifications of the triplet sections and equalizers were added.

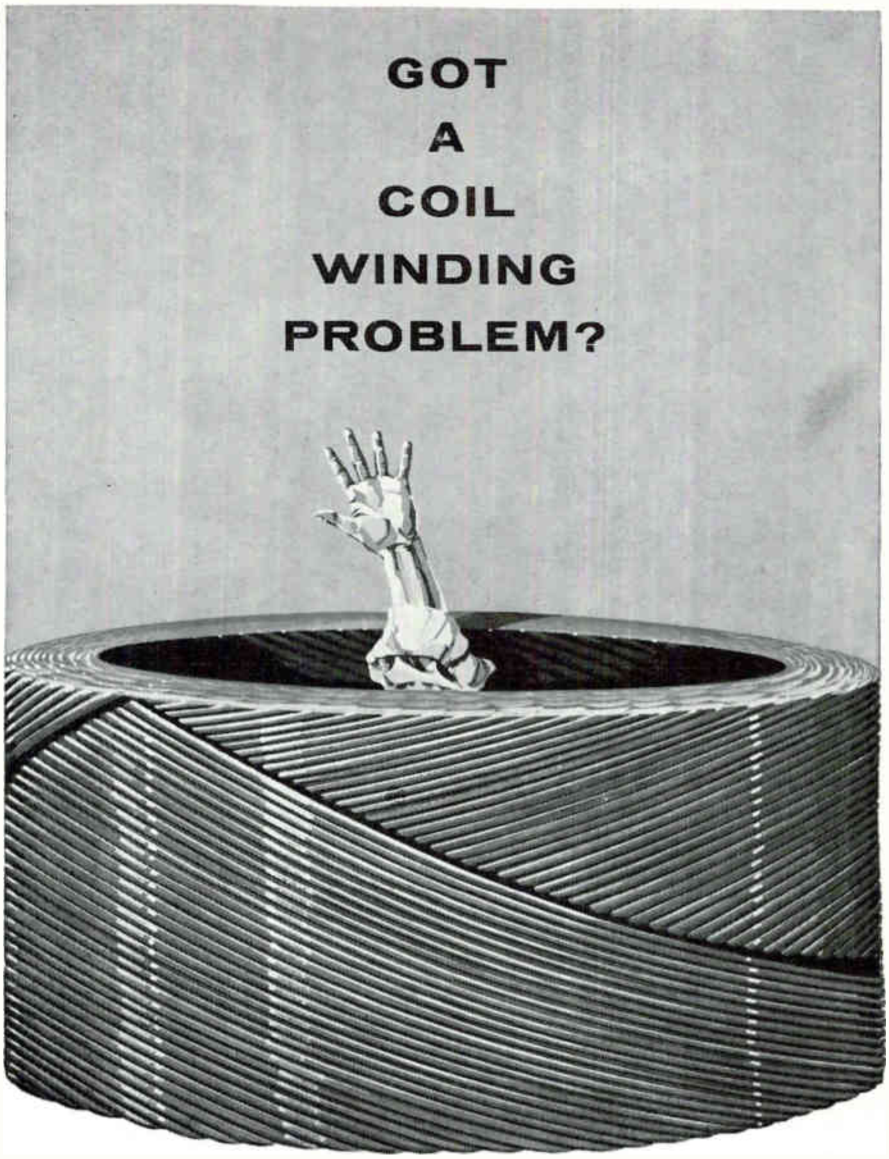
Tracking precision was obtained by the use of line-of-sight stabilization gyros on the antenna, a two-channel monopulse receiver that virtually eliminates the common agc and phase shift problems, opposed servomotor drives to minimize backlash errors, digital ranging and digital data readout.

TRANSMITTER—The transmitter uses a stable local oscillator that drives a traveling-wave tube. Modulation is introduced in an ssb modulator. A final klystron amplifier has a high-power pulse output.

Resonant frequency was planned to be above the ship's vibration frequency of 0 to 10 cps. Although mounts are built of steel, an aluminum truss supports the honeycomb panels of the C-band antenna for lightness.

Radar for Aris 2, also to be built by Sperry, will surpass the performance characteristics of this radar for Aris 1, Sperry says.

Other instrumentation subsystems, besides the IIR, on Aris 1 include: operations control center, stabilization and navigation, communications, data handling, telemetry, meteorology, timing and optical equipment.




CAMBION® Custom Winding Service can be the answer to your coil winding problems. We're completely equipped to wind your coils precisely, to meet your exact electrical and mechanical specifications. Coils are unconditionally guaranteed in any quantity — as are the more than 10,000 different items in the CAMBION line of electronic components. Your coils can be thoroughly tested in our environmental laboratory whenever necessary, if your problems are unusual. CAMBION is prepared to help you design your coils.

Actually, the CAMBION line of regular and shielded coil forms is so broad and so versatile that you rarely have to resort to special designs. There are models and sizes to meet practically every requirement for both conventional and printed circuits. This means you get faster service, greater dependability and easier procurement over the years. Materials are selected and finishes are applied with the greatest care — and all parts are non-ferrous and electro-plated to withstand severe service conditions.

**If you're all wound up in coil winding problems, call on CAMBION. Discover how we can save you both time and money. For estimate, send prints and quantity requirements to Cambridge Thermionic Corporation, 437 Concord Avenue, Cambridge 38, Massachusetts. Phone: TRowbridge 6-2800.**

CAMBRIDGE THERMIONIC CORPORATION
CAMBION®
The guaranteed electronic components

"The Light Touch In Automation and Control"

IBM STARTED USING **CLAIREX**

**PHOTOCONDUCTIVE CELLS**

*6 Years Ago*

as

**RELIABLE**

System Components

*And Still Does!*

Reliability in computer components means a great deal to IBM and its customers; down time is extremely expensive. Clairex photoconductive cells, because of their rigidly controlled parameters and ability to perform indefinitely with little or no maintenance, have been among components used for years by IBM. The Clairex cells function as the "eyes" of important IBM light-actuated tape drive controls.

These tape drives are now operating in thousands of computer systems around the world — providing daily proof through performance of Clairex reliability!

You too can enjoy this confidence in supply. Clairex cells have been employed by hundreds of major firms in outer space, photography and dozens of other interesting fields. These cells offer a broad range of characteristics to the designer engineer in the largest line of both glass and metal photoconductive cells available to the industry.

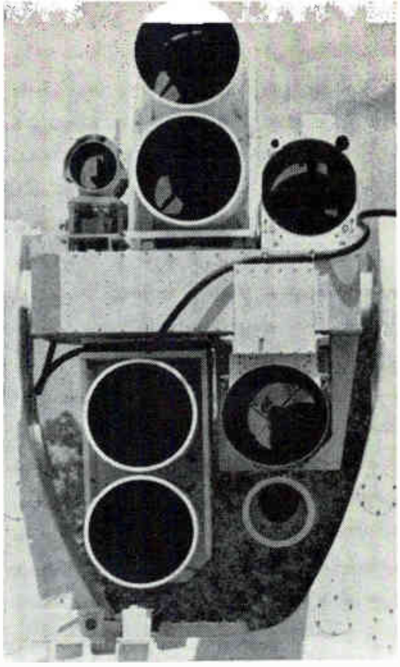
**CLAIREX CORPORATION**

*The Oldest Manufacturer of Cadmium Sulfide and Cadmium Selenide Photoconductive Cells*

8 West 30th Street, N. Y. 1, N. Y.

# Twin Tracker Follows Missiles

*Infrared system measures radiation of missiles on Atlantic Range*



BUSINESS END *of infrared tracker and measurement system*

TWO NEW INFRARED tracking and measuring systems for the Atlantic Missile Range will undergo operational tests shortly at Patrick Air Force Base, Fla.

One of the nearly identical systems will be installed nine miles south of Cape Canaveral where it will be used to measure missile plume radiation during launch through second stage burnout. The second system is slated for Ascension Island. It will obtain radiometric data from space vehicles during reentry and provide trajectory data during electronics blackouts.

Heart of each system is a high-sensitivity, high-resolution infrared tracker which provides error signals to a modified Nike-Ajax pedestal positioning system. The composite tracking circuit is accurate to better than ±0.2 mil in both azimuth and elevation, the developers report.

TRANSDUCERS — Measurements in the infrared spectrum from 1 to 14 microns are provided by an infrared radiometer with a dual-barrel, 12-inch-aperture optical unit utilizing lead sulphide and thermistor detectors.

The spectral region from 0.24 through 1.0 micron (visible light and ultraviolet) is covered by a photometer that electromechanically monitors radiation time sequentially over six distinct infrared wavelength intervals.

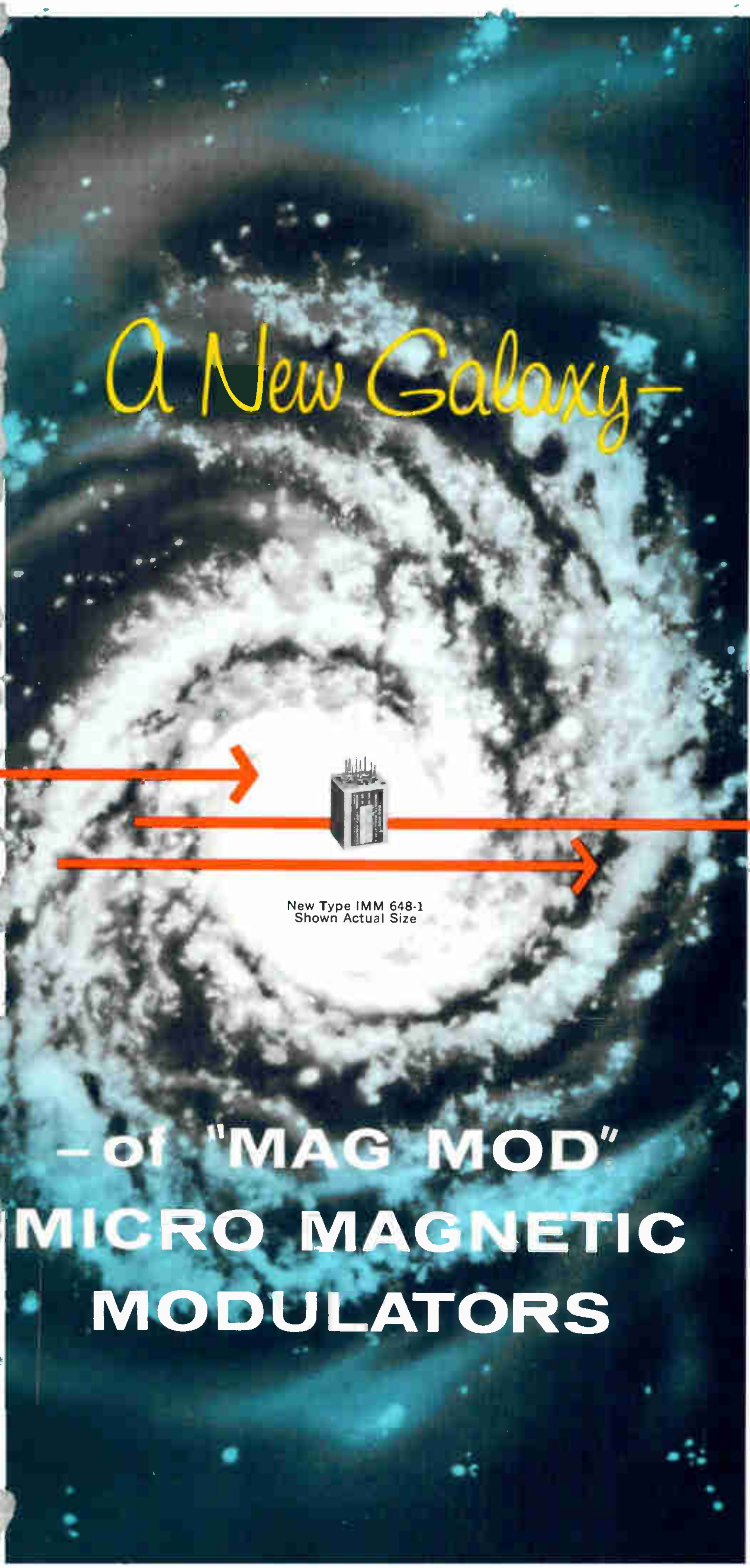
An infrared scanner will scan the target vicinity making irradiance measurements in minute increments of its field of view. This instrument is capable of resolving the location of a source of radiation to 1/784 of the area it covers.

System integration and installation are the responsibility of Metric Systems Corp. The system was developed by Pan American and the Atlantic Missile Range Development Division.

## New Telephone Exchange Works with Old Ones

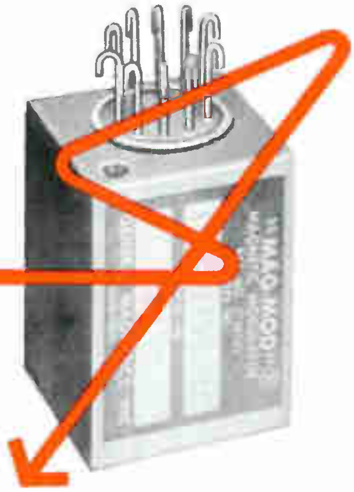
GENERAL Telephone & Electronics has announced development of an electronic telephone exchange compatible with existing electromechanical switching equipment. The system can be used to expand existing step-by-step offices or to equip new offices.

It is designed to provide high-speed control over switching operations and provide new services such as automatic forwarding of calls, conference calls, call-waiting tone, two-digit dialing and authorization codes for direct distance dialing. The system is also self-monitoring. A pilot model developed by Automatic Electric will be field tested next year.




**1952-1962...weight reduced from 5 ounces to 0.1 ounce!**

The product of 2 years of intensive development work, new completely microminiaturized magnetic modulators feature an essentially drift-free circuit with superior phase and gain stability over wide environmental ranges. All the ruggedness, dependability, wide dynamic range and stability that are characteristic of the larger magnetic modulators are engineered into this new magnetic circuit. "MICRO MAG MODS" are shock and vibration proof, provide the ultimate in reliability and unlimited life.



## Absolute Reliability in Micro Magnetics

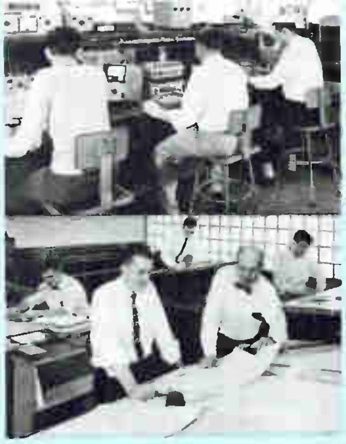
An entire circuit module compensated for phase, gain and zero drift over entire temperature range.

- **0.1 Cubic Inch Volume**
- **0.1 Ounces in Weight**
- **Infinite Standby and Service Life**
- **Low Milliwatt Power Consumption**
- **High Shock and Vibration Resistance**

**GENERAL MAGNETICS • INC**

135 BLOOMFIELD AVENUE
BLOOMFIELD, NEW JERSEY

*Turn to Reverse Side for Specifications and Data—*



There is No Substitute for Reliability

New!

# "MICRO MAG MOD"® MAGNETIC MODULATORS

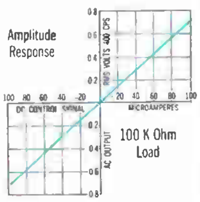
## –provide repeatable data over years of continuous, unattended operation!

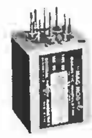
"MAG MODS" provide four quadrant operation, extreme stability with negligible change of phase, gain and zero position over a wide temperature range. Design is simple, lightweight, rugged with no vacuum tubes, semiconductors or moving parts to limit life. "MAG MODS" offer infinite design possibilities and impedance levels, and are adaptable for algebraic addition, subtraction, multiplying, dividing, raising to a power and vector summing.

**ADVANTAGES:**

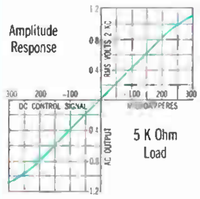
- Electrical zero point and gain, repeatability and stability over entire service life
- Extremely broad bandwidth
- Carrier frequencies as high as 1 megacycle
- Input signal current resolution better than 0.01 $\mu a$
- Absolute reliability—unlimited life
- High shock and vibration proof
- Low milliwatt power consumption

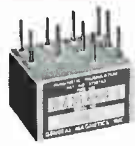
Micro Magnetic Modulator Type IMM-655-2



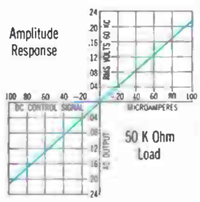



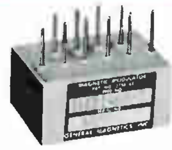
Micro Magnetic Modulator Type IMM-648-1



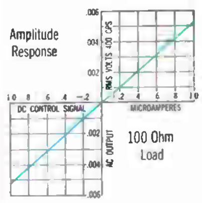



Micro Magnetic Modulator Type IMM-664-1



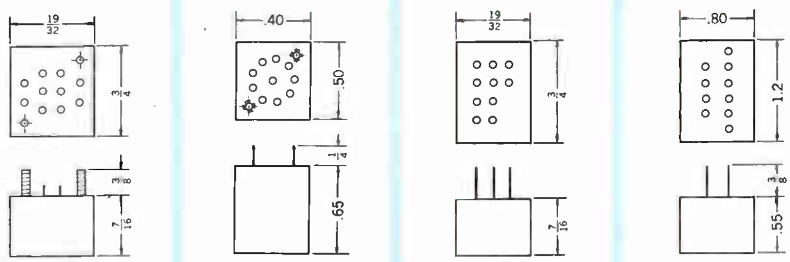



Micro Magnetic Modulator Type IMM-680-1




| TYPE NUMBER | IMM-655-2 | IMM-648-1 | IMM-664-1 | IMM-680-1 |
|---|---|---|---|---|
| Reference Carrier Voltage and Frequency | 3 V @ 400 cps | 2 V @ 2 KC | 10V @ 60 KC | 115 V @ 400 cps |
| Input Control Signal Range | 0 to ±100 $\mu a$ DC | 0 to ±300 $\mu a$ DC | 0 to ±100 $\mu a$ DC | 0 to ±10 $\mu a$ DC |
| DC Resist. of Input DC Signal Winding | 3 K ohms | 1400 ohms | 90 ohms | 20 K ohms |
| AM Phase Reversing AC Output Range | 0 to 0.8 V RMS @ 400 cps | 0 to 1.0 V RMS @ 2 KC | 0 to 200 mv RMS @ 60 KC | 0 to 30 mv RMS @ 400 cps |
| Differential Gain RMS mv AC Output/$\mu a$ DC Signal Input | 7 mv/$\mu a$ | 4 mv/$\mu a$ | 2 mv/$\mu a$ | 5 mv/$\mu a$ |
| AC Output Null (Noise Level) mv RMS | 5 mv RMS Max. | 5 mv RMS Max. | 10 mv RMS Max. | [redacted] 100 $\mu v$ RMS Max. |
| Output Impedance | 14 K ohms | 1000 ohms | 11 K ohms | Approx. 150 ohms |
| External Load | 100 K ohms | 5 K ohms | 50 K ohms | 100 ohms |
| Excitation (Carrier Winding) Impedance | 3 K ohms | 1700 ohms | 750 ohms | 90 to 100 K ohms |
| Zero Drift over Temp. Range Referred to DC Input Terminals | ±0.1 $\mu a$ Max. | 0.5 $\mu a$ Max. | – | 0.05 $\mu a$ Max. |
| Hysteresis in % of Max. Input DC Signal | 0.2% Max. | 0.2% Max. | 0.5% Max. | 0.1% Max. |
| % Harmonic Dist. in Output Product Wave | 15% | 10% to 15% | 5% | 20% |
| Temperature Range | –55°C to +125°C | –55°C to +125°C | –55°C to +125°C | –55°C to +125°C |
| Frequency Response | 5 K Series, 108 cps | Over 200 cps | Over 5 KC | Over 100 cps |
| Overall Dimensions (in Inches) | 19/32 x 3/4 x 7/16 | 0.4 x 0.5 x 0.65 | 19/32 x 3/4 x 7/16 | .80 x 1.2 x .55 |
| Type of Mounting | Two 2-56 Studs | Two 0-80 Inserts | Printed Circuit Board 1/10th Grid Plug-in | Two 4-40 Studs |
| Approximate Weight (in Ounces) | 0.2 | 0.1 | 0.2 | 0.2 |

**GENERAL MAGNETICS • INC**
135 BLOOMFIELD AVENUE
BLOOMFIELD, NEW JERSEY




Catalogs available on Micro Magnetic Modulators, Standard Magnetic Modulators, Miniaturized Multiplying Modulators, Transistor Oscillators. Call or write for your copies, or ask to have a GENERAL MAGNETICS representative contact you for consultation on specific applications.


## THAT'S ABOUT THE SIZE OF IT

Slap 10,000 *pf* of stable capacitance in just .176 of a square inch of your circuit board with this new Corning TY capacitor. It's the TY09, the biggest of a small but stable bunch.

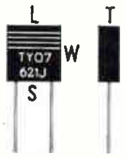
All our TY's give you ultrastable capacitive elements of fused glass and foil. The new case and potting compound eliminate inter-component, wire, or chassis short circuits.

You'll find TY's mount easily because we space the parallel leads uniformly on .100″ grids and they're symmetrical with the case. Welding or soldering is easier, too, with the gold-flashed Dumet leads. We *weld* them to the conductive plates to give you greater strength.

Check this table for the TY sizes and ratings you need. All of them perform at 300 volts from −55°C. to +125°C. with no derating.

← CIRCLE 34 ON READER SERVICE CARD

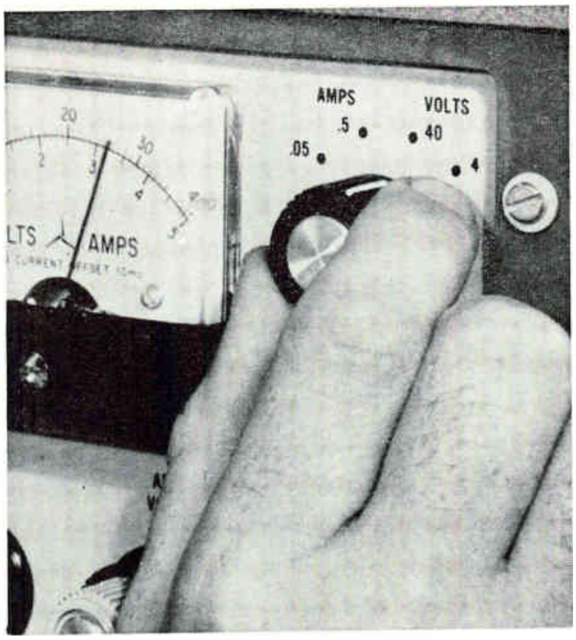
| | Capacitance Range pf | | | | | |
|---|---|---|---|---|---|---|
| | Min. | Max. | L±.005″ | W±.010″ | T±.005″ | S±.020″ |
| TY06 | 1 | 560 | .300″ | .200″ | .115″ | .200″ |
| TY07 | 560 | 1000 | .300″ | .300″ | .115″ | .200″ |
| TY08 | 1001 | 2700 | .500″ | .300″ | .115″ | .400″ |
| TY09 | 2701 | 10000 | .900″ | .700″ | .195″ | .800″ |




Get more information fast from Corning Glass Works, 3901 Electronics Drive, Raleigh, North Carolina.

**CORNING**
**Electronic Components**

CIRCLE 35 ON READER SERVICE CARD




# The Big Switch in Power Supplies...TRYGON's New Half-Rack

## *With Single Switch Hi-Lo Meter Range*

The single switch, providing Hi-Lo meter ranges from 0 to 4 or 0 to 40 volts, and 0 to 50 or 0 to 500 milliamps, is only one of the reasons why more and more users will recognize Trygon's new Half-Rack as tops among Transistorized power supplies for performance and operational reliability. Here's a unit that proves itself time and again with such Trygon exclusives as hand-wired circuits, and remote sensing which automatically corrects the slightest variation in voltage at the load.

**There are other exciting features too:**

- *Constant Voltage Operation with Adjustable Current Limiting*
- *Constant Current Operation with Adjustable Voltage Limiting*
- *Remote Programming and Remote Voltage Sensing*
- *Parallel and Series Operation*
- *Highest Quality: Lower Price than any comparable supply*

Add all these up and it's easy to see why the big switch is to Trygon, for the ultimate in transistorized half-racks that deliver more performance in less space than any other similar units available.

| | |
|---|---|
| **Output:** | |
| Model HR40-500 | 0-40 VDC @ 0-500 ma |
| Model HR20-1.5 | 0-20 VDC @ 0-1.5 Amp. |
| **Ripple:** | |
| Model HR40-500 | 250 microvolts max. RMS |
| Model HR20-1.5 | 500 microvolts max. RMS |
| **Regulation:** | |
| Load | 0.05% or 10 mv, NL to FL |
| Line | 0.01% or 2 mv, 105-125 VDC input |
| **Recovery Time:** | Better than 50 usec to recover within 10 mv for 100% step change in rated load |
| **Stability:** | 0.05% or 10 mv for 8 hours after initial warm-up |
| **Temperature Coefficient:** | 0.02%/°C |
| **Price:** | |
| Model HR40-500 | $149.00 |
| Model HR20-1.5 | $159.00 |

*Send today for complete details on the extensive Trygon line of transistorized D.C. Power Supplies.*

*Model HR40-500 (illustrated) and Model HR20-1.5 are available for rack or bench use.*

**TRYGON ELECTRONICS, INC.**
111 Pleasant Ave., Roosevelt, L.I., N.Y. — 516-FR 8-2800

...THE TRUSTED SOURCE FOR TRANSISTORIZED POWER


## MEETINGS AHEAD

ULTRASONIC SYMPOSIUM, IRE-PGUE; Columbia University, New York City, **Nov. 28-30.**

FALL JOINT COMPUTER CONFERENCE, IRE-PGEC, AIEE, ACM; Sheraton Hotel, Philadelphia, Pa., **Dec. 4-6.**

VEHICULAR COMMUNICATIONS CONFERENCE, IRE-PGVC; Disneyland Motel, Anaheim, Calif., **Dec. 6-7.**

SPACE PHYSICS CONFERENCE, American Rocket Society; Philadelphia, Pa., **Dec. 26-31.**

MILLIMETER AND SUBMILLIMETER CONFERENCE, IRE; Orlando Section; Cherry Plaza Hotel, Orlando, Florida, **Jan. 7-10.**

RELIABILITY & QUALITY CONTROL SYMPOSIUM, IRE-PGRQC, AIEE, ASQC, EIA; Sheraton Palace Hotel, San Francisco, Calif., **Jan. 21-24.**

INSTITUTE OF ELECTRICAL & ELECTRONICS ENGINEERS WINTER GENERAL MEETING & EXPOSITION, IEEE; Statler and New Yorker Hotels, New York City, **Jan. 27-Feb. 1.**

MILITARY ELECTRONICS WINTER CONVENTION, IRE-PGMIL; Ambassador Hotel, Los Angeles, Calif., **Jan. 30-Feb. 1.**

QUANTUM ELECTRONICS INTERNATIONAL SYMPOSIUM, IRE, SFER, ONR, Unesco Building and Parc de Exposition, Paris, France, **Feb. 11-15.**

ELECTRICAL & ELECTRONIC EQUIPMENT EXHIBIT, ERA, ERC; Denver Hilton Hotel, Denver, Colo., **Feb. 18-19.**

SOLID STATE CIRCUITS INTERNATIONAL CONFERENCE, IRE-PGCT, AIEE, University of Pennsylvania, Sheraton Hotel and U. of P., Philadelphia, Pa., **Feb. 20-22.**

PACIFIC COMPUTER CONFERENCE, AIEE; California Institute of Technology, Pasadena, Calif., **March 15-16.**

IEEE INTERNATIONAL CONVENTION, Institute of Electrical and Electronics Engineers; Coliseum and Waldorf-Astoria Hotel, New York, N. Y., **March 25-28.**

ENGINEERING ASPECTS OF MAGNETOHYDRODYNAMICS SYMPOSIUM; IRE-PGNS, AIEE, IAS, University of California, UCLA, Beverly, Calif., **April 10-11.**

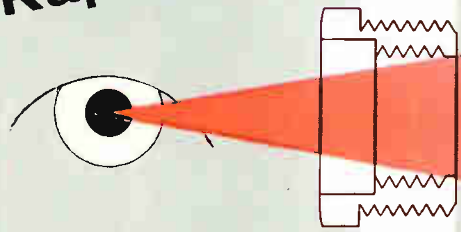
SOUTHWESTERN IRE CONFERENCE, IRE, Dallas Memorial Auditorium, Dallas, Texas, **April 17-19.**

NON-LINEAR MAGNETICS SPECIAL TECHNICAL CONFERENCE, IRE-PGEC, PGIE, AIEE; Shorham Hotel, Washington, D. C., **April 17-19.**

### *ADVANCE REPORT*

ELECTRONIC CIRCUIT PACKAGING SYMPOSIUM, *University of Colorado, at the University, Boulder, Colo., Aug., 14-16, 1963. Jan. 15 is the deadline for submitting three copies of a 500-word outline to: Sherman B. Sheffield, Bureau of Continuation Education, Room 352 Chemistry Building, University of Colorado, Boulder, Colo. Papers on overall circuit packaging techniques and on specific designs are desired. Principal selection criterion will be the contribution to advancing the state-of-the-art of circuit packaging as applied in actual production situations.*

## Especially Designed for Rapid, Easy Installation!



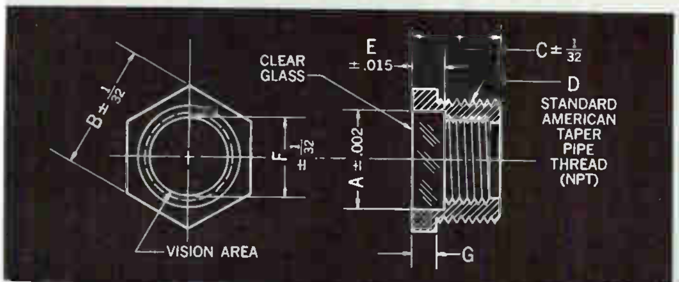
# PIPE-THREADED

CLEAR GLASS
HERMETICALLY
SEALED

# OBSERVATION WINDOWS

HTW SERIES WINDOWS ARE AVAILABLE IN A WIDE RANGE OF SIZES

STANDARD AMERICAN TAPER PIPE THREAD (NPT) FOR QUICK INSTALLATION




Dimensions for HTW Series Sealed Windows (In Inches)

| PART NO. | A | B | C | D | E | F | G |
|---|---|---|---|---|---|---|---|
| HTW-1 | .525 | .687 | .500 | 3/8 | .125 | .437 | 5/32 |
| HTW-2 | .675 | .875 | .562 | 1/2 | .200 | .562 | 3/16 |
| HTW-3 | .825 | 1.062 | .750 | 3/4 | .200 | .687 | 9/32 |
| HTW-4 | 1.035 | 1.437 | .812 | 1 | .250 | .875 | 1/4 |
| HTW-5 | 1.300 | 1.790 | .875 | 1 1/4 | .250 | 1.125 | 11/32 |
| HTW-6 | 1.635 | 2.000 | .937 | 1 1/2 | .500 | 1.468 | 3/8 |
| HTW-7 | 1.890 | 2.500 | 1.000 | 2 | .500 | 1.687 | 7/16 |

Ruggedly constructed and hermetically sealed for

**AIR CONDITIONING, REFRIGERATION AND HEATING EQUIPMENT**
**ELECTRICAL AND ELECTRONIC AND PHOTO SENSITIVE DEVICES**
**CONTROL AND OTHER SEALED OR PRESSURIZED MECHANISMS**

E-I sealed glass windows are designed for observing internal conditions in hermetically sealed mechanical, electrical and electronic equipment. These windows are precision made to provide "space age" reliability . . . feature super-rugged E-I compression seals that have been proven for utmost reliability in major missile and space projects. For complete data and recommendations on your particular requirements, call or write E-I, today.

E I ®

Patented in the U.S.A., No. 3,035,372; in Canada, No. 523,390; and in the United Kingdom, No. 734,583.

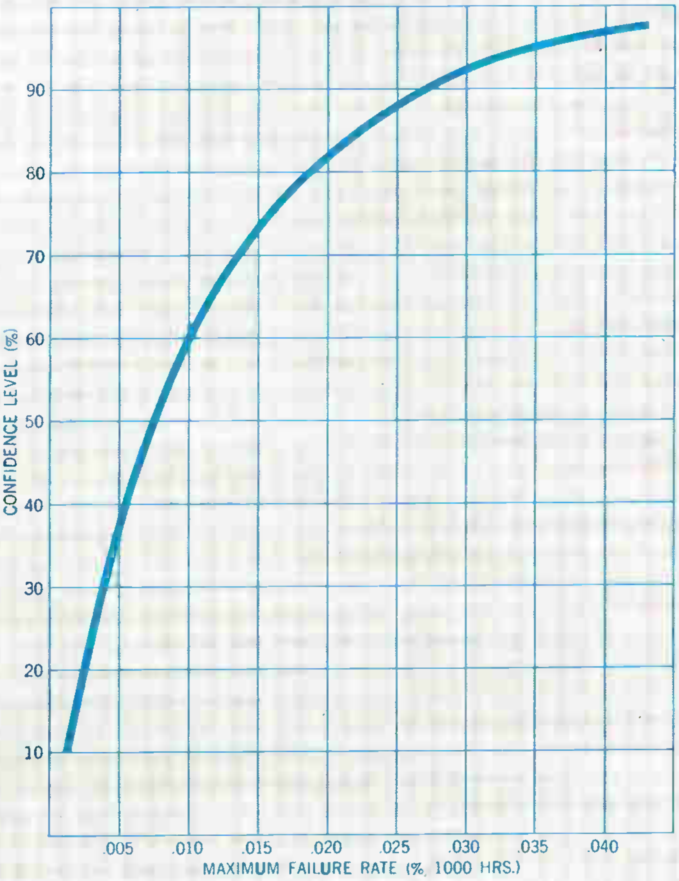
**ELECTRICAL INDUSTRIES**
*A Division of Philips Electronics & Pharmaceutical Industries Corp.*
MURRAY HILL, NEW JERSEY—Telephone: 464-3200 (Code 201)



CIRCLE 37 ON READER SERVICE CARD

"Ultra-Reliable" is a name that we have given to both a new program and a new potentiometer—after 3½ years of evaluation. The program—unprecedented in its severity, thoroughness, and single-mindedness—has but one goal: reliability. The potentiometer—the first of its kind ever available—offers statistically verified reliability as its key advantage.

Never before has a company reliability program been so




# INTRODUCING A PROVEN BOURNS CONCEPT: ULTRA-RELIABILITY

## A METHOD *NOW* PRODUCING POTENTIOMETERS WITH STATISTICALLY VERIFIED RELIABILITY

**MAX. FAILURE RATE: 0.01% PER 1000 HOURS (60% CONFIDENCE LEVEL)**

(Curves are based on a constant failure rate (Poisson distribution)

comprehensively planned and implemented. Never before has a potentiometer undergone such relentless checking, sampling, screening, and testing. Selected personnel produce the units, working with small, rigidly controlled lots in a separate production area. And behind every potentiometer is the Bourns record of reliability—15 years of participation in the most important programs of our time. If you want potentiometers that squarely meet the most urgent demands of critical projects, you want Bourns Ultra-Reliable potentiometers. Complete acceptance test results accompany every shipment. Documentation of reliability as test verification progresses beyond 0.01% (FR/1000 hrs.) is sent to each customer on a quarterly basis.

## THE EIGHT BASIC STEPS TO ULTRA-RELIABILITY

### 1. START WITH HIGH INHERENT RELIABILITY

Basis of the Ultra-Reliable Trimpot® potentiometer is the familiar Trimpot Model 224, chosen because its advanced design offers the best inherent reliability and because it has the highest level of achieved reliability.

### 2. ISOLATE PRODUCTION

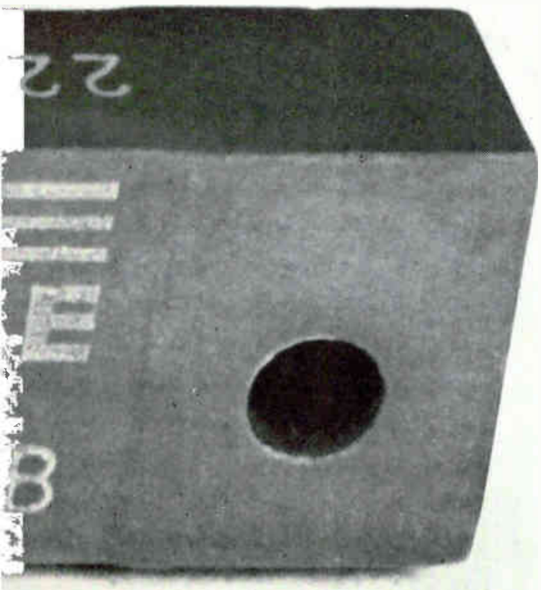
Ultra-Reliable units are produced independently of all other Bourns potentiometers to preclude the possibility of inadvertent use of standard line parts and to more effectively implement special manufacturing techniques and controls.

### 3. KEEP PRODUCTION LOTS SMALL, CONTROL RIGID

Each lot of approximately 240 units is numbered, and an individual number is printed on every finished product. In addition, each production order contains the inspection number assigned to individual lot quantities of the piece parts. By this means a trace can be made of all parts that comprise an Ultra-Reliable unit.

### 4. INCREASE Q.C. AND PIECE-PART INSPECTION

All piece-parts undergo 100% inspection (plus audit inspection verification checks) and are tagged with an inspection lot number. Quality control is maintained at the installation of every part and throughout process and production operations. After in-process inspections, units undergo a pre-seal inspection, the first of three electrical test sequences.



### 5. STEP UP TESTING, RAISE TEST STANDARDS

Units undergo 100% screening under the following test conditions to prevent the possibility of "infant mortality":

(a) High-temperature stability: 24 hours at 175°C—25° higher than maximum operating temperature.

(b) Temperature cycling: two cycles from −65°C to +175°C—25° higher than maximum operating temperature.

(c) Load-life burn-in: 50 hours at twice rated power.

Upon satisfactory completion of these tests, all units are again electrically inspected.

### 6. CROSS-CHECK WITH SAMPLING TESTS

After the lot is sealed and has passed a third and final electrical inspection, it is impounded by quality control, subject to successfully completing a statistically representative acceptance test performed for vibration, humidity, and rotational cycling. Test samples are not released to stock; they are either discarded or used in extended testing. Failure of any unit under test condemns the entire lot.

### 7. PACK AND SHIP UNITS INDIVIDUALLY

Industry records show that component reliability is often impaired in handling and shipping. To provide maximum protection, Bourns packs units individually in padded shipping containers under surveillance of quality-control, packaging, and shipping inspectors.

### 8. RUN LONG-TERM TESTS

Seven hundred units have completed a 10,000-hour load-life test with full power applied per MIL-R-19A (also some at ¼, ½, twice, and three times rated power) to supply achieved-reliability data. Bourns also will soon make available wear-out curves for various power levels, high-temperature exposure, temperature cycling, and humidity.

### 40-PAGE ULTRA-RELIABLE PROCUREMENT DOCUMENT AVAILABLE

This comprehensive document is all that the standard engineer needs to draft a specification for an Ultra-Reliable potentiometer, complete with all controls and call-outs. It is available upon request where you desire more specific information for your application. Just write or call, and your personal copy will be delivered by a Bourns field engineer.

### SPECIFICATIONS-TRIMPOT® ULTRA-RELIABLE POTENTIOMETER


ACTUAL SIZE

Element: Wirewound
Resistances: 100Ω to 20KΩ
Power rating @ 70°C: 0.5 watt
Max. oper. temp.: 150°C
Humidity: Meets MIL-STD-202, Method 106

### AVAILABLE AS AN OFF-THE-SHELF ITEM FROM OUR PLANT IN RIVERSIDE, CALIF.

For your personal, detailed introduction to this product, write for three-page brochure on the Ultra-Reliable Trimpot Potentiometer.

BOURNS

BOURNS, INC., TRIMPOT DIVISION
1200 COLUMBIA AVE., RIVERSIDE, CALIF.
PHONE 684-1700 · TWX: 682-9582
CABLE: BOURNSINC.

Manufacturer: Trimpot® potentiometers; transducers for position, pressure, acceleration. Plants: Riverside, California; Ames, Iowa; and Toronto, Canada.

CIRCLE 39 ON READER SERVICE CARD

# RELIABILITY SERVICES
## In the palm of your hand

***Utilize a single organization capable of planning and implementing all phases of reliability.***

**United Testing Laboratories' reliability engineering staff, complemented by extensive facilities, provides a total program capability — planning, organization, documentation, performance, analysis, interpretation, *decision* — United Testing Laboratories will perform tasks ranging from assistance in proposals through reliability determination and demonstration.**

**Reliability objectives are accomplished at significant savings by proper planning and appropriate application of data obtained in all phases of development and testing.**

**United Testing Laboratories offers these services which are oriented to the specific requirements of the Department of Defense, NASA, and other major prime contractors.**

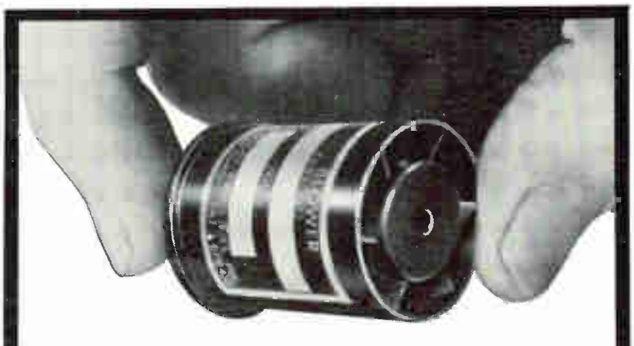
**Call or write to the address nearest you.**

Test Facilities • Sunnyvale, Calif. (San Francisco Area), 150 Wolfe Road, RE 9-5900.
• Monterey Park, Calif. (Los Angeles Area), 573 Monterey Pass Road, CU 3-4168.
• Alexandria, Va. (Washington, D.C. Area), 4416 Wheeler Ave., 836-7200.

**UNITED TESTING LABORATORIES** *a division of United ElectroDynamics, Inc.*

**CIRCLE 201 ON READER SERVICE CARD**

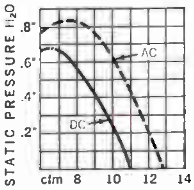
---



## A.C. OR D.C. SMALLEST VANEAXIAL BLOWERS

Only 1⅛" in diameter by a maximum 1¾" long, these smallest blowers move 10 cfm of air against 0.6" $H_2O$ back pressure! Use these rugged sub-miniature blowers for spot cooling of critical components where space is cramped and weight is important.

VAX-1 blowers operate on 26 v.d.c. or less, or 26 v.a.c., 400 cycles. Weight is 1.4 ounces. Mounts with standard servo ring clamps. (Globe makes larger blowers also.) Request Bulletin XAV from Globe Industries, Inc., 1784 Stanley Avenue, Dayton 4, Ohio.




GLOBE INDUSTRIES, INC.

 **CIRCLE 40 ON READER SERVICE CARD**

---

## THE NEW *SUPER* WEE-DUCTOR

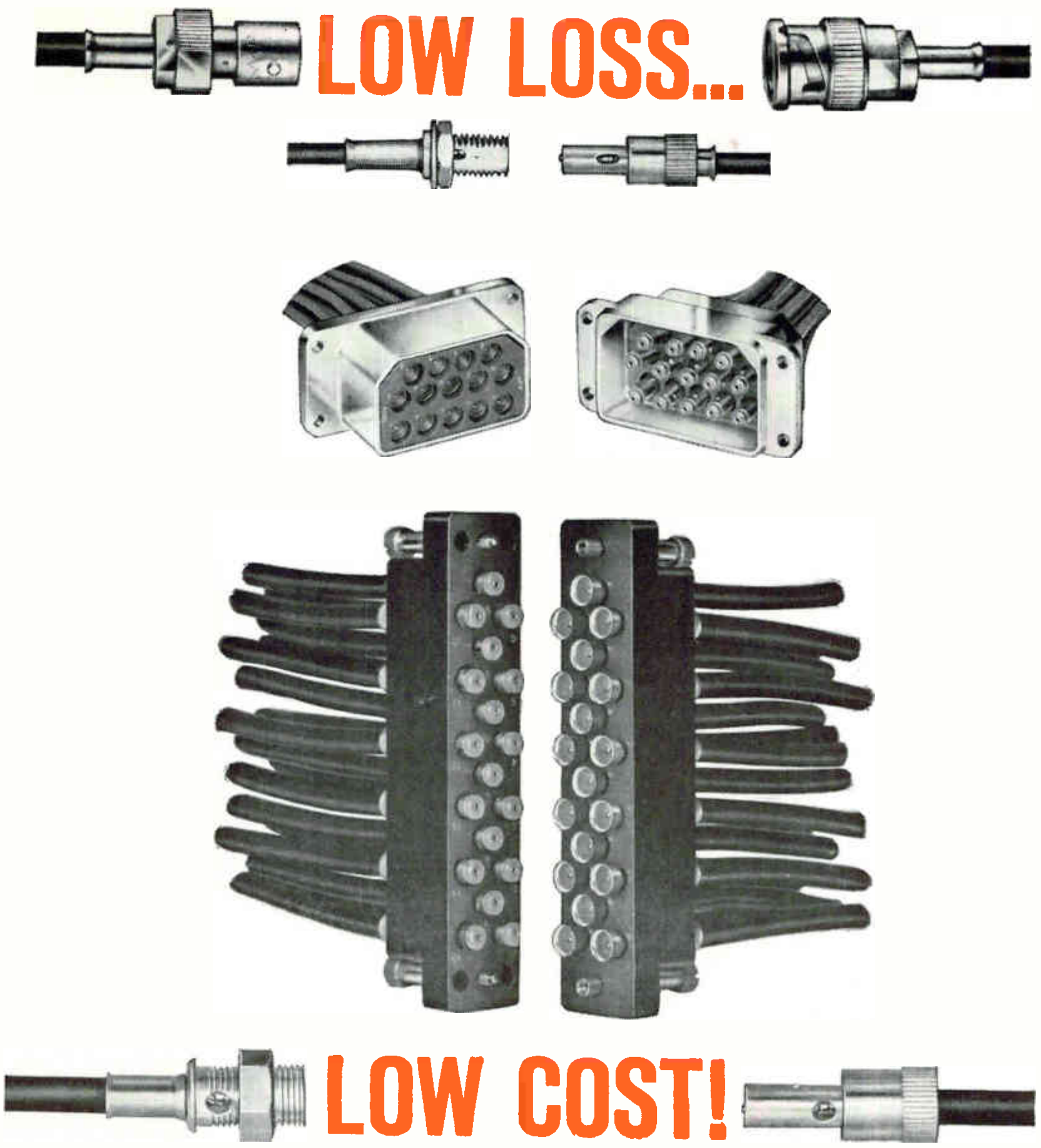
An ultra reliable MOLDED SHIELDED r.f. subminiature inductor—available in inductances from 0.1 $\mu$H to 100,000 $\mu$H in 73 values.

The **SUPER** WEE-DUCTOR is shielded for minimum coupling in high density packaging and has extremely low dc resistance. Only 0.410" long and 0.157" in diameter, the **SUPER** WEE-DUCTOR meets all the requirements of MIL-C-15305B (Amendment #1), Grade 1, Class B, including moisture and immersion resistance and operation from −55°C to +125°C.

**For complete engineering data, write Dept. WL-30, or phone 201-464-9300. All values available from stock.**

**NYTRONICS, INC.**
550 Springfield Ave., Berkeley Heights, N.J.
Design Leaders
STANDARD components to meet CUSTOM requirements

**CIRCLE 202 ON READER SERVICE CARD**




**JUST ONE CRIMP DOES IT!**

With all COAXICON* connectors you get simultaneous, one-crimp termination of inner conductor, outer braid and cable support. This exclusive AMP feature results in a more than 50% saving in applied costs over other solderless coaxial connector assemblies . . . even more when compared to those applied by solder. The contacts are pre-assembled, furnished ready for attachment. This means no assembly costs resulting from time loss and production slow-ups. Add to this the low initial cost (priced lower than comparable coaxial equipment) and you have the most economical coaxial connections on the market . . . by far!

**PERFORMANCE**

Price is nice, but what about quality? Test reports confirm minimum discontinuity up to 500 megacycles. At 500 megacycles impedance mismatch is only 1.06 to 1.09. And with the plus feature of AMP's matching tool and terminal technique, you further insure reliability by eliminating human error, hit-or-miss connections, cold solder joints.

**THE STANDARD OF EXCELLENCE**

.000030" non-porous gold over .000030" nickel contact plating is standard with AMP. This, combined with cantilever-beam contact retention springs, assures you of maximum conductivity, uniform contact pressures, longer insertion/extraction life.

Choose from a wide range of COAXICON connectors—single-in-line, bayonet and threaded nut types; multiple, in a wide variety of configurations, including coax and pin and socket mixes. Standard, miniature and sub-miniature contact sizes will handle a primary dielectric insulation range of .040" to .146".

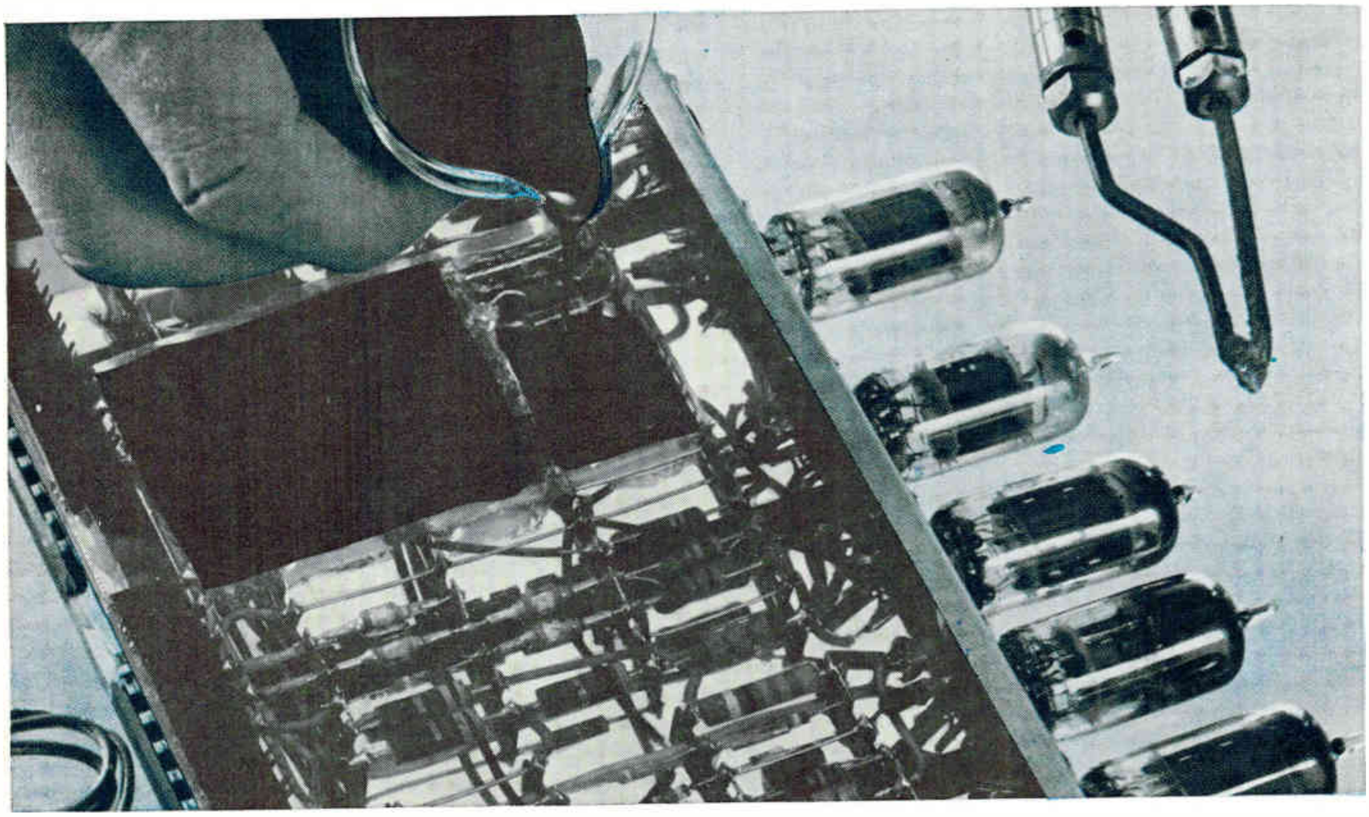
Just add up the advantages: speed of application, lower initial and applied costs, low noise level, superior plating, wide selection. Then, put an AMP end to your coaxial connection problems. Get the complete story today!

*Trademark of AMP INCORPORATED

**AMP INCORPORATED**
Harrisburg, Pennsylvania

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

# To meet tough-spot specs



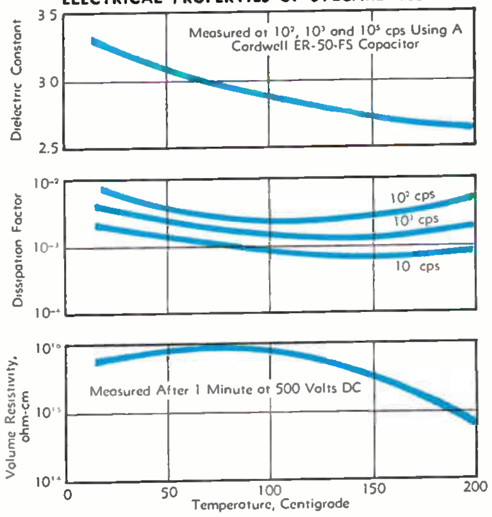
## For resilient protection, specify easy-processing Sylgard® 183

Specify Sylgard 183, the new opaque solventless silicone resin, for embedding, potting, or encapsulating circuits or impregnating components. It is resilient . . . has excellent dielectric properties, heat stability and mechanical strength.

***Processing is simple*** with Sylgard 183. Blend it with a curing agent and pour it in place . . . it cures without exothermic heat to a tough, flexible, impervious jacket. Because of its low viscosity . . . about the same as No. 40 engine oil . . . Sylgard 183 flows rapidly around the most intricate shapes. It cures in sections of unlimited thickness, and even in completely sealed assemblies. Curing time can be varied from four hours at 65 C (150 F) to only 15 minutes at 150 C (300 F). After curing, the material can be used immediately at temperatures from —65 to 250 C (—85 to 500 F). No post cure is required.

***Protection is assured*** because fully cured Sylgard 183 withstands heat, moisture, shock, vibration, ozone, voltage stress and thermal cycling over a wide range of temperature, frequency and humidity. This new Dow Corning resin is compatible with metals, plastics, glass, asbestos, ceramics, natural and synthetic fibers, and also with Dow Corning's transparent solventless casting resin, Sylgard 182, as shown above. When sealed components must be repaired or replaced, Sylgard 183 can be cut away, repairs made, and new Sylgard 183 poured in place. It bonds tightly to the original embedment. To cut application costs . . . and to assure recoverability of costly components . . . specify Sylgard 183.

**EFFECT OF TEMPERATURE ON ELECTRICAL PROPERTIES OF SYLGARD 183**




**CIRCLE 289 ON READER SERVICE CARD**

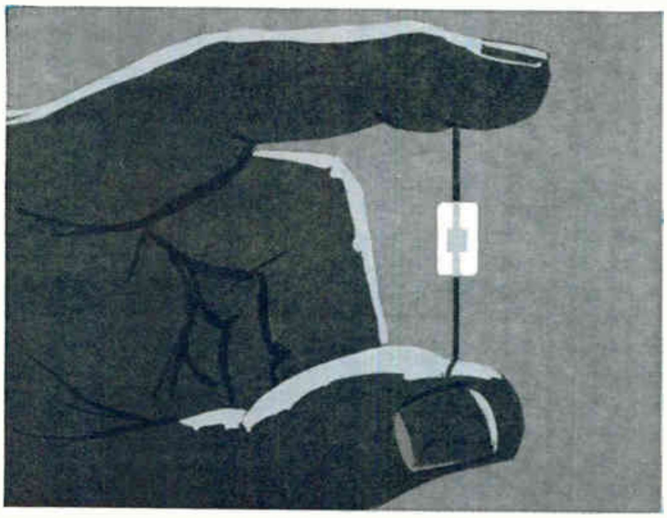
Dow Corning is your best source for a broad line of silicone fluids, gels, elastomers and rigid forms for potting, filling, embedding and encapsulating

first in silicones

**Dow Corning**

# –specify these silicones

## To package silicon diodes

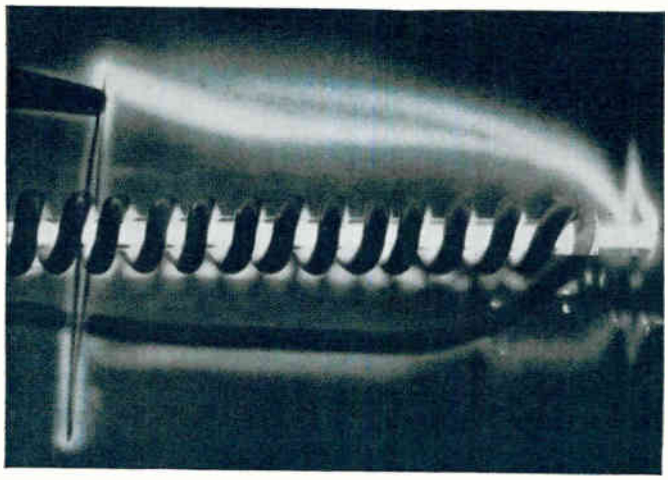


Mechanical strength and good dielectric properties at temperatures to 175 C minimum were requirements for the protective package needed by Motorola Semiconductor Products, Inc., for their new glass surface-passivated "Surmetic"* zener diode. The material specified is a Dow Corning Molding Compound developed for this application. It molds easily and quickly at temperatures and pressures that will not damage the semiconductor junctions . . . produces a void-free package that eliminates moisture and corona problems . . . doesn't soften when device leads are soldered . . . has withstood storage in air at 400 C and operating tests of 1000 hours at 200 C . . . is a big contributing factor to the high 175 C operating junction temperature rating of these Motorola "Surmetic" devices. A plus in military application: the Dow Corning Silicone Molding Compound will not flame.

* "Surmetic" — a trademark of Motorola, Inc.

CIRCLE 290 ON READER SERVICE CARD

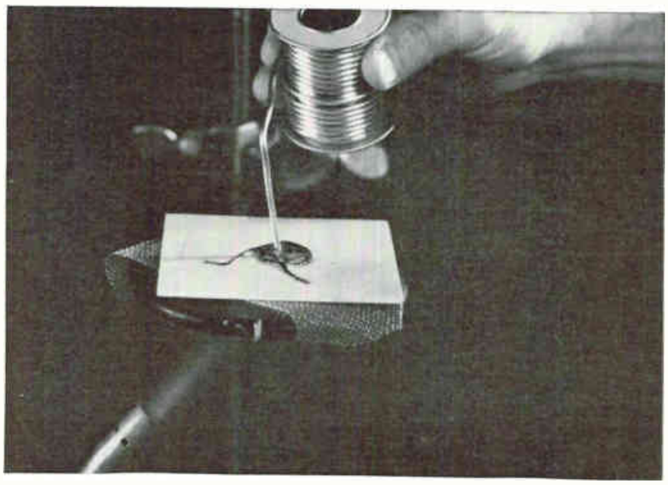
## Silastic spurns corona



Corona discharge can cause rapid insulation failure, but not when wire and cable are insulated with Silastic®, the Dow Corning silicone rubber. Samples subjected to over 12,000 hours of this test, which creates a high concentration of ozone, show no signs of cracking or checking when flexed. Other important Silastic properties: flexibility and stability from −130 to 500 F; consistently high dielectric strength under adverse conditions; inertness to oxygen, many chemicals; resistant to water, vapor, steam, weathering; minimum deterioration due to age, thermal cycling, or exposure to radiation.

CIRCLE 291 ON READER SERVICE CARD

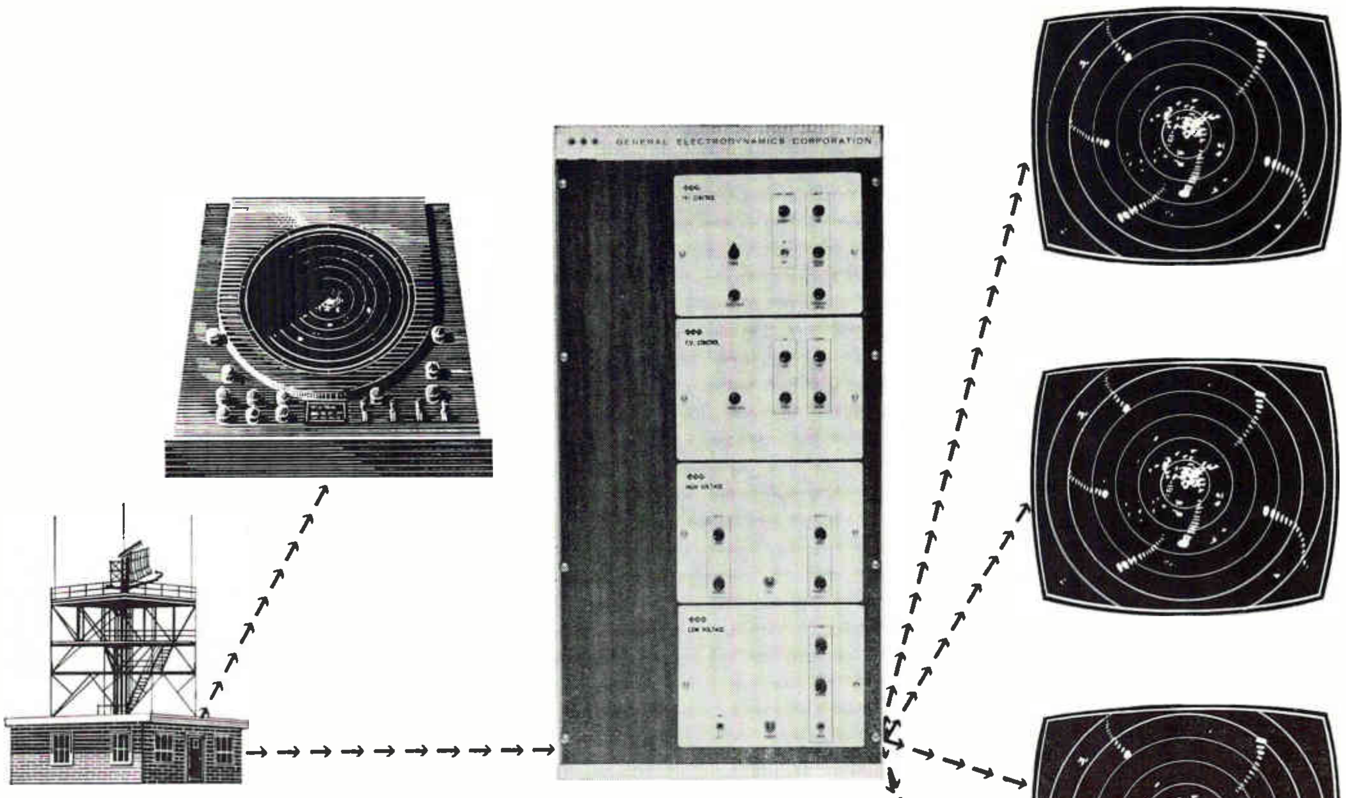
## Laminates resist solder heat

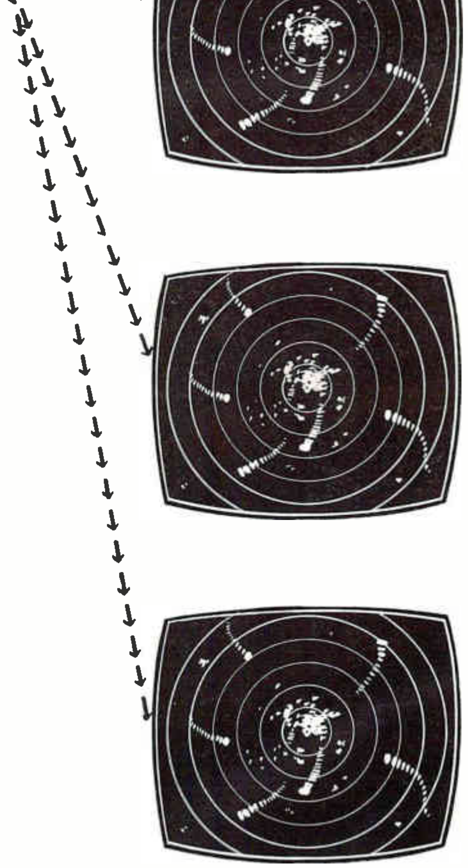


The heat needed to melt solder won't loosen terminals from silicone-glass laminates, even where complex wiring requires repeated soldering in small, confined areas. Long-term heat resistance is also exceptional . . . up to 250 C continuous for years . . . much higher for short periods. In addition, silicone-glass laminates retain excellent dielectric properties despite moisture, storage, environmental aging, changing ambients, and shock. They offer low loss factor, low moisture absorption, good resistance to arcing, corona, corrosion. Weight-strength ratios are high, and machinability, even in thin sections, is exceptional.

CIRCLE 292 ON READER SERVICE CARD

For detailed data on these silicones, contact
Dow Corning Corporation, Dept. 3911, Midland, Michigan



# Now Multiple PPI Displays Under High Ambient Light Conditions... With GEC Scan Converter

With GEC's *transistorized* 6021 Scan Converter, it is no longer necessary to look at rapidly decaying PPI displays in dark surroundings. Any number of inexpensive TV monitors can be operated from one PPI source with controlled image storage time affording more reliable evaluation of displayed information.

Readily tailored to your specific requirements through its plug-in functional modules, the 6021 Scan Converter is capable of:

◆◆◆TRANSLATION of video information from one scanning mode to any other.

◆◆◆STORAGE and INTEGRATION of video information.

◆◆◆TIME-COORDINATE TRANSFORMATION for expansion or reduction of bandwidth.

Contact GEC for more information about conversion of radar PPI to TV, TV standards conversion or conversion of slow scan narrow band TV to standard TV or vice versa.

**Qualified electronic engineers are needed for work in the field of Scan Conversion. Address inquiries to Professional Placement Manager. An equal opportunity employer.**

. . . *advanced electronics at work*

G E C®

**GENERAL ELECTRODYNAMICS CORPORATION**

4430 FOREST LANE • GARLAND, TEXAS • BROADWAY 6-1161

# HERE'S WHY FLUKE DC DIFFERENTIAL VOLTMETERS CHALLENGE COMPARISON

★ **ACCURACY**
±0.01%
0-500V DC

★ **DURABILITY**

★ **LOW COST**
$895.00 FOB SEATTLE

**FLUKE MODEL 821A** Now—for the first time—it is possible to obtain ±0.01% accuracy with a differential voltmeter over a 0-500V DC range *regardless of source impedance!* Built-in rugged construction, plus the use of highest quality components and latest manufacturing techniques guarantee long, trouble-free operation. Through simplified circuitry and conservative design, factory selection of components is virtually eliminated insuring ease-of-maintenance . . . minimum down-time. Fluke instruments cover many applications such as: calibrating, testing, and stability measurements of regulated power supplies, DC voltmeter calibration, AC voltmeter calibration and precise AC voltage or current measurements when used with an AC/DC transfer standard. The John Fluke Mfg. Co. is the most experienced manufacturer of differential voltmeters—with over 18,000 in use today! Buy with confidence from the company that developed the *differential voltmeter!*

## PARTIAL SPECIFICATIONS:

**ABSOLUTE ACCURACY:** ±0.01% of input voltage from 0.5 to 500V. ±0.01% of input voltage plus 10 microvolts below 0.5V.

**INPUT RESISTANCE:** Infinite at null from 0 to 500V

**METER RESOLUTION:** 5uv maximum; 1 MV full scale.

**CALIBRATION:** 500V working reference supply calibrated against built-in standard cell.

**STANDARD CELL STABILITY:** 0.003% per year.

**INPUT POWER:** 115/230V AC ±10%, 50-400 cps, 60 watts.

## FEATURES:

• Infinite resistance at null over entire 0-500V range • Polarity switch • Taut-band suspension meter • Standard cell reference • Recorder output • In line readout with automatic lighted decimal • No zero controls

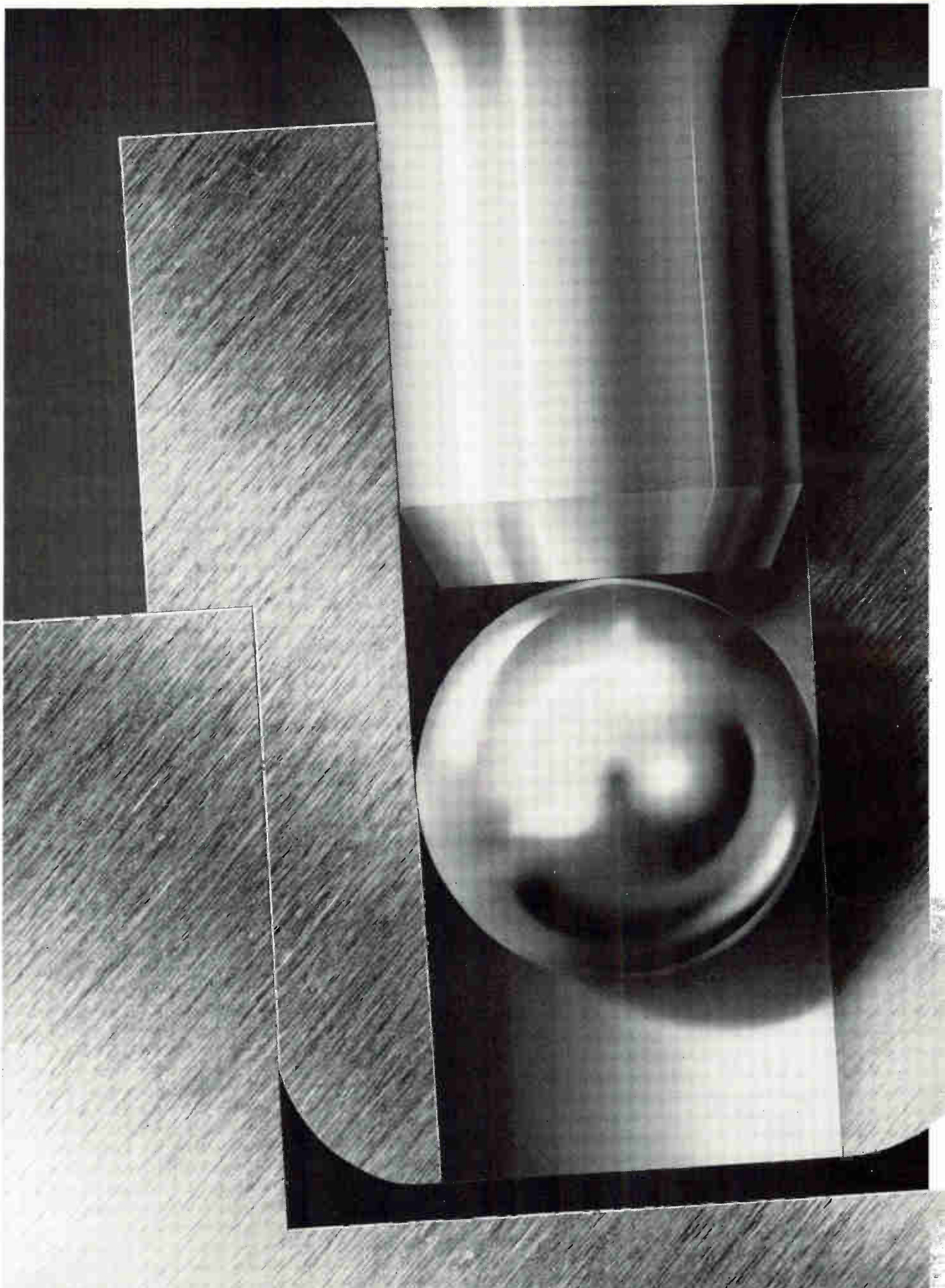
**The complete FLUKE line of differential voltmeters offers a variety of test/measuring instruments to meet every application at minimum cost. Ask for a demonstration or write for detailed information.**

*John Fluke Mfg. Company, Inc. Seattle 33, Wash.* FLUKE INSTRUMENTS
*Box 7428 PR 6-1171 TWX—Halls Lake TLX—852*

All prices FOB Seattle. Prices and data subject to change without notice.



CIRCLE 45 ON READER SERVICE CARD



# MINIMUM FRICTION... ANOTHER REASON WHY AE'S MM-22 MILITARY RELAY APPROACHES ABSOLUTE RELIABILITY

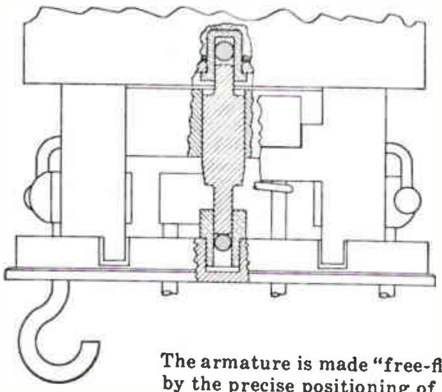
A new approach to armature retention has reduced friction to the point where the rotary armature virtually floats.

As shown in the illustrations, the finely balanced armature rotates between two precision-ground stainless-steel ball bearings. The bearings are press-fitted into the upper and lower phosphor bronze bearing sleeves and automatically located to the exact depth that assures the precise amount of end play for effortless motion.

This close attention to the smallest details in the design of the MM-22 relay has resulted in a degree of reliability heretofore unattainable. For instance, AE MM-22's on miss test show contact resistance of *less than 50 milliohms after 3.5 million operations.*

If your tests of microminiature sealed relays have shown an alarming probability of system failure, then the AE MM-22 is the answer to your problems. For more information, write for Circular 1999 to: The Director, Military Equipment Sales, Automatic Electric, Northlake. Illinois.


AE's MM-22 military relay (2PDT, 3 amp.) shown actual size.

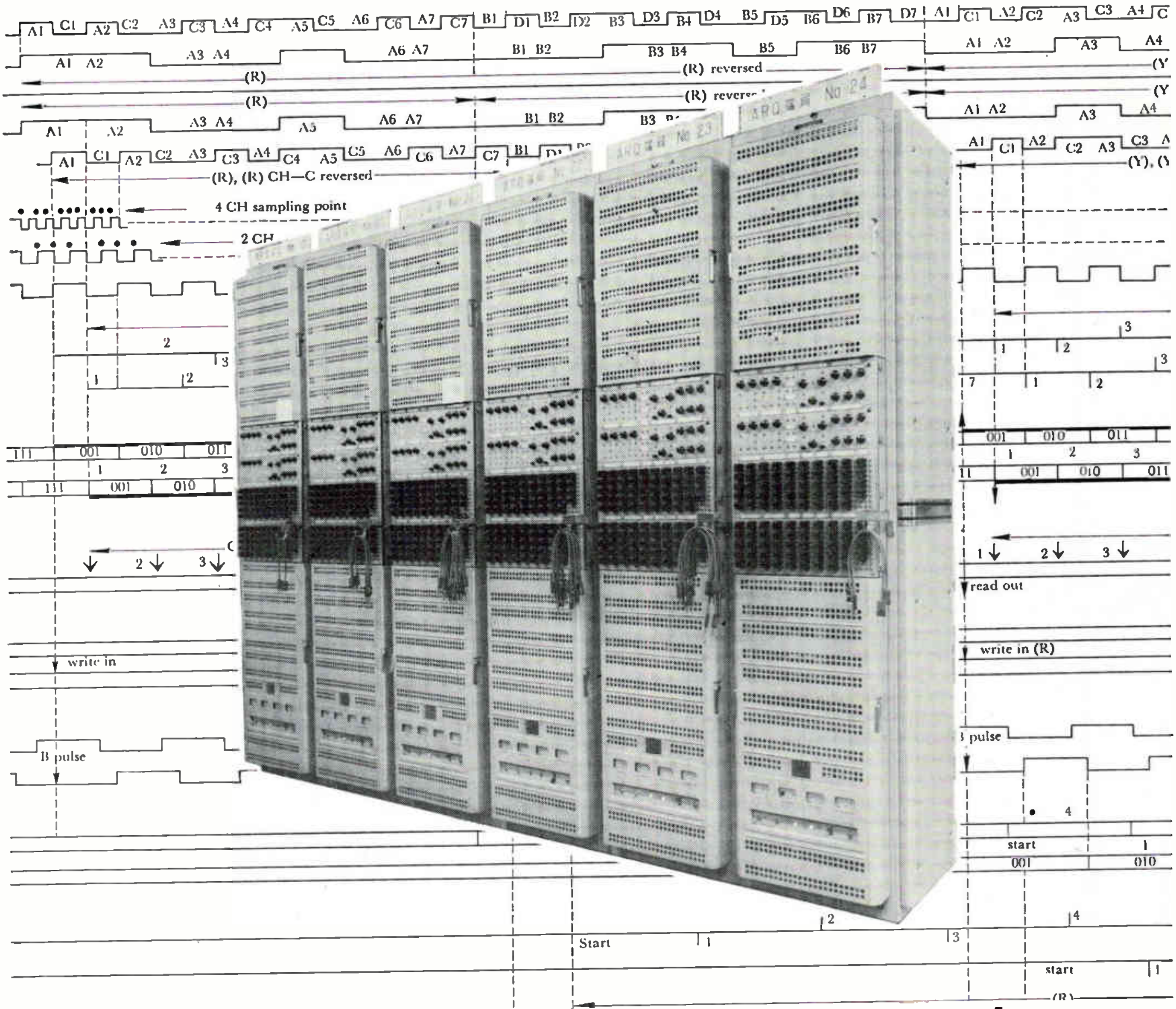


The armature is made "free-floating" by the precise positioning of the ball bearings that support the armature pin. The adjustment is made automatically on each individual relay so that the distance between ball bearings is always the same.

**AUTOMATIC ELECTRIC**

Subsidiary of

**GENERAL TELEPHONE & ELECTRONICS** GENERAL SYSTEM



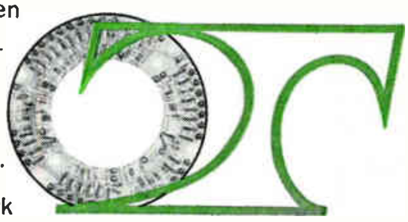

# New Parametronic ARQ equipment requires much less power, no maintenance

**Mitsubishi Electric's TZ-3 ARQ equipment for multiplex telegraphy with automatic error correction employs a new electronic element called the parametron. This device enables the equipment to operate effectively on only one-fourth the power ordinarily required. Unlike regular equipment which depends on mechanical parts, vacuum tubes and semi-conductors, parametronic ARQ equipment requires no routine maintenance and takes up only half as much space making possible considerable savings in installation and operating costs. For complete details on the technical specifications of parametronic equipment and its extensive capabilities, write:**

**MITSUBISHI ELECTRIC MANUFACTURING COMPANY**
**Head Office: Tokyo Building, Marunouchi, Tokyo** **Cable Address: MELCO TOKYO**

# Tempo means aerospace programmer flexibility

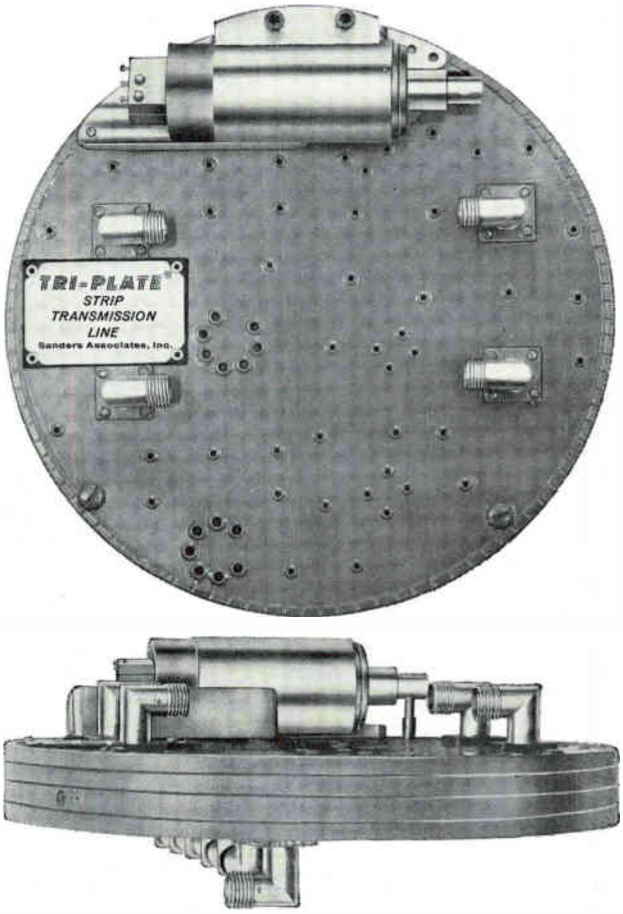
From microseconds to months or years—with an infinite number of stops between—Tempo Programmers automatically trigger a series of events in precisely-timed, predetermined sequence. Modular construction provides flexibility to meet last minute changes in program requirements—a necessity for Quick-Reaction Projects. Count on—and receive—solid-state timing accuracy and reliability in your next project.



**TEMPO INSTRUMENT INCORPORATED** Plainview, L. I., New York

Microwave, semiconductor and fast switching circuits with high density packaging, that heretofore have been thought impractical or impossible to build because of their bulk or complexity, are now successfully produced in TRI-PLATE Strip Transmission Line. □ In breadboarding, packaging and quantity production, what the concept of strip transmission promised, TRI-PLATE techniques deliver — they've made the concept a practical reality! □ TRI-PLATE circuitry provides packaging versatility to solve the most difficult problems. The broadband mono-pulse front end for S-band shown below contains nine hybrid rings, three channel step attenuators, three balanced mixers and six internally mounted 1N831 diodes in a multi-layer package of less than 17 cubic inches. Engineered to conform to the customer's space and size requirements, it measures just $5\frac{3}{4}''$ in diameter and is less than $\frac{5}{8}''$ thick. This is but one example of how TRI-PLATE circuitry makes possible high density packaging which would

# Compact packages made possible with Tri-Plate® techniques




be impossible to achieve with conventional coaxial or waveguide techniques. □ To help you speed the time from design to breadboard to prototype to production with known characteristics, there are more than 600 TRI-PLATE Modules — including over 150 TRI-PLATE Mounts for standard and advanced semiconductor devices — available from Sanders. They let you test new circuit ideas — no matter how different or daring — with speed, ease and economy. You can go from paper schematics to functioning circuits in just minutes to evaluate new design concepts. □ And a system designed in TRI-PLATE Modules can be produced in quantity as an Integrated TRI-PLATE Package, with performance equal to if not better than that of the modular prototype, and with great savings in size and weight. □ For more information about Strip Transmission Line and how TRI-PLATE Products have made it a practical reality, for the latest literature — including specifications and prices — or for consultation regarding your specific requirements, write to Sanders Associates, Inc., Microwave Products Department, Nashua, New Hampshire.

®REG. T.M.; EXTENSIVE PATENT COVERAGE. SANDERS ASSOCIATES, INC.

**CREATING NEW DIRECTIONS IN ELECTRONICS**

**SANDERS TRI-PLATE® STRIP TRANSMISSION LINE**


# RESISTOR RELIABILITY

## FOR SOPHISTICATED MILITARY SYSTEMS

For more than a decade now, Mepco has been producing precision resistor components for Hi-Quality — Hi-Reliability military systems. The superiority of Mepco film resistors has been demonstrated in extensive laboratory test programs and in monitored field installations where a failure rate of .0002% per 1000 hours has been proven.

Mepco can be of assistance to you by supplying finished proven reliability specifications, a testing facility capable of performing all types of MIL environmental testing, and Hi-Rel sealed type carbon or metal film resistors.

If your project includes high-reliability programming for resistor components, a team of Mepco high-reliability specialists will be glad to work with you in the development of standards.

MEPCO

**MEPCO, INC.** MORRISTOWN, NEW JERSEY
Manufacturers of Precision Resistors

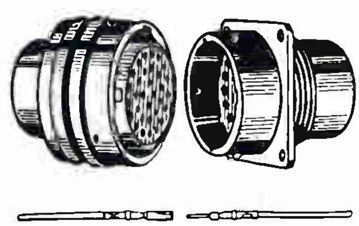

# There are no "weak-ends" in Avnet's delivery of Bendix Connectors.

Your local Avnet headquarters supplements Bendix Scintilla by serving your emergency and prototype Connector requirements quickly and flexibly. Take advantage of Avnet's on-time delivery for your needs of Bendix Pygmy types PT and SP and other special types; Pygmy crimp types PTCE and PTSE; MS, MS-E, MS-R, QWLD, SR rack & panel.

A call to your local Avnet stocking facility will prove that you needn't have "weak-ends" in your delivery of Bendix Connectors.

**BENDIX**

**AVNET**



**AVNET** AVNET ELECTRONICS CORP.

*THE AVNET SYSTEM*
*Men / Methods / Materials / Management*

LOS ANGELES, CAL., 213 UP 0-6141; SUNNYVALE, CAL., 408 RE 6-0300; SEATTLE, WASH., 206 GL 4-4911; PHOENIX, ARIZ., 602-273-1261; SALT LAKE CITY, UTAH, 801-487-7566; CHICAGO, ILL., 312 GL 5-8160; WESTBURY, L. I., N. Y., 516 ED 3-5800; BURLINGTON, MASS., 617 BR 2-3060.

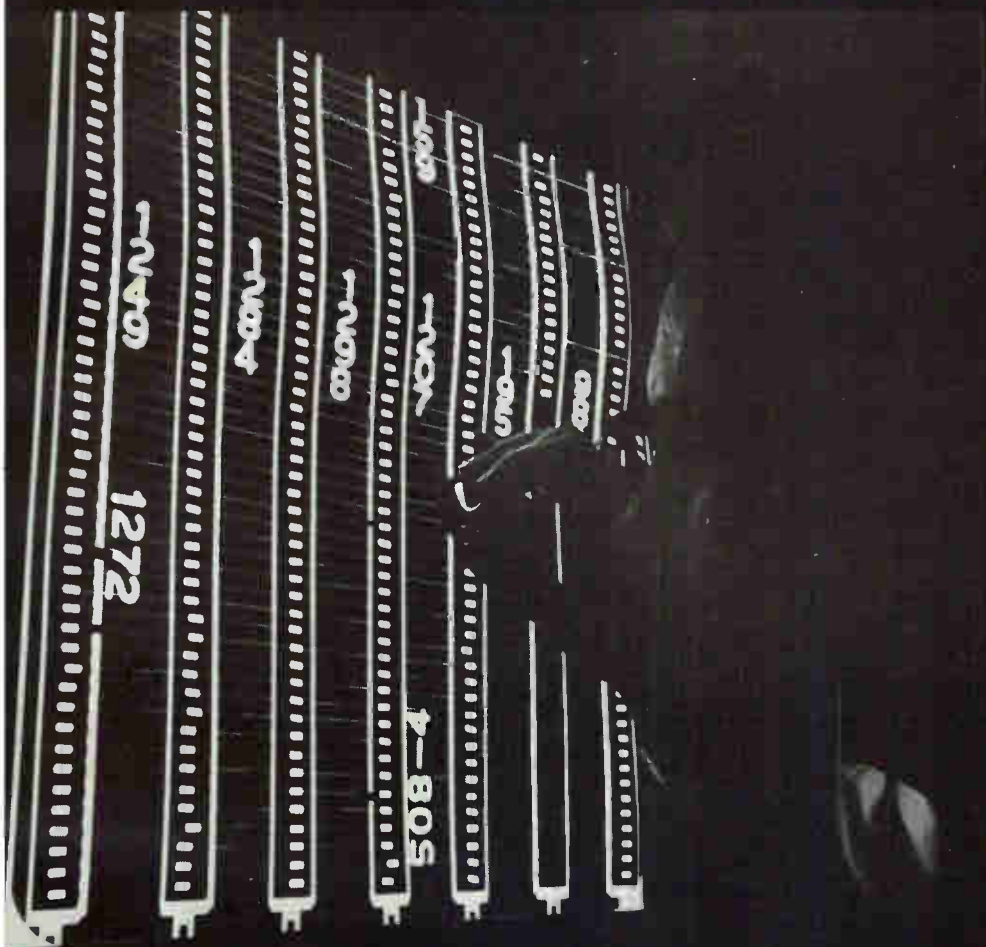
# RELIABILITY: 1962

By JOHN M. CARROLL
Managing Editor

© 1962 **electronics**, a McGraw-Hill Publication

MATHEMATICS OF RELIABILITY

X-RAYS of high-reliability resistors for Minuteman project




SYSTEMS DESIGN

DESIGNING RELIABLE CIRCUITS

LIFE TESTING

PHYSICS OF FAILURE

COMPONENT RELIABILITY

REPRINTS AVAILABLE
SEE READER SERVICE CARD

# INTRODUCTION

*For more than a decade everyone in our industry has been talking*

*demanding it. But even a few years ago a high proportion of all*

**RELIABILITY** has been a concern of both manufacturers and users of electronic equipment since the beginnings of the electronics industry. Reliability is one subject about which everybody has an opinion and in which everybody considers himself to be expert. In the last forty years more has been said and written and more misinformation circulated on the subject of reliability than on any other subject in the field of electronics. Five years ago one could make the same observation about reliability that Mark Twain did about the weather: Reliability was something everybody talked about but nobody did anything about. However, this state of affairs is changing rapidly. Reliability today is becoming as much a quantitative discipline as the design of bandpass filters.

In the popular conception, reliability is linked somehow with quality. Moreover, both these attributes are somehow related in the level of dependable performance consumers have come to expect of a product. And fifty years ago nobody really knew what either quality or reliability was. Consumers would, however, have a feeling that one manufacturer or artisan made a "good" product and others did not do so. In those days the consumer could rely only on the manufacturer's brand name or the artisan's reputation.

**QUALITY CONTROL**—In the 1920's Walter Shewhart of Bell Telephone Laboratories made an important discovery that put the control of quality—which will now be defined as the ability of a product to meet established specifications—on a scientific basis. Shewhart found that in repetitively manufactured products, some defects were purely random while others were attributable to certain definable causes. Furthermore, he found that modern statistics, then less than twenty years old, could be used to identify from small samples the attributable failures and that the corresponding sources of defects could then be eliminated or reduced.

However, statistical quality control didn't really come into its own until World War II. Then a whole method-

# MATHEMATICS

*Modern statistics and probability permit assigning numerical reliability requirements. Even the term reliability is defined as a probability. Knowledge of failure frequency distributions and their parameters is essential in reliability prediction*

**FAILURE DISTRIBUTION**—Assume that time is plotted as the abscissa of a chart and that the time base is divided into equal units. Then on the ordinate can be plotted the number of failures occurring in a given population of units within each segment of time. The result is a series of abutting rectangles called a failure histogram. A smooth curve may be drawn through the tops of the rectangles comprising the histogram and this curve can then be normalized in terms of percent failure of the original population. This results in a failure frequency distribution $f(t)$ that meets the criterion of a frequency distribution in mathematical statistics, namely that its integral from zero to infinity is equal to one.

*about reliability — manufacturers promising it, and customers*

*military electronics equipment was inoperable at any given time*

ology of control charts and statistical procedures was brought to bear on products mass-produced for the Armed Forces. However, these techniques were still measuring only conformity to established specifications and nothing had yet been said about how well or how long the equipment would perform in actual service. Although industry had largely solved its quality-control problems, it had not yet come to grips with its reliability problem.

At first the reliability problem was not too serious. When equipment failed, there were usually enough competent technicians and spare parts around so that it could be repaired and restored to service in a reasonable time. However, in the late 1940's the complexity of electronic equipment increased almost exponentially. The electron-tube complement of late-model equipment went from dozens of electron tubes to hundreds and even thousands. Meanwhile the electronics industry grew so rapidly that an acute shortage of engineers and technicians developed —a shortage plagues us even today. Thus by the early 1950's a Navy survey showed that at any given time 70 percent of all naval electronic equipment was inoperable and Army electronic equipment was just as bad if not worse.[1]

**BASIC APPROACHES**—About this time there were two basic approaches to reliability. The first was set forth by Robert Lusser of the Army Ordnance Corps' Redstone Arsenal in Huntsville, Alabama. Lusser emphasized testing equipment and components to destruction to analyze and understand the failure modes or means by which the items failed. Hopefully these failure modes could then be corrected by better engineeering design or improved manufacturing technology.

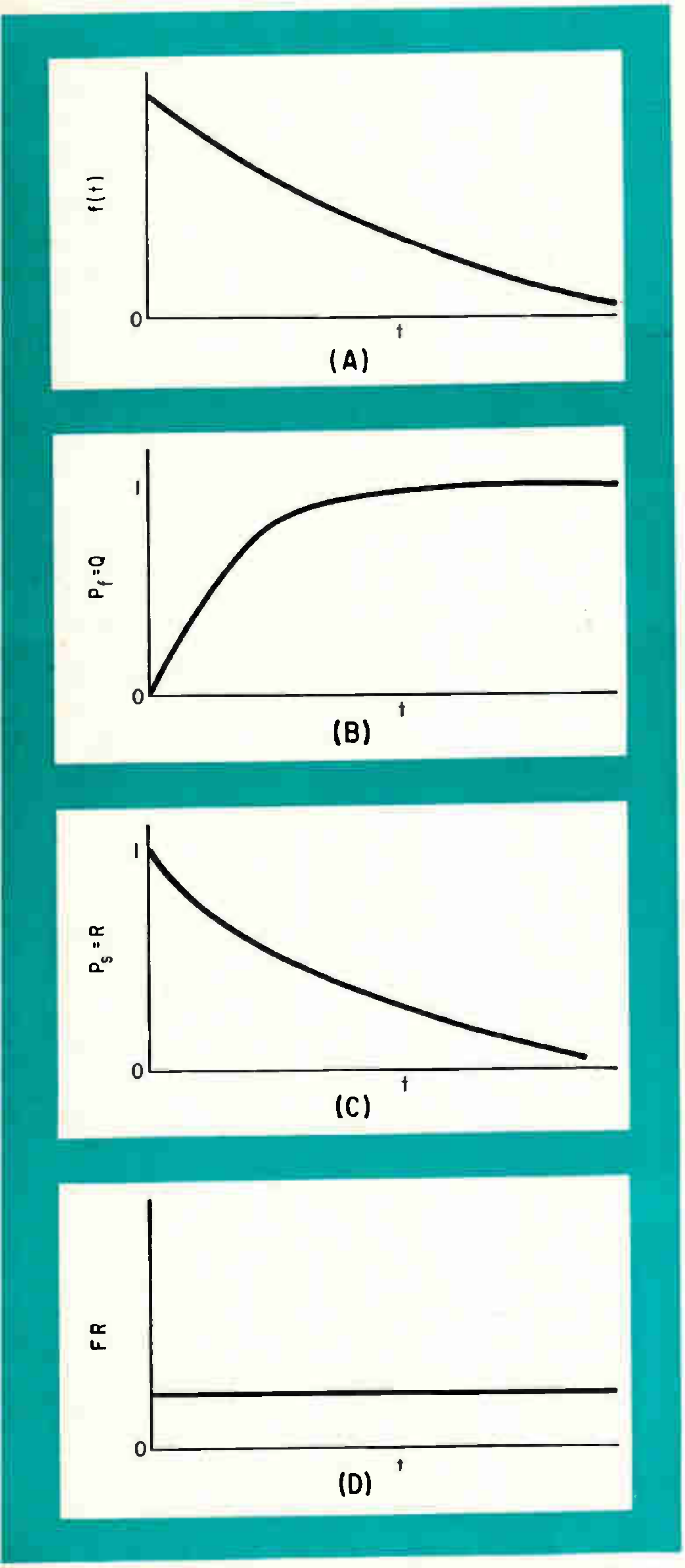
The second approach to reliability was set forth by the late R. R. Carhart of the Rand Corporation in Santa Monica, California. Carhart suggested a statistical analysis of failure data—an approach reminescent of Shewhart's approach to the quality-control problem of earlier times.

# OF RELIABILITY

**RELIABILITY FUNCTION**—Now such a frequency distribution may be integrated point by point to form a cumulative frequency distribution $F(t)$ or CDF. Mathematically this is called a probability function and, in this case, the function is a plot of the probability of failure ($P_f$) as the ordinate against time as the abscissa. If the probability of failure is subtracted point by point from unity, the result is the probability of success ($Ps = 1 - P_f$). And when this is done the resulting curve is called a reliability function, $R = 1 - Q$, where $Q$ is the probability of failure ($P_f$) or the unreliability.

This experimental work leads to a working definition of reliability: reliability is the probability that a unit or a part will perform its intended function under design conditions for a specified period of time. Also inherent in this statement is the definition of failure which is that a part or equipment fails to perform its intended function under operating conditions. Thus a drift in the value of a precision resistor is as much a failure as its burning out completely, while burning out a transistor when it is used far above rated load should not properly be considered a failure.

**EXPONENTIAL FUNCTION**—When engineers began plotting failure distributions for electronic equipment, they found that most of the failure distributions for parts




**EXPONENTIAL** frequency distribution: failure frequency distribution (A), cumulative frequency distribution or probability of failure (B), reliability function or probability of success (C) and failure rate (D)—Fig. 1

already "burned in" or for equipment already "debugged" but still within its designed useful life took on the shape of a negative-exponential curve as shown in Fig 1A. Its failure frequency took the form

$$f(t) = \frac{1}{m} \exp[-(t/m)]$$

where $t$ is mission time and $m$ is mean time between failures or MTBF.

Mean time between failures is estimated by putting several equipments on life test under controlled conditions and recording the operating time in hours until each one fails. When a unit fails, it is repaired and the time until it fails again is recorded. The average length in hours of these operating periods is an estimate of $m$ and is called MTBF.

When equipment or parts cannot be repaired, the operating time to each failure is recorded and the average length in hours determined. This quantity is sometimes called MTTF or mean time to failure. In both cases, these means estimate parameter $m$.

The negative exponential failure frequency function integrates to

$$P_f = F(t) = 1 - e^{-t/m}$$

and reliability is given by

$$R = P_s = e^{-t/m}$$

Figure 1B is the cumulative distribution function and Fig. 1C is the reliability function.

**NORMAL DISTRIBUTION**—On the other hand when engineers plotted the failure experience with mechanical parts such as rotating machinery, they found the failure frequency distribution had the classical bell-shaped, normal or gaussian distribution shown in Fig. 2A.

A normal failure frequency distribution function has the form

$$f(t) = \frac{1}{\sigma\sqrt{2\pi}} \exp[-(t-m)^2/2\sigma^2]$$

where sigma is the standard deviation and is estimated by random variable $S$ where

$$S^2 = \sum_{i=1}^{n} (t_i - \bar{m})^2/(n-1)$$

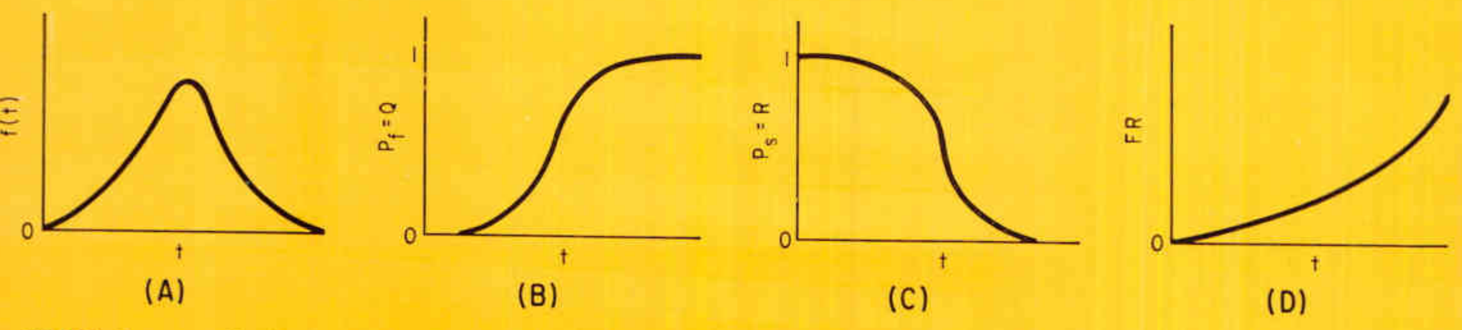
where $t_i$ is any operating period, $\bar{m}$ is the MTBF and $n$ is the number of operating periods.

The gaussian CDF (Fig. 2B) is equal to

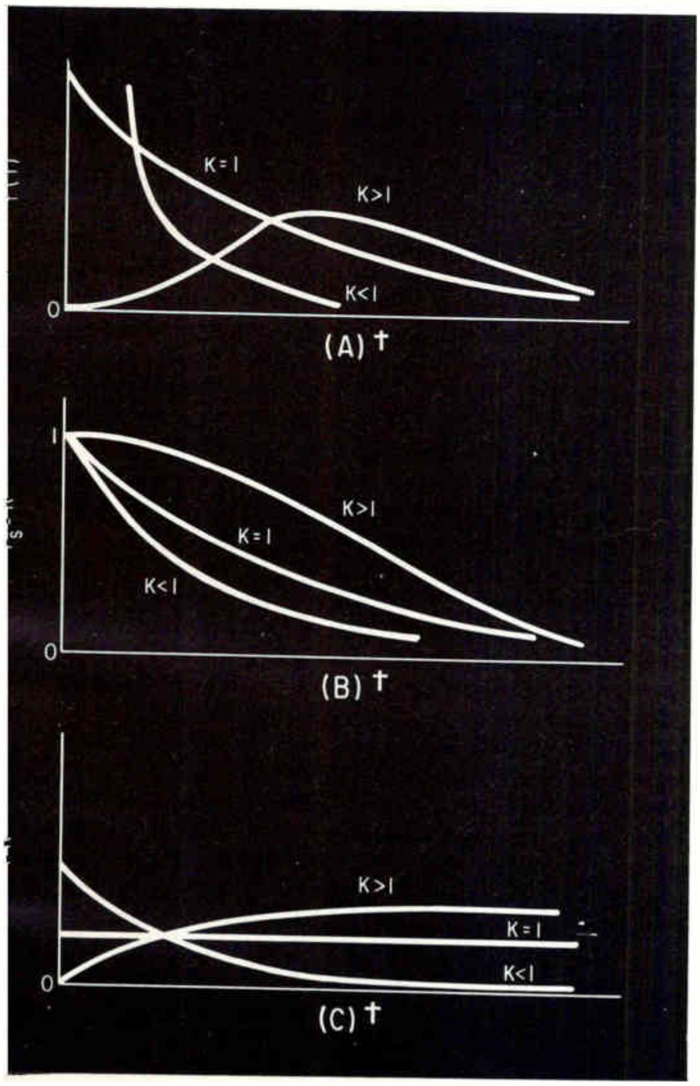
$$P_f = F(t) = \int_0^t f(t)\,dt$$

for which complete tables are available. And reliability (Fig. 2C) is simply

$$R = P_s = 1 - Q = 1 - \int_0^t f(t)\,dt$$




**NORMAL** frequency distribution: failure frequency distribution (A), probability of failure (B), reliability (C) and failure rate (D)—Fig. 2




**GAMMA** frequency distribution: failure frequency distributions (A), reliability functions (B) and failure rates (C)—Fig. 3

But there were some types of equipment whose failure experience would be fitted by neither the negative exponential nor by the gaussian curve. So mathematicians looked for other functions to fit experience in such cases. They tried the gamma distribution illustrated in Fig. 3. And they tried the beta distribution. They achieved success in certain limited cases.

**WEIBULL DISTRIBUTION**—Then they tried, with greater success, the Weibull distribution shown in Fig. 4. The Weibull distribution is a special case of the gamma distribution and includes parameters alpha and beta, known respectively as the scaling and shaping parameters. Generally in reliability work alpha is set equal to one. Parameter beta corresponds to K in the gamma distribution. Now if beta is set equal to one, the negative exponential distribution results (Fig. 4A). And if beta is set equal to three or more the curve begins to approach the gaussian distribution (Fig. 4C). When beta is less than one, the distribution looks something like the negative exponential but has a much steeper dropoff (Fig. 4B). The Weibull distribution has turned out to be extremely useful in reliability work. Corning Glass, for example, reports upon running failure tests on 29,000 fixed glass capacitors for a total of 166 million test hours that a Weibull failure distribution results.[2]

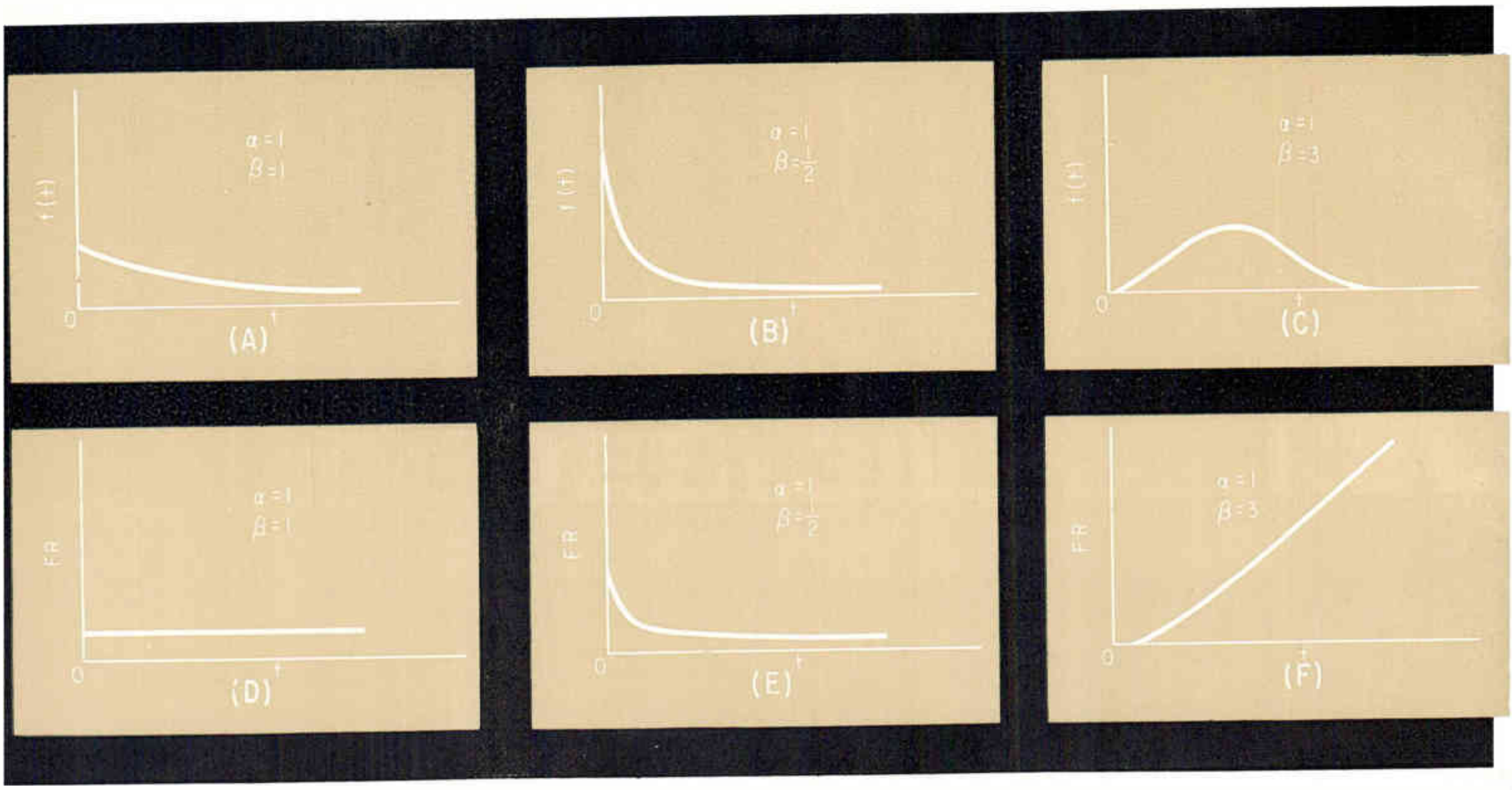
In the Weibull distribution

$$f(t) = \alpha\beta t^{(\beta-1)} \exp\left(-\alpha t\right)^{\beta}$$

where

$$m = \alpha \left(\frac{1}{\beta}\right)!$$

**FAILURE RATE**—An important concept in reliability work is that of failure rate or lambda. Failure rate is defined mathematically as the integral of the failure frequency distribution taken from some time $t$ to another time $t + h$ divided by the integral of the failure frequency distribution taken from $t$ to infinity. Quantity $h$




**WEIBULL** frequency distributions: failure frequency distributions (A to C), failure rates (D to F)—Fig. 4

is the basic unit of time, taken usually as one hour

$$FR = \lambda = \int_{t}^{t+h} f(t)\,dt \Bigg/ \int_{t}^{\infty} f(t)\,dt$$

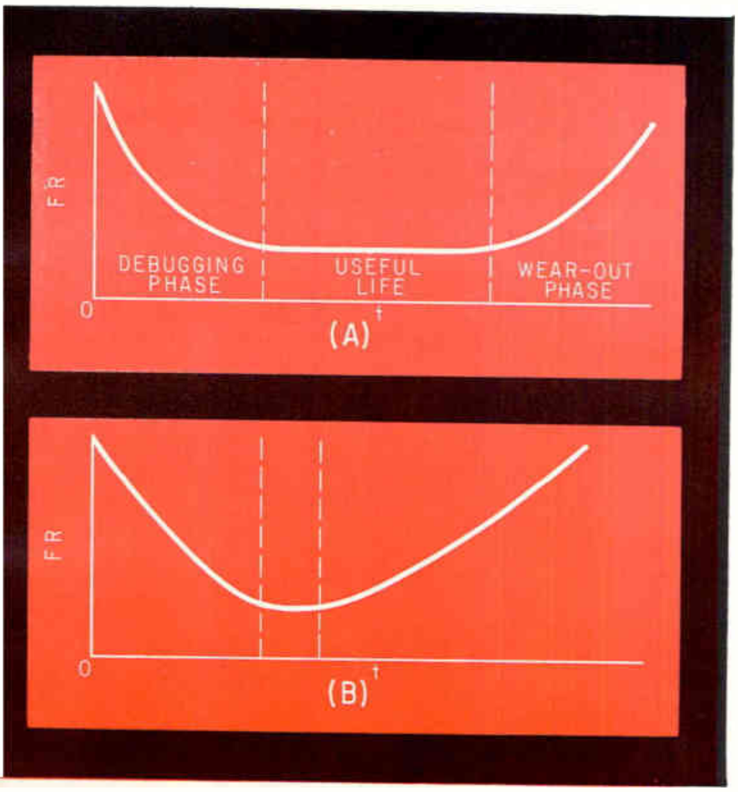
For the negative exponential distribution failure rate lambda turns out to be a constant and equal to $1/m$; where $m$ is estimated by MTBF. This is shown graphically in Fig. 1D. Thus lambda may have the dimensions of failures per hour, percent failure per thousand hours ($10^{-5}$) or failures per million hours ($10^{-6}$). The constant-failure-rate property of most electronic equipment makes it follow the negative exponential curve of failure frequency distribution and forms the basis of the whole science of electronics reliability engineering as it exists today.

The normal distribution leads to an entirely different and more complex situation. Here there is a constantly increasing failure rate, Fig. 2D. Again, the Weibull distribution gives a failure rate that depends upon the value of beta. Failure rate is increasing when beta is greater than one (Fig. 4F); it is constant when beta is equal to one (Fig. 4D); and it is decreasing when beta is less than one (Fig. 4E).

**BATHTUB CURVE**—In plotting the failure rate of electronic equipment from the cradle to the grave, it is seen that the equipment follows the exponential or constant-failure-rate curve during only part of its lifetime. But this part represents the useful life and consequently is the period that concerns us the most. Useful life is also known as the longevity, normal operating portion, poisson portion, and the random-failure portion as well as the constant-failure-rate portion.

This failure-rate curve from cradle to grave takes on the classic bathtub shape that is basic to reliability engineering, Fig. 5A. This bathtub curve is also characteristic in human mortality experience and there are three distinct regions. The first region is characterized by a decreasing failure rate, which would correspond to a Weibull distribution with a beta less than one. This is known to engineers as the debugging phase. It is also called the early-failure portion or the infant-mortality portion of the curve. The other sloping side of the bathtub represents a constantly increasing failure rate and denotes the wearout phase of life during which a piece of equipment can be no longer economically maintained. It represents a gaussian failure frequency distribution.

Going back for analogy to the human-mortality tables, for male Americans the infant-mortality phase of life effectively ends at about age thirteen, while the wearout phase begins at about age thirty-five. Electronic equipment is characterized by a long useful life and this is what makes the exponential failure law so important in electronics reliability engineering (Fig. 5A). Mechanical equipment, on the other hand, is characterized by a short longevity (Fig. 5B) and it may indeed be said that mechanical parts are from, the time they are manufactured,




**BATHTUB** failure-rate curve for electronic equipment (A) and for mechanical equipment (B)—Fig. 5

embarked on a constantly accelerating journey to the scrap heap.

**FAILURE-RATE DATA**—The key to reliability prediction is the failure rates of the components making up electronic equipment. Much parts-failure-rate data has been collected in the last five years, although in some cases these data are today justly regarded as apochryphal. Generally, failure rates are expressed in percent failures per thousand hours or in failures per million hours. However, other scales are useful with special types of components such as batteries, where failure rates are expressed in failures per million charge/discharge cycles or in relays where failure rates are given in failures per million cycles of operation. Table I lists different methods of reporting failure rates for special classes of components.[3]

**RELIABILITY CALCULATIONS**—Use of the exponential failure law can be illustrated by a simple example. Given that an aircraft bombing-navigation system must demonstrate 90-percent reliability for a 10-hour mission, what should be the MTBF?

$$R = \exp(-t/m)$$
$$m = 1/0.0105 = 95 \text{ hours}$$

If the reliability were to be 99 percent for a 10-hour mission, MTBF would have to be 1,000 hours. The valves given in Table II help in reliability calculations.

## UNITS FOR EXPRESSING FAILURE RATES — TABLE I

| COMPONENT | UNIT |
|---|---|
| battery | failures/$10^6$ charge-discharge cycles |
| bolt, explosive | failures/$10^6$ cycles of operation |
| connector | failures/$10^6$ hours/pin |
| magnetic amplifier | failures/$10^6$ hours/core |
| Primacord | failures/$10^6$ cycles of operation |
| Jato rocket | failures/$10^6$ cycles of operation |
| relay | failures/$10^6$ cycles of operation |
| switch | failures/$10^6$ cycles of operation |
| socket | failures/$10^6$ hours/pin |
| cathode-ray tube | failures/$10^6$ hours/gun |

## VALUES FOR RELIABILITY CALCULATIONS — TABLE II

| x | $e^{-x}$ | x | ln x |
|---|---|---|---|
| 0.01 | 0.99005 | 0.7 | −10 + 9.643 |
| 0.02 | 0.98020 | 0.8 | −10 + 9.777 |
| 0.05 | 0.95123 | 0.9 | −10 + 9.895 |
| 0.07 | 0.93239 | 0.95 | −10 + 9.949 |
| 0.09 | 0.91393 | 0.99 | −10 + 9.990 |
| 0.10 | 0.90484 | | |

# LIFE TESTING

*The reliability of a small sample can tell a lot about what to expect from a production run if you analyze the data properly. New sequential testing techniques are gaining wide favor. But are we in danger of life testing ourselves into national bankruptcy?*

In practice, the reliability of a class of equipment or component part is determined by life-testing samples selected randomly from a larger population. The act of making predictions about the behavior of a large population is known as statistical inference. Statistical inference does not tell how any given unit from a population will behave but it does permit making a statement that, for example, 95 percent of the units in a population will have a minimum MTBF of 200 hours. The interval from 0 to 95 percent is called the confidence interval.

**CHI-SQUARED DISTRIBUTION**—In reliability testing another frequency distribution known as the chi-squared distribution is frequently useful. From a normal distribution with a mean $\mu$ and a variance $\sigma^2$, $n$ independent observations $x_1, \ldots, x_n$ are made and the so-called standardized variables computed

$$u_i = (x_i - \mu)/\sigma$$

The quantity

$$\chi^2(n) = \sum_{i=1}^{n} u_i^2$$

is called chi squared. Now if several values of chi squared are computed, the distribution of their appearances $f(\chi^2)$ can be plotted against values of chi squared to produce a frequency distribution function. The mean of the chi-squared distribution is $n$, the sample size, and the variance is equal to $2n$.

The negative exponential distribution is a special case of the more general chi-squared distribution with two degrees of freedom. (See Fig. 6A). In this application the term two degrees of freedom refers to a sample size of two used in deriving the chi-squared function. Therefore, $\chi^2$ (2 df) $= 2t/m$ and for a random sample of life-test results $(t_1, t_2, \ldots, t_n)$

$$\chi^2 (2n \text{ df}) = 2n\bar{t}/m$$

where $\bar{t}$ is the mean of the sample times. Extensive tables of the chi-squared distribution are available. An abbreviated table is presented in Table III. This table tabulates degrees of freedom against probability in percent, which for this purpose corresponds to the confidence level.

**PRACTICAL EXAMPLE**—As an example[4] consider that five pieces of equipment are put on life test and the following results are achieved: 3, 5, 179, 229 and 204 hours until failure. The first step is to estimate mean time betwen failures. This is estimated by

$$\sum_{i=1}^{n} t_i/n = 1{,}020/5 = 204 \text{ hours}$$

Next, find the minimum true mean time between failures at the 95-percent confidence level. With a sample size of 5 there are $5 \times 2 = 10$ degrees of freedom. Since only the minimum true MTBF is sought the upper tail of the chi-squared distribution curve is selected. See Fig. 6B.

Note that the chi-squared distribution for 10 degrees of freedom begins to look a normal distribution (Fig. 6A). Looking at Table III, $\chi^2$ for 10 df at the 95-percent confidence level corresponds to $\chi^2 = 18.3$.

A probability equation may now be set up stating that the probability is 95 percent that chi squared is greater than or equal to 0 and less than or equal to 18.3. Recalling that

$$\chi^2 = \frac{2n\bar{t}}{m} = \frac{2{,}040}{m}$$

$$\text{Prob} \left(0 \leq \frac{2{,}040}{m} \leq 18.3\right) = 0.95$$

and

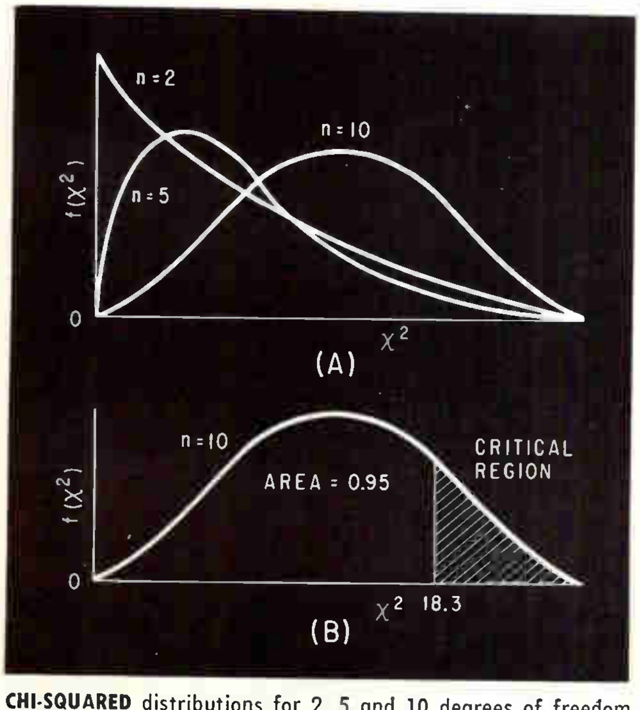
$$\text{Prob} (111.5 \leq m \leq \infty) = 0.95$$

This means at the 95-percent confidence level, the mean time between failures is at least 111.5 hours.

To determine the reliability of the equipment for a mission time of 50 hours $R = \exp(-50/111.5) = 0.638$ or a reliability of 63.8 percent. If, however, the MTBF must be known with 99-percent confidence then we can state only that minimum MTBF is 88 hours and the reliability for this particular application is 56.7 percent.

**POISSON DISTRIBUTION**—The problem of reliability testing can also be examined from the point of view of the poisson distribution. The poisson distribution is a discrete distribution as opposed to continuous distributions such as the exponential, normal or chi squared. It

**RELIABILITY** test of transistors at Raytheon's Mountain View, Calif. plant




**CHI-SQUARED** distributions for 2, 5 and 10 degrees of freedom (A) and chi-squared distribution showing one-tailed test at 95-percent confidence level (B)—Fig. 6

### FRACTILES OF CHI-SQUARED DISTRIBUTION — TABLE III

| DEGREES OF FREEDOM | PROBABILITY IN PERCENT 90.0 | 95.00 | 99.0 |
|---|---|---|---|
| 2 | 4.61 | 5.99 | 9.21 |
| 4 | 7.79 | 9.49 | 13.3 |
| 6 | 10.6 | 12.6 | 16.8 |
| 8 | 13.4 | 15.5 | 20.1 |
| 10 | 16.0 | 18.3 | 23.2 |

minimum of 600 hours of operation without failure must be achieved but this only gets into the accept region. The test would have to continue at least 1,800 hours before any decision could be made to accept or reject the equipment.

**INDUSTRY EXPERIENCE**—Today most major military contracts have numerical reliability requirements and provide for tasks to be performed by contractors. Much of the accepting testing done today is done to Agree standards. But the first implementation of the Agree testing procedures was done at Hoffman Electronics.[6] The firm contracted to manufacture 10,000 airborne Tacan navigational transceivers model AN/ANK-21C for the Air Force. Hoffman had already made 3,000 Tacan airborne sets for the Navy to conventional specifications.

# DESIGNING RELIABLE

*The proof of the pudding may indeed be in the eating but the electronics engineer can make a good estimate of the reliability of a circuit before it even gets to the breadboard. The key to design of reliable circuits is to know your basic components well*

**SAMPLE RELIABILITY CALCULATION**

| | | |
|---|---|---|
| capacitors | 3 × 0.01 | = 0.03 |
| diode | 1 × 0.20 | = 0.20 |
| joints | 22 × 0.008 | = 0.18 |
| potentiometer | 1 × 0.25 | = 0.25 |
| resistors | 6 × 0.25 | = 1.50 |
| solenoid | 1 × 0.05 | = 0.05 |
| switch | 1 × (negligible) | |
| transistors | 2 × 0.50 | = 1.00 |
| | | 3.21 × 150 = 481.5 |

MTBF = $10^6/481.5$ = 2,077 hours
R = exp (−200/2,077) = 0.908 = 90.8 percent

Despite the recent emphasis on testing both in reliability and quality control work, an astute observation credited years ago to some unknown quality-control engineer still holds true: "You cannot make a Ford into a Cadillac by inspecting it." The truth about reliability is that it must be built into a part, circuit or system from the beginning. Unless reliability is designed into a unit no amount of inspection, repair or modification will gain back the lost opportunity of making a reliable unit in the first place.

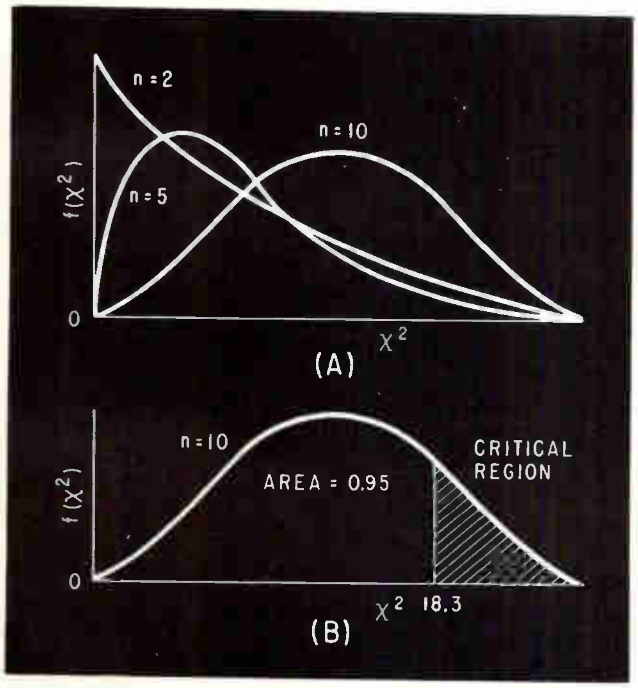
Fortunately, the constant-failure-rate characteristic of most electronic components makes it possible for the engineer to estimate the reliability of a proposed system before it ever comes to the breadboard stage, and in many cases, a quantitative estimate of reliability must be part of a bid for a government contract.

**INITIAL ESTIMATE**—An initial reliability estimate for electronic products can be made by merely counting the number and type of active elements in the product and specifying the environment in which it will be operated. This can be accomplished using the chart of Figure 9.[7] The chart is applicable to any heterogeneous equipment with at least 10 active elements. Active elements include electron tubes, transistors, relays, capacitors and diodes.

This initial estimate is, however, only the first step in reliability synthesis. The next step is to determine the reliability of the equipment circuit by circuit using the failure rates of each component. When two components are in series in a reliability sense, their total reliability is the product of the two reliabilities. Consequently, their combined failure rate is the sum of their two failure rates. Figure 10A illustrates this concept. The term series is used here in a reliability sense not in a circuit-analysis sense. Two components of a circuit are considered to be in series as far as reliability is concerned if the failure of either component will cause the circuit to fail.

**CIRCUIT ANALYSIS**—Figure 11 is a simple transistor control circuit for which it is desired to estimate reli-

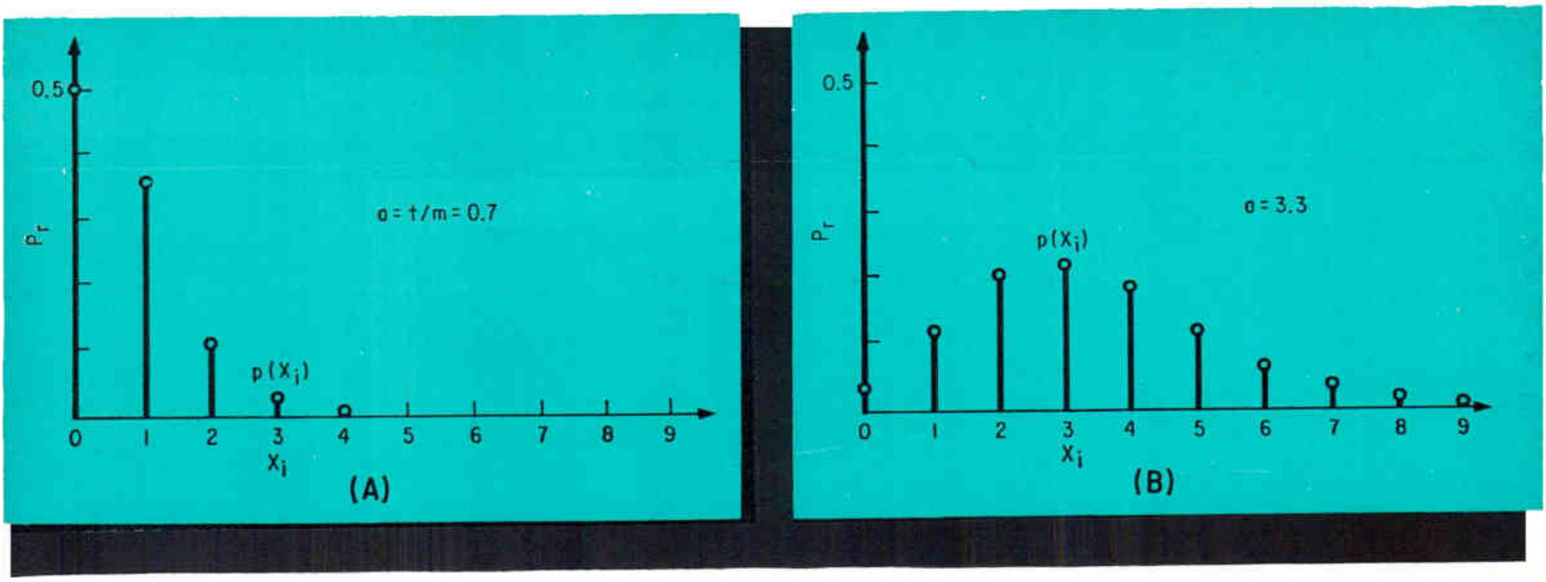
**RELIABILITY** test of transistors at Raytheon's Mountain View, Calif. plant




**CHI-SQUARED** distributions for 2, 5 and 10 degrees of freedom (A) and chi-squared distribution showing one-tailed test at 95-percent confidence level (B)—Fig. 6

### FRACTILES OF CHI-SQUARED DISTRIBUTION — TABLE III

| DEGREES OF FREEDOM | PROBABILITY IN PERCENT 90.0 | 95.00 | 99.0 |
|---|---|---|---|
| 2 | 4.61 | 5.99 | 9.21 |
| 4 | 7.79 | 9.49 | 13.3 |
| 6 | 10.6 | 12.6 | 16.8 |
| 8 | 13.4 | 15.5 | 20.1 |
| 10 | 16.0 | 18.3 | 23.2 |




**POISSON** distributions for *a* equal to 0.7 (A) and for *a* equal to 3.3 (B)—Fig. 7

is used to perform probability studies on events that occur infrequently. Two poisson functions are illustrated in Fig. 7.

Suppose a piece of equipment is observed for a long period of time. And this period of time is then divided into many smaller time periods of equal length. A count is made of the time periods in which no failures are observed, in which one failure is observed, two failures and so on. Then these data are normalized with respect to the total number of time periods observed and the probability of failure plotted against $x$, the number of failures in a given time period $(0, 1, 2, \ldots n)$.

The poisson distribution function is defined as the probability of $x$ failures occurring in a time period 0 to $t_1$, that is

$$p(x) = e^{-a}\, a^x / x\,!$$

where $a = t/m$. When $x = 0$ this represents the probability that no failures occur in the test interval.

In the poisson distribution, as in all discrete frequency distributions, the cumulative frequency distribution or probability function is derived by summation rather than integration. This is to say, adding up the probabilities of no failures in the unit time period, one failure, 2 failures and so on. This summation, of course, is equal to unity, which fulfills the requirements of a probability function.

In determining confidence levels in the poisson situation, work with a chi-squared distribution having $(2x + 2)$ degrees of freedom. In this case, chi squared equals quantity 2A.

**CALCULATION**—As an example:[4] find how long a piece of equipment must be run on test without failure to demonstrate at the 95-percent confidence level a reliability of 99 percent or greater for a two-hour mission.

Reliability is given by

$$R = \exp(-t/m)$$

and

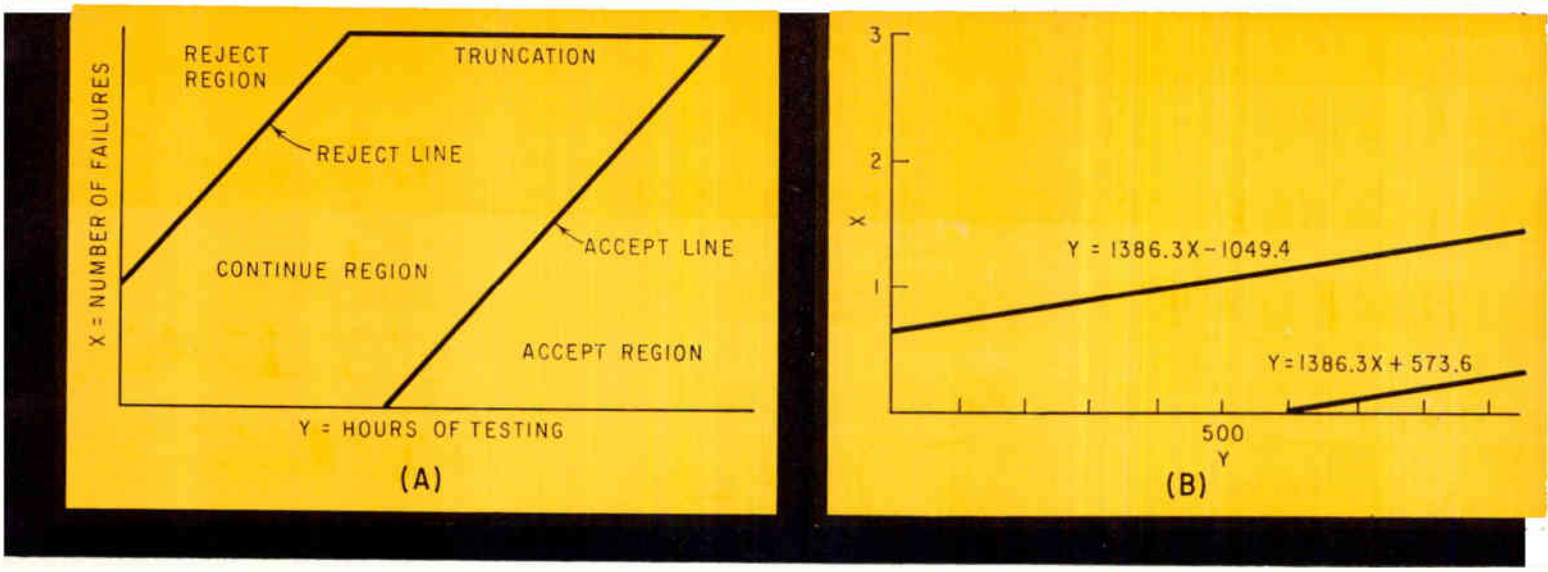
$0.99 = \exp(-2/m)$ or $m = 200$ hours MTBF. A probability equation is set up to determine $A$, the poisson constant, equal to $t/m$, such that

$$\text{Prob}\ (0 \leq a \leq A) = 0.95$$

Since this is a poisson case and there is to be no fail-

## AGREE TEST ENVIRONMENTS — TABLE IV

| ENVIRONMENT | LEVEL OF SEVERITY L | M | H | X |
|---|---|---|---|---|
| Temperature | 25 ± 5°C | 40 ± 5°C | cycled −55 to 55°C | cycled −65 to 70°C |
| Vibration | none | 25 ± 5 cps ± 1/32 in. max amplitude | same as M | same as M |
| Input Voltage | nominal | max permissible +0, −2% | same as M | same as M |
| On-Off Cycling | Three hours on plus long enough to stabilize at both high and low temperatures by actual measurement | | | |




**SEQUENTIAL TESTING** setup for AGREE testing (A) and results of example given in text (B)—Fig. 8

ure within the time period studied, $x = 0$, consult Table III to find the 95-percent confidence level with two degrees of freedom. Here chi squared = 5.99 and constant $A = 3$. The probability equation becomes

$$\text{Prob}\ (0 \leq \frac{t}{200} \leq 3) = 0.95$$

which requires a test time $t$ of 600 hours. If this test is to be conducted at 99-percent confidence level, test time $t$ = 1,842 hours or 77 days.

**SEQUENTIAL TESTING**—One of the most important developments in the field of reliability testing was the report of the Advisory Group on Reliability of Electronic Equipment, or so-called Agree Report, published in 1957.[5] One portion of this report recommends standards for acceptance testing of electronic equipment based on the technique of sequential testing. The Agree Report recommends four levels of severity of environment: L, M, H and X corresponding to low, medium, high and extra high. These environments include operation at elevated ambient temperatures, which may involve temperature cycling; operation under conditions of vibration; varying input voltage; and on-off cycling. The environmental requirements of the Agree Report are shown in Table IV.

In sequential testing a chart is set up in which the number of failures $x$ is plotted as the ordinate and test time $y$ is plotted as the abscissa as shown in Fig. 8A. The $xy$ plane in the first quadrant is divided into three regions by two parallel lines of positive slope.[3] The lower line is called the accept line; the upper line is called the reject line. The three regions are called the accept region, continue-to-test or continue region and reject region. The equation of the accept line is

$$y = (\ln k/C)\,x - (\ln B/C)$$

The equation for the reject line is

$$y = (\ln k/C)\,x - (\ln A/C)$$

where $A = (1 - \beta)/\alpha$
$B = \beta/(1 - \alpha)$
$k = T_1/T_2$
and $C = (1/T_2) - (1/T_1)$

Quantity $\alpha$ is defined as the producer's risk. This is the risk of incorrectly rejecting a good item because of an unfavorable test report. Quantity $\beta$ is defined as the consumer's risk or the risk of incorrectly accepting a poor item because of a good test report. Factor $T_1$ is the contract mean time between failures, while $T_2$ is the minimum acceptable MTBF. The contract usually establishes $T_2$ and $\beta$; the manufacturer may then select $T_1$ in accordance with the test plan he is going to follow and frequently sets $\alpha$ equal to $\beta$. Two common test plans are in use: the 2/1 plan and 3/2 plan.

The first plan implies a $T_1/T_2$ ratio equal to two. This is the loosest requirement recommended in the Agree Report. In a 2/1 plan, the manufacturer can truncate the test even if still in the continue region at 14 times MTBF or $T_1$. However, a 3/2 plan is often required and in this case, he can truncate in the continue region only after 33 times MTBF. In any event he must wait 3 times MTBF before making any decision to accept or reject.

**EXAMPLE**—Consider the testing example given in the poisson case now carried out under the Agree test procedure. It is required to demonstrate an MTBF of 200 hours. A customer wants to take no more than a 5-percent chance of accepting a defective unit. In this work consumers' risk is equivalent to the confidence level of the test.

Now the manufacturer must set $T_1$ equal to 200 hours and $\beta$ equal to 0.05. Assume a 2/1 test plan and set $T_2$ equal to 100 hours. Let $\alpha$ equal 0.05 meaning the manufacturer will take no more than a 5-percent risk of failing to ship an acceptable unit. In this example

$A = (1 - \beta)/\alpha = 19$
$B = \beta/(1 - \alpha) = 0.053$
$K = T_1/T_2 = 2$
and $C = (1/T_2 - 1/T_1) = 0.005$

The equation for the accept line is therefore

$$y = 1{,}386.3x + 573.6$$

The equation for the reject line is

$$y = 1{,}386.3x - 1{,}049.4$$

These lines are plotted in Fig. 8B.

The results illustrate the severity of Agree testing. Note that under these conditions, as in the poisson case, a minimum of 600 hours of operation without failure must be achieved but this only gets into the accept region. The test would have to continue at least 1,800 hours before any decision could be made to accept or reject the equipment.

**INDUSTRY EXPERIENCE**—Today most major military contracts have numerical reliability requirements and provide for tasks to be performed by contractors. Much of the accepting testing done today is done to Agree standards. But the first implementation of the Agree testing procedures was done at Hoffman Electronics.[6] The firm contracted to manufacture 10,000 airborne Tacan navigational transceivers model AN/ANK-21C for the Air Force. Hoffman had already made 3,000 Tacan airborne sets for the Navy to conventional specifications.

# DESIGNING RELIABLE

*The proof of the pudding may indeed be in the eating but the electronics engineer can make a good estimate of the reliability of a circuit before it even gets to the breadboard. The key to design of reliable circuits is to know your basic components well*

**SAMPLE RELIABILITY CALCULATION**

| | | | |
|---|---|---|---|
| capacitors | 3 × 0.01 | = 0.03 | |
| diode | 1 × 0.20 | = 0.20 | |
| joints | 22 × 0.008 | = 0.18 | |
| potentiometer | 1 × 0.25 | = 0.25 | |
| resistors | 6 × 0.25 | = 1.50 | |
| solenoid | 1 × 0.05 | = 0.05 | |
| switch | 1 × (negligible) | | |
| transistors | 2 × 0.50 | = 1.00 | |
| | | 3.21 | × 150 = 481.5 |

MTBF = $10^6/481.5$ = 2,077 hours

R = exp (–200/2,077) = 0.908 = 90.8 percent

Despite the recent emphasis on testing both in reliability and quality control work, an astute observation credited years ago to some unknown quality-control engineer still holds true: "You cannot make a Ford into a Cadillac by inspecting it." The truth about reliability is that it must be built into a part, circuit or system from the beginning. Unless reliability is designed into a unit no amount of inspection, repair or modification will gain back the lost opportunity of making a reliable unit in the first place.

Fortunately, the constant-failure-rate characteristic of most electronic components makes it possible for the engineer to estimate the reliability of a proposed system before it ever comes to the breadboard stage, and in many cases, a quantitative estimate of reliability must be part of a bid for a government contract.

**INITIAL ESTIMATE**—An initial reliability estimate for electronic products can be made by merely counting the number and type of active elements in the product and specifying the environment in which it will be operated. This can be accomplished using the chart of Figure 9.[7] The chart is applicable to any heterogeneous equipment with at least 10 active elements. Active elements include electron tubes, transistors, relays, capacitors and diodes.

This initial estimate is, however, only the first step in reliability synthesis. The next step is to determine the reliability of the equipment circuit by circuit using the failure rates of each component. When two components are in series in a reliability sense, their total reliability is the product of the two reliabilities. Consequently, their combined failure rate is the sum of their two failure rates. Figure 10A illustrates this concept. The term series is used here in a reliability sense not in a circuit-analysis sense. Two components of a circuit are considered to be in series as far as reliability is concerned if the failure of either component will cause the circuit to fail.

**CIRCUIT ANALYSIS**—Figure 11 is a simple transistor control circuit for which it is desired to estimate reli-

The Air Force, however, required a demonstrated mean time between failure of 150 hours and a longevity of 2,000 hours. The tests were to be conducted at Agree testing level H and a confidence level of 90 percent. The contract required testing of 60 sets out of 1,000 sets manufactured each month. Total test time was to be 3,150 hours with less than 20 units failing and no more than 6 failures in any one piece of equipment.

Tests run on existing Tacan sets by Naval Air Development Center seemed favorable. Reliability calculations indicated a 210-hour mean time between failures. However, when sets produced to existing design were subjected to Agree testing, they proved to be below standard by almost an order of magnitude. This required extensive redesign of the sets and some original development work.

# CIRCUITS

ability. The equipment of which this circuit is a part will be airborne. Mission time will be 200 hours. The first step is to list the number and types of components whose failure will cause the circuit to fail. Recall that a failure in reliability work occurs when a circuit no longer performs within design limits. This circuit contains 3 paper Mylar capacitors, 1 silicon diode, 2 silicon amplifier transistors, a solenoid, a toggle switch, 6 carbon deposited resistors, a potentiometer and 22 printed-circuit solder joints.

Now the failure rate of each type of component is determined from tabulated data and modified by use of environmental factors and by reference to derating curves if necessary. Then the failure rates are multiplied by the number of components of each type. All the failure rates are now added together since the assumption is made that all the components are in series in a reliability sense.

At this point a major problem arises: namely that of component failure rates. There are many compendiums of component failure-rate-data, one of which is shown in abbreviated form in Table V.[3] Note that there are three columns in Table V. Usually the middle column, representing a mean failure rate, is used and multiplied by an environmental factor greater than or equal to one. Some companies, however, select the higher failure rate

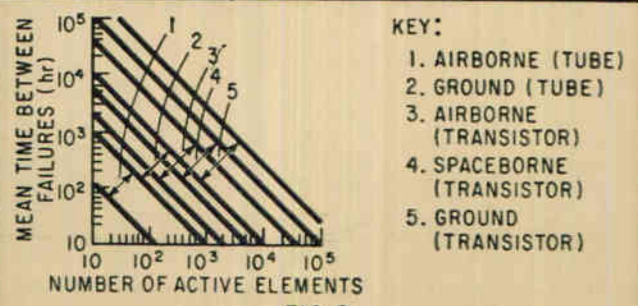



FIG. 9

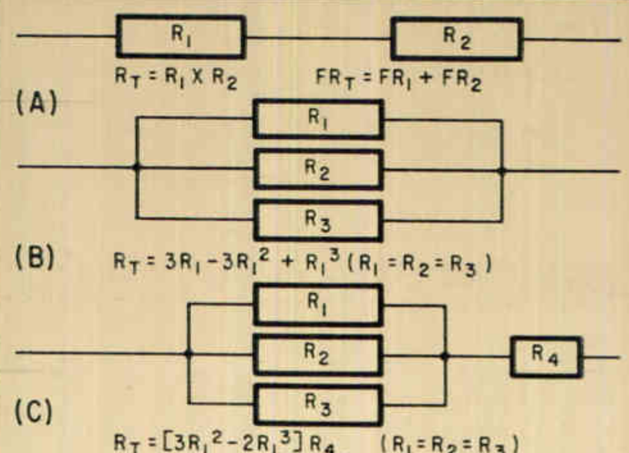



FIG. 10

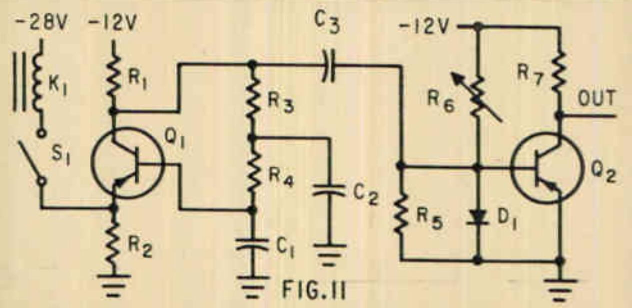



FIG. 11

**INITIAL ESTIMATE** of equipment reliability from number of active elements—Fig. 9

**RELIABILITY SYSTEM** configurations: series reliability (A), parallel reliability or redundancy (B) and time-sequenced redundancy (C)—Fig. 10

**TRANSISTOR** circuit used in example of reliability estimation—Fig. 11

PROCESSING DATA on power transistor life tests at Delco Radio div of General Motors

## TYPICAL FAILURE RATE DATA — TABLE V

| COMPONENT | FAILURES/$10^6$ HOURS Upper | Mean | Lower |
|---|---|---|---|
| capacitor, paper Mylar | 0.014 | 0.010 | 0.006 |
| diode, silicon | 0.250 | 0.200 | 0.150 |
| joint, solder, printed circuit | 0.080 | 0.008 | 0.004 |
| potentiometer, carbon deposited | 0.750 | 0.250 | 0.100 |
| resistor, carbon deposited | 0.570 | 0.250 | 0.110 |
| solenoid | 0.910 | 0.050 | 0.036 |
| *switch toggle | 0.123 | 0.060 | 0.015 |
| transistor, silicon, amplifier | 0.840 | 0.500 | 0.310 |

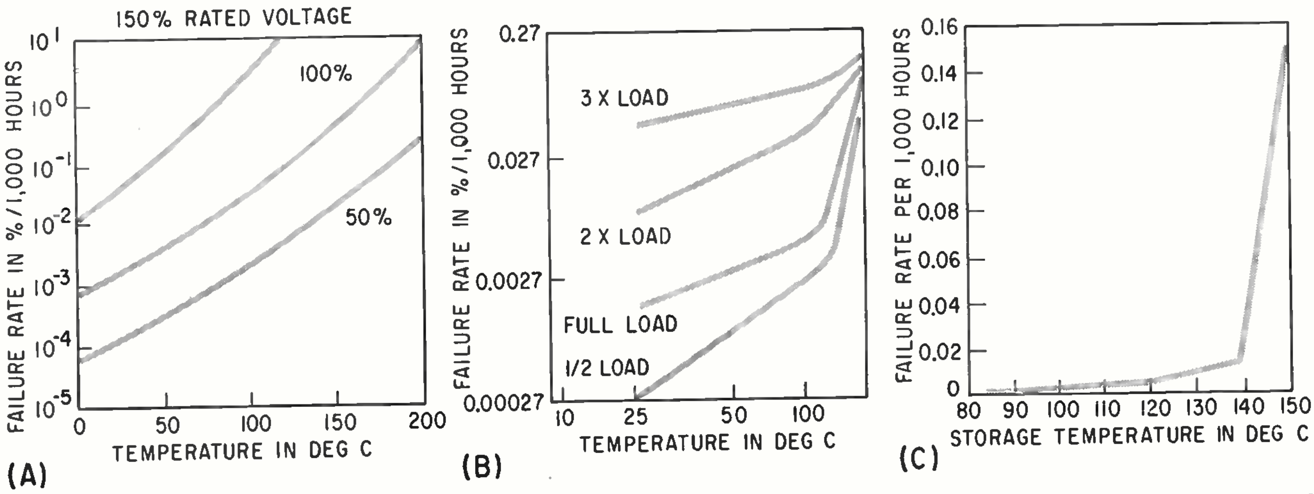
*failures per $10^6$ cycles

## ENVIRONMENTAL WEIGHTING FACTORS — TABLE VI

| ENVIRONMENT | K FACTOR |
|---|---|
| Laboratory | 1 |
| Ground | 10 |
| Shipboard | 20 |
| Trailer | 30 |
| Rail | 40 |
| Bench | 60 |
| Aircraft | 150 |
| Early Missiles | 400 |
| Present Missiles | 1,000 |

and multiply by environmental factors less than or equal to one. However, much of the failure-rate information in use in our industry was derived under less-than-controlled conditions. In fact, a lot of it represents nothing more than some engineer's informed guess. Moreover, several years of use in reliability engineering has had the effect of canonizing much of this apochryphal information.

However, remembering that reliability synthesis from a circuit diagram is only an estimate and that its prime value is in identifying the most reliable of alternative ways of designing a circuit, existing failure-rate data




DERATING curves for capacitors (A), resistors (B) and variation of failure rate with storage temperature for power transistors—Fig. 12

## IMPROVEMENTS DESIRED IN PARTS FAILURE RATES — TABLE VII

| COMPONENT | Military Parts Typical Failure Rates at 70C 70% Rated %/1,000 Hr | TYPICAL FAILURE RATE REQUIREMENTS | | | |
|---|---|---|---|---|---|
| | | Minuteman Objectives %/1,000 Hr | Estimated Midas Reqts %/1,000 Hr | Estimated Polaris Reqts %/1,000 Hr | Estimated Manned Space Vehicles %/1,000 Hr |
| Transistors - Silicon General Purpose | 0.1 | 0.001 | 0.0008 | 0.05 | 0.0005 |
| Diodes - Silicon General Purpose | 0.075 | 0.001 | 0.0008 | 0.02 | 0.0005 |
| Capacitors | | | | | |
| Solid Tantalum | 0.5 | 0.001 | 0.0008 | 0.06 | 0.0005 |
| Foil Tantalum | 0.17 | 0.001 | 0.0008 | 0.03 | 0.0005 |
| Glass | 0.006 | 0.0006 | 0.0004 | 0.001 | 0.0003 |
| Paper | 0.016 | 0.0006 | 0.0004 | 0.005 | 0.0003 |
| Resistors | | | | | |
| Metal Film | 0.053 | 0.0004 | 0.0003 | 0.03 | 0.0002 |
| Wire Wound | 0.23 | 0.001 | 0.0008 | 0.06 | 0.0005 |

does provide a valuable first approximation to reliable circuit design.

**ENVIRONMENTAL FACTORS**—The next step in the reliability synthesis detailed in the editorial panel is to apply an environmental factor to the failure rate of the circuit. A list of environmental factors is given in Table VI.[3] These are the so-called K factors used by the Martin Co.

With the circuit under study the total failure rate comes to 3.21 per million hours. Multiplying this by a K factor of 150 for airborne equipment, the final failure rate is 481.5 per million hours. This corresponds to a mean time between failures of 2,077 hours. Putting this into the reliability formula yields a reliability of 90.8 percent for a 200-hour mission.

**DERATING CURVES**—An additional refinement may be had over the use of mean failure rate data by employing the so-called derating curves. Figure 12A is a typical failure-rate versus temperature curve for one type of capacitor.[8] This curve also takes into account the percent of rated voltage applied to the unit. In this way derating curves relate the failure rate to operating conditions for components that are particularly sensitive to certain environmental factors. Figure 12B is a curve for resistors[9] derived from 1,000-hours test data and represents 60-percent confidence estimates for the case in which failure is defined as a plus or minus 0.5-percent change in resistance. Figure 12C shows a curve of failure rate versus storage temperature for a type of power transistor.

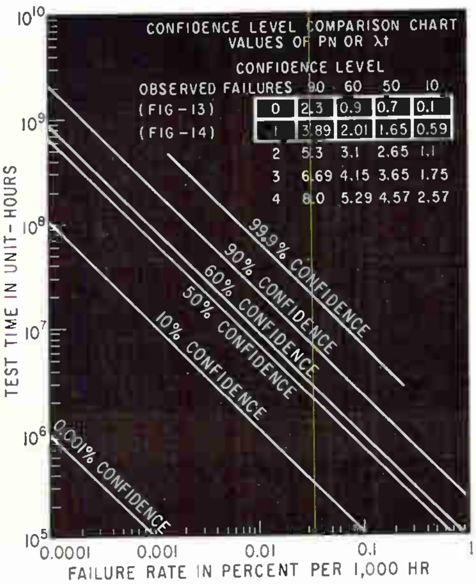
A detailed study of failure-rate data indicates a large amount of work remains to be done in component part reliability.[10] Table VII compares a few existing component-part failure rates with present and future requirements.[11] An objective of seeking to improve parts failure rates by 2 or more orders of magnitude is not at all unusual.

**IMPROVING FAILURE DATA**—Much work has been done in connection with the Minuteman components improvement program to derive failure-rate data based on laboratory experience under controlled conditions. Also the Electronic Industries Association is compiling a compendium of parts failure rate data based on 100 billion hours of operating time: airborne, shipborne, ground and laboratory; 26 sources have contributed data on 61 basic components.[12]

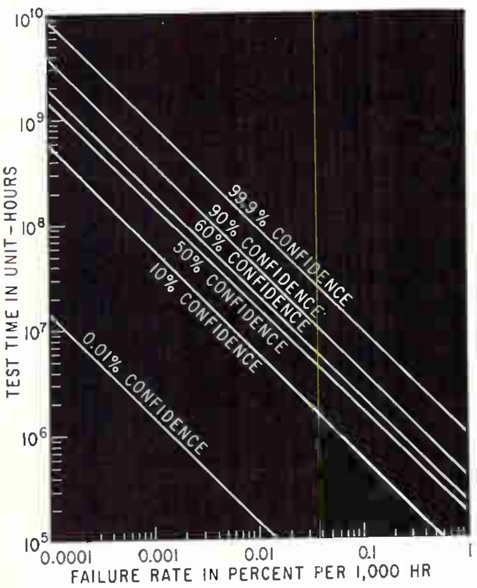
An important factor in disseminating parts failure data is the Interservice Data Exchange Program (IDEP),[2] which collects and makes available part and component test results to eliminate redundant testing by military contractors. Only data first discussed with the parts manufacturer are circulated.

As of June, 3,000 reports had been circulated and the number is increasing at the rate of 300 a month. As of June, 100 contractors were participating in the program. There are three offices: Army Ballistic Missile Agency, Huntsville, Ala. for Army missile contractors; Naval Ordnance Laboratory, Corona, Calif. for Navy missiles and Aerospace Corp., Los Angeles, for Air Force missile and space work.

*Failure-rate data is essential to design of reliable circuits but much of the data available represents only someone's educated guess. However this situation is changing. The armed services are exchanging failure data and manufacturers have hit on the real answer: make it right the first time*




**CONSUMER** confidence level versus test time with no defects observed—Fig. 13




**CONSUMER** confidence level versus test time with one defect observed—Fig. 14

## INITIAL QUALIFICATION SAMPLE SIZES — TABLE VIII

40% CONSUMER'S RISK

| Allowable Failures c | Cum. Unit Hr n | Probability of Rejection at 2.6 × Qualification Level (M level = 1%/1,000 hr) | |
|---|---|---|---|
| 0 | 91,500 | 90.6% | multiply unit hours |
| 1 | 202,000 | 96.7% | for P (0.1%/1,000) |
| 2 | 310,000 | 98.7% | level by 10, for R |
| 3 | 418,000 | 99.5% | (0.01%/1,000) level by |
| 4 | 525,000 | 99.8% | 100, and for S (0.001%/ |
| 5 | 630,000 | 99.9% | 1,000) level by 1,000 |

## DISQUALIFICATION TEST — TABLE IX

10% PRODUCER'S RISK

| Allowable Failures c | Cum. Unit Hr n | Probability of Disqualification at 2 × Qualification Level (M level = 1%/1,000 hr) | |
|---|---|---|---|
| 0 | 10,600 | 19.02% | multiply unit hours |
| 1 | 53,200 | 28.8% | for P (0.1%/1,000) |
| 2 | 110,000 | 37.8% | level by 10, for R |
| 3 | 175,000 | 46.1% | (0.01%/1,000) |
| 4 | 243,000 | 53.5% | level by 100, and |
| 5 | 315,000 | 60.1% | for S (0.001%/1,000) |
| | | | level by 1,000 |

## ALLOWABLE DEFECTS IN SINGLE LOTS — TABLE X

| Allowable Defects (c) from Disqualification Table | Allowable Defects Permitted in Single Lot Sample |
|---|---|
| 1 | 1 |
| 2 | 1 |
| 3 | 2 |
| 4 | 2 |
| 5 | 3 |

# COMPONENT RELIABILITY

The problem of determining failure rates for electronic components has been studied closely by both government and industry. An answer to this question was suggested in the Darnell Report also know as PSMR-1 (Parts Specifications Management for Reliability).[13] The new view of failure-rate data is that parts should be manufactured to specified failure-rate levels so that the designer may confidently use the manufacturer's failure-rate figures. Accordingly, provision has been made for component failure-rate levels from 1 percent to 0.001 percent per thousand hours.[14] These rates are designated by the letters M, P, R and S. There is also a provision for an L level if the current state of the art for a particular part is such that the existing failure rate is higher than one percent per 1,000 hours.

**INITIAL QUALIFICATION**—A manufacturer must qualify initially at a desired failure-rate level at a 40-percent consumer's risk. In doing this, a process producing a product whose failure rate is 1/10 the qualification level is qualified at least 9 times out of 10 while a process producing a product whose failure rate is 2.6 times higher than the qualification level will fail to qualify at least 9 times out of 10. Initial qualification sample sizes are given in Table VIII. Suppose a manufacturer wishes to qualify at level R and chooses the plan that allows one defect in his sample. For initial qualification he must log 20.2 million unit hours with only one defect ($m$ = 202,000 at level M × 100 = 20,200,000 hr).

**DISQUALIFICATION**—Disqualification criteria is derived with a producer's risk of 10 percent. A process producing a product with a failure rate of twice the failure-rate level will be disqualified at least 28 percent at the time. Table IX gives the disqualification sample sizes. If the manufacturer wishes to retain his qualification at the R level, he must, on a continuing basis, log 5.32 million unit hours with only one failure. Thus, if the specification to which the producer is supplying the products requires 1,000 hours of life testing and permits no acceleration, he must test 5,320 parts with no more than one failure or suffer disqualification. If the manufacturer's product fails to pass these tests he can elect either to ship goods at a higher failure-rate level and presumably a lower selling price, or in the hope he can still qualify, to increase the allowable failures by taking a larger sample size.

**TEST CONDITIONS**—In lot-by-lot testing, the sample size for each lot in any continuous series of 10 to 40 lots must be equal. At levels L, M and P the lot sample size must be at least 1/10 the disqualification sample size and in no case less than 10. At level R, the lot sample size must be at least 1/20 the sample determined for the disqualification sample and for level S at least 1/40. Table X relates allowable defects from the disqualification table to allowable defects permitted in a single lot sample; thus even by increasing sample size the manufacturer can never outdo the damage done by having produced a single unreliable lot.

Figures 13 and 14 are nomographs relating test time, failure rate, confidence level, and defect levels. Figure 13 assumes no observed defects; Fig. 14 assumes one observed defect. Thus, assuming a test experience of 10 million unit hours with one observed defect, Fig. 14 shows this to correspond to a failure rate of 0.016 percent per thousand hours at the 50-percent confidence level, 0.039 percent per thousand hours at the 90-percent confidence level, and 0.095 percent per thousand hours at the 99.9-percent confidence level.

The Electronic Industry Association's proposals have been completed and submitted to the military with respect to paper, solid tantalum and tantalum foil capacitors and fixed film and fixed composition resistors. Work is underway on several other classes of parts.[15]

**TUBE IMPROVEMENT**—Meanwhile, the military is doing some work on its own with respect to setting failure-rate specifications for electronic parts.[16] Noting that 70 percent of maintenance actions and spare parts usage by the Strategic Air Command is for electronic equipment, the Air Force recently contracted to purchase 6AH6 vacuum tubes to a 1 percent per thousand hour reliability specification. A failure was defined to be a change in transconductance, variation in heater current, open or short circuit or any of seven other defects. Tests were to be conducted at 100 percent rated voltage and power and at 165 degrees C ambient. A lot was defined as one mount-line week or one Selex-machine run. The required sample size was 75,000 tube hours per lot meaning 75 tubes life tested for 1,000 hours each. Producer's risk set at 5 percent and consumer's risk at a 10 percent chance of accepting a lot having a failure rate of 7 percent per 1,000 hours.

As a result of this work, the mean failure rate of reliable tubes decreased to 0.65 percent per 1,000 hours, sample size was raised to 110,000 hours and the yield from 85 to 95 percent. Field testing showed that the reliable tube produced no failures in 204,764 tube hours while conventional tubes of this type produced 2 failures in 243,414 tube hours.

**MARKOV CHAINS**—The advanced mathematical concept of Markov chains has been used to extrapolate reliability predictions on components for which life-test data is incomplete.[17] Failure time is given as $T = N\xi$ where $\xi$ is a column unity vector and $N$ is the fundamental matrix. Here $N = (I - Q)^{-1}$ where

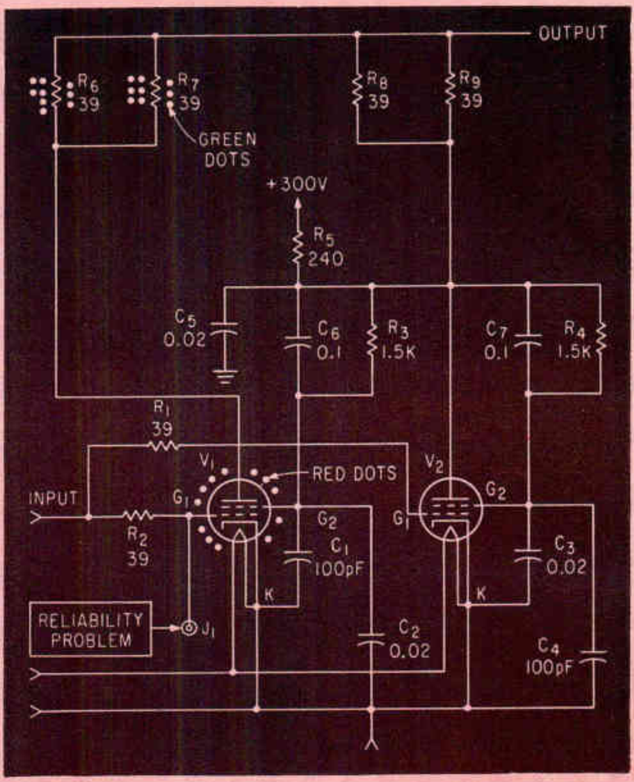
$I$ is the identity matrix and $Q$ is a submatrix of the Markov transitional matrix $P$

$$P = \begin{bmatrix} I & 0 \\ R & Q \end{bmatrix}$$

where 0 is the null vector, $R$ is a matrix containing transitional elements that describes the process entering an absorbing state and $Q$ is a matrix containing transient elements. The originator of this technique considered the design life as 20 units. He tested 3 elements for their design life then used 2-unit acceptance tests on the others.

Of course, not all reliability problems in circuit design are solved by analyzing the schematic diagram. Reliable design is a result of continuing attention from the initial concept through breadboarding, prototype fabrication and manufacturing. It requires a constant feedback of information and a monitoring of engineering work through frequent design reviews. Many firms have set up a formal system of design reviews that bring to bear the experiences of many engineers upon a problem.

**MEASLES CHART**—One example of a reliability technique applicable to equipment that has moved from the diagram to the hardware stage is the so-called measles chart.[18] This technique is useful in the field, in the factory and on the test bench. As shown in Fig. 15, failures are indicated on the schematic diagram. A red dot shows a true failure, a green dot shows failure through a testing error, mishandling, or a failure associated with the primary failure. In the example shown, an accidental grounding or loading of grid No. 1 of vacuum tube $V_1$ was found to be the reason for repeated failures. Accidental grounding removed the grid bias from the tube causing excessive plate current.




**MEASLES CHART** used to locate and diagnose reliability problem areas—Fig. 15

# SYSTEMS DESIGN

***It is not all component reliability or even circuit design but how the circuits work together that tells whether a mission is GO or not. Systems design includes many exotic techniques: group redundancy, majority logic, fail-safe design, time-sequenced redundancy—even self repair***

The formula for a series reliability has an analogy in the technique of parallel or redundant reliability.[19] Group redundancy may be defined as the use of two or more components operating in parallel such any one fulfills system requirements. Should one component fail, the remaining members of the group can function adequately.[20] Thus parallel reliability provides an alternative path in case one path becomes inoperable due to a failure.

Redundancy may be adapted on almost any level. Consider, for example, the bombing navigation system in the B-58 bomber, the model AN/ASQ-42V.[21] Here redundancy is provided by paralleling complete systems with identical spare units, by paralleling selected units with rendundant replacements and by providing spare units to replace any of several units having similar functions. Furthermore, the plan provides less accurate alternative methods of performing complex computations and uses self-sensing, fail-safe design techniques.

**BINOMIAL DISTRIBUTION**—The formulas for parallel or redundant reliability are derived from the binomial distribution. The binomial distribution is another discrete probability distribution like the poisson. The binomial distribution gives the probability of $x$ survivals out of the population $n$. As in the poisson case, the probabilities are found from $x = 0$ to $x = n$, and the sum of survival probabilities from $x = 0$ to $x = n$ is equal to 1. Probabilities given by

$$\text{Prob } (x \text{ survivals out of } n) = \frac{n!}{x!\,(n-x)!}\, p^x\, (1-p)^{n-x}$$

where $p$ is the probability of survival or reliability of one unit.

**PARALLEL REDUNDANCY**—Consider the block diagram in Figure 10B. There are 3 parallel units. As long as one unit survives the equipment will function. Each unit has the same reliability, which is to say, the same probability of survival

$$R_1 = R_2 = R_3 = p$$

The binomial distribution for success of the mission is found by calculating the probability that one unit survives, two units survive and all three units survive. The sum of these probabilities is the probability of success of the mission or the reliability of the redundant system

$$\frac{3\times2\times1}{1\times2\times1}\, p^1\,(1-p)^2 = 3p - 6p^2 + 3p^3$$

$$\frac{3\times2\times1}{2\times1\times1}\, p^2\,(1-p)^1 = 3p^2 - 3p^3$$

$$\frac{3\times2\times1}{3\times2\times1\times1}\, p^3\,(1-p)^0 = p^3$$

$$3p - 3p^2 + p^3$$

$$R_T = 3R_1 - 3R_1^2 + R_1^3$$

**MAJORITY LOGIC**—Figure 10C shows another type of redundancy that is called majority or voting logic. In this case there are three parallel circuits and a gate or voting circuit. To have successful operation, at least two of the three parallel circuits must survive as well as the voter. Therefore, the overall reliability of the system is the parallel combination of $R_1$, $R_2$ and $R_3$ in series with $R_4$. In this instance, parallel reliability is calculated using binomial distribution to find the probability of three circuits surviving and of two circuits surviving

$$R_1 = R_2 = R_3 = p$$

$$\text{Prob (2 survive)} = 3p^2 - 3p^3$$

$$\text{Prob (3 survive)} = p^3$$

$$3p^2 - 2p^3$$

$$R_T = [3R_1^2 - 2R_1^3]\, R^4$$

**TIME SEQUENCING**—A move complex situation occurs where parallel circuits are time sequenced. Here two circuits are arranged in parallel, but only one carries the signal at a time. The second channel is not activated unless and until the first channel fails. The formula for time-sequenced parallel reliability is

$$R_T = e^{-\lambda t} \sum_{i=0}^{n-1} \frac{(\lambda t)^i}{i\,!}$$

where $t$ is mission time, $\lambda$ the failure rate of each circuit since circuits are assumed to have equal failure rates, and $n$ is the number of circuits. For the case of two paths only this formula simplifies to

$$R_T = R_1\,(1 - \ln R_1)$$

**ON-AIR REPAIR**—There is also the case in which the repairs can be made to equipment while it is operating and in this case reliability is given by

$$R_T = \frac{n\,!\,\lambda^{q+1}\,t}{(n-q-1)\,!\,u^q}$$

where $n$ is the number of redundant circuits, $q$ is the number of failures that can be allowed without causing system failure, $u$ is the repair rate, which must be less than failure rate by a factor of 500 or more, and $\lambda$ is the failure rate.[22]

Systems reliability work often involves advanced mathematics. One graphical method has been developed for solving for the reliability of a system that uses majority logic in which three out of four parallel circuits must operate and uses failure detecting and switching circuits. This method traces out all possible combinations of subsystem performance of a hypothetical population of 1,000,000 systems and determines how many successes result after attrition due to failure.[23]

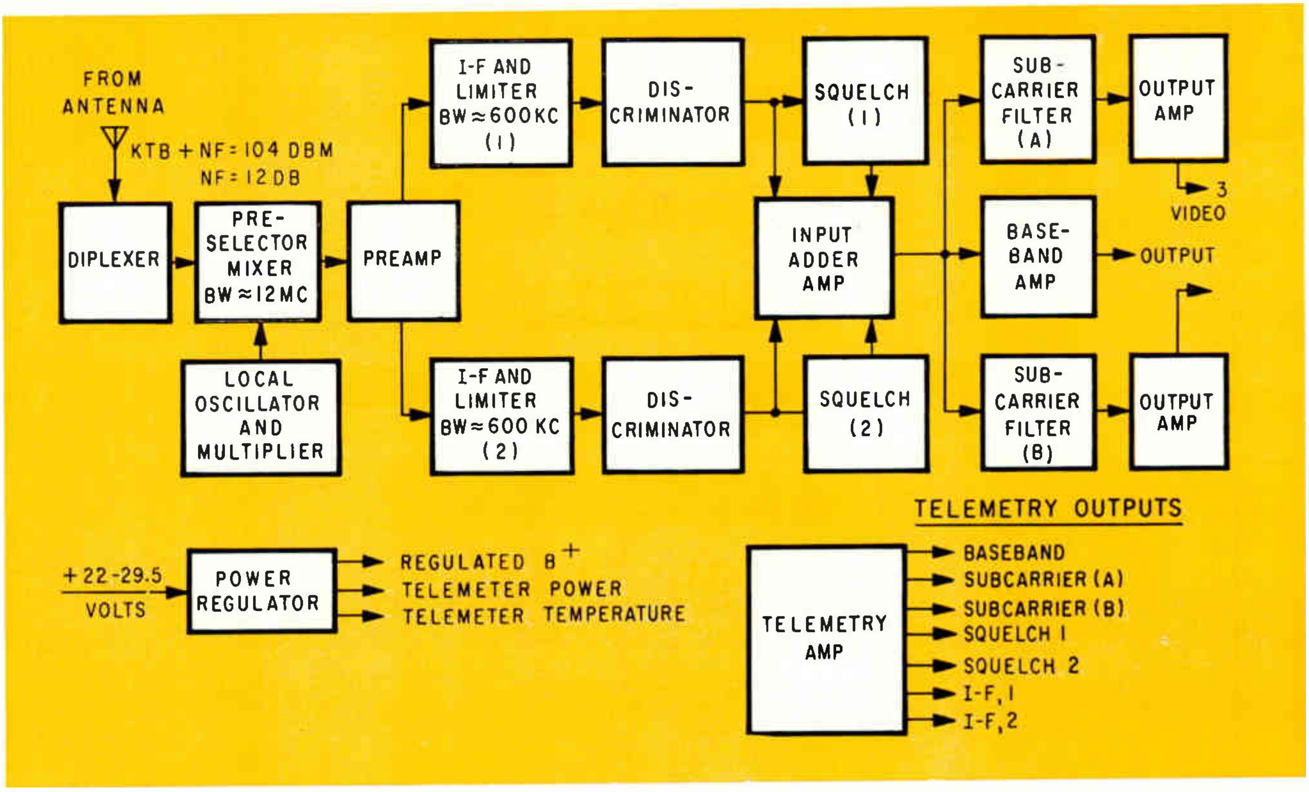
**VALUE ANALYSIS**—Monte Carlo techniques have been used in reliability studies. Given the reliability data for each system component, it is possible to determine the reliability of a multimoded system such as a radar with search, acquisition and track modes of operation.[24] The method can influence systems design by indicating those components of a set that should have the highest reliability. The system yields MTBF for any system mode sequence, can evaluate equipment changes and compare and evaluate different tactical operations.

Sometimes in systems reliability work it is convenient to look at the availability of a piece of equipment. Availability is defined as the ratio of total operating time less down time to total operating time and takes into account not only of the reliability of equipment but also of its maintainability.

Studies of reliability from a value-engineering point of view have related availability to fire power in each of several configurations of a proposed weapons system. Possible improvements in reliability can then be evaluated in terms of resulting improvements in relative firepower and in terms of the cost of making these reliability improvements.[25]

**EQUIPMENT DESIGN**—A recently designed f-m S-band receiver for use in space vehicles has been described[26] that corporates several modern approaches to reliability. The equipment uses all solid-state components and is designed in modular form. It has a 96.3-percent probability of success in a one-year mission considering a 25-percent duty cycle and a 92.3-percent probability of success with a 50-percent duty cycle.

Its noise factor is 12 db for all environmental life




**SPACE TELEMETRY** receiver embodying several reliability design concepts—Fig. 16

conditions and its r-f center-frequency stability is plus or minus 0.003 percent over a temperature range of −40 to 80 deg C. The set weighs 13 lb and occupies 290 cubic inches. The receiver makes use of both functional and component reliability. Component reliability results from series-parallel connections used in the local oscillator, power regulating and filter circuits. Functional reliability is derived from use of dual i-f amplifiers and discriminators. The receiver uses transistors having high $h_{fb}$ and $h_{fe}$ cutoff frequencies to compensate for degradation of performance in the Van Allen radiation belt. The receiver is made up of 40 potted modules with welded grid-matrix wiring. The receiver's block diagram is shown in Fig 16.

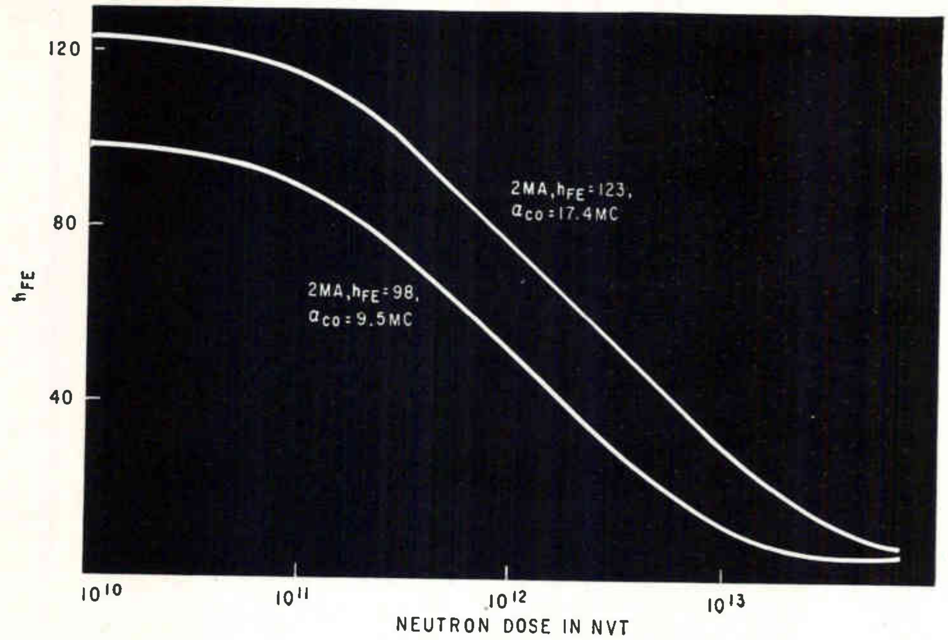
# PHYSICS OF FAILURE

*Some engineers think that statistical techniques may have gone about as far as they can go. If so, we must now look to the solid-state physicist to tell us what really makes one part fail and another last forever. We have to know about radiation, how metals work together and what goes on inside crystal lattices*

As reliability of electronic parts and equipment has improved during the past decade, the job of the reliability engineer has become more difficult. Testing parts for their conformity to the stringent Minuteman failure-rate specifications or even to lower failure-rate specifications requires putting extremely large lot samples on life test.

In equipment testing there may frequently not be enough units manufactured so that an adequate sample can be taken for life testing. This often means that an undue amount of time is required for reliability testing. In an industry that moves as fast as ours, the equipment may become obsolete before it is accepted.

Furthermore, a substantial investment in time and equipment is required for reliability testing. All these problems are compounded as the military services demand ever lower failure rates and ever higher confidence levels. One may reasonably inquire if we are not in




**EFFECT** of neutron radiation on transistor forward static current gain—Fig. 17

danger of life testing ourselves in this national bankruptcy. The biggest problem in modern reliability engineering today is to obtain trustworthy reliability data cheaply, conveniently and in the shortest possible time.

The Markov-chain technique may be one approach to this problem. But it is too early to have much real confidence in such a method.

**ACCELERATION**—One of the earliest approaches to this problem was accelerated life testing. It is known that operating stresses such as voltage, current and frequency and environmental stresses such as temperature, radiation, mechanical shock and vibration, moisture, and low air pressure compound a reliability problem. Admittedly, the useful life of a part or piece of equipment is related in some way to the operating and environmental stresses to which it is subjected. The trouble is that no one has ever written a valid functional relationship and who is then to say if 1,000 hours at 150 deg C is equivalent to 10,000 or 100,000 hours at 50 deg C?

Generally, structural weaknesses, susceptibility to corrosion and to arc-over at low atmospheric pressure can be determined by short-term testing under high-stress conditions. Furthermore, operating stresses and temperature can certainly be controlled for an accelerated life test.[11] But a great deal of engineering experimentation is necessary to correlate life-test data taken at high operating stress and temperature levels to useful life under design conditions. This is doubly true in regard to radiation environments.

**NUCLEAR RADIATION**—Figure 17 illustrates that the semiconductor devices are indeed affected by nuclear radiation. But there are many conflicting experimental results as to what this effect is. In one study silicon and germanium diodes and transistors were exposed to radiation after the conventional high-temperature stresses and operating life tests. After a dose of $3 \times 10^7$ roentgens it was found that forward and reverse currents decreased in silicon diodes but increased in germanium diodes.[27] In another study, abrupt-junction silicon diodes for use as particle counters were radiated with 2 Mev electrons to a total dosage $7 \times 10^6$ electrons per square centimeter. It was found that barrier-junction capacitance increased as much as 130 percent during radiation in high resistivity diodes but did not noticeably increase in lower resistivity units.[28]

**NOISE ANALYSIS**—There is a quiet ground swell of interest in correlating the noise of a device with failure experience. In one study of tin-oxide resistors it was found that although not all noisy resistors were poor performers, all resistors that failed early were abnormally noisy. Perhaps this line of investigation can be pursued further with other electronic parts.[29]

The author has often noted intuitively that equipment that gives a good deal of trouble in the debugging phase frequently has a short MTBF during its operating life. However, no correlation studies have been done due to the general lack of documented failure experience during debugging.

The problems of life testing have lead many engineers to observe that statistical reliability studies may have gone about as far as they can go and that future improvement in electronic equipment and parts will result only from better understanding of the physical mechanisms of failure. On the surface this seems to imply a return to the Lusser philosophy of testing to destruction. However, today we are dealing with failures that occur very infrequently and there is a serious problem in getting sufficient be enabled to meet the stringent parts-failure-rate requirements now coming into general use.

On the systems level, the engineer has at his disposal many useful techniques among which are parallel redundancy, majority logic, time-sequenced redundancy, fail-safe circuit design, and provision for on-the-air repair and maintenance to be performed either manually or automatically.[40,41] As yet only first approximation solutions are available for most practical systems reliability problems. However, much work is being done in this area and modern mathematical techniques are making important inroads.

## REFERENCES


(1) T. Budne, IRE Reliability Training Course, Princeton, N. J., 1962.

(2) *Reliability Digest*, Vol. 1, No. 6, The Martin Co., June 1962.

(3) "Reliability Data Book" and "Estimating Reliability", The Martin Co., Baltimore, Md.

(4) D. Van Der Reyden, IRE Reliability Training Course, Princeton, N. J., July 1962.

(5) Reliability of Military Electronic Equipment, AGREE Report, U. S. Government Printing Office, Washington, D. C., June 1957.

(6) A. F. Floyd, History and Results, Symposium on Electronic Systems Reliability, Kansas City, Mo., 1961.

(7) *Reliability Digest*, Vol. 2, No. 5, The Martin Co., June 1961.

(8) *Reliability Digest*, Vol. 2, No. 7, The Martin Co., July 1962.

(9) Documented Reliability, International Resistance Corp., March 1962.

(10) R. Greenburg, Reliability of Germanium Power Transistors, Wescon, 1962.

(11) J. E. Aalseth, Accelerated Life Testing of Electronic Parts, Physics of Failure Symposium, Chicago, 1962.

(12) Component Parts Failure Data Compendium, EIA Task Group on Component Parts Failure Data, Feb. 1962.

(13) Parts Specification Management for Reliability, Report I, Office of Director of Defense Research and Engineering and Office of the Assistant Secretary of Defense, Supply and Logistics, Washington, D. C., May 1960.

(14) Established Failure Rate Levels for Component Parts, EIA Recommendation, Electronic Industries Association, New York, 1962.

(15) EIA Established Reliability Program, Parts Division Report, Electronic Industries Association, New York, April 2-September 11, 1962.

(16) F. J. Ruther, Lot-By-Lot Process Control, North East Research and Engineering Meeting, Nov. 1962.

(17) C. W. G. Fulcher, Failure Prediction for Nonmaintainable Electronic Components, 7th Symposium on Ballistic Missile and Space Technology.

(18) C. D. Jeffcoat, Measles Chart, Westinghouse, Baltimore, Md.

(19) S. N. Greenberg, Treatment of Redundancy in Design, "Reliability Analysis Data for Systems and Component Design Engineering", Dept. of Commerce OTS PB 181,080.

(20) J. H. S. Chin, Group Redundancy in Space Electronics, 19th National Meeting, Operations Research Society of America.

(21) M. D. Katz, H. Jaffe and S. A. Rosenthal, Designing Reliability Into the B-58 Bombing-Navigation System, 7th National Symposium on Reliability and Quality Control.

(22) N. J. McAfee, IRE Reliability Training Course, Princeton, N. J., July.

(23) W. E. Marshall, Graphic Method for Solving Reliability Logic Configurations, 3rd New York Conference on Electronic Reliability.

(24) K. Curtin, A Monte Carlo Simulation of the Operational Effectiveness of Multi-Moded Systems, 3rd New York Conference on Electronic Reliability.

(25) M. M. Tall, Reliability and Value Engineering, 3rd New York Conference on Electronic Reliability.

(26) R. L. Sims and D. W. Hanna, Space Electronics Equipment—A Space Receiver, 1962 National Symposium on Space Electronics and Telemetry.

(27) V. R. Honnold and C. B. Schock, The Effects of High Energy Radiation on Failure Mechanisms in Semiconductor Devices, Physics of Failure Symposium, Chicago, 1962.

(28) R. V. Babcock, Anomolous Radiation Damage Effect on Capacitance of Silicon Diodes, Physics of Failure Symposium, Chicago, 1962.

(29) J. G. Curtis, Current Noise Measurement as a Failure Analysis Tool for Film Resistors, Physics of Failure Symposium, Chicago, 1962.

(30) D. R. Earles and M. F. Eddins, Failure Therblig Failure Rates, Wescon, 1962.

(31) R. A. Hein, The Effects of Gas Ambient on the Failure of Traveling-Wave Tubes, Physics of Failure Symposium, Chicago, 1962.

(32) F. Aubin, Reliability Studies of Mesa Transistors, IRE International Convention, 1962.

(33) NASA-Wide Quality Assurance Meeting, Washington, D. C., June 5-6, 1962.

(34) K. W. Doversberg, High Power Dynamic Life Tests of Transistors, Wescon, 1962.

(35) M. A. Schafft and J. C. French, Characteristics of Second Breakdown and Transistor Failure, Physics of Failure Symposium, Chicago, 1962.

(36) R. Scarlett and W. Shockley, Thermal Instability and Hot Spots in Power Transistors, Physics of Failure Symposium, Chicago, 1962.

(37) H. J. Queisser, Dislocations in Semiconductor Device Failure, Physics of Failure Symposium, Chicago, 1962.

(38) R. P. Nanavati, Some Physical Mechanisms Contributing to Tunnel-Diode Failures, Physics of Failure Symposium, Chicago, Sept. 1962.

(39) K. Greenough, Primary Modes of Failure Occurring at Material Interfaces in Thin-Film Solid-State Devices, Physics of Failure Symposium, Chicago, Sept. 1962.

(40) J. Klion, Self Repair Techniques, 9th Annual Air Force Science and Engineering Symposium.

(41) RADC Reliability Notebook, U. S. Department of Commerce, OTS 62-535.


## BIBLIOGRAPHY


I. Bazousky, "Reliability: Theory and Practice", Prentice-Hall, Englewood Cliffs, N. J., 1961.

K. A. Brownlee, "Statistical Theory and Methodology in Science and Engineering", John Wiley & Sons, Inc., New York, 1960.

R. S. Burington and D. C. May, Jr., "Handbook of Probability and Statistics With Tables", McGraw-Hill Book Co., Inc., New York, 1953.

S. R. Calabro, "Reliability Principles and Practices", McGraw-Hill Book Co., Inc., New York, 1962.

E. L. Crow, et al, "Statistics Mannual", Dover Publications. Defense Electronics Supply Center, Standardization Data for Hi-Reliability Components, Dayton, Ohio, Aug. 1962.

A. J. Duncan, "Quality Control and Industrial Statistics", Richard D. Irwin, Inc., Chicago, 1959.

D. R. Earles, "Reliability Growth Prediction During the Initial Design Analysis", The Martin Co., Baltimore, Md.

F. M. Gyrna, Jr., N. J. McAfee, C. M. Ryerson and S. Zwerling, "Reliability Training Text", Institute of Radio Engineers Inc., New York, March 1960.

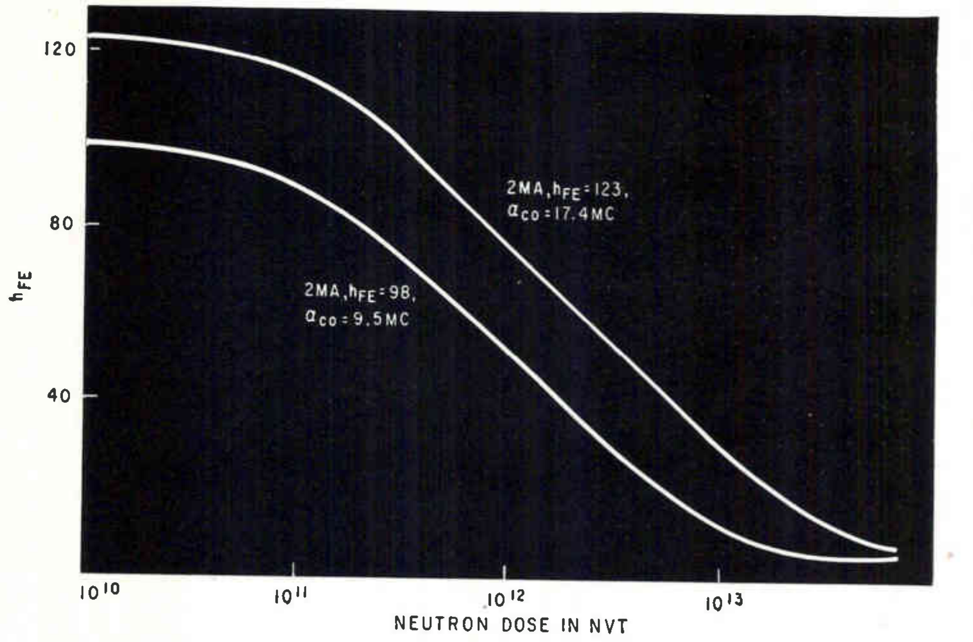
K. Henney, I. Lopatin, E. T. Zimmer, K. Adler and J. J. Naresky, "Reliability Factors for Ground Electronic Equipment", McGraw-Hill Book Co., Inc., New York, 1956.

K. Henney, C. Walsh and H. Mileaf, "Electronic Components Handbook", Vol. I, II and III, McGraw-Hill Book Co., Inc., New York, 1958.

D. K. Lloyd and M. Lipow, "Reliability Management, Methods and Mathematics", Prentice-Hall, Englewood Cliffs, N. J., 1962.

E. Parzen, "Modern Probability Theory and Its Applications", John Wiley & Sons, Inc., New York, 1960.


**Resistor X-rays in the frontispiece** of the report were made by International Resistance




**EFFECT** of neutron radiation on transistor forward static current gain—Fig. 17

danger of life testing ourselves in this national bankruptcy. The biggest problem in modern reliability engineering today is to obtain trustworthy reliability data cheaply, conveniently and in the shortest possible time.

The Markov-chain technique may be one approach to this problem. But it is too early to have much real confidence in such a method.

**ACCELERATION**—One of the earliest approaches to this problem was accelerated life testing. It is known that operating stresses such as voltage, current and frequency and environmental stresses such as temperature, radiation, mechanical shock and vibration, moisture, and low air pressure compound a reliability problem. Admittedly, the useful life of a part or piece of equipment is related in some way to the operating and environmental stresses to which it is subjected. The trouble is that no one has ever written a valid functional relationship and who is then to say if 1,000 hours at 150 deg C is equivalent to 10,000 or 100,000 hours at 50 deg C?

Generally, structural weaknesses, susceptibility to corrosion and to arc-over at low atmospheric pressure can be determined by short-term testing under high-stress conditions. Furthermore, operating stresses and temperature can certainly be controlled for an accelerated life test.[11] But a great deal of engineering experimentation is necessary to correlate life-test data taken at high operating stress and temperature levels to useful life under design conditions. This is doubly true in regard to radiation environments.

**NUCLEAR RADIATION**—Figure 17 illustrates that the semiconductor devices are indeed affected by nuclear radiation. But there are many conflicting experimental results as to what this effect is. In one study silicon and germanium diodes and transistors were exposed to radiation after the conventional high-temperature stresses and operating life tests. After a dose of $3 \times 10^7$ roentgens it was found that forward and reverse currents decreased in silicon diodes but increased in germanium diodes.[27] In another study, abrupt-junction silicon diodes for use as particle counters were radiated with 2 Mev electrons to a total dosage $7 \times 10^6$ electrons per square centimeter. It was found that barrier-junction capacitance increased as much as 130 percent during radiation in high resistivity diodes but did not noticeably increase in lower resistivity units.[28]

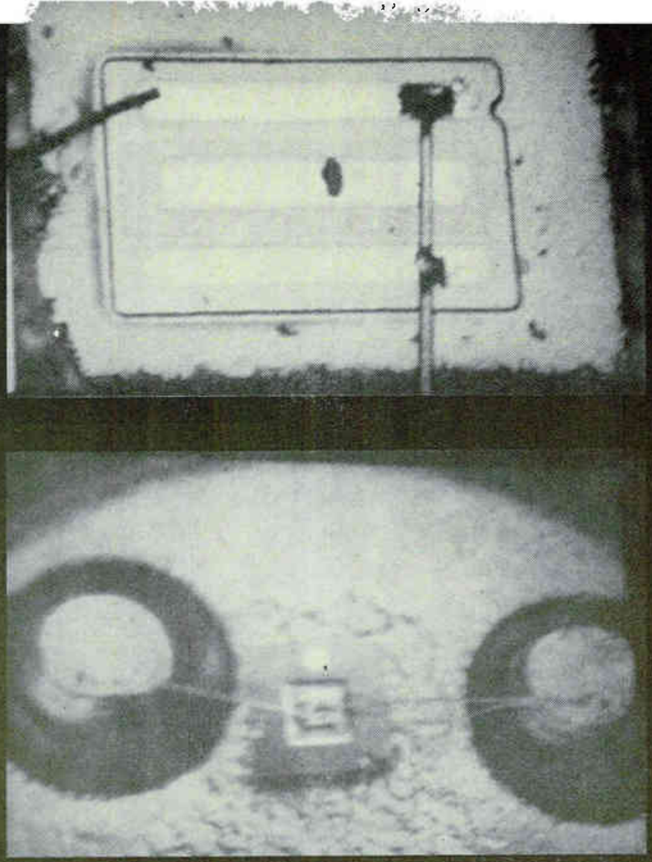
**NOISE ANALYSIS**—There is a quiet ground swell of interest in correlating the noise of a device with failure experience. In one study of tin-oxide resistors it was found that although not all noisy resistors were poor performers, all resistors that failed early were abnormally noisy. Perhaps this line of investigation can be pursued further with other electronic parts.[29]

The author has often noted intuitively that equipment that gives a good deal of trouble in the debugging phase frequently has a short MTBF during its operating life. However, no correlation studies have been done due to the general lack of documented failure experience during debugging.

The problems of life testing have lead many engineers to observe that statistical reliability studies may have gone about as far as they can go and that future improvement in electronic equipment and parts will result only from better understanding of the physical mechanisms of failure. On the surface this seems to imply a return to the Lusser philosophy of testing to destruction. However, today we are dealing with failures that occur very infrequently and there is a serious problem in getting sufficient

## FAILURE THERBLIGS — TABLE XI

**Adhere** — cling or stick fast at interfaces
**Arc** — electrical discharge through ionized gas
**Backlash** — lost motion in mechanical movement
**Bind** — hinderence in mechanical movement
**Brinnel** — indentation of surface
**Carborize** — destructive distillation of organic substances out of contact with air
**Chafe** — unwanted rubbing with friction
**Contaminate** — render unfit by adding foreign substances, particles or coatings
**Deform** — change in form of design feature due to stress
**Distort** — change in signal characteristics
**Drift** — change in operating parameters due to change in material characteristics
**Fracture** — break, part or whole
**Leak** — loss of energy through imperfect seal or insulation
**Noisy** — signal disturbances, random
**Open** — discontinuity of circuit, flow path or equipment interface
**Short** — path of low resistance shunting a high resistance
**Unstable** — fluctuation of strength level related to energy acceptance and stress generation



**PURPLE PLAGUE** or gold-aluminum corrosion in a transistor, (top right); one-hundred-percent short in transistor, Univac (lower right)

failure experience to analyze and identify physical failure modes. However, a good deal of work on the physics of failure is presently underway.

**FAILURE MODES**—Table XI lists seventeen failure therbligs, so named analogy to the basic work motions categorized by Dr. Lillian and the late Major Frank Gilbreth. It is proposed that a symbol be assigned to each block of the success diagram and that boolean algebra be used to develop a success or failure model. This categorizing of failure modes may also be useful in assigning failure rates, determining and studying alternate configurations, and as a first step in fail-safe analysis.[30]

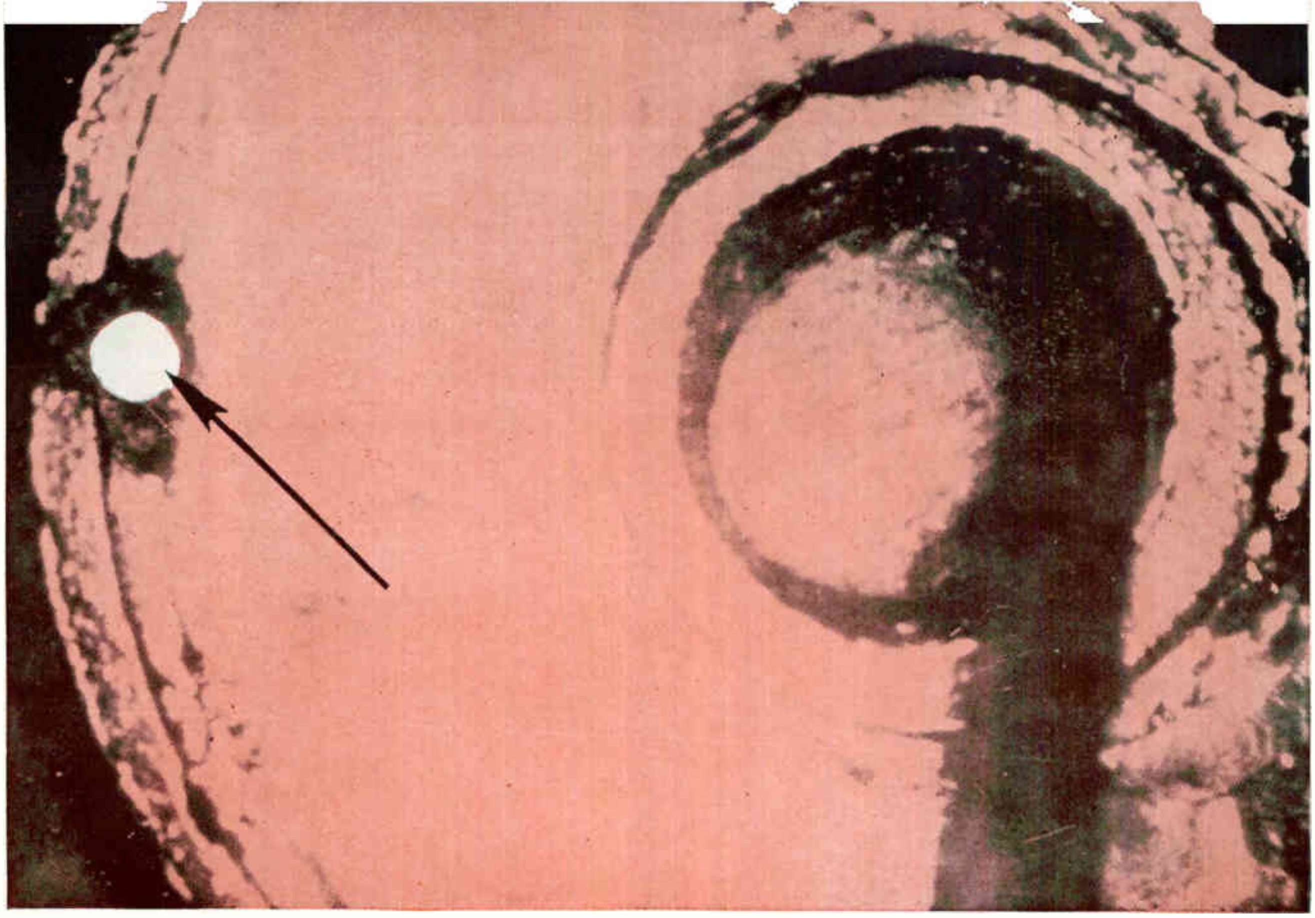
**MESAS AND PLANARS**—Most failure-mode studies today deal with semiconductor components although some work concerns newer electron tubes such as the traveling-wave tube where special emphasis is attached to maintaining a hard vacuum to avoid cathode deterioration, catastrophic arcing and beam spreading.[31] One semiconductor study concerned new type mesa and planar transistors. In one example, the first samples of a mesa failed 100 percent on environmental test. The failures were found to be in the thermal compression bonds. In some cases the lead whisker had been almost cut through by the bonding tool. In other cases, the whisker lifted off the junction and sometimes a brittle gold-silicon eutectic formed. Other failure modes proved to be surface contamination, leaks in cans or glass-to-metal seals, junction degradation by uneven diffusion, foreign particles in the can and detachment of the chip from the header in planar units.[32]

In another study, trouble with thermal compression bonds turned out to be caused by overlaying the bond with heat-sensitive lacquer. When the lacquer expanded, the whisker lifted off the die. Of course, some of the failure modes lie in the test procedure, as in the case where a transistor was being 100 percent rejected because someone was putting *npn* units into a *pnp* test set.[33]

**POWER TRANSISTORS**—Considerable work has been done in studying failure modes of germanium power transistors. One investigator found that burn through or punch through caused by melting or vaporizing of germanium is the highest single cause of failure. Failure rates for power transistors were seen to increase almost exponentially with voltage or temperature. The rate doubles for every 10 deg C rise in temperature and increases 2½ times for every 10 volts of collector voltage.[34]

Secondary collector breakdown causes a collector-to-emitter short circuit and occurs in a region a few mils in diameter extending through the germanium wafer. When secondary breakdown occurs, an increase in collector to emitter voltage at first causes only a slight increase in collector current but more applied voltage causes the actual collector-to-emitter voltage to decrease as the current avalanches and is limited by only a very small resistance.[35]

The internal moisture problem in power transistors has been attacked by use of hermetic seals and by using



**BURN THROUGH** in a junction power transistor, Delco

dessicants such as molecular sieves or getters of BaO or $Al_2(SO_4)_3$. Poor hermetic seals can cause breathing of the unit.

Modern circuit design has largely done away with the problem of thermal runaway and devices are stable to 125 deg C or higher but above 150 deg C, indium melts and in some units this can cause short or open circuits.[10]

Studies have been done on silicon power transistors to determine why hot spots occur. These areas with diameters of 100 microns may attain temperatures of 300 deg C. The current density buildup in hot spots causes localized alloying or diffusion resulting in early failure of the device.[36]

Some workers feel that crystal in dislocations are at the root of many semiconductor problems. These dislocations enhance diffusion causing doping inhomogenities and can result in emitter-to-collector shorts or weak spots in base layers. Furthermore foreign metals precipitate at these dislocations causing softness in *p-n* junctions.[37]

**TUNNEL DIODES**—In tunnel diodes, motion of ions has been detected in the strong electric fields of degenerate *p-n* junctions. Under these conditions additional band-gap states are introduced, the transition region widens, and the probability of tunneling diminishes.[38]

**THIN FILMS**—Reliability studies have turned to thin-film devices in anticipation of future developments in the components field. One study involved thin-film metal-electrode to glass-dielectric interfaces, semiconductor-resistance-film to substrate interfaces, and metal film to anodized-oxide interfaces. Structural defects found in dielectrics were due in part to chemical and mechanical interaction at the electrode-dielectric interface and diffusion of the electrode material into the dielectric. Contamination of semiconductor films from their substrates and structural defects in the films due to thermal and structural properties at the interface were also revealed.[39]

**SUMMING UP**—Interesting as all these physics of failure studies are, they are as yet of little help in designing reliable equipment. However, that they are being done is in itself an important fact. Reliability engineering cannot forever remain wedded to statistical techniques. On the other hand neither does the solid-state physicist offer any panacea for all the problems of reliability. The truth is that the battle for reliable electronic equipment must be fought on many fronts.

The formalized program for parts reliability inspection at the factory will in time provide circuit designers with trustworthy failure-rate data from which they can make valid estimates of circuit reliability and choose the best alternate design for the circuit based on intelligent trade-offs between cost and reliability.

Studies of the physics of failure will permit the parts manufacturer to better understand the materials he works with and the production processes he uses and thereby be enabled to meet the stringent parts-failure-rate requirements now coming into general use.

On the systems level, the engineer has at his disposal many useful techniques among which are parallel redundancy, majority logic, time-sequenced redundancy, fail-safe circuit design, and provision for on-the-air repair and maintenance to be performed either manually or automatically.[40,41] As yet only first approximation solutions are available for most practical systems reliability problems. However, much work is being done in this area and modern mathematical techniques are making important inroads.

## REFERENCES


(1) T. Budne, IRE Reliability Training Course, Princeton, N. J., 1962.

(2) *Reliability Digest*, Vol. 2, No. 6, The Martin Co., June 1962.

(3) "Reliability Data Book" and "Estimating Reliability", The Martin Co., Baltimore, Md.

(4) D. Van Der Reyden, IRE Reliability Training Course, Princeton, N. J., July 1962.

(5) Reliability of Military Electronic Equipment, AGREE Report, U. S. Government Printing Office, Washington, D. C., June 1957.

(6) A. F. Floyd, History and Results, Symposium on Electronic Systems Reliability, Kansas City, Mo., 1961.

(7) *Reliability Digest*, Vol. 2, No. 5, The Martin Co., June 1961.

(8) *Reliability Digest*, Vol. 2, No. 7, The Martin Co., July 1962.

(9) Documented Reliability, International Resistance Corp., March 1962.

(10) R. Greenburg, Reliability of Germanium Power Transistors, Wescon, 1962.

(11) J. E. Aalseth, Accelerated Life Testing of Electronic Parts, Physics of Failure Symposium, Chicago, 1962.

(12) Component Parts Failure Data Compendium, EIA Task Group on Component Parts Failure Data, Feb. 1962.

(13) Parts Specification Management for Reliability, Report I, Office of Director of Defense Research and Engineering and Office of the Assistant Secretary of Defense, Supply and Logistics, Washington, D. C., May 1960.

(14) Established Failure Rate Levels for Component Parts, EIA Recommendation, Electronic Industries Association, New York, 1962.

(15) EIA Established Reliability Program, Parts Division Report, Electronic Industries Association, New York, April 2-September 11, 1962.

(16) F. J. Ruther, Lot-By-Lot Process Control, North East Research and Engineering Meeting, Nov. 1962.

(17) C. W. G. Fulcher, Failure Prediction for Nonmaintainable Electronic Components, 7th Symposium on Ballistic Missile and Space Technology.

(18) C. D. Jeffcoat, Measles Chart, Westinghouse, Baltimore, Md.

(19) S. N. Greenberg, Treatment of Redundancy in Design, "Reliability Analysis Data for Systems and Component Design Engineering", Dept. of Commerce OTS PB 181,080.

(20) J. H. S. Chin, Group Redundancy in Space Electronics, 19th National Meeting, Operations Research Society of America.

(21) M. D. Katz, H. Jaffe and S. A. Rosenthal, Designing Reliability Into the B-58 Bombing-Navigation System, 7th National Symposium on Reliability and Quality Control.

(22) N. J. McAfee, IRE Reliability Training Course, Princeton, N. J., July.

(23) W. E. Marshall, Graphic Method for Solving Reliability Logic Configurations, 3rd New York Conference on Electronic Reliability.

(24) K. Curtin, A Monte Carlo Simulation of the Operational Effectiveness of Multi-Moded Systems, 3rd New York Conference on Electronic Reliability.

(25) M. M. Tall, Reliability and Value Engineering, 3rd New York Conference on Electronic Reliability.

(26) R. L. Sims and D. W. Hanna, Space Electronics Equipment—A Space Receiver, 1962 National Symposium on Space Electronics and Telemetry.

(27) V. R. Honnold and C. B. Schock, The Effects of High Energy Radiation on Failure Mechanisms in Semiconductor Devices, Physics of Failure Symposium, Chicago, 1962.

(28) R. V. Babcock, Anomolous Radiation Damage Effect on Capacitance of Silicon Diodes, Physics of Failure Symposium, Chicago, 1962.

(29) J. G. Curtis, Current Noise Measurement as a Failure Analysis Tool for Film Resistors, Physics of Failure Symposium, Chicago, 1962.

(30) D. R. Earles and M. F. Eddins, Failure Therblig Failure Rates, Wescon, 1962.

(31) R. A. Hein, The Effects of Gas Ambient on the Failure of Traveling-Wave Tubes, Physics of Failure Symposium, Chicago, 1962.

(32) F. Aubin, Reliability Studies of Mesa Transistors, IRE International Convention, 1962.

(33) NASA-Wide Quality Assurance Meeting, Washington, D. C., June 5-6, 1962.

(34) K. W. Doversberg, High Power Dynamic Life Tests of Transistors, Wescon, 1962.

(35) M. A. Schafft and J. C. French, Characteristics of Second Breakdown and Transistor Failure, Physics of Failure Symposium, Chicago, 1962.

(36) R. Scarlett and W. Shockley, Thermal Instability and Hot Spots in Power Transistors, Physics of Failure Symposium, Chicago, 1962.

(37) H. J. Queisser, Dislocations in Semiconductor Device Failure, Physics of Failure Symposium, Chicago, 1962.

(38) R. P. Nanavati, Some Physical Mechanisms Contributing to Tunnel-Diode Failures, Physics of Failure Symposium, Chicago, Sept. 1962.

(39) K. Greenough, Primary Modes of Failure Occurring at Material Interfaces in Thin-Film Solid-State Devices, Physics of Failure Symposium, Chicago, Sept. 1962.

(40) J. Klion, Self Repair Techniques, 9th Annual Air Force Science and Engineering Symposium.

(41) RADC Reliability Notebook, U. S. Department of Commerce, OTS 62-535.


## BIBLIOGRAPHY


I. Bazousky, "Reliability: Theory and Practice", Prentice-Hall, Englewood Cliffs, N. J., 1961.

K. A. Brownlee, "Statistical Theory and Methodology in Science and Engineering", John Wiley & Sons, Inc., New York, 1960.

R. S. Burington and D. C. May, Jr., "Handbook of Probability and Statistics With Tables", McGraw-Hill Book Co., Inc., New York, 1953.

S. R. Calabro, "Reliability Principles and Practices", McGraw-Hill Book Co., Inc., New York, 1962.

E. L. Crow, et al, "Statistics Mannual", Dover Publications. Defense Electronics Supply Center, Standardization Data for Hi-Reliability Components, Dayton, Ohio, Aug. 1962.

A. J. Duncan, "Quality Control and Industrial Statistics", Richard D. Irwin, Inc., Chicago, 1959.

D. R. Earles, "Reliability Growth Prediction During the Initial Design Analysis", The Martin Co., Baltimore, Md.

F. M. Gyrna, Jr., N. J. McAfee, C. M. Ryerson and S. Zwerling, "Reliability Training Text", Institute of Radio Engineers Inc., New York, March 1960.

K. Henney, I. Lopatin, E. T. Zimmer, K. Adler and J. J. Naresky, "Reliability Factors for Ground Electronic Equipment", McGraw-Hill Book Co., Inc., New York, 1956.

K. Henney, C. Walsh and H. Mileaf, "Electronic Components Handbook", Vol. I, II and III, McGraw-Hill Book Co., Inc., New York, 1958.

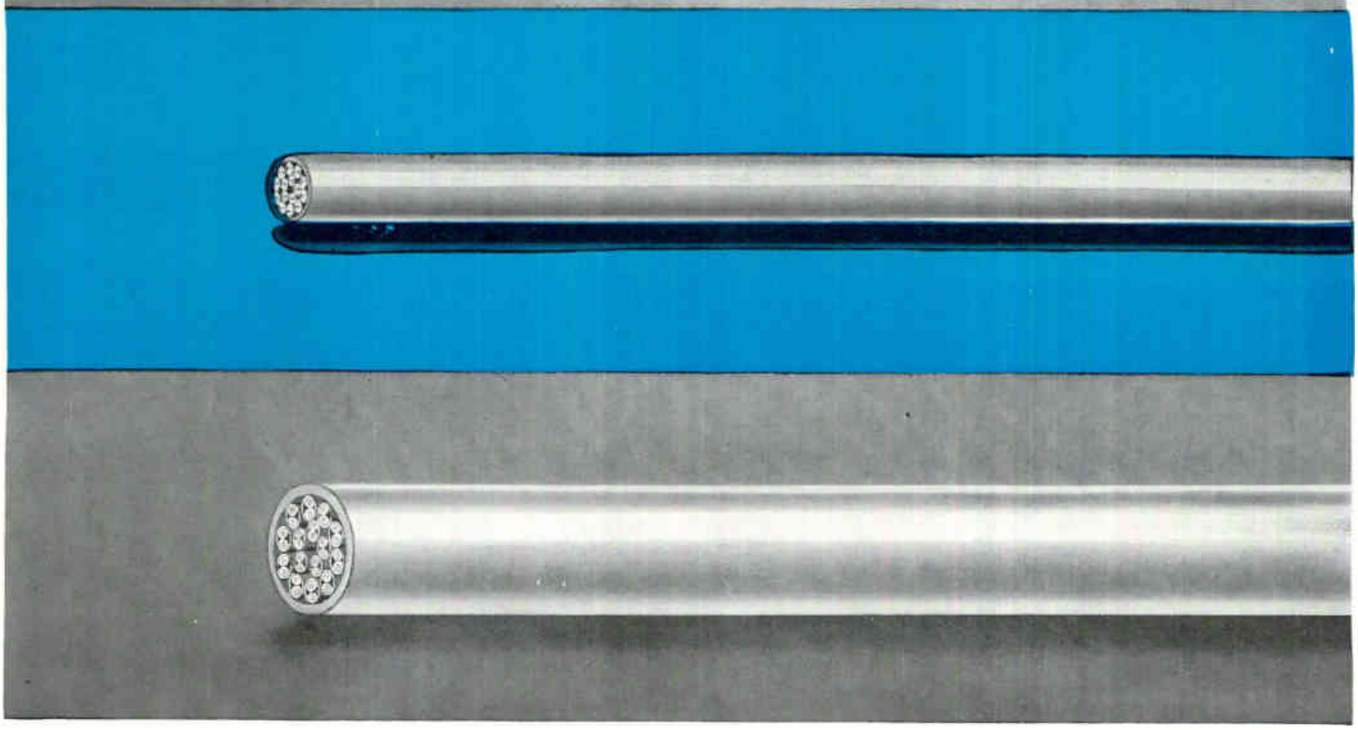
D. K. Lloyd and M. Lipow, "Reliability Management, Methods and Mathematics", Prentice-Hall, Englewood Cliffs, N. J., 1962.

E. Parzen, "Modern Probability Theory and Its Applications", John Wiley & Sons, Inc., New York, 1960.


**Resistor X-rays in the frontispiece** of the report were made by International Resistance

# *Which cable has the*

# Beldfoil*?

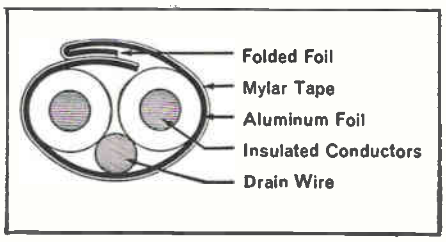


Both shielded cables have the same number of twisted pairs with identical AWG. But . . . the cable with exclusive Belden BELDFOIL is smaller in diameter.

**What does this mean to you?** It means that when you specify BELDFOIL, you are really buying extra space—extra conduit space, extra raceway space, extra console and rack space.

A new development by Belden—BELDFOIL shielding is 100% effective. It is a major development in quiet cables. BELDFOIL eliminates crosstalk and is superior for stationary or limited flexing at both audio and radio frequencies.

BELDFOIL shielding is a lamination of aluminum foil with Mylar which provides a high dielectric strength insulation that is lighter in weight, requires less space, and is usually lower in cost. For multiple-paired cables, with each pair separately shielded, the Mylar is applied *outside* with an *inward* folded edge.** This gives 100% isolation between shields and adjacent pairs.




***For complete specifications, ask your Belden electronics jobber.***

*Belden Trademark Reg. U. S. Pat. Off.
**Patent applied for

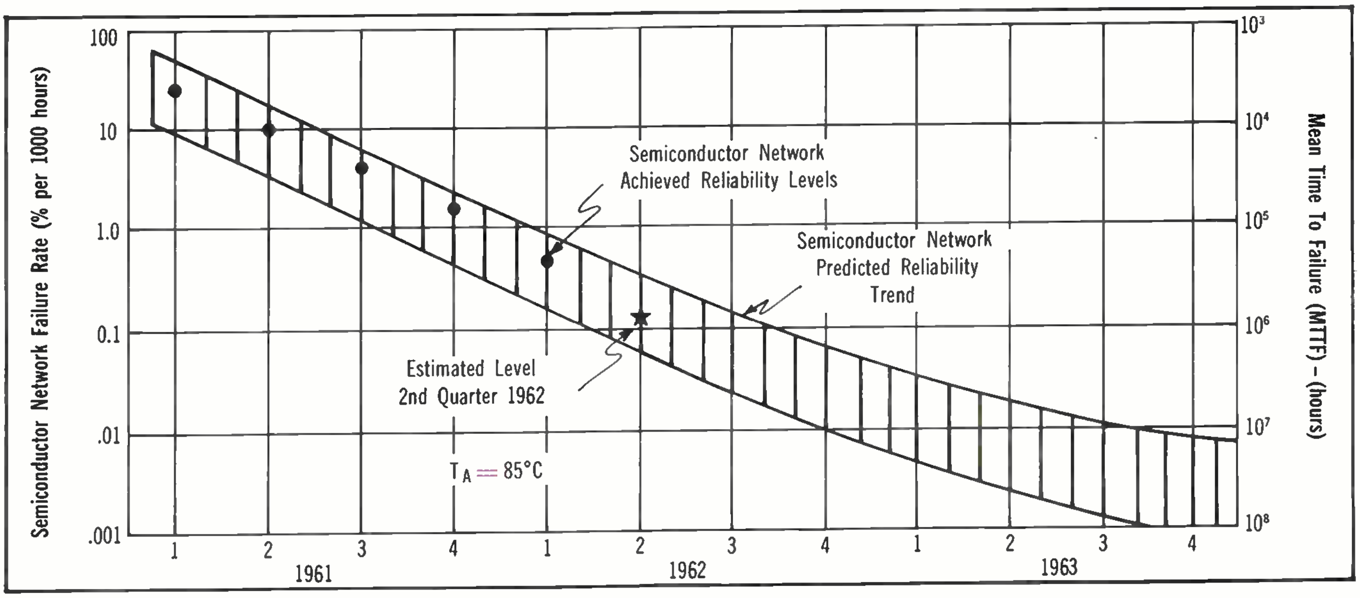
**Belden**
WIREMAKER FOR INDUSTRY
SINCE 1902
CHICAGO

power supply cords • cord sets and portable cordage • electrical household cords • magnet wire • lead wire • automotive wire and cable • aircraft wires • welding cable

8-5-0

Vol. I, No. 3

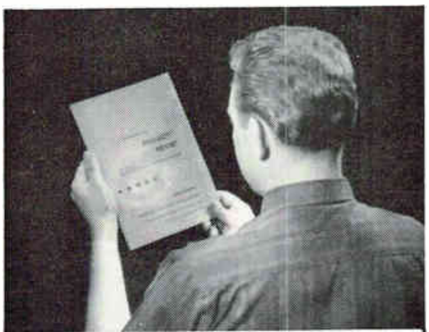
# NEW WAYS TO IMPROVE YOUR CIRCUIT RELIABILITY




The chart above shows a circuit failure rate of about 0.13% per 1000 hours at 85° C. Use of acceleration factors determined through test data would give an approximate circuit failure rate of 0.02% per 1000 hours at room ambient.

## First Report Issued on Reliability of SOLID CIRCUIT* Semiconductor Networks

Texas Instruments has just published a 50-page report, comprehensively covering tests on Series 51 SOLID CIRCUIT semiconductor networks. A total of 365 of these micro-electronic devices manufactured during the fourth quarter of 1961 and the first quarter of 1962 were placed on environmental tests, life tests and step-stress tests. Here is a summary of the test results:



SOLID CIRCUIT semiconductor network, actual size.

**ENVIRONMENTAL TESTS:** The environmental test series indicated that the 85 units tested were capable of withstanding environmental stresses in excess of those normally required of semiconductor devices used in military applications.

**LIFE TESTS:** A total of 255 TI semiconductor networks were placed on life test — both operating and storage — for a total of 355,000 circuit hours. Since each network contains approximately 20 discrete components interconnected as a circuit, this is the equivalent of more than 7,000,000 component hours. The results of these tests and similar data obtained subsequent to the issuance of the report show the reliability trend indicated by the chart above.

**STEP-STRESS TESTS:** Twenty-five semiconductor networks were temperature-stressed to destruction. Defect-analysis of all failed parts were performed to determine failure modes. Process improvements and even more stringent process control have already been established as a result of the tests.

If you would like a personal copy of the complete semiconductor-network reliability report, ask for Bulletin 549-1.

**Trademark of Texas Instruments Incorporated*

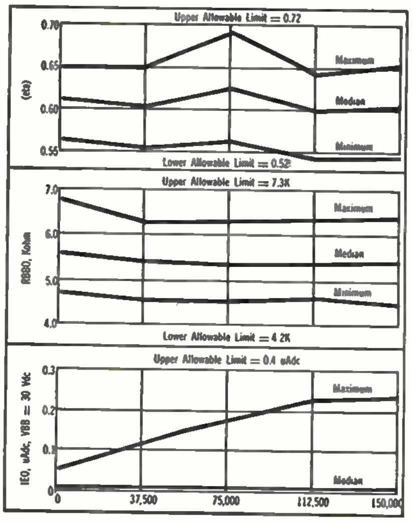
# Over-all Circuit Reliability Increased With TI Unijunctions

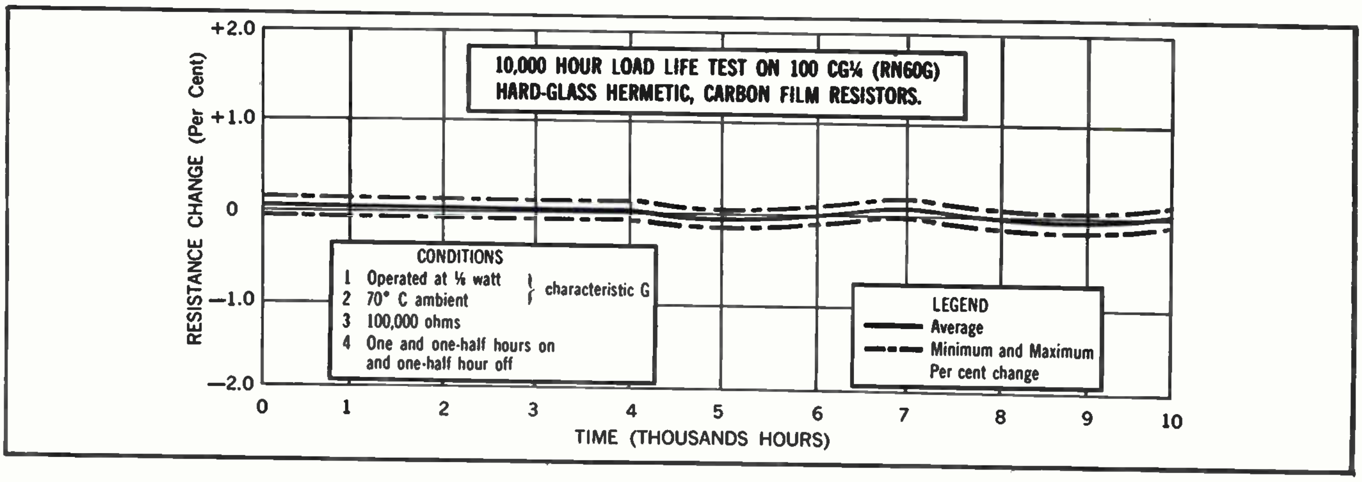
**HERE'S HOW:** A single Texas Instruments unijunction transistor will do the job of several ordinary transistors and resistors in many applications. This means greater over-all reliability (and economy) for your circuits, since fewer components and fewer connections mean fewer opportunities for trouble to occur. In addition, TI unijunctions are highly reliable semiconductor devices themselves. More than a half-million unit test hours (both high-temperature storage and operating life) have already been accumulated — without a single catastrophic or degradation failure. Operating characteristics of the devices have remained well within acceptable parameters (see the charts on operating life below).

A full line of 22 unijunction transistors is now available from Texas Instruments. These units feature dissipation to 600 milliwatts, interbase resistance from 4.0 to 12 kilohm, intrinsic standoff ratios from 0.47 to 0.8, and extremely low peak emitter current ranging from 6 to 25 microamps.

The special characteristics of TI unijunctions — particularly their highly stable negative resistance — make the devices ideal for high-reliability applications such as relaxation oscillators, sawtooth generators, trigger circuits, counters and bi-stable circuits.

Ask for bulletin 504-2, containing a number of useful circuit applications for unijunctions.




# 30 Million Test Hours Now Run on TI Hermetic Film Resistors

More than 30 million unit hours of extended load life have been run on Texas Instruments CG series hard-glass, hermetic film resistors. Not a single catastrophic failure has occurred during these tests, for a remarkably low failure rate of 0.003% per thousand hours (60% confidence level). In addition to this impressive evidence of built-in resistor reliability, TI has accumulated a "library" of test data on resistor stability.

**TEST CONDITIONS:** Over the past two years, more than 60 standard production lots of CG1/4 and CG1/8 resistors have been subjected to long-term load life tests, up to 10,000 hours per lot. These tests include: five ambient temperatures — from 25°C to 175°C; seven wattage levels — 0, 1/64, 1/32, 1/16, 1/8, 1/4, 1/2 w; three maximum voltages — 250, 300, 350v; and 35 ohmic values — 24.9 ohms to 1 megohm.

**STABILITY PROOF:** The graph above shows one test, typical of the series. Notice the exceptional stability indicated by the drift curve, even under conditions of maximum power and maximum continuous working voltage.

You may be surprised to learn how economically you can buy TI hermetic resistors which provide all of the superior performance indicated by the test data. Ask your Texas Instruments sales engineer for more detailed information, or write for Bulletin 504-3.

If you would like to have more detailed specifications and application information on the products featured in this advertisement, call your local TI sales engineer or write to Texas Instruments Incorporated, P. O. Box 5012, Dallas 22, Texas.

Semiconductor Networks Bulletin 549-1
Unijunction Transistors Bulletin 549-2
Hermetic Film Resistors Bulletin 549-3

SEMICONDUCTOR-COMPONENTS DIVISION

TEXAS INSTRUMENTS
INCORPORATED
13500 N. CENTRAL EXPRESSWAY
P. O. BOX 5012 • DALLAS 22, TEXAS

19549

## To Contractors and Subcontractors on U. S. Government Projects

# Western Electric offers high reliability diodes, transistors and magnetrons

■ Western Electric's Laureldale, Pennsylvania, plant is now in its tenth year of producing semiconductor devices of ultra-high quality and reliability for government applications.

■ Devices designed by a resident Bell Telephone Laboratories group have performance standards exceeding specification requirements which are based on MIL-S-19500B.

■ Mechanized production facilities and a comprehensive statistical quality control program assure uniformity and contribute to obtaining ultimate process capabilities.

■ For further information on Western Electric-Laureldale electron devices and magnetrons . . .

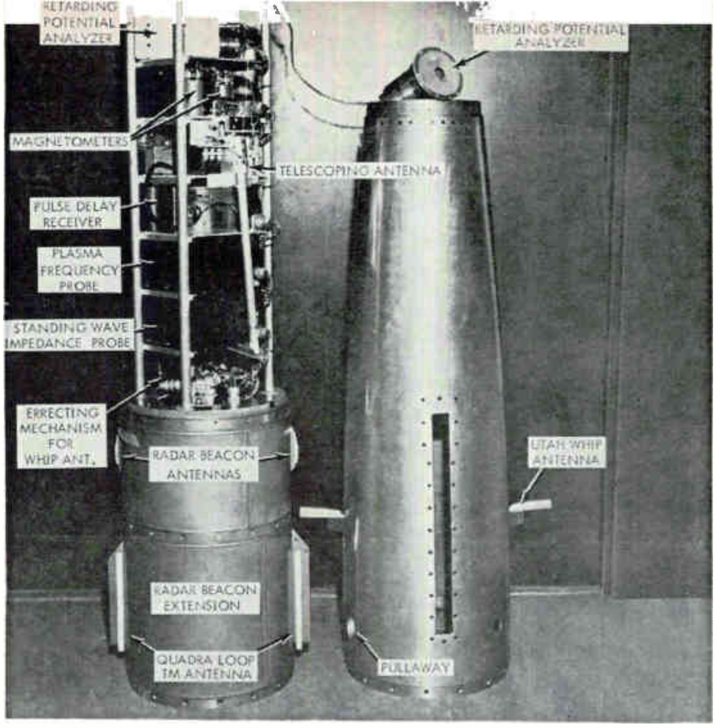
Telephone — Area Code 215 — 929-5811

**LAURELDALE PLANT**

**MAKER OF ELECTRON PRODUCTS**

Western Electric

MANUFACTURING AND SUPPLY BELL SYSTEM UNIT OF THE BELL SYSTEM




PLASMA FREQUENCY PROBE *mounted in payload of Astrobee 200 rocket*

# New Ionosphere Measurement Technique:

# PLASMA FREQUENCY PROBE

*By exciting the ionosphere plasma with a varying r-f signal, this probe measures plasma resonance, from which electron density is calculated*

By OBED C. HAYCOCK and KAY D. BAKER

Upper Air Research Lab., Univ. of Utah, Salt Lake City, Utah

**WHY IONOSPHERE RESEARCH?**

*Highly ionized layers of the earth's atmosphere, known collectively as the ionosphere, are produced by radiation from the sun and from outer space. Studies of ionization intensity, measured by electron densities and spatial and temporal variations, aid in understanding the interactions between the earth's atmosphere and the sun's radiations. Also, because the ionosphere affects and sometimes controls radio transmission, data on electron density can improve radio communication*

THE UPPER AIR Research Laboratory at the University of Utah has for several years used rocket and satellite techniques for determining electron density of the ionosphere. The first method used was the pulse delay system in which pulses of r-f energy are transmitted through the ionosphere between a rocket and ground and the electron densities calculated from the variation of propagation.[1] The second technique was the r-f impedance probe.[2] This system measures the induced impedance changes of an antenna mounted on a rocket or satellite. Electron densities are calculated from the measured changes. Recently a technique has been developed that directly measures the plasma frequency of an ionized medium from which the electron density can be calculated. The probe (photo) measures the plasma frequency of the ionosphere.

The interaction of an electromagnetic wave and the free electrons of an ionized medium give the electrons an oscillatory motion, thus adding a conduction current to the displacement current. (In the ionosphere, ions other than electrons need not be considered since these other ions, due to their much higher mass, will not achieve significant velocities compared to those of the free electrons.) The velocity of the electrons not suffering collisions with other particles will lag the exciting electric field by a phase difference of 90 degrees, that is, the conduction current of electrons will lag the exciting electric field by this phase difference. The free-space displacement current leads the exciting electric field by a phase difference of 90 degrees; therefore, these two currents differ in phase by 180 degrees and the magnitude of the resultant current will equal their difference. Since each of these currents is in phase quadrature with the exciting electric field, the average energy absorbed from the exciting electromagnetic wave is zero when electron collisions are neglected.

EQUIVALENT CIRCUITS — The excited electrons will suffer collisions with other particles, however, dissipating energy and appearing as a loss term. An equivalent circuit of the ionosphere showing the effects of these components is shown in Fig. 1A, with a phasor diagram. The quantities are considered to be values per unit volume, that is, the equivalent circuit treats a cubic meter of the plasma. In Fig. 1A, $\epsilon_o$ is the permittivity of free space, $E$ electric field intensity, $m$ and $e$ the mass and charge of the electron, respectively, $N$ the number of electrons per unit volume, and $\nu$ is the collisional frequency or the average number of electron collisions per second per cubic meter of the plasma. At high frequencies the capacitive displacement current term, $i_c$, predominates and thus the free-space condition is approached. As the frequency is lowered, the electron current, $i_N$, becomes larger until the plasma frequency or parallel-resonant point is reached where the two opposed components are equal. It should be possible, therefore, to excite the plasma with an r-f signal, vary the frequency of the exciting field, and measure the resonant frequency.

Once the plasma frequency of the medium is known, it is easy to calculate the electron density. When terrestrial magnetic field effects are neglected, and at altitudes where collisions are negligible (above 80 Km), the operation becomes simply

$$N = \left(\frac{1}{80.6}\right)(10^{12})\,(f_N^2)$$

where $f_N$ is the plasma frequency in megacycles and $N$ the electron density in electrons per cubic meter.[3]

To determine the plasma resonance frequency, a dipole antenna mounted on a vehicle passing through the ionosphere is excited with a low-level r-f signal. The antenna voltage and current are compared in phase as the frequency is varied; the frequency where they are in phase will be the plasma frequency, corresponding to parallel resonance in the equivalent circuit shown in Fig. 1A.

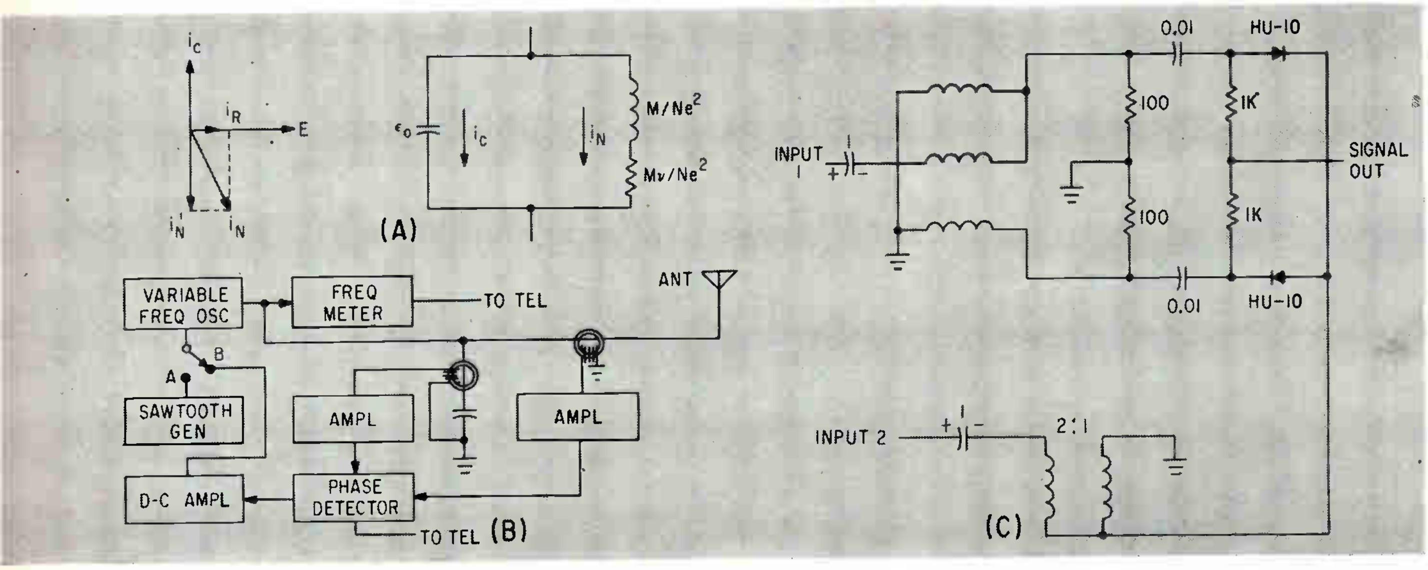
A dipole from 8 to 12 feet in length is used to excite a fair sized region of the plasma away from the vehicle body even though a zero phase relationship between antenna voltage and current at plasma resonance exists independently of the physical length of the antenna. As the plasma frequency is approached the antenna element becomes infinitesimally small electrically, regardless of its physical length, since the wavelength in the medium approaches an infinite value. (The wavelength in the ionized medium is

$$\lambda = \lambda_o\,[1/\sqrt{1-(f_N/f)^2}]$$

where $\lambda_o$ is the free space wavelength and $f$ is the exciting frequency.) This is the condition where quadrature component of the electron current $i_N$ just equals and cancels the displacement current flowing from the antenna. Hence, only a small current flows in the antenna circuit, the condition of resonance in Fig. 1A.

EXPERIMENT—A plasma frequency experiment was flown in an Astrobee 200 sounding rocket from Eglin Gulf Test Center, 12:35 CST on April 30, 1962. The payload section and lower portion of the nose cone are shown in the photo. This payload, denoted as AA15.196, also contains other experiments.

The plasma frequency probe system is shown in Fig. 1B. In the sweep mode, which corresponds to the switch in position $A$, a sawtooth




EQUIVALENT *circuit of ionosphere (A); probe system for rocket (B); and phase detector (C)—Fig. 1* generator sweeps the frequency of r-f oscillator over a frequency range of 2 to 11 Mc. The locked mode is obtained when the switch is in position *B*. In this position the oscillator will lock onto the plasma frequency, if it is within the range of the instrument. The low r-f voltage, less than a volt in magnitude, is applied to the antenna.

The antenna consists of two telescoping elements. The elements are stored collapsed to a length of 20 inches in a cavity in the rocket skin (photo) until the rocket is out of the dense portion of the atmosphere, about 60 Km. It is then released and folds out to a position normal to the rocket body and is telescoped out to a length of 10 feet by a gas generator. One antenna element is electrically driven with respect to the rocket body; the other half of the dipole is for another experiment.

The r-f voltage is applied to the antennas and the antenna current monitored by a current transformer. The transformer consists of a ferrite toroid about 1¼ inches in diameter with a ¾-inch hole and wound with ten turns of small wire. It is mounted at the base of the antenna element with the element passing through the hole in the toroid. Thus, the current is sampled at the point where it flows into the antenna element. The output of the antenna current transformer is amplified and constitutes one input to the phase detector. The other input, the antenna voltage monitor, is derived as is the current input, except that the transformer samples the current through a small fixed capacitor. This signal is sent through an amplifier, which is matched to the antenna current amplifier, and then to the phase detector. The voltage and current sampling circuits are matched from the transformers up to the phase detectors so that any phase shifts through the two circuits will be equal.

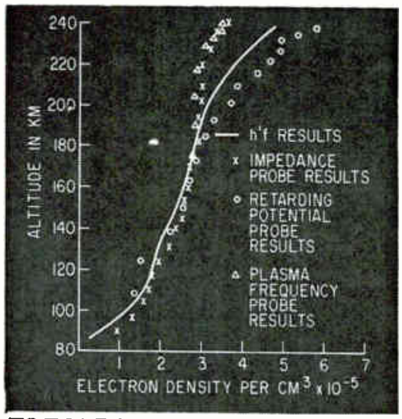
The phase detector, Fig. 1C, is a balanced demodulator in which there is no output when the two signals are in phase quadrature. This will be true when the antenna voltage and current are in phase, since the antenna voltage is sampled as a current through the fixed capacitor. As the frequency is swept through its range, the output of the phase detector will pass from a value corresponding to a positive antenna phase angle, through zero phase at the plasma frequency, to a negative phase, assuming the plasma frequency lies in the range swept. The output of the phase detector is biased positively so that the voltage will be in the range of 0 to +5 v. This voltage is applied to a voltage controlled subcarrier oscillator of the f-m/f-m telemetry system.

To obtain data, the frequency of the oscillator must be accurately known. The frequency meter converts the frequency to a voltage that gives an analog output in the range of 0 to +5 v. This modulates a second subcarrier oscillator in the telemetry system.

The analysis of the data for this sweep mode consists of inspecting the output of the two telemetry channels and by correspondence noting the frequency at which the phase passes through zero. Also, the losses or collisions of the ionosphere can be determined by noting the slope of the phase plot as it passes through the zero position.

TELEMETRY — The sweep-frequency plasma probe requires two telemetry channels for display of the data. In some applications, particularly in earth satellites, there is shortage of telemetry channels. An experimenter may be allowed only six commutator segments, each sampled once a second. Such data sampling prohibits use of the sweep system. The locked frequency system is being developed for these applications. Here the oscillator frequency is not continuously swept, but locks on the plasma frequency. As a system check, this system was incorporated in the Astrobee 200 flight and required the d-c amplifier and the switch shown in Fig. 1B. When in the locked mode, switch position *B*, the output of the phase detector is used as a signal that is applied through a feedback loop to control the oscillator frequency. Thus, in the locked mode it is necessary to measure only the frequency of the oscillator. This can be done by sampling the frequency meter. At satellite altitudes the plasma frequency gives complete information since collisions are negligible.

In the Astrobee 200 system, the sweep and locked modes were used in a time-sharing sequence by electronically switching the input of the frequency control point of the oscillator alternately to the sawtooth generator and the output of the d-c amplifier.



ELECTRON DENSITY *measurements made on rocket flight—Fig. 2*

Figure 2 shows the results of three rocket borne electron density measurements for Rocket AA 15.196 as well as the h'f record from the Santa Rosa Island ionosphere sounder taken at 12:30 CST, 30 April. The h'f record is plasma frequency versus height data taken from the ground by sending r-f pulses into the ionosphere at vertical incidence and noting the highest frequency that is reflected at the various heights above the earth. Thus, certain regions of the ionosphere can be investigated from the ground.[3] Data analysis for the plasma-frequency probe is still underway; only preliminary data are available. Data points are shown from the plasma-frequency experiment and are in agreement with other methods of electron-density measurement.

This reasearch was sponsored by Air Force Cambridge Research Laboratories. The authors express their appreciation for this aid and also to W. Pfister and James C. Ulwick of that agency for their cooperation.

REFERENCES

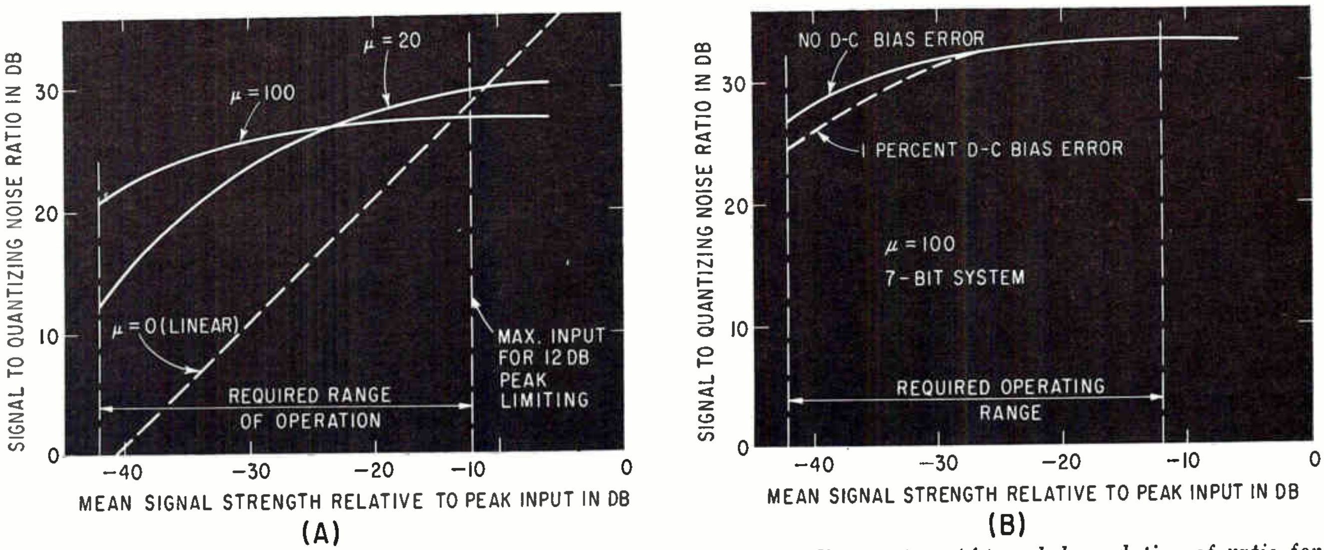

(1) O. C. Haycock, J. I. Swigart and D. J. Baker, Electron Densities of the Ionosphere Utilizing High-Altitude Rockets, *IRE Trans*, AP-7, No. 4, p 414, Oct. 1959.

(2) O. C. Haycock and Kay D. Baker, Measuring Antenna Impedance in the Ionosphere, ELECTRONICS, 34, No. 2, p 88, Jan. 13, 1961.

(3) F. E. Terman and J. M Pettit, "Electronic Measurements", McGraw-Hill Book Co., New York, p 470, 1952.

# Better Speech Quantizing

*Linear ratio encoder uses automatic-gain-controlled amplifier. It requires only a six-bit binary code for quantizing, has constant-level output and needs no complementary expansion at the receiving end*




VARIATION *of signal-to-quantizing-noise ratio for a 6-bit speech encoding system (A) and degradation of ratio for bias error of 1 percent (B)—Fig. 1*

TO OBTAIN pulse-code modulation (pcm) from speech, the input voltages, handled by a quantizing stage, must be compressed by either an instantaneous compandor or an agc (automatic gain controlled) system.

While attention has been given to compandor,[1,2,3,4] agc schemes have been rejected, mainly because they require an amplifier in each input channel.

This system performs as an agc, employs 6-bit linear encoding, removes speech mean-level variations and does not require an amplifier on each input. It is based on a reference voltage for the digital converter derived from the mean level of the sampled waveform. The digital output of the converter is the ratio of the instantaneous input and mean input levels.

The system performs better than an instantaneous compandor in that it does not require accurate matching of nonlinear characteristics and needs no complementary expanding at the receiving end.

PCM REQUIREMENTS—A pcm system must handle voltage excursions and mean-level variations of speech.

The voltage distribution of a speech envelope may be represented by a negative exponential; this is valuable in analyzing a system's performance, but does not indicate the range of reproduction. The upper limit may be estimated by noting that the probability of occurrance of a voltage four times larger than the mean value is only 1 percent. Hence, it is reasonable to clip the voltage peaks 12 db above the mean value; the subjective distortion is detectable, however, and some relaxation would be acceptable.

At low levels, the amplitude distribution of speech affects the quantizing noise of the digitized signal. By taking the distribution into account, it is possible to calculate the signal-to-quantizing-noise ratio for various pcm systems.[2] Sources[1,2] indicate that 30 db is tolerable for high-quality speech.

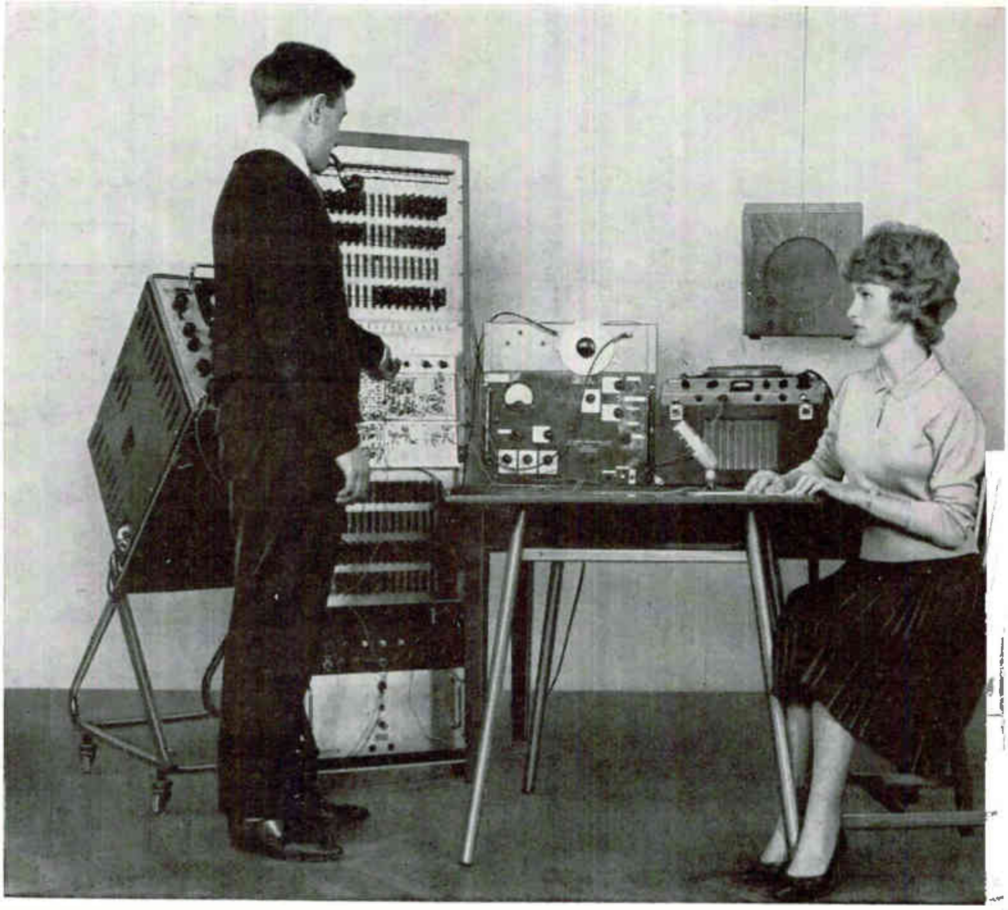
Consider the variation in mean

# for Pulse-Code Modulation

By J. D. HOWELLS
English Electric Aviation Ltd.,
Luton, England

**SIMPLER AND BETTER ENCODING**

*This ratio quantizing system is said to be simpler and better than previous ones. It uses a 6-bit binary code where conventional systems would need 7 bits or more. Since speech compression is linear, neither accurate matching of the characteristics nor complementary expansion are needed at the receiving end. Instead of quantizing the instantaneous speech input, the ratio of input to mean level is encoded. Thus, not only is a mean constant output obtained, but the advantages—and none of the disadvantages—of both logarithmic and linear encoding are combined*



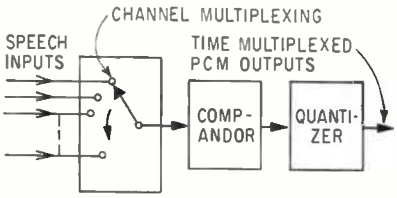
MAKING TEST *recordings of linear ratio quantizing system*

level at the input of a pcm system; 98 percent of signals lie within ±13 db of the median level. For a military system, the talker volume and land-line loss gives a variation of ±15 db. Therefore, a variation of 30 db may be taken as a design criterion.

A pcm system is therefore required to handle a variation of 30 db in the mean input level, and reproduce the speech at a signal-to-quantizing-noise ratio of at least 30 db, with peak clipping 12 db above the mean of any input.

SIGNAL COMPRESSION—With a linear system, an 11-bit code would be required. However, using nonlinear compression, a 6 or 7-bit code would be sufficient to compress the same signal.

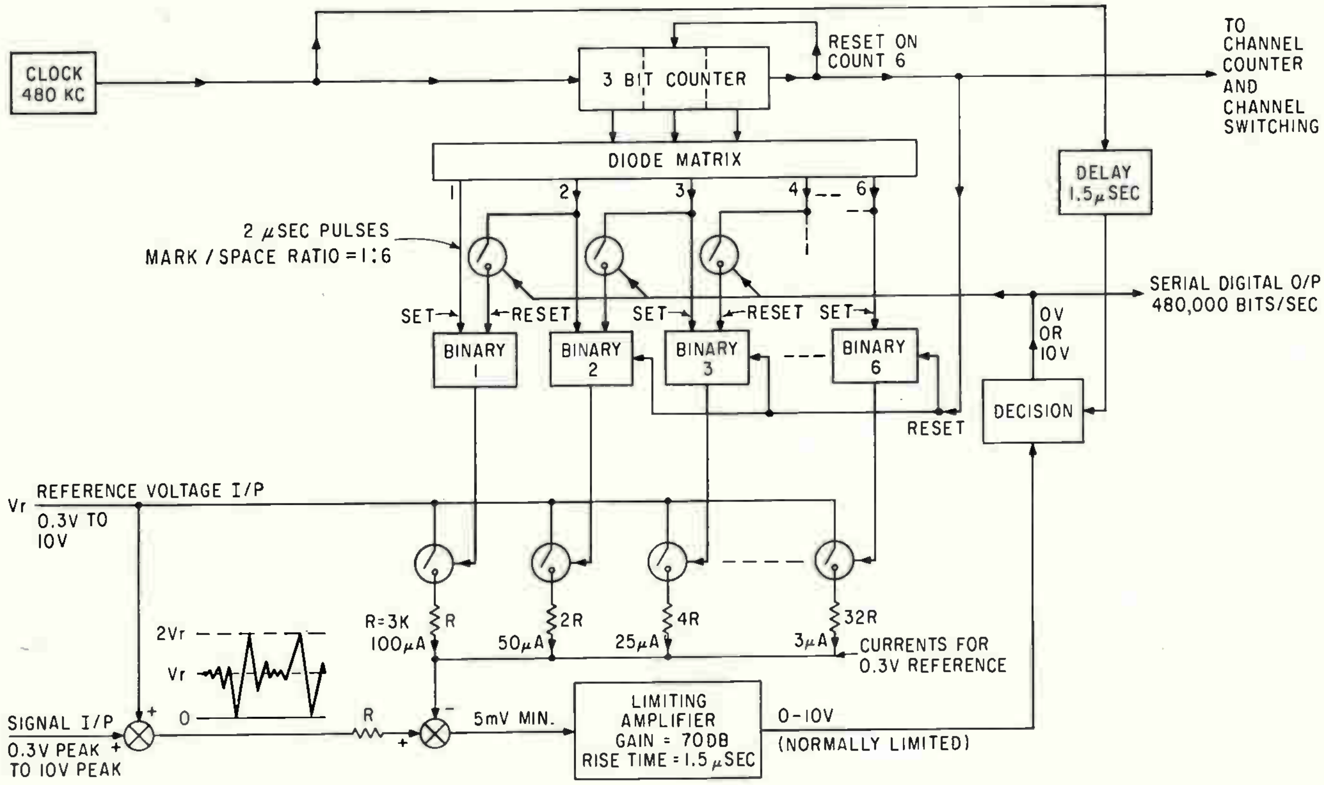
Nonlinear compression gives preferential treatment to low-level signals. A logarithmic transfer characteristic $V_{out} = \log(1 + \mu v)$ where $\mu$ is a constant and $v$ is the instantaneous input voltage, is normally used.



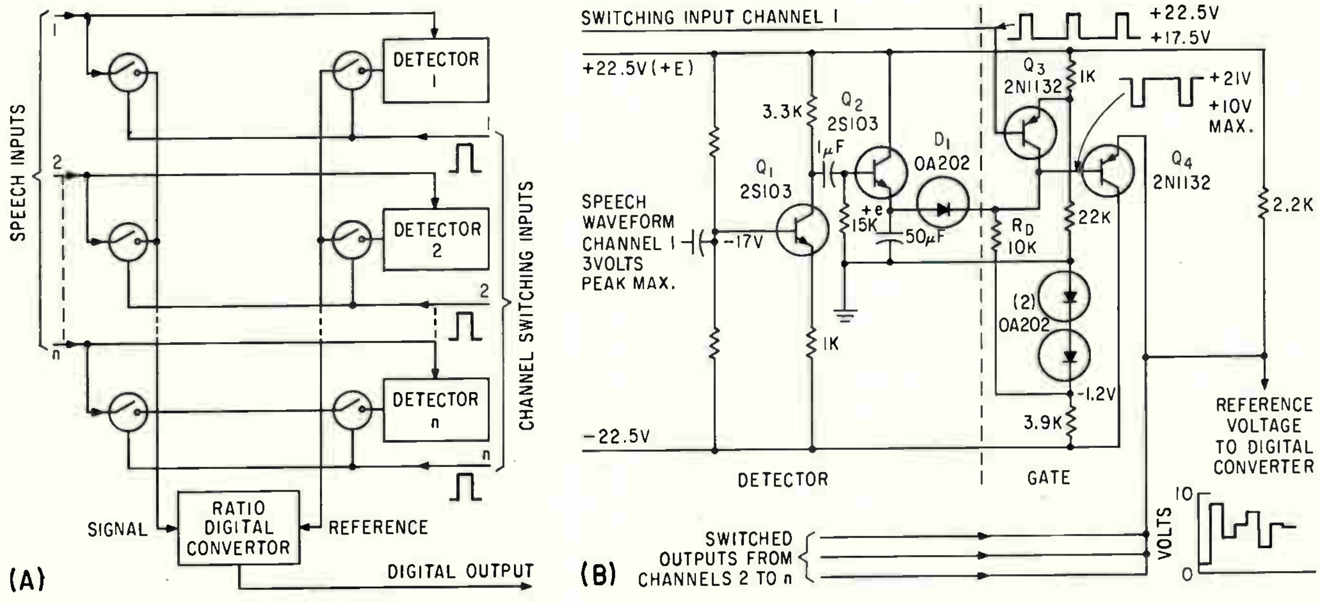

MULTIPLEXED *channels in a pcm system—Fig. 2*

The parameters of the system are determined by considering the signal-to-quantizing-noise ratio over the input range of 30 db (Fig. 1A). The exponential distribution of speech amplitudes is taken into account in the construction of the curves, which are drawn for a 6-bit code (64 level) at $\mu$ = 0, 20 and 100. Since the signal-to-quantizing-noise ratio is directly proportional to the number of quantizing steps, a 6 db improvement is obtained if the code is increased from 6 to 7 bits. (20 log $(2^7/2^6)$ = 6 db.)

Logarithmic compression produces a region in which the output signal-to-noise ratio is substantially independent of changes in the input level; the region becomes larger as




DIGITAL CONVERTER *for ratio quantizing unit; only four of the six binaries are shown—Fig. 3*




SET OF SIGNALS *multiplexed for ratio quantizing (A). Detector and gate circuits that supply reference voltage to the digital converter (B)—Fig. 4*

$\mu$ increases. For the 6-bit code system, the best signal-to-ratio performance occurs at $\mu = 100$, which gives a ratio of between 21 and 27.5 db over the 30-db range. An increase in the maximum input level to allow for 6 db of peak limiting, which produces apparent but not severe distortion, brings the ratio up from 21 to 24 db; this is still short of the required 30 db. Resorting to a 7-bit code, the signal-to-quantizing-noise ratio over the 30-db input range is between 27 and 33.5 db for 12-db peak clipping, or 30 to 33.5 db for 6-db peak clipping.

It has been assumed that there is no d-c bias error at the input of the compandor; otherwise, at low signal levels, a degradation occurs. Figure 1B shows the effect of a bias equal to 1 percent of the peak input, which gives rise to a loss of 2 db in the signal-to-noise ratio.

Thus, a logarithmic compandor needs a 7-bit code, and complementary expansion and compression at the two ends of the link. All signals are reproduced at their correct amplitude; a quiet speaker or a high land-line loss appears as a weak signal at the receiving end.

CONSTANT LEVEL ENCODING—In a gain-controlled encoder it is convenient to assume that all signals presented to the pcm are at a constant mean level. Using logarithmic encoding, there is no gain in the signal-to-quantizing-noise ratio.

With linear encoding, the signal-to-noise ratio of a 6-bit system with 12-db peak limiting is 29 db, or, with 6-db peak limiting, 35 db. Therefore, there is no need for a 7-bit code, since the improvement can hardly be detected.

In a constant-level system, all speech transmitted over the link is reproduced at the same mean level. Although cancellation of circuit losses is desirable, some loss of speech intonation will occur. The loss is a function of the time constant of the averaging circuit, which must be made sufficiently long so that short-term variations in the speech amplitude are reproduced. Experiments indicate that a short time constant (about 1 sec) is, adequate; and with 5 or 10 seconds little realism or intelligibility are lost.

Rapid rises in level must be accompanied by rapid falls in gain; otherwise, the system overloads after a quiet period.

A second noticeable effect of controlled-level operation is that the circuit noise rises when the speaker ceases talking. This effect is most apparent on a good circuit where the gain change is maximum between quiet and signal conditions. On these circuits, it should be possible to maintain the noise to a low level, and the 30-db gain increase should not be troublesome.

Although the gain-controlled system is desirable, it is not normally considered since a separate audio amplifier must be used on each input channel. If this operation were achieved more simply, the adoption of linear encoding would remove the requirement for any expansion circuit at the receiver and any impairment of the signal-to-noise ratio due to d-c bias errors.

PRACTICAL SCHEMES — The methods available for logarithmic companding form a comparison with the constant-gain method. Consider a practical system in which several channels are time multiplexed to a single link. Multiplexing and companding are shown in Fig. 2; a single compandor and quantizer serve all channels of a group.

Companding may be achieved independently of the quantizing operation using a continuously variable analog circuit; nonlinear elements, provide the required characteristic. This makes it difficult to control its characteristic accurately and to match it with a complementary function at the receiving end.

An improved method[1] incorporates the logarithmic characteristic into the quantizing operation. A ladder of accurate current attenuators are switched in or out of the circuit by binary codes, until the attenuated current equals the input drive current. Electronic switches are used; the unit meets the speed of operation required for 24 time-multiplexed channels. The law is repeatable and can be easily matched at the receiving end.

Each stage of the current attenuators uses three transistors, while a binary voltage attenuator uses only one. Similar attenuators are used at the transmitting and receiving ends of the link.

LINEAR QUANTIZING—Constant level encoding requires a gain-controlled audio amplifier in each channel and this is uneconomical.

As an alternative, the quantizing stage can be used as a ratio device; the system is arranged so that a digital output, equal to the ratio of instantaneous input and mean input level, is obtained. The digital converter is easily arranged but additional circuits are needed to store the mean levels and switch them to the converter in synchronism with the channel input.

A block diagram of the digital converter connected to give a ratio output is shown in Fig. 3. The instantaneous signal voltage is compared, in sequence, to $\frac{1}{2}V_r$, $\frac{1}{4}V_r$, $\frac{1}{8}V_r$, . . . where $V_r$ is the reference voltage. A yes or no indication is obtained on each comparison indicating whether the summed voltage is greater or smaller than the signal input voltage.

These yes-no indications set up a chain of binaries, so that the cumulative sum is remembered, and also form the digital output to the transmission line. The binaries are reset, and a new sampling operation begun at the completion of each 6-bit word.

SYSTEM OPERATION—Figure 3 refers to 10 multiplexed channels, each with a sampling rate of 8 Kc. The sampling operations are controlled by a 480 Kc clock that drives a 3-bit counter and a diode matrix. The counter resets on a count of 6, and produces pulse outputs from the matrix of approximately 2 $\mu$sec. duration that continuously cycle outlets 1 to 6. The reset pulse also feeds a similar counter and matrix for counting and switching the 10 multiplexed channels.

Binaries 1 to 6 are the storage elements for the digital output. On the reset pulse, at the completion of each measurement, binaries 2 to 6 are reset to zero, but binary 1 is switched on by the appearance of the 2 $\mu$sec pulse on the 1 output of the matrix. This switches $\frac{1}{2}V_r$ to the differencing point. The other differencing input is derived from the sum of the signal and the reference, such that the net waveform is always positive. This is attenuated by a factor of two so that the peak input to the differencing network is $V_r$. Therefore, depending on whether signal waveform is $V_r^+$ $V_r^-$ at the time of the sample, the output from the differencing network will be above or below zero, and this causes the amplifier to saturate in one direction. The actual decision on the amplifier output is taken 1.5 $\mu$sec after the input is applied; the decision unit supplies a 0 or 1 pulse both to the transmission line, and to the number 1 binary. The sense of this pulse is such that if the $\frac{1}{2}V_r$ increment is too large, binary 1 will be reset to its off state on the appearance of the 2 pulse from the matrix. This pulse, which is initiated by the clock, also sets binary 2 on, and applies a $\frac{1}{4}V_r$ increment to the amplifier. Again, this increment is either retained or rejected by the decision unit on the amplifier output. The cycle proceeds through the 6 digits of the measurement, each digit having half the significance of the previous one, and producing a 0 or 1 output, until the least significant digit $\frac{1}{64}V_r$ is reached. When the decision on this element has been made, all the binaries except number 1 are reset to zero, and the system starts on the next measurement. The changeover to the next multiplexed channel as shown in Fig. 4A is in synchronism with the completion of a measurement.

One measurement is completed in 12.5 $\mu$sec; and a serial digital output is obtained, which lags the clock time by 1.5 $\mu$sec. This output represents in binary form the ratio of instantaneous input voltage to the reference voltage, $V_r$, derived from the input signal.

In Figure 4A, the mean value of each of the inputs is derived separately and switched to the reference input of the converter in synchronism with the signal. Two electronic gates and an envelope detector are needed on each channel. In the nonlinear compression system, one gate and a common compandor are required per channel. The gate input signals switch the gates 1 to $n$ in sequence; prf is 8 Kc.

The detector is required to rectify speech signals over a 30-db range, to have a discharge time constant of about 5 seconds and to charge in a few milliseconds; thus a peak, rather than a mean, detector must be employed.

DETECTOR—A circuit that meets these requirements is shown in Fig. 4B. The gating circuit for the reference voltage, together with the means of adding the various outputs, are also shown.

The absolute value of the maximum signal input is 9 db above 1 volt, or approximately 3 volts. Signals 30 db below this level, peak levels of 0.1 volt, must be handled. Therefore, a buffer amplifier precedes the detector and has a voltage gain of 3.3 times, giving a range of 0.3 volt to 10 volts peak on the base of rectifying transistor $Q_2$. The current through this transistor charges a 50-$\mu$f capacitor in its emitter circuit to 10 volts in 10 msec, with a current of 50 ma.

The detector allows the charge of the memory capacitor to rise rapidly when a speech input is applied, thus keeping the overload period to a minimum. The discharge time constant is determined by the resistor $R_D$ and the conduction time of diode $D_1$.

Normally, $D_1$ is held off by switching transistor $Q_3$, and the voltage applied to the base of $Q_4$ is nearly the full rail voltage $E$. During the sampling time of the channel, $Q_3$ is cutoff allowing $D_1$ to conduct, thereby applying the capacitor voltage to $Q_4$. The effective discharge resistance on the capacitor is therefore $R_D$ times the duty ratio or $nR_D$, where $n$ is the number of multiplexed channels. Assuming 10 channels, the diagram values give a time constant of 5 sec.

In one group of channels all the output transistors, $Q_4$, are held at $+E$ volts, except the channel transmitted which will be at the peak signal voltage, $+e$. This voltage appears on the common emitter line, and forms the reference input voltage to the digital converter.

The effect of tolerances on the performance of the system must be noted. Variations in the standing voltages across the transistors and the diode, and in the gain of the buffer amplifier, will cause errors in the d-c output. The effect is most marked at the small signal end, but the circuit shown is designed to cancel the transistor emitter-base potentials; the maximum error does not exceed 0.1 volt. This is 20 percent of the minimum signal, and can cause an error of ±2 db in the determination of the reference voltage, causing the working point on the signal-to-quantizing-noise ratio graph, Fig. 1A, to move. A change in the signal-to-noise ratio and also a change in the peak limiting level thus occurs. But the total excursion is only 4 db and the distortion introduced is tolerable in the low-signal condition. The performance of logarithmic companding schemes also falls off with small signals, particularly if likely tolerances are taken into account, Fig. 1B.

Since linear encoding is employed there is no performance loss due to bias errors.

PERFORMANCE — The performance of a constant-level link is considered satisfactory; one desirable effect is the cancellation of land-line loss. Two features that need attention are the speed of response of the detector circuit, such that overloading at the beginning of speech is reduced to a tolerably low level, and the maintenance of a low noise level, such that there is no excessive increase in background noise level during silent periods.

The problem of hybriding the go and return paths is also more severe than in a conventional system, due to the higher available gain in the transmission path. Special measures may, therefore, be necessary to increase the isolation above that achieved with normal hybrid transformers.


REFERENCES

(1) R. F. Purton, "A Survey of Telephone Speech-signal Statistics and the Significance in the choice of a P.C.M. Companding Law", *Proc. IEE*, Part *B.*, January 1962.

(2) Bernard Smith, "Instantaneous Companding of Quantised Signals", *The Bell System Technical Journal*, May, 1957.

(3) "Discussion on P.C.M. Companding Law". *IEE Meeting*, May 15th, 1962.

(4) J. C. H. Davis, "A P.C.M. Logarithmic Encoder for a Multi-channel T.D.M. System", Paper presented *IEE*, May 15th.

**SIMPLE AND INEXPENSIVE**

*This circuit was developed to meet the requirement for a simple demodulator for f-m data tape recording. As a number of channels of information had to be handled and the budget was limited, the complexity and cost of the circuit were reduced as much as possible consistent with achieving a substantially linear frequency-voltage characteristic over the range of 1 to 10 Kc. No complicated setup precedure is necessary*

# Simple F-M Demodulator for Audio Frequencies

By K. R. WHITTINGTON, Tube Investments Research Laboratories, Hinxton Hall, Saffron Walden, Essex, England

*Developed for f-m data tape recording, this transistor circuit converts f-m frequencies to proportional d-c levels*

THIS F-M DEMODULATOR is based on the well-known pulse-counting method of frequency measurement. The input which is usually roughly sinusoidal, is converted to a train of pulses of equal amplitude and length. These pulses are smoothed so that the mean d-c level is directly proportional to the number of pulses occuring in unit time. If the output is to be connected to a meter or pen-recorder, the mechanical time-constants of these instruments are sufficient to give a mean d-c output reading and the circuit is simple. If the output is to be fed to an oscilloscope or level-discriminator circuit, it is necessary to use R-C smoothing of the pulse train.

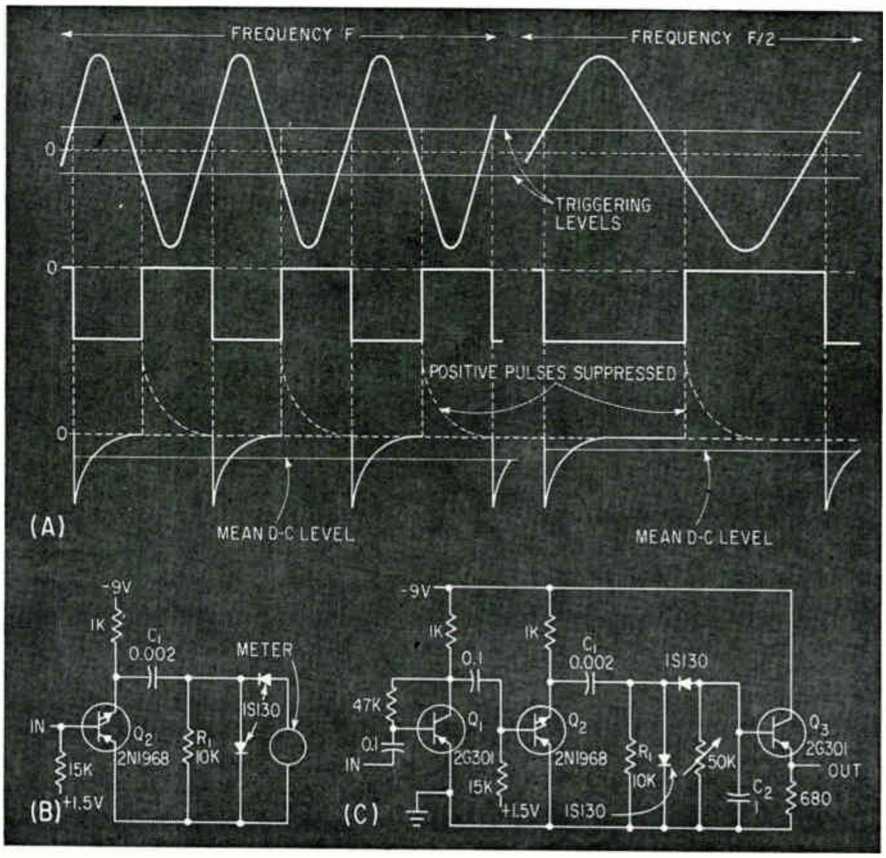
The shape of the pulses to be averaged is immaterial if shape is independent of frequency. Here the pulses were formed by converting the input signal to a square wave and differentiating the leading edge of the square wave, as in (A). The basis circuit (B) can be used with a meter; and (C), a slight elaboration on this circuit uses a limiting transistor $Q_1$ at the input to avoid overloading switching transistor $Q_2$, and R-C smoothing, with output emitter-follower $Q_3$.

Transistor $Q_2$ is a *pnpn* switch that takes the place of a conventional flip-flop or Schmitt trigger. It is triggered ON when the input signal exceeds a level of about 200 mv on its negative-going half-cycle, and stays saturated until the input exceeds a similar level on its positive half-cycle. The signal at the $Q_2$ collector is differentiated by $C_1R_1$ and the positive half-cycles filtered out by the diode network. In (C), the output d-c level is produced by using the pulse train to charge capacitor $C_2$.

Limiter $Q_1$ was added because excessive signal input voltages could produce frequency doubling at the collector of $Q_2$.

This simple circuit gives remarkably good results. A curve of frequency against output voltage over the range 0-9 Kc shows a linearity within 1 percent. However the supply potential must be reasonably stable, since any change here will be reflected in the output.

This article is published by permission of the directors of Tube Investments Limited.




WAVEFORMS *(A) at input (top), collector of $Q_2$ (middle), output (bottom); basic one-transistor circuit (B); three-transistor circuit with R-C smoothing (C)*

TINY BEACON *is about the same size as a package of cigarettes and is encapsulated for improved mechanical stability and protection*

# Tiny Solid-State

*Here is a versatile transmitter with small size and high power output in the 100 to 140 or 220 to 260 Mc ranges. The circuit features a crystal oscillator with 0.0025-percent stability and an unusual varactor tripler*


By STANLEY D. CZERWINSKI and FRED S. LINN
Sperry Phoenix Company,
Div. of Sperry-Rand Corp., Phoenix, Arizona


OBJECTS CAN BE FOUND on land or sea by vhf radio beacons and conventional direction-finding equipment. Recent development of small, lightweight, efficient, low-cost beacons has made this technique practical in many new applications.

Solid-state transmitters operating in the 100 to 140 Mc and 220 to 260 Mc ranges can produce power outputs as high as 4 watts. These units are small enough to be carried in a pocket, rugged enough to be mounted on or included in recoverable objects and sufficiently reliable to be used in survival kits. Circuits for voice communication can be added with little or no increase in weight and size.

Frequency monitoring is simple and reliable. When used with low-temperature mercury batteries, these beacons will operate at temperatures ranging from −20 to 160 F with a shelf life of several years.

EFFICIENCY—The beacon and its battery pack should be a minimum percentage of the payload to be recovered.

Since the battery accounts for most of the weight and volume, the transmitter should be highly efficient.

Efficiency begins with the selection of minimum power output to reliably meet operational requirements. A 1-watt locating beacon can provide a usable signal for direction-finding equipment such as the AN/ARC-27 with an AN/ARA-25 d-f at distances as great as 90 miles. A timing circuit in the beacon with a 30-percent duty cycle will conserve battery life without degrading the performance of direction-finding equipment.

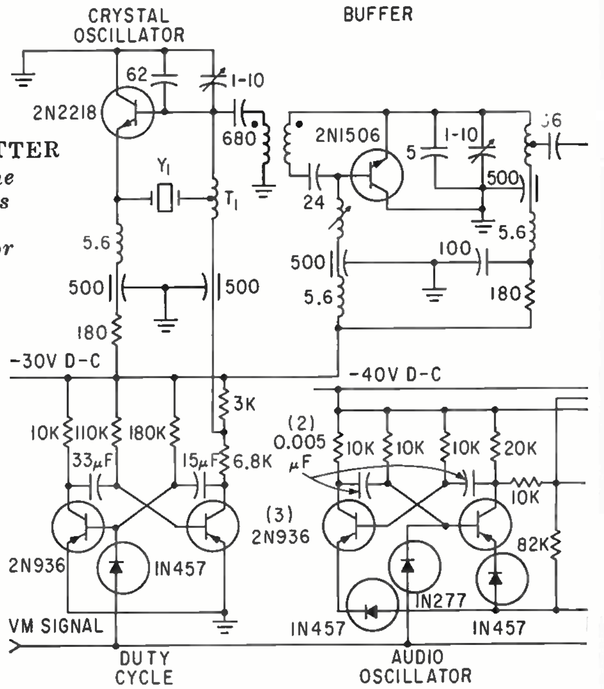
A block diagram for this type of unit is shown. The unit weighs 28 ounces including batteries and occupies a total volume of 30 cu in. The transmitter will operate continuously for 30 hours and still deliver an r-f output of 500 milliwatts.

The schematic diagram of a 4-watt beacon recently developed for NASA Manned Spacecraft Center is shown schematically.

CIRCUIT — The oscillator employed is a class-C Hartley with the crystal in the feedback loop. Frequency stability of 0.0025-percent over a temperature range of −30 F to 165 F is achieved with negative-coefficient capacitors in the tank circuit. The location of the tap on $T_1$ is critical because it determines the amount of feedback and controls oscillator stability, power output and efficiency. This oscillator operates at one third the transmitter output frequency and delivers 200 mw r-f at 20-percent efficiency.

The preamplifier and power amplifier are class-C common-emitter stages with a combined gain of 14 db and an efficiency of 65-percent. The preamplifier uses a single 2N1506 and the power amplifier three 2N1506's in parallel. The output transistors are not matched, but do require separate bias adjustment. The circuit was designed with grounded collectors to simplify the use of heat sinks normally required for high-power operation. Transmitter efficiency is largely determined by that of the r-f power amplifier

TRANSMITTER *includes tone generator as well as provision for voice modulation*

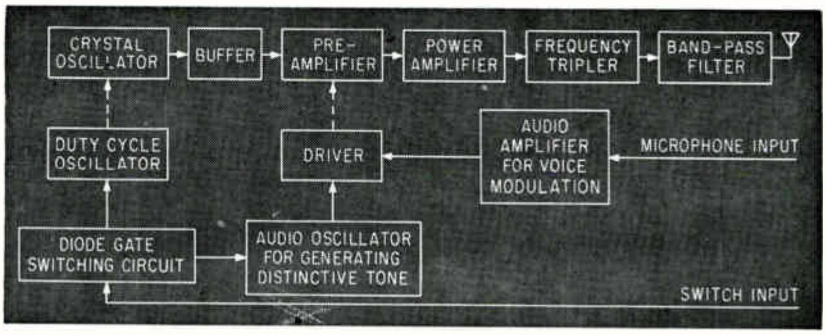


# Transmitter May Save Your Life

## SOS

*This tiny radio transmitter can be one's only friend in an otherwise hostile environment. When lost on land or sea it is a comfort to know that this unit has a voice with a range of up to 200 miles.*

*Advanced techniques in solid-state circuit design and packaging now permit high vhf power outputs in small transmitters. An added bonus is that the beacon can be voice modulated*



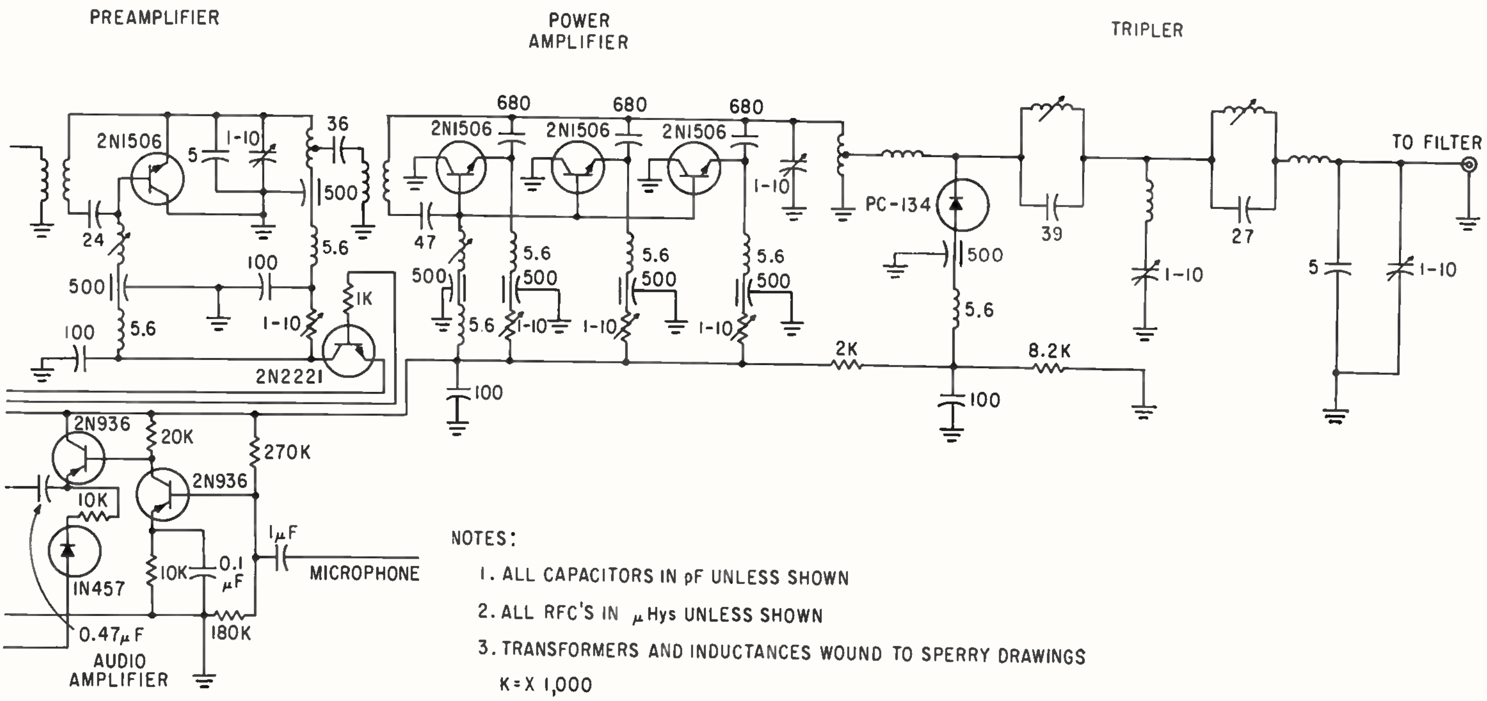

TYPICAL 4-WATT BEACON *is made up of both basic r-f and special circuits that meet operational requirements*

which uses most of the total d-c input required.

TRIPLING—The most efficient method of obtaining power at 220-260 Mc is to generate and amplify the r-f signal at one-third the carrier frequency and obtain the carrier signal with a passive frequency multiplier. Here, the frequency tripler is a PC-134 varactor shunt circuit; this yields a conversion loss of 1.5 db. The tripler is followed by a band-pass filter that removes unwanted harmonics. This filter has an insertion loss of 0.5 db. The overall efficiency of the 4-watt transmitter is 33-percent. Precise assembly techniques are necessary to obtain these efficiencies. For example, fixed capacitors are used rather than trimmers and the output coil is decoupled from the neutralizing coil by separation or shielding, rather than perpendicular physical placement.

The basic circuit can be modified to provide voice modulation, a distinctive tone or a reduced duty cycle for increased battery life. Diode switching circuits are used to change from mode to mode. Voice modulation requires a class-C common-emitter buffer amplifier to isolate the crystal oscillator from the preamp and maintain stability. The duty cycle is controlled by an astable multivibrator that keys the crystal oscillator for two seconds in each five-second interval.

The tone generator is also an astable multivibrator that modulates the preamplifier to produce either a 1,000 cycle tone or a distinctive, swept-frequency tone; the latter being generated by sweeping the audio multivibrator circuit with the integrated output of the duty cycle multivibrator. Range tests have shown that 50-percent voice modulation will provide intelligible communication at ranges up to 100 miles. The tone modulation is audible as far as 200 miles.




NOTES:

1. ALL CAPACITORS IN pF UNLESS SHOWN
2. ALL RFC'S IN μHys UNLESS SHOWN
3. TRANSFORMERS AND INDUCTANCES WOUND TO SPERRY DRAWINGS

K = X 1,000

# Easy-to-Use Nomographs Eliminate Filter Calculations

*Charts enable engineers to pick component values for constant-K and m-derived filters quickly and accurately. Technique handles both simple and composite designs*

By W. C. SANDERS and B. E. PACKHAM
Electronic Systems & Products Division, Martin Company, Baltimore, Maryland

FILTER DESIGN using standard equations usually involves long and tedious calculations. These nomographs make the design of constant-*K* and *m*-derived filter sections simple and fast.

The nomographs have been made on the assumption that the input and output impedances to the filter sections are equal. The frequency range is from 1 cps to 500 Mc and impedance terminations from 3.5 ohms to 30 megohms. Values of *m*, for the *m*-derived sections, are plotted from 0.2 to 0.9. Composite filter design has been taken into account in the nomographs.

While only unbalanced filters are covered, the usual rules for transformation from unbalanced to balanced filter sections apply.

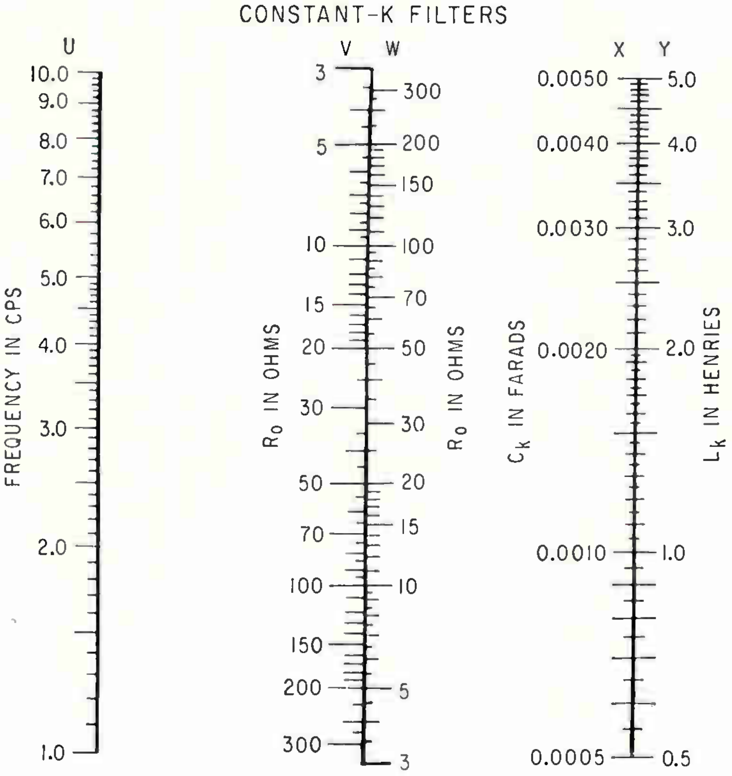
CONSTANT-K SECTIONS — The nomograph shown in Fig. 1 is used to determine the capacitance and inductance values of high or low-pass constant-*K* sections. For the capacitance, locate the cut-off frequency on scale *U* and the termination impedance on scale *V*; draw a straight line between these two points and read the capacitance from scale *X*. Inductance is found in the same manner, connecting *U* and *W* and reading the result on scale *Y*.

Powers of ten are manipulated to raise or lower the nomograph magnitudes to the appropriate level:

(1) Add the powers of ten of the frequency and impedance. The sum, with the sign changed, is the power of ten of the capacitance.

(2) Substract the power of ten of the frequency from that of the impedance. The difference is the power of ten of the inductance.

Actual filter values are obtained by referring to the sche-




NOMOGRAPH *for determining component values of constant-K filter sections—Fig. 1*

## FOCUS ON TOMORROW

Never satisfied with past accomplishments, Sperry's R & D staff continually focuses attention on the future, probing for new approaches, advanced materials, superior compositions and untried applications in the microwave, electronics and solid state fields.

Sperry Microwave / Clearwater takes pride in the achievements of its R & D staff. These experienced and highly qualified physicists are recognized experts in their specialized fields.

*Their recent creative studies and experiments have produced exciting new applications for ferroelectric materials.* Small, high-speed ferroelectric switches of simple design and outstanding reliability are now a reality. Broadband detection techniques for microwave, infrared and optical radiation are on the horizon. Other advanced studies and informative experiments cover magnetic solids, dielectric materials, hexagonal ferrites and laser instrumentation.

This constant concentration in pure and applied research in our highly specialized field — backed by complete laboratory and production facilities — places Sperry / Clearwater in an enviable position for the generation of new design techniques and demonstration of feasibility of new and better products.

SPERRY

*DIVISION OF SPERRY RAND CORPORATION* **SPERRY MICROWAVE ELECTRONICS COMPANY** **CLEARWATER, FLORIDA**

Microwave Components and Antennas • Radar Test Sets • Solid State Devices and Materials • Microline Instruments • Systems Instrumentation

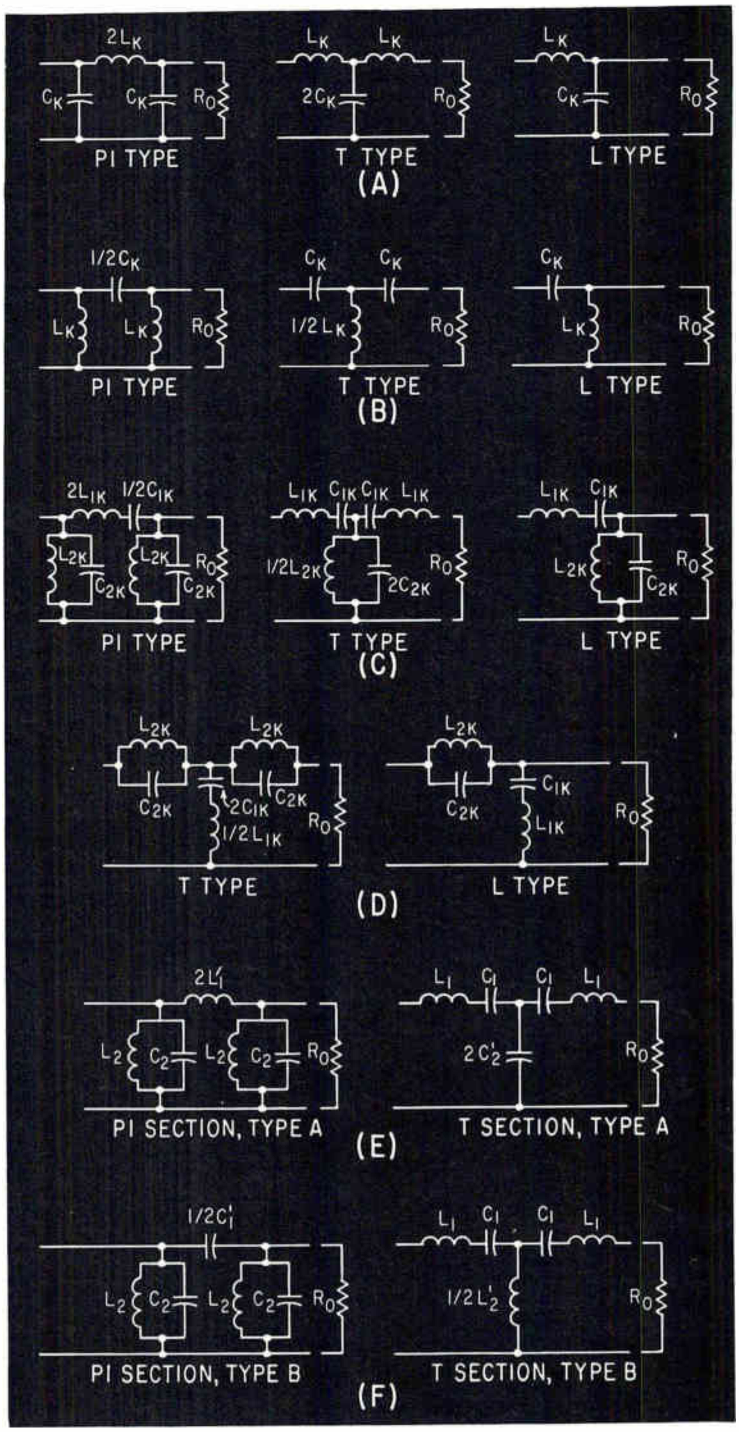
matics of constant-*K* sections, Fig. 2, and noting the values on the desired configuration.

*Example 1.* Find the value of the components of a constant-*K*, low-pass pi section, with cut-off frequency of 20 Mc ($2 \times 10^7$ cps) and termination impedance ($R_o$) of 50 ohms.

(1) Find 2 on scale *U* and connect with 50 on scale *V*.

(2) Significant figures of $C_k$, from scale *X* : 0.00156.

(3) Power of ten of $C_k$: seven (power of frequency) plus zero (power of impedance) equals seven; change sign, (−7).




CONSTANT-K FILTERS; *low-pass (A), high-pass (B), band-pass (C), band-reject (D) and three-element type A (E) and type B (F)—Fig. 2*

Therefore, $C_k = 0.00156 \times 10^{-7}$ or 156 pf.

(4) Find 2 on scale *U* and connect with 50 on scale *W*.

(5) Significant figures of $L_k$, from scale *Y*: 3.9.

(6) Power of ten of $L_k$: zero (power of impedance) minus seven (power of frequency) equals minus seven (−7). Hence, $L_k = 3.9 \times 10^{-7}$ or 0.39 $\mu$h.

(7) Referring to the schematic for constant-*K* low-pass pi (Fig. 2A) sections, the capacitors will equal $C_k$ which is 156 pf and the inductance will equal twice $L_k$ or 0.78 $\mu$h.

This entire procedure can be used for band-pass or band-reject sections after deriving the values to be used on scale *U*. For $C_{2k}$ and $L_{1k}$, substract $f_1$ (low-frequency cut-off) from $f_2$ (high-frequency cut-off) and use the result on scale *U*. To find the value on scale *U* for $C_{1k}$ and $L_{2k}$, use the relation $f_1 f_2/(f_2 - f_1)$. Lay this result on scale *U* for $C_{1k}$ and $L_{2k}$.

*Example 2.* Find the value of the components of a constant-*K* bandpass T-section, 14 to 18 Mc, with a termination impedance of 75 ohms.

(1) Determine the value of *f* on *U* scale for $C_{2k}$ and $L_{1k}$. Since $f_1 = 14 \times 10^6$ cps and $f_2 = 18 \times 10^6$ cps, then $f = (18 - 14) \times 10^6$ cps.

(2) Find 4 on scale *U* and connect with 75 ohms on scale *V*.

(3) Significant figures of $C_{2k}$, from scale *X*: 0.00053.

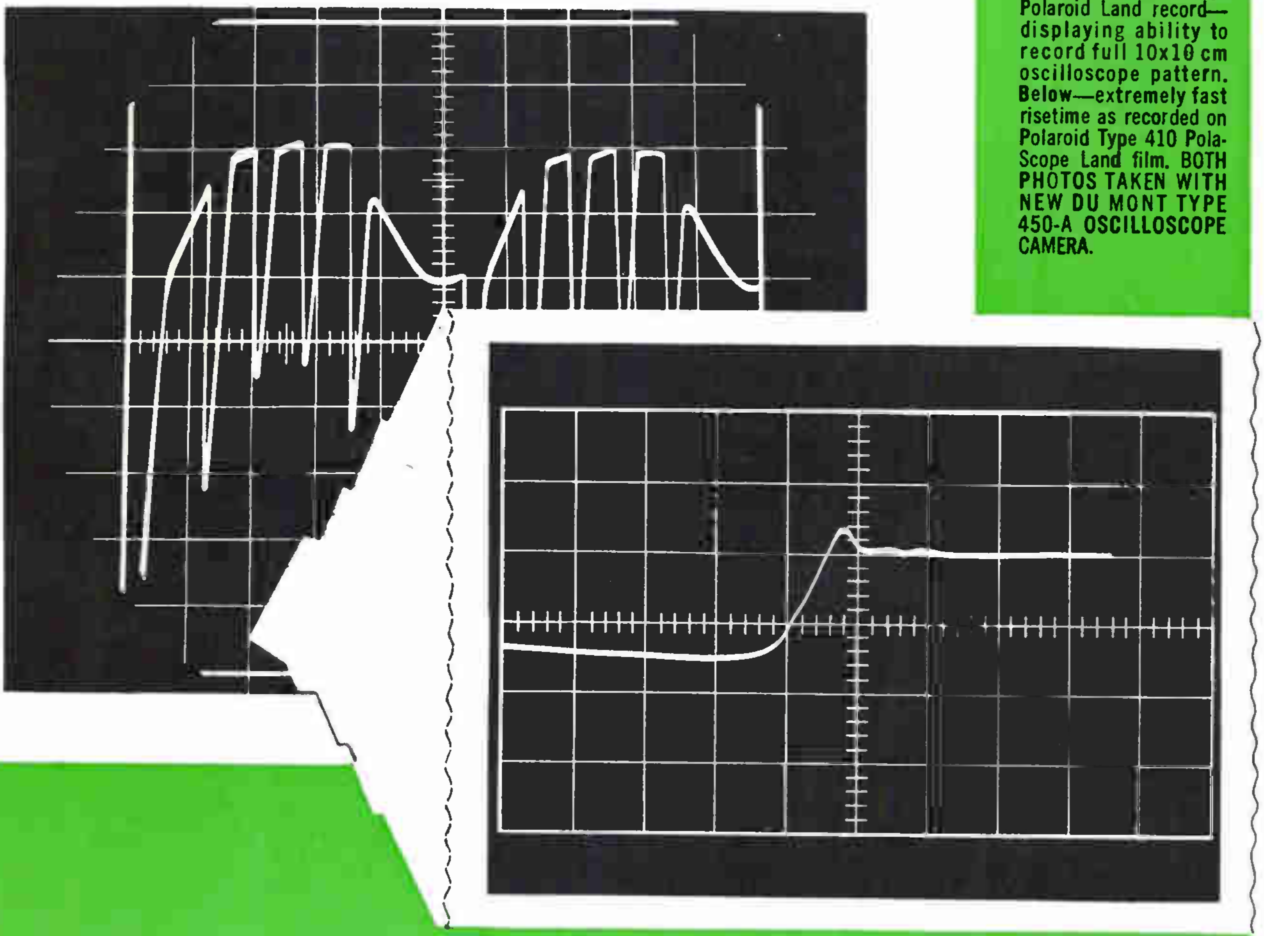
(4) Power of ten of $C_{2k}$: six (power of *f*) minus zero (power of impedance) equals six; change sign, (−6). Therefore, $C_{2k} = 0.00053 \times 10^{-6}$ or 530 pf.

(5) Find 4 on scale *U* and connect with 75 on scale *W*.

(6) Significant figures of $L_{1k}$, from scale *Y*: 2.95.

(7) Power of ten of $L_{1k}$: zero (power of impedance) minus six (power of *f*) equals minus six (−6). Hence, $L_{1k} = 2.95 \times 10^{-6}$ or 2.95 $\mu$h.

(8) Determine value of *f* on *U* scale for $C_{1k}$ and $L_{2k}$: $f = f_1 f_2/$



Left—4"x5" extra-large Polaroid Land record—displaying ability to record full 10x10 cm oscilloscope pattern. Below—extremely fast risetime as recorded on Polaroid Type 410 PolaScope Land film. BOTH PHOTOS TAKEN WITH NEW DU MONT TYPE 450-A OSCILLOSCOPE CAMERA.

# Biggest–Fastest

## WITH DU MONT 450-A CAMERA AND POLAROID LAND FILM

...get the largest scope photos obtainable with any camera, and photograph extra fast risetimes sharply on 10-second Polaroid Land films. Use the most versatile scope recording system in industry—the Du Mont Type 450-A camera with interchangeable backs and lenses (plus 37 accessories for extending its capabilities even further), and Type 410 PolaScope Land film with an effective 10,000 ASA rating. This recording system, because of the permanent-like attachment (vs. movable) of the various lenses and the extremely high-speed film, provides the sharpest possible photos of risetimes up to 2 nsec.. 10-second 4" x 5" Polaroid Land prints are "snapped" with the same camera simply by interchanging backs and quick-disconnect lenses. 35 mm and moving-film records are made with the 450-A by similar interchanges. Send for completely detailed literature on this and other Du Mont recording systems.

**The NEW Du Mont 450-A**

Hinged swingaway back—eliminating frequent mounting and removal

Dark slide for light-tight interchange of camera backs

Object-to-image ratios of 1:1 to 1:0.222 with same camera

Simultaneous data recording

DU MONT

**ALLEN B. DU MONT LABORATORIES**

*DIVISIONS OF*

FAIRCHILD CAMERA AND INSTRUMENT CORPORATION, 750 BLOOMFIELD AVENUE, CLIFTO



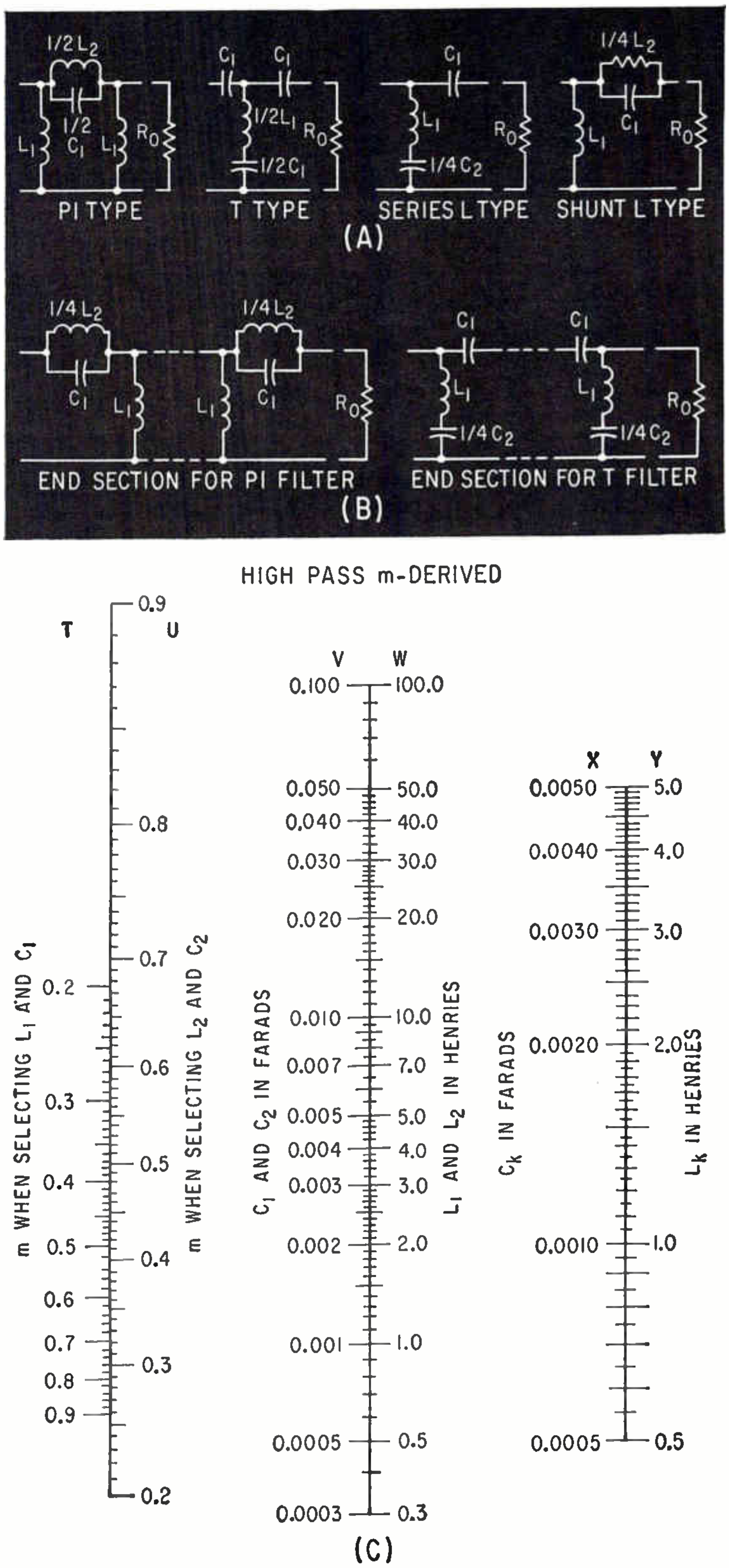
CIRCLE 95 ON READER SERVICE CA

$(f_2\text{-}f_1) = 6.3 \times 10^7$ cps.

(9) *Repeat Steps 2 through 7* using 6.3 for $f$ and determine: $C_{1k} = 0.00335 \times 10^{-8}$ or 33.5 pf; $L_{2k} = 1.9 \times 10^{-7}$ or 0.19 $\mu$h.

(10) Refer to Fig. 2C; the actual values are: $L_{1k} = 2.95$ $\mu$h, $C_{1k} = 33.5$ pf, $\frac{1}{2}$ $L_{2k} = 0.095$ $\mu$h, $2C_{2k} = 1{,}060$ pf.

Band-reject sections are handled in the same manner.




HIGH-PASS *m-derived filters (A), end sections (B) and nomograph for determination of component values—Fig. 3*

THREE ELEMENT BAND-PASS—There are two types of three-element bandpass filters, *A* and *B* (Fig. 2E and 2F), with a pi and T section each. The nomograph for the constant-*K* filter (Fig. 3C) is used in the same manner. The value of $f$ for scale *U* is found from

| | | |
|---|---|---|
| *Type A*: | $f=f_1+f_2$ | for $L_1'$ and $C_2'$ |
| | $f=f_2-f_1$ | for $L_1$ and $C_2$ |
| | $f=f_1^2/(f_2-f_1)$ | for $L_2$ and $C_1$ |
| *Type B*: | $f=(f_2-f_1)f_2/f_1$ | for $L_1$ and $C_2$ |
| | $f=f_1f_2/(f_2-f_1)$ | for $L_2$ and $C_1$ |
| | $f=f_1f_2/(f_1+f_2)$ | for $L_2'$ and $C_1'$ |

*m*-DERIVED SECTIONS—Constant-*K* filters are adequate for some uses but the impedance does not remain constant as frequency changes, and attenuation of frequencies near cut-off (but outside the passband) is often not sufficient.

Several T-sections, connected in series, give any required attenuation outside and passband, but a large number of them would often be necessary. To avoid the use of many constant-*K* sections, *m*-derived sections with high attenuation characteristics are used either alone or with constant-*K* sections. (See Fig. 3A, B and 4A, B, C.)

The characteristic impedance and the frequency cut-off of the *m*-derived section must be the same as those of the constant-*K* sections. This is taken into account in the nomographs of Fig. 3C and 4D.

The value of *m* is determined from

$$m = \sqrt{1-(f_c/f_\infty)^2} \text{ for low-pass filter,}$$

$$m = \sqrt{1-(f_\infty/f_c)^2} \text{ for high-pass filter,}$$

where $f_c$ is the frequency cut-off and $f_\infty$ is the frequency of infinite attenuation.

Selecting $f_\infty$ just above or below cut-off (for low-pass and high-pass respectively) greatly increases the rate of attenuation outside the passband. Tandems of *m*-derived, or *m*-derived and constant-*K*, sections result in



CIRCLE 97 ON READER SERVICE CARD→

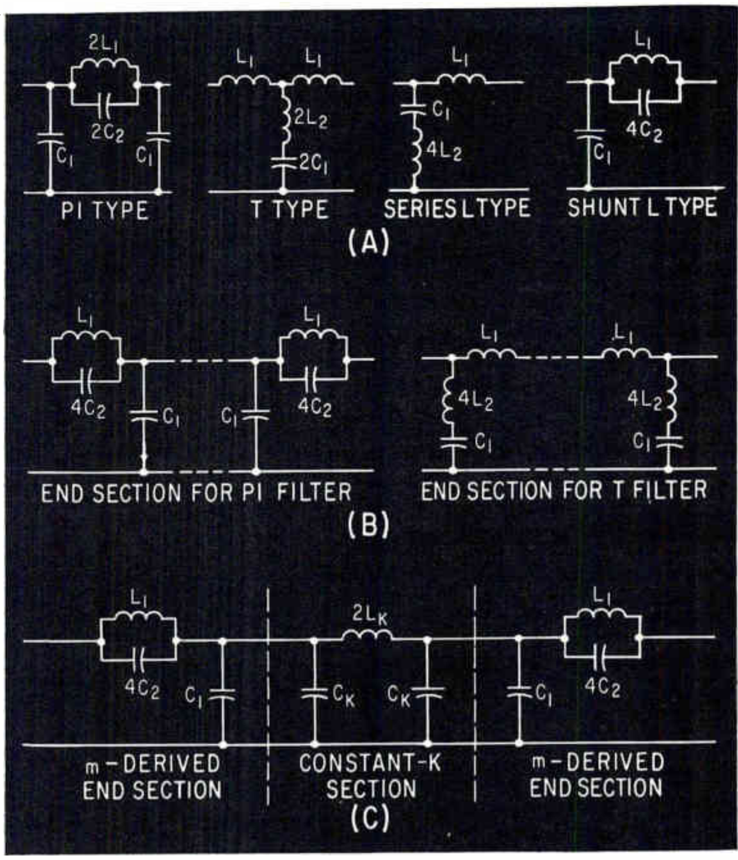
# nothing but talk...talk...talk...

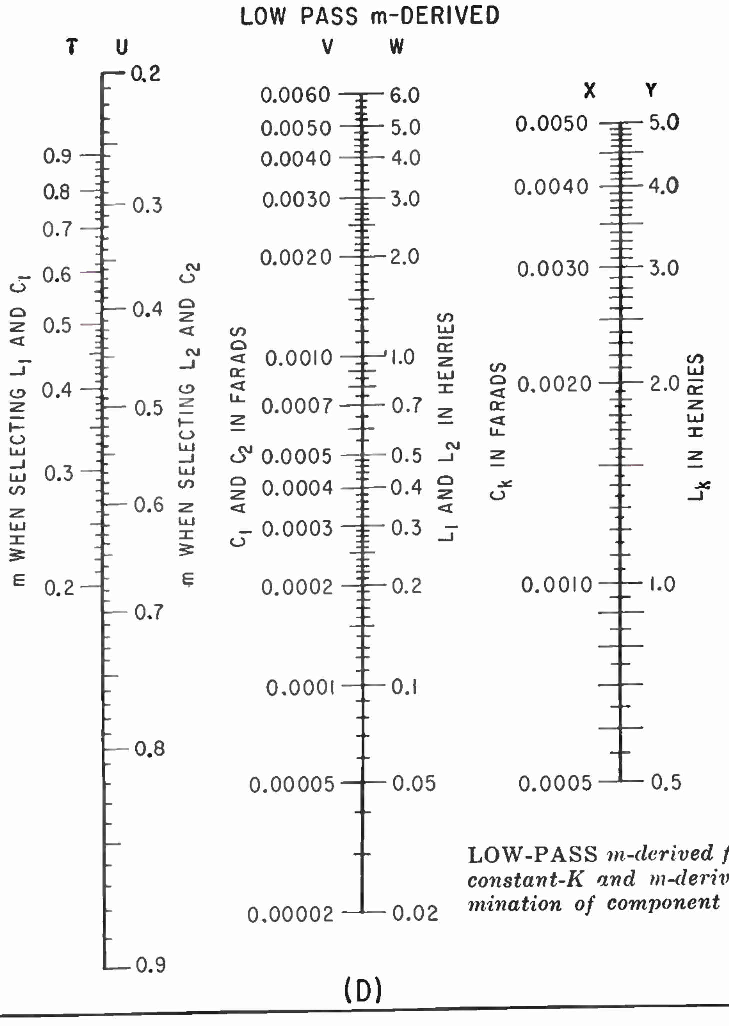
LEACH SATELLITE RECORDER/REPRODUCERS are now in orbit storing lots and lots and lots of data . . . playing back when and where needed.

The unit shown here records on ¼-inch Mylar-base magnetic tape up to 210 minutes at 1.8 ips . . . transmits back to earth in 8:07 minutes. As it transmits, it erases itself and records all over again.

Seven pounds light and seven inches narrow, this Leach Satellite Recorder/Reproducer has taken the rockiest launch in stride, works in temperatures from —30°F to 130°F with an average power consumption of only 4 watts.

If you're in the satellite making business, you should make it your business to know more about this recorder/reproducer and how it can be adapted to your needs. You can know, too. Just send a line to Leach. You will get complete specs on this specially engineered recorder as well as other high environmental tape recorders—in the return mail.




LOW-PASS *m-derived filters (A), end sections (B), mixed constant-K and m-derived (C) and nomograph for determination of component values (D)—Fig. 4*

high attenuation over the entire stopband. (See Fig. 4C.)

At $m = 0.6$, the filter's impedance is nearly constant for frequencies lower than 0.85 $f_o$ (low-pass) or higher than $1.19f_c$ (high-pass); thus, these sections are best suited for connection to constant impedance lines.

To use the nomographs, first determine the values of $C_k$ and $L_k$ with the constant-$K$ nomograph as was done before. After picking $m$ on the basis of the previous discussion or using the nominal value $m = 0.6$, determine the intermediate values of $C_1$, $C_2$, $L_1$, and $L_2$. The ultimate values of these are determined from reference to the schematics as was done before.

*To find* $C_1$: Line a straightedge between the values of $C_k$ on scale $X$ and $m$ on scale $T$. Read the value for $C_1$ from scale V.

*To find* $C_2$: Line a straightedge between the value of $C_k$ on scale $X$ and $m$ on scale $U$. Read the value of $C_2$ from scale $V$.

*To find* $L_1$: Line a straightedge between $L_k$ on scale $Y$ and $m$ on scale $T$. Read the value of $L_1$ from scale $W$.

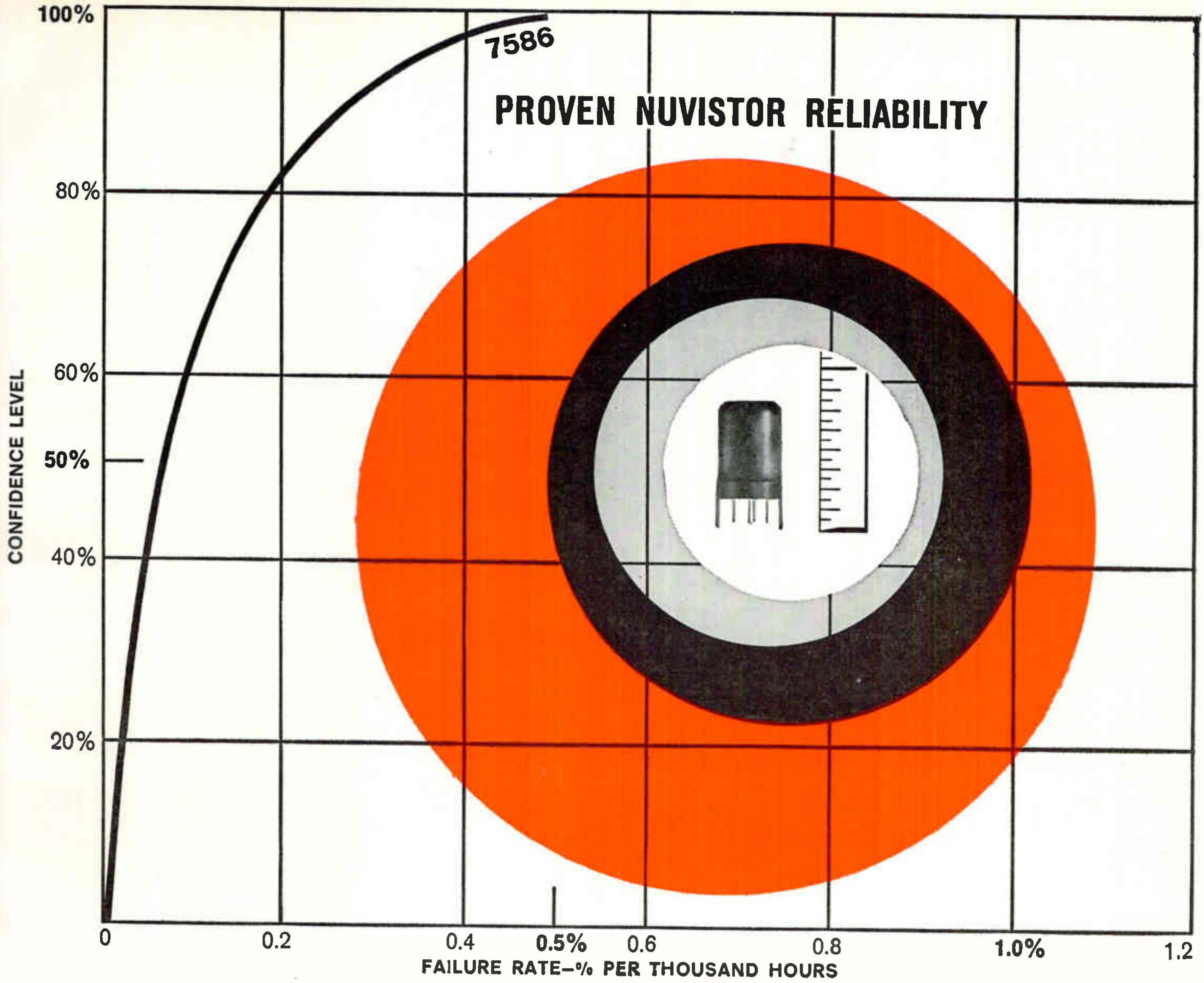
*To find* $L_2$: Line a straightedge between $L_k$ on scale $Y$ and $m$ on scale $U$. Read the value of $L_2$ from scale $W$.

When a power of ten is involved for $C_k$ or $L_k$, the same power is transferred to the results read from scales $V$ and $W$ for $C_1$, $C_2$, $L_1$ and $L_2$.

The calculation of attenuation can be accomplished by any one of four or five methods and cannot be conveniently displayed graphically.

## BIBLIOGRAPHY

P. H. Moles "Filter Design Data for Communications Engineers," 1st Ed., John Wiley & Sons, N. Y., 1962.




## RCA-7586 FAILURE RATE IS:

# 0.36% OR LESS PER THOUSAND HOURS WITH A 95% CONFIDENCE LEVEL

...and at a 50% confidence level, the failure rate is only 0.084% or less per 1,000 hours. These extremely low failure rates shown with corresponding confidence levels on the chart above, are based on more than 1,000,000 tube hours of *actual* life testing. Many of the life tests have been run beyond 5000 hours with no sustained downward trend in transconductance observable in the distribution.

This data indicates you can be 95% sure that RCA-7586 nuvistor triodes, operated under conditions equivalent to those described, would have less than 4 failures out of each 100 tubes after 10,000 hours of operation.

These life test results demonstrate conclusively the *extra* reliability the tiny nuvistor tube brings to your electronic systems.

**FIELD OFFICES:**

**EAST:** 744 Broad St., Newark 2, New Jersey
HUmboldt 5-3900

**MIDWEST:** Suite 1154, Merchandise Mart Plaza
Chicago 54, Illinois
WHitehall 4-2900

**WEST:** 6801 E. Washington Blvd.
Los Angeles 22, Calif.
RAymond 3-8361
1838 El Camino Real, Burlingame, Calif.
OXford 7-1620

Tests were conducted under two sets of field conditions as shown:

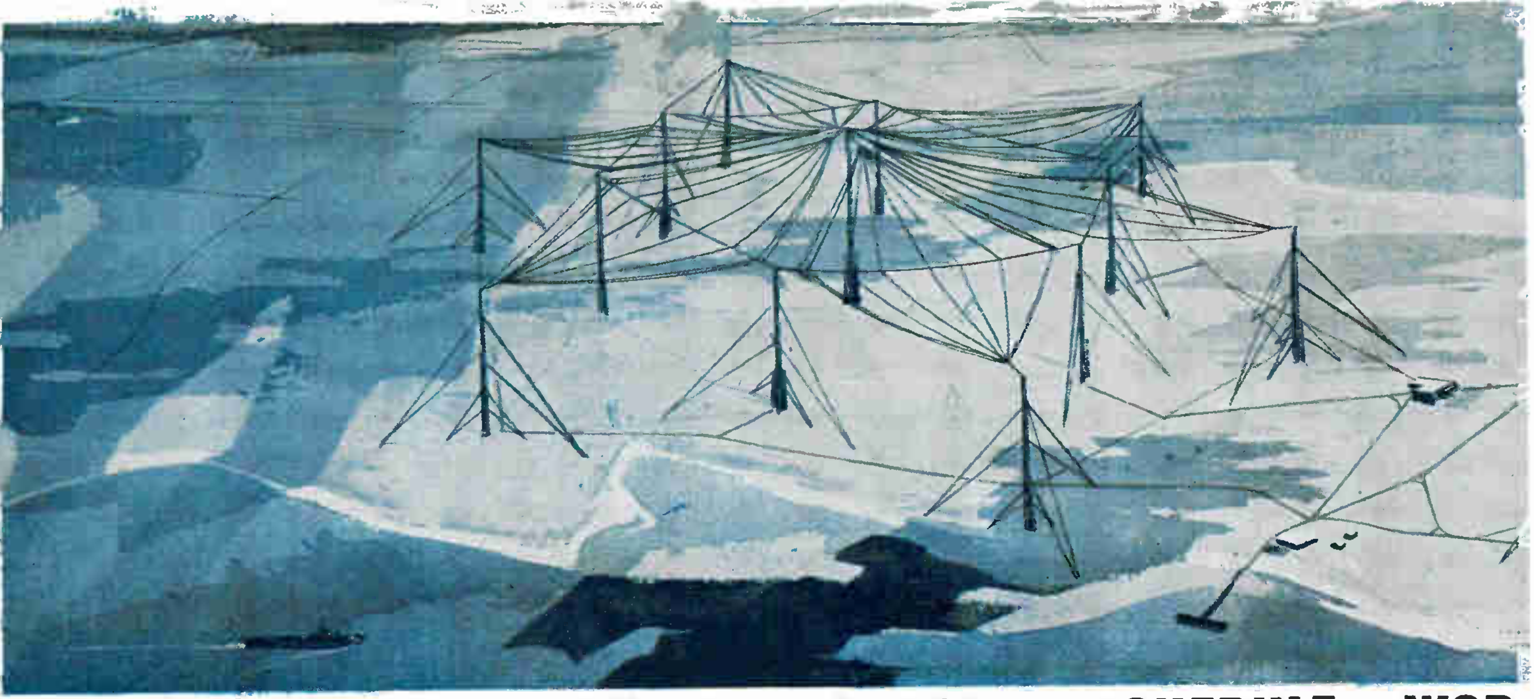
**NUVISTOR LIFE TEST CONDITIONS**

| | *Test Conditions #1* | *Test Conditions #2* |
|---|---|---|
| Heater Volts | 6.3 | 6.3 |
| Heater-Cathode Volts | 100 | 0 |
| Plate Volts | 100 | — |
| Plate-Supply Volts | — | 75 |
| Grid Volts | −1.85 | — |
| Cathode Resistor—Ohms | — | 100 |
| Grid-Circuit Resistance—Megohm | 0.5 | 0.5 |
| Metal-Shell Temperature—°C | 150 | 150 |
| Plate Dissipation—Watts | 1 | 0.75 |

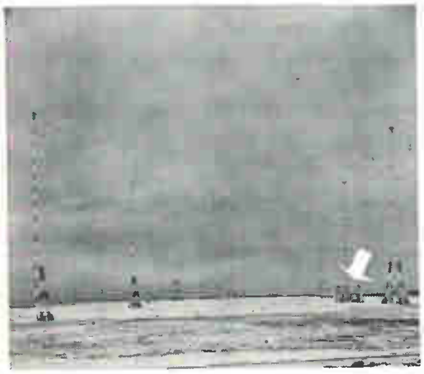
Start now to give your circuits the extra advantage of nuvistor reliability and performance. For technical data on the 7586, get in touch with your RCA Field Representative or write Commercial Engineering, Section K-19-DE-4, RCA Electron Tube Division, Harrison, N.J.

RCA **The Most Trusted Name in Electronics**

CIRCLE 100 ON READER SERVICE CARD→

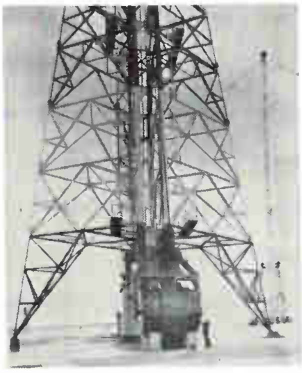


# NOW OPERATIONAL...ONE YEAR AHEAD OF SCHEDULE...WOR

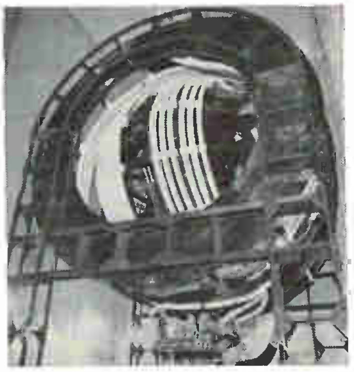


2800 acres . . . an area greater than two dozen Pentagon Buildings . . . two identical antenna arrays . . . center towers nearly as high as the Empire State Building support the gigantic spider web of steel towering a thousand feet up and embracing two square miles . . . nearly an entire peninsula at Cutler, Maine. (Arrow indicates comparative size of Helix House to tower.)

(Arrow points to truck. Compare Helix House size in first photo.) 8-story Helix House contains antenna coupling and automatic de-icing equipment to rid the immense antenna system of ice. Buried beneath the ground: another 11 million feet of copper wire in the radiating system terminating in the sea water itself.



42 counter-weight towers—36 of them like this—carrying tremendous counter balances of 202 tons each to maintain and correct antenna tension and strain from winds up to 150 knots or ice forming on the 64 miles of bronze antenna.

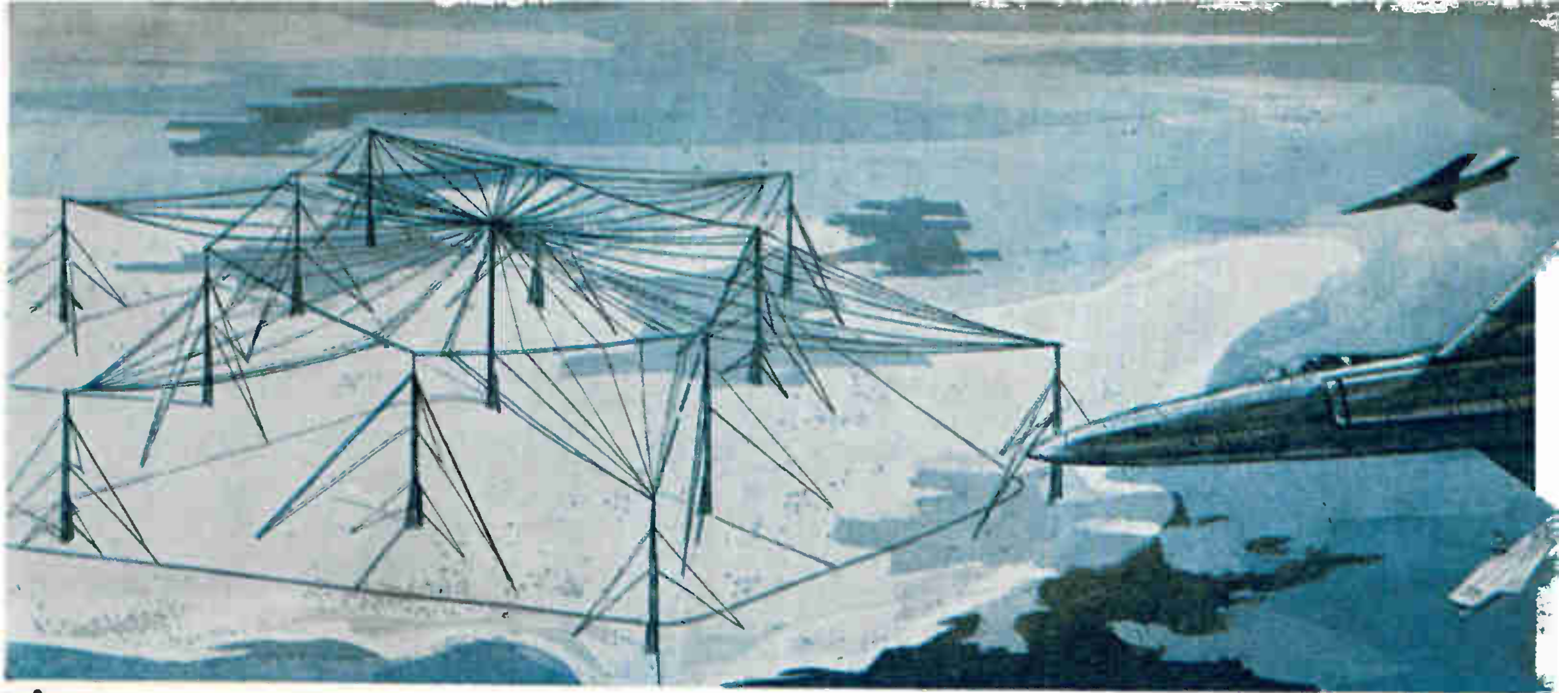


Enormous variometer coil for inductance to tune the antenna system through a range of 14 to 30 KC . . . very low frequency. These VLF radio waves penetrate the depths of the sea to submerged submarines.

THIS AMAZING ENGINEERING ACHIEVEMENT RESULTED FROM SUPERB TEAMWORK BETWEEN THE PRIME CONTRACTOR — CONTINENTAL ELECTRONICS . . . THE UNITED STATES CONGRESS . . . AND THE U.S. NAVY . . . WORKING TOGETHER IN HARMONY TO STRENGTHEN AND SOLIDIFY NATIONAL DEFENSE. THAT THE U.S. NAVAL RADIO STATION AT CUTLER WAS COMPLETED IN RECORD TIME, ONE FULL YEAR AHEAD OF SCHEDULE IS ADEQUATE TESTIMONY TO THE SMOOTH EFFICIENCY OF THIS COMBINED EFFORT.

**Continental**
MANUFACTURING
4212 South Buckner Boulevard ■ Dallas 27, Texas

DESIGNERS AND BUILDERS OF THE WORLD'S

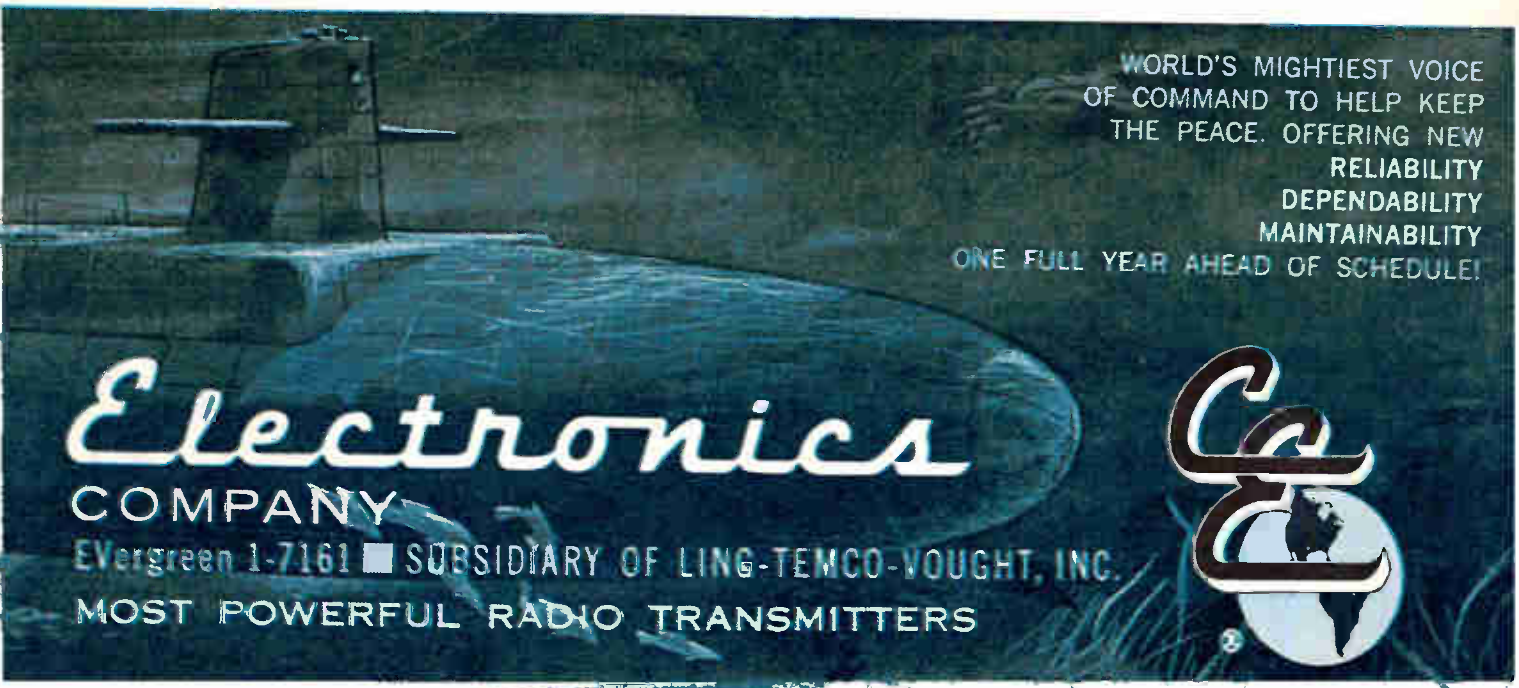


# )'S MOST POWERFUL TRANSMITTER...2,000,000 WATTS VLF

Huge Helix coil 20 feet in diameter and 40 feet tall is wound with 3½ inch Litz Wire . . . just one of the scores of huge components that combine to give this new communication station maximum power . . . range . . . reliability . . . and the special penetration possibilities VLF possesses that no normal high frequency radio provides.

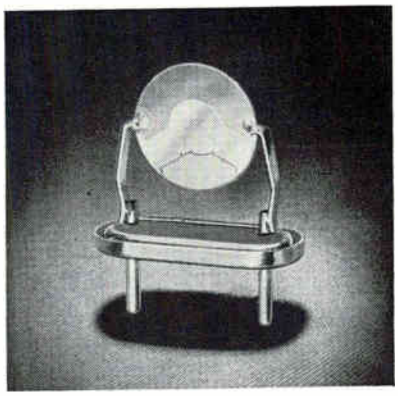
Control console and portion of the unique CEMC Type-125 2,000,000 watt VLF Transmitter that propagates along the curvature of the earth instead of bouncing off the IONOSPHERE: thus eliminating dead communication areas or skip distances to give this Naval voice of command greater range and improved reliability.

In one instant 2,000,000 watts will blast the U. S. Navy's voice of command around the world. At the control console, during operation, push-button simplicity provides a new and highly reliable major element of command to the U. S. Navy . . . another element of that might by which the nation promotes the keeping of the peace.

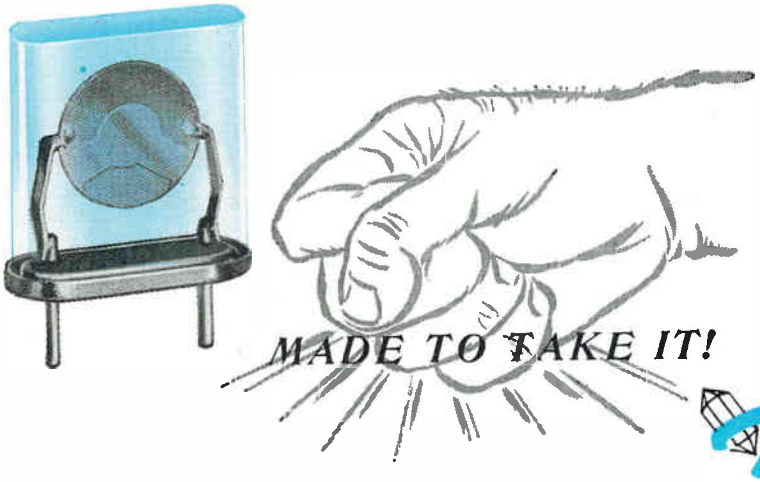


# J MOUNT *(RUGGEDIZED)*

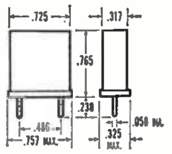
Designed for rugged application and space proven by such leading systems manufacturers as Goddard Space Flight Center, Motorola Inc., and Jet Propulsion Lab. Midland quartz crystal units, utilizing the exclusive J-Mount, are available in a frequency range from 1.65 MC to 150 MC in the Type ML-6J holder and 10 MC to 150 MC in the Type ML-18J crystal holder. Typical standard production limits in this 1.65 MC to 150 MC frequency range are 0°C to +60°C @ ±.0005% frequency tolerance and −55°C to +105°C @ .0015% frequency tolerance. Exact tolerance for a given temperature range is determined prior to purchase according to application requirements. For complete listing and technical data on standard quartz crystals, holders, and mounts available for immediate delivery, write for catalog, "Midland Crystals and Crystal Filters — for military and commercial applications".



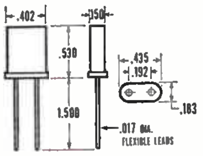
SHOCK: 150 G (11 MS)
VIBRATION: 25G (20-2KC)




**TYPE ML-6J**
**1.65 MC -150 MC**




**TYPE ML-18J**
**10 MC-150 MC**




**Midland** MANUFACTURING COMPANY
DIVISION PACIFIC INDUSTRIES INC.
3155 Fiberglas Rd., Kansas City 15, Kan.

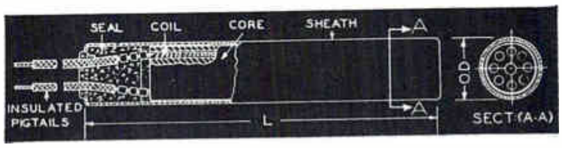
*WORLD'S LARGEST PRODUCER OF QUARTZ CRYSTALS AND CRYSTAL FILTERS*

CIRCLE 203 ON READER SERVICE CARD

---

**FREE FLOW *WITHOUT* CLOGGING . . .**

## KETTLE VALVES *ELECTRICALLY HEATED* with TRENT CARTRIDGE HEATERS




High grade nickel chromium heater coils run parallel in pre-formed ceramic insulator . . . assure fast, uniform heat response. Select from complete range of terminal styles, including specially insulated pigtail type. Heaters use brass or steel sheath (stainless steel on order). Available from ⅜" to 1⁵⁄₁₆" diameters; 30 to 1000 watts. Write for Bulletin 74-TE. **Let A TRENT Electrical Heating Specialist show you the many applications for TRENT Cartridge Heaters.**

200R

**TRENT INC.** Electrically Heated Industrial Equipment
**203 Leverington Ave., Philadelphia 27, Pa.**
In Canada: Pioneer Electric Eastern Ltd., Toronto

---

# CALIBRATE FREQUENCY ANYWHERE ON EARTH TO 0.000000003%

## WITH THE SOLID STATE MODEL LF 400 VLF RECEIVER/CORRELATOR

The new Interstate Model LF 400 VLF Receiver/Correlator tunes any of three VLF world-wide transmissions, and electronically compares the signal phase to a local oscillator for calibration of local equipment. Accuracy of 3 parts in 10 billion over a few hours is easy to attain. In addition, the rugged solid state unit, with 1 microvolt sensitivity, provides an output timing pulse synchronized to the incoming VLF signal. Write for brochure.

WRITE TO: *Interstate* ELECTRONICS CORPORATION

707 East Vermont Ave. • Anaheim, California • Phone 714-772-2222
(A subsidiary of Interstate Engineering Corporation)
NATIONWIDE REPRESENTATIVES

ANOTHER *Interstate* SOLID-*state* INSTRUMENT

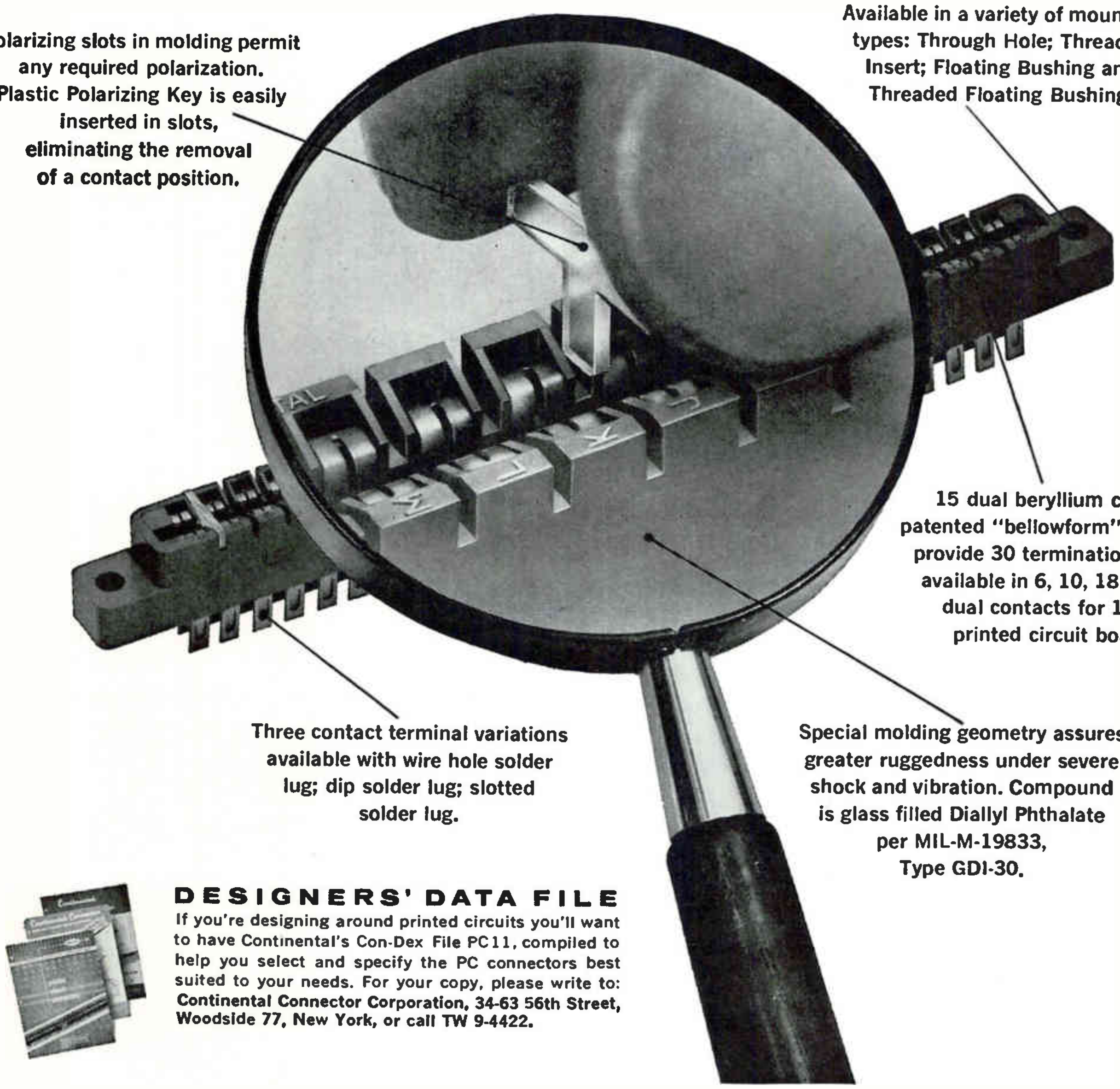
CIRCLE 204 ON READER SERVICE CARD

# DESIGNED TO MEET MIL-C-21097

*Series 600-11 with "Bellowform" Contacts and Polarizing Slots*

Polarizing slots in molding permit any required polarization. Plastic Polarizing Key is easily inserted in slots, eliminating the removal of a contact position.

Available in a variety of mounting types: Through Hole; Threaded Insert; Floating Bushing and Threaded Floating Bushing.



15 dual beryllium copper patented "bellowform" contacts provide 30 terminations. Also available in 6, 10, 18 and 22 dual contacts for 1/16" printed circuit board.

Three contact terminal variations available with wire hole solder lug; dip solder lug; slotted solder lug.

Special molding geometry assures greater ruggedness under severe shock and vibration. Compound is glass filled Diallyl Phthalate per MIL-M-19833, Type GDI-30.

**DESIGNERS' DATA FILE**

If you're designing around printed circuits you'll want to have Continental's Con-Dex File PC11, compiled to help you select and specify the PC connectors best suited to your needs. For your copy, please write to: **Continental Connector Corporation, 34-63 56th Street, Woodside 77, New York, or call TW 9-4422.**

MICRO-MINIATURE • SUB-MINIATURE • MINIATURE • PRINTED CIRCUIT • RIGHT ANGLE PIN & SOCKET • CENTER SCREWLOCK

# CONTINENTAL CONNECTORS

CONTINENTAL CONNECTOR CORPORATION • WOODSIDE 77, NEW YORK



CIRCLE 103 ON READER SERVICE CARD

Zero Failures in Over a Million Tube Hours

# a proven new high in reliability for frame grid tubes

**AMPEREX, largest manufacturer of frame grid tubes, announces two 10,000-hour Premium Quality tubes, types 6922M and 7737M, with specified failure rates exceeding the reliability requirements of Mil Specs MIL-E-1/1168A and MIL-E-1/1451 respectively.**

In a stringent four-year reliability testing program, the AMPEREX 6922M twin triode, designed for use in radar, oscilloscopes, computers, broadband amplifiers and critical airborne applications, achieved a failure rate of 0.10%/1000 hours for inoperatives and 0.17%/1000 hours for total failures. 2860 tubes were each tested for 1000-hour periods for a total of 2,860,000 tube hours.

*DATA: TYPE 6922M:* Gm=12,500 μmhos at 15 ma.; Amplification Factor=53, AFR=1.0%/1000 hours; Mechanical Outline T-6½, 9-pin miniature, maximum height 1$\frac{15}{16}$″.

The 7737M, a ruggedized, non-microphonic version of the JAN 6688, was similarly tested. This Premium Quality pentode was designed for critical airborne applications, coaxial cable amplifiers and video and broadband IF amplifiers in communications and radar equipment. In 1962, the 7737M achieved a failure rate of zero %/1000 hours for inoperatives and 0.75%/1000 hours for total failures.

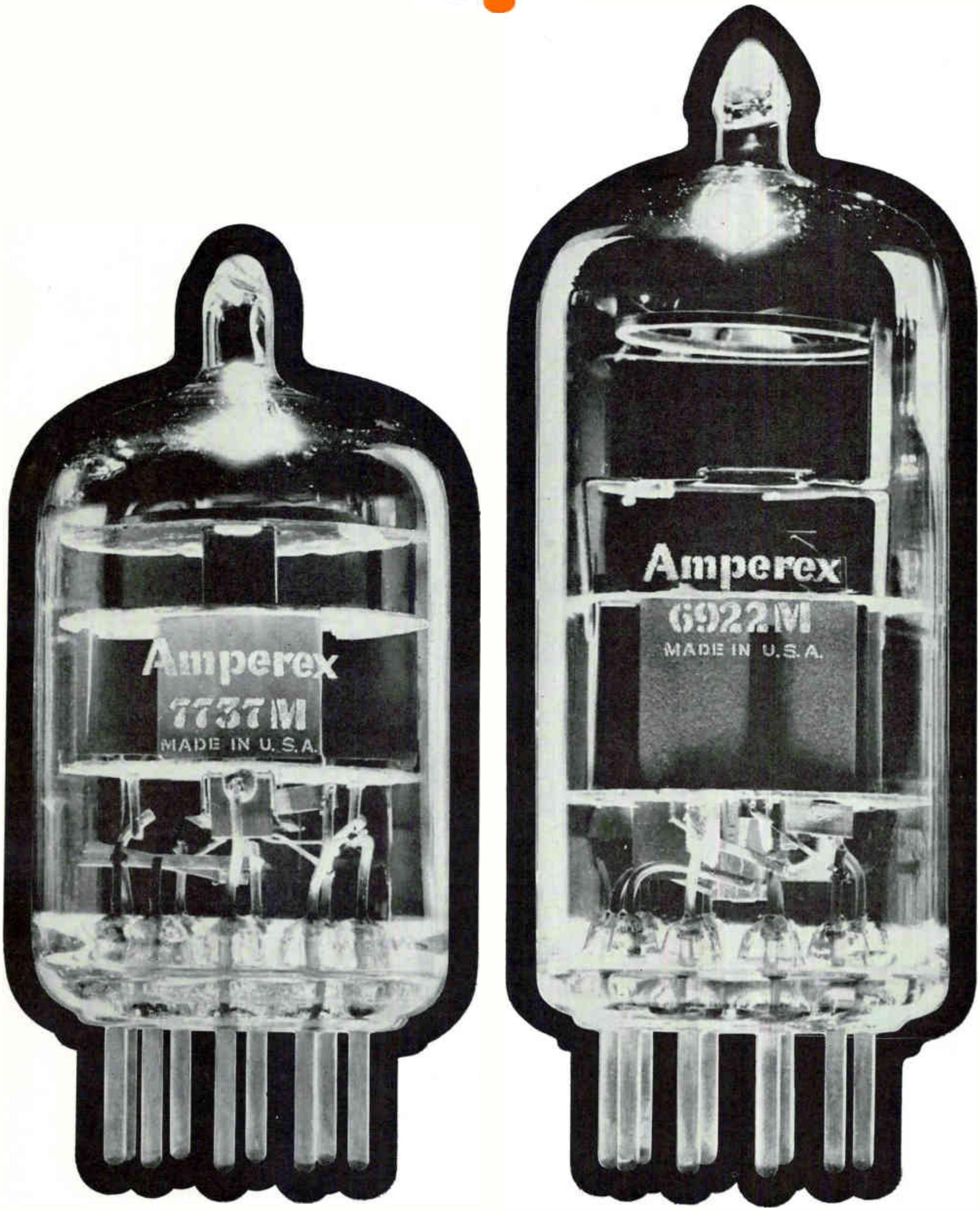
*DATA: TYPE 7737M:* Gm=16,500 μmhos at 13 ma.; Amplification Factor=33, AFR=1.0%/1000 hours; Mechanical Outline T-6½, 9-pin miniature, maximum height 1½″.

The 6922M and 7737M are available in production quantities, with specified failure rates, to MIL Specs MIL-E-1/1168A and MIL-E-1/1451 respectively. To guarantee the Specified Failure Rates, the military specifications require test procedures using one acceptance figure for a cumulative total of 250 tubes resulting from 5 successive samplings of 50 tubes each, and another acceptance figure for the individual 50-tube samplings. This procedure, employing the unusually large quantities of tubes in both the individual samplings and the total cumulative samplings, guarantees the statistical significance and accuracy of the result. Results achieved in 10,000-hour life tests of individual lots of both tube types enable us to guarantee the reliability and specify the failure rates of these tubes.

**The complete story of this unparalleled achievement in tube reliability is available in a new brochure: "Guaranteed Reliability with AMPEREX Premium Quality Frame Grid Tubes." This new brochure describes the production techniques used in the manufacture of AMPEREX frame grid tubes and presents a detailed analysis of how AMPEREX conceived and conducted these reliability tests and life studies. Write for your free copy to: AMPEREX Electronic Corporation, Special Purpose Tube Department, 230 Duffy Avenue, Hicksville, Long Island, New York.**

IN CANADA: PHILIPS ELECTRON DEVICES LTD., 116 VANDERHOOF AVENUE, TORONTO 17, ONTARIO

**Ask Amperex®**


Amperex
7737M
MADE IN U.S.A.
Amperex
6922M
MADE IN U.S.A.

# Interferometer Is Designed for Gemini Radar

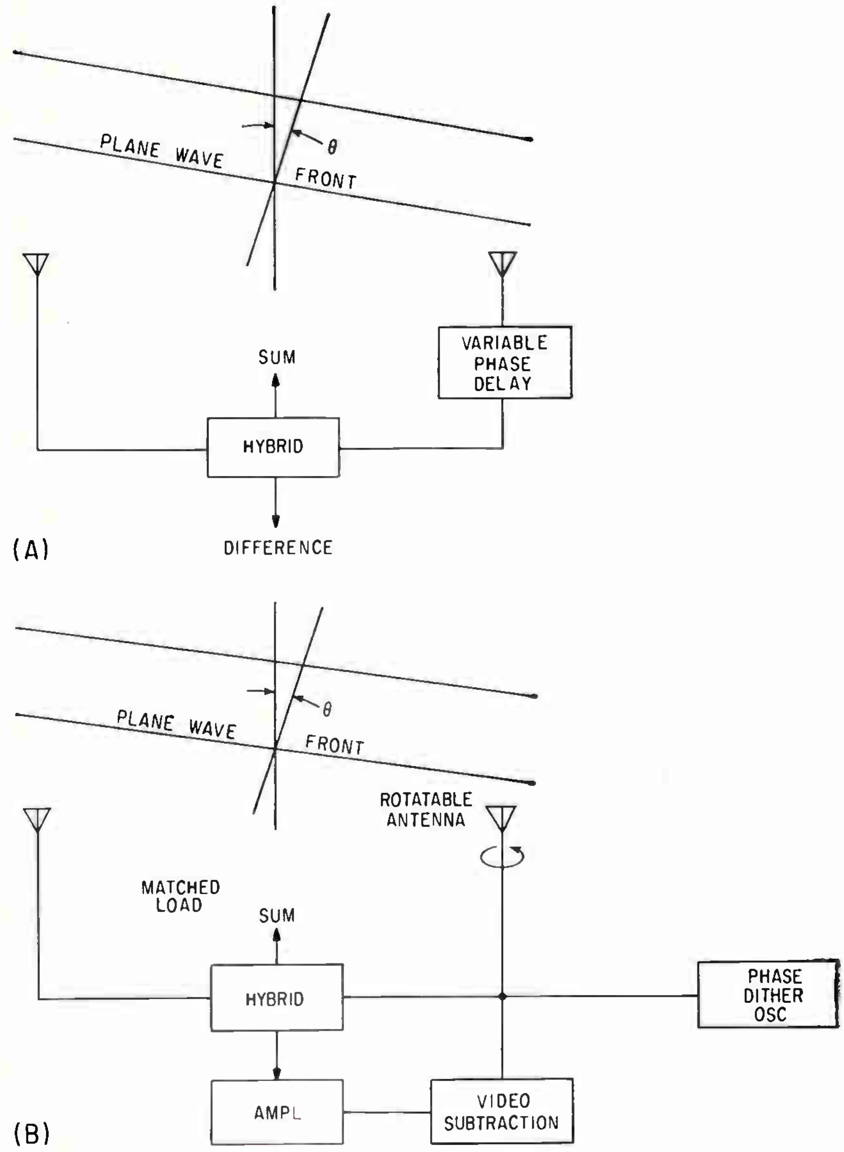
*System permits use of low-inertia antenna to aid space rendezvous*

SATELLITE rendezvous in the Gemini series may be accomplished with radar using a small, low-inertia antenna. In this application, an interferometer antenna can provide angular accuracies comparable to those of the much larger antennas generally used with fire-control radar.

The interferometer was described at the 1962 National Symposium on Space Electronics and Telemetry in a paper by M. S. Wheeler and P. S. Hacker, Air Arm Division, Westinghouse Electric Corp.

The radar to aid two satellites in similar orbits to rendezvous will acquire at ranges of 250 miles and track in range and angle in to 20 feet. This performance is feasible using a cooperative system (radar transponder) having a delayed return offset in frequency.

The interferometer antenna will acquire targets within ±25 degrees in azimuth and elevation and track with an accuracy of about 1 milliradian. This type tracking is possible because of the cooperative radar, which gives a high signal-to-noise ratio and has low angular glint, and because of the relatively low angular rates.




CONVENTIONAL *interferometer (A) is modified (B) for use with Gemini radar—Fig. 1*

PRINCIPLE—The interferometer measures a space angle by comparing phase of the signals from two antennas, as in Fig. 1A. The effect is that of a phase monopulse antenna in which the difference pattern can be moved by shifting phase until the null coincides with the target. The variable phase delay determines angle $\theta$ when the difference arm of the hybrid is nulled. The hybrid ensures antenna matching to the sum and difference terminals independently of the phase delay.

For automatic tracking, this interferometer requires gain channels in both the sum and difference arms of the hybrid and a precise variable phase delay. These problems have been solved by the Gemini system in Fig. 1B. To steer the null, phase is shifted by rotating a circularly polarized antenna in a circularly polarized field of like rotation sense. Phase shift is exactly linear with rotation angle. This approach is feasible because transponder polarization can be specified.

Phase delay is modulated (dithered) in one arm of the interferometer synchronously with pulse repetition rate. Using a single-channel receiver, phase on alternate receptions is changed $\pm\Delta$. The final error is the video difference signal between adjacent pulse returns. Error sensing is thus the same as with sequential lobing.

The two difference patterns are shown in Fig. 2 for a phase shift of $+\Delta$ and $-\Delta$ when the target is $\theta_o$ degrees from broadside. The error



CIRCLE 107 ON READER SERVICE CARD→

### LOW COST

# POWER SUPPLIES

### WIDE RANGE
### FLEXIBILITY


# CHECK KEPCO

## ABC GROUP
REGULATED DC SUPPLY

## 10 MODELS from 0-2V/1A to 0-2500V/2ma

**STABILITY:** Less than 0.05% or 3 mv, whichever is greater, over a period of 8 hours at constant ambient temperature.

**RIPPLE:** Less than 0.5 millivolt rms.

**RECOVERY TIME:** 50 microseconds.

**AMBIENT OPERATING TEMPERATURE:** −20°C to +50°C maximum.

**TEMPERATURE COEFFICIENT:** Output voltage changes less than 0.05% per °C.

**INPUT REQUIREMENTS:** 105-125v ac, 50-440 cycles.

**PROMPT DELIVERY . . . MOST MODELS FROM STOCK**

## 0.05% REGULATION and STABILITY

### TRANSISTORIZED MODELS

| MODEL | DC OUTPUT RANGE | | INPUT AMPS (MAX.) | OUTPUT IMPEDANCE OHMS MAX. | | | PRICE |
|---|---|---|---|---|---|---|---|
| | VOLTS | AMPS | | DC to 100 CPS | 100 CPS to 1 KC | 1 KC-100 KC (+ µhy)* | |
| ABC 2–1M | 0–2 | 0–1 | 0.3 | 0.001 | 0.01 | 0.1 +0.5 | $179 |
| ABC 7.5–2M | 0–7.5 | 0–2 | 0.5 | 0.002 | 0.01 | 0.05+0.5 | $159 |
| ABC 15–1M | 0–15 | 0–1 | 0.5 | 0.008 | 0.01 | 0.02+0.2 | $159 |
| ABC 30–0.3M | 0–30 | 0–0.3 | 0.3 | 0.05 | 0.02 | 0.1 +1 | $119 |
| ABC 40–0.5M | 0–40 | 0–0.5 | 0.5 | 0.04 | 0.02 | 0.04+0.2 | $159 |

### HYBRID MODELS

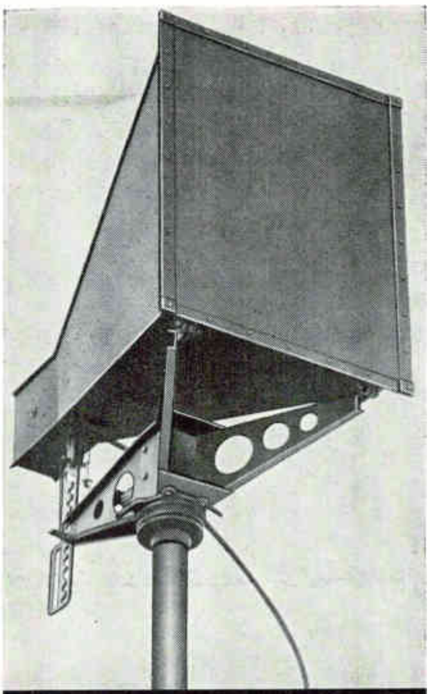
| MODEL | DC OUTPUT RANGE | | INPUT AMPS (MAX.) | OUTPUT IMPEDANCE OHMS MAX. | | | PRICE |
|---|---|---|---|---|---|---|---|
| | VOLTS | MA | | DC to 100 CPS | 100 CPS to 1 KC | 1 KC-100 KC (+ µhy)* | |
| ABC 200M | 0–200 | 0–100 | 0.5 | 1 | 0.5 | 2+1 | $199 |
| ABC 425M | 0–425 | 0–50 | 0.5 | 4 | 1 | 2+1 | $199 |
| ABC 1000M | 0–1000 | 0–20 | 0.5 | 25 | 2 | 2+1 | $274 |
| ABC 1500M | 0–1500 | 0–5 | 0.3 | 150 | 2 | 2+1 | $274 |
| ABC 2500M | 0–2500 | 0–2 | 0.3 | 625 | 2 | 2+1 | $334 |

*Effective series inductance.

FOR DETAILED SPECIFICATIONS ON MORE THAN 250 STANDARD MODEL POWER SUPPLIES SEND FOR KEPCO CATALOG B-621

**kepco** inc. ® 131-38 SANFORD AVENUE • FLUSHING 52, N.Y., U.S.A. • Phone (212) IN 1-7000
TWX# (212) 539-6623 • Cable Address: KEPCOPOWER, NEWYORK

*See our Catalog in* eem File System — electronic engineers master — Sec. 4000



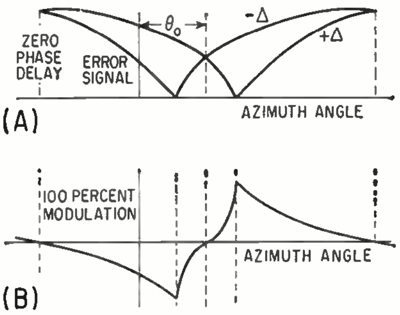
# ANTENNA CAPABILITIES

The advanced design and precision construction of Ainslie antenna systems and associated equipment bear testimony to nearly two decades of microwave communication, detection and identification experience. By virtue of complete design-to-delivery capabilities and facilities, Ainslie Corporation offers its customers not only comprehensive standard lines of mesh, spun and horn antennas, but also the flexibility required to develop custom designed prototypes for on-schedule delivery.

We invite your inquiry.

Ainslie CORPORATION

531 Pond Street
Braintree 85, Massachusetts




ERROR *signal (A) for phase dither is shown with final error signal (B) after video subtraction—Fig. 2*

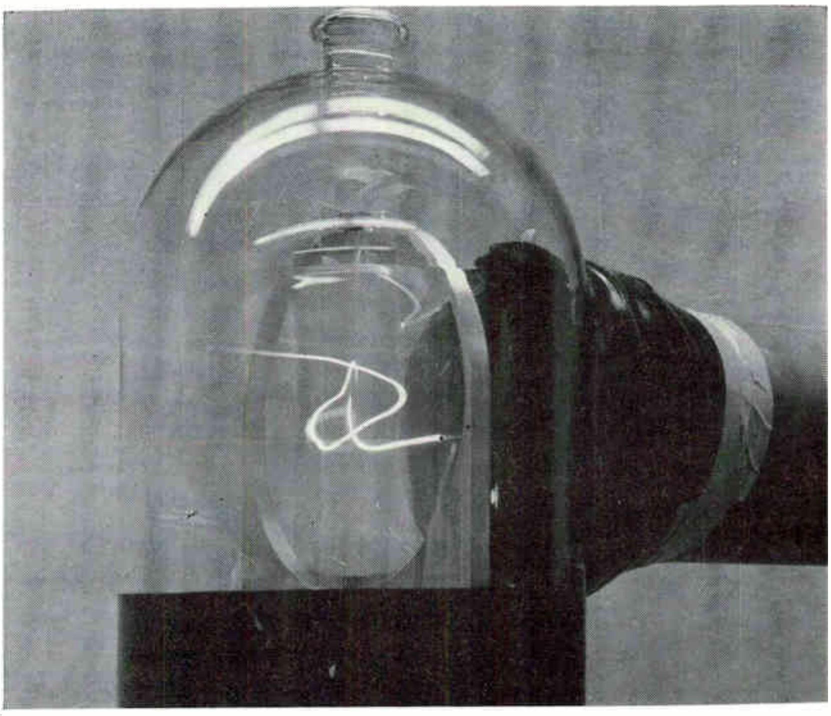
signal for target angle $\theta$ can be nulled by changing phase delay so that $\phi = -(2\pi/\lambda)\ d \sin \theta_o$.

GEMINI ANTENNA—In the interferometer, four Archimedian spiral elements spaced a quarter wavelength above the ground plane are arranged in a square. The element in one corner is one of a pair along the perpendicular axis and does not rotate. The element in the opposite corner is the transmitter and is also stationary. Rotating elements in each coordinate for zero differential phase delay (excluding dither phase) results in a null from the video subtraction circuit when the target is directly ahead of the antenna. A target return from any other direction produces an error signal, which is used to control the rotatable antennas to track the transponder on the mating vehicle. Space angles to the target are obtained from the direction cosines read from pickoffs on the antenna shafts.

This antenna design with its balun produces on-axis circularity of 0.2 db. Relative gain of one spiral to the other within 50 degrees of the forward axis is within 0.1 db.

ELEMENT SPACING — Large spacing between antenna elements in a two-element interferometer permits angles to be determined more accurately because of the large change in phase relative to a change in space angle. However, many nulls appear in the forward direction as spacing is increased, making angular indications ambiguous. For this application, antenna spacing was made as large as pos-

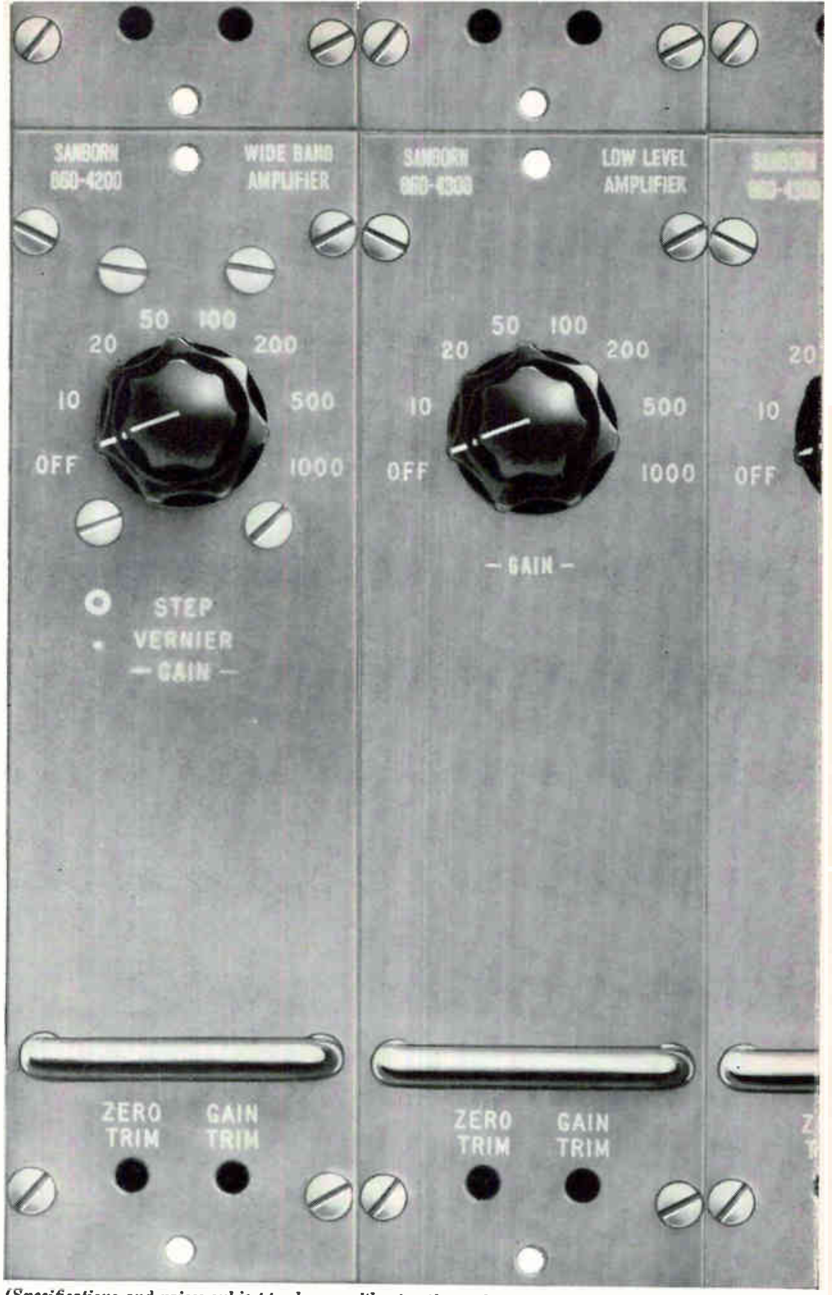
## CRT Displays in Three Dimensions



EXPERIMENTAL *model of three-dimensional display device is shown during tests at Hughes Research Laboratories. See* ELECTRONICS, *p 54, Nov. 2*


# Sanborn data amplifiers

(Three types available now — more on the way)




*(Specifications and prices subject to change without notice; prices are FOB Waltham, Mass.)*

Match amplifier characteristics much more closely to your over-all *system* requirements — and pay for only the performance you need — by choosing from these newly-developed, all solid-state DC data amplifiers now available from Sanborn. Ask your local Sanborn Sales-Engineering Representative for complete specifications, application help and a copy of the Industrial Division Catalog — or write the Main Office in Waltham.

• • • • •

## Wide Band, Floating Input—Floating Output "FIFO"

Bandwidth DC to 3 db down at 10 KC • Input isolated from output • Max. gain 1000, smooth gain covers intermediate ranges or switch out for calibrated gains of 1000 to 50 • Input impedance 100 meg. min. at DC, output impedance 60 ohms • Output capability ±10 V at 10 ma • Common mode rejection (1000 ohms in either input lead) 160 db at DC, 120 db at 60 cps • Linearity ±0.1% of 10 V full-scale at DC • Recovery from 500% overload is 300 μsec to 1% of f.s. output • Recovery from 20 V overload is 1 millisecond to 1% of f.s. output • Model 860-4000 "FIFO", $825. Model 860-4000P (grounded output ±5 V at ±100 ma, impedance less than 1 ohm), $900.

## DC—50 KC, 3-Terminal Floating Amplifier

Gain 1000 to 10 in 1, 2, 5 ratios; does not phase invert • Input impedance 100 meg. at DC • Output ±10 V ±100 ma, impedance less than 0.2 ohm • Linearity ±0.01% of 10 V output • Gain stability ±0.01% at DC at constant ambient for 40 hours • Model 860-4200, including internal power supply, $650.

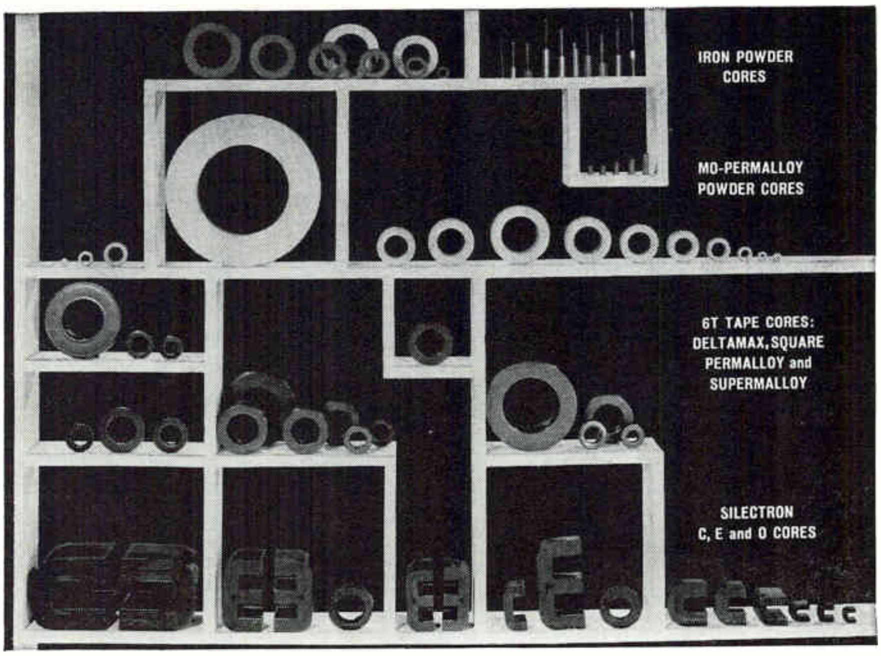
## Narrow Band, Floating Input — Floating Output

Bandwidth DC to 3 db down at 100 cps • Optional plug-in output filters to limit bandwidth • Floating input isolated from floating output • Gain 1000 to 10; fixed step attenuator, gain trim and zero trim controls • Input impedance 300,000 ohms min., output impedance 75 ohms • Output ±5 V, ±2.5 ma • Linearity ±0.05% of 5 V output • Recovers from ±10 V overload in 200 ms • Common mode rejection (1000 ohms in either input lead) 130 db at 60 cps • Model 860-4300, $425.

INDUSTRIAL DIVISION
SANBORN COMPANY
175 Wyman Street, Waltham 54, Massachusetts
A SUBSIDIARY OF HEWLETT-PACKARD COMPANY

CIRCLE 109 ON READER SERVICE CARD

# 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 and technical material are available—write for data.

ADDRESS DEPT. E-11

**ARNOLD**
SPECIALISTS in MAGNETIC MATERIALS

THE ARNOLD ENGINEERING COMPANY, Main Office: MARENGO, ILL. 2998 RIA
BRANCH OFFICES and REPRESENTATIVES in PRINCIPAL CITIES

ting, eight xenon flash lamps on a revolving drum are used. The lamps can be fired individually or in sequences of two, four or eight.

Repeat firing of lasers at rapid rates is presently restricted by the cooling-off time required for the xenon lamp. The use of multiple lamps will enable pulse rates to be increased while providing the cool-off time needed for each lamp. After additional testing, the firm expects to be able to determine and control energy level and output required for welding and cutting.

In industrial applications, laser beams will provide a means for melting small controlled areas of the pieces to be joined without contamination. Similarly, they will enable materials to be cut and vaporized. The accurate straight line of the laser beam is also promising for optical tooling and could be used to produce almost perfectly aligned missile assemblies and aircraft wing sections.

## Heat Waves Reveal Moon Is Colder Than Supposed

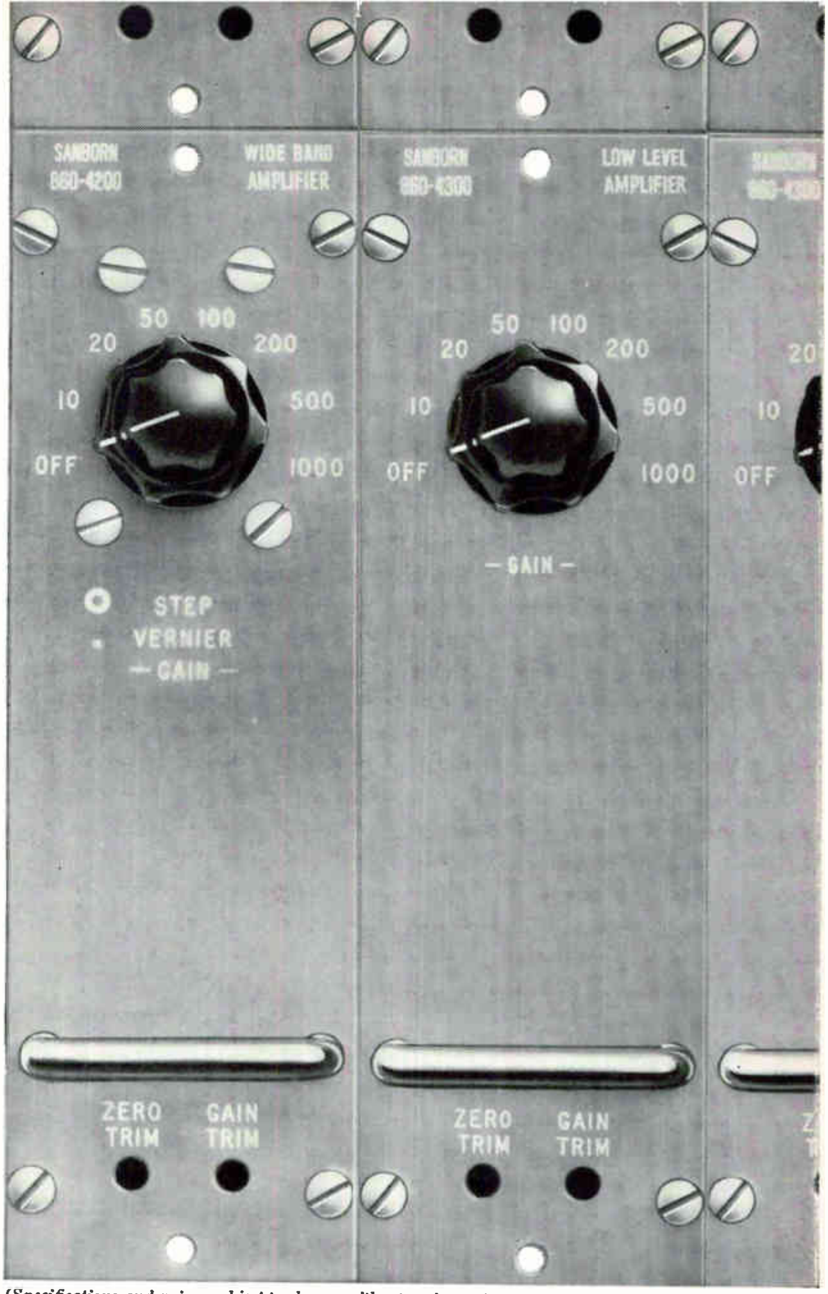
LUNAR night gets at least 30 degrees colder than has been supposed. Also, hot spots on the moon remain warm several days after the lunar sunset. These and other conclusion are based on observations made using a new infrared telescope.

The instrument is said to be 20 to 50 times more sensitive than previous systems for measuring temperatures of comparitively cold celestial obejects. It is operated by California Institute of Technology at a site 13,000 feet above sea level. The telescope senses radiation through a window in the earth's atmosphere that passes infrared having a wavelength of about 0.01 millimeter. The project, sponsored by the Caltech Division of Geological Sciences, receives support from the National Science Foundation and the National Aeronautics and Space Administration.

Sensitivity of the telescope results partly from the use of gold-surfaced mirrors, which are very effective in reflecting infrared waves. Also, a special germanium crystal detector is used that is doped with mercury atoms and cooled by liquid hydrogen to about


# Sanborn data amplifiers

(Three types available now — more on the way)




*(Specifications and prices subject to change without notice; prices are FOB Waltham, Mass.)*

Match amplifier characteristics much more closely to your over-all *system* requirements — and pay for only the performance you need — by choosing from these newly-developed, all solid-state DC data amplifiers now available from Sanborn. Ask your local Sanborn Sales-Engineering Representative for complete specifications, application help and a copy of the Industrial Division Catalog — or write the Main Office in Waltham.

• • • • •

## Wide Band, Floating Input—Floating Output "FIFO"

Bandwidth DC to 3 db down at 10 KC • Input isolated from output • Max. gain 1000, smooth gain covers intermediate ranges or switch out for calibrated gains of 1000 to 50 • Input impedance 100 meg. min. at DC, output impedance 60 ohms • Output capability ±10 V at 10 ma • Common mode rejection (1000 ohms in either input lead) 160 db at DC, 120 db at 60 cps • Linearity ±0.1% of 10 V full-scale at DC • Recovery from 500% overload is 300 μsec to 1% of f.s. output • Recovery from 20 V overload is 1 millisecond to 1% of f.s. output • Model 860-4000 "FIFO", $825. Model 860-4000P (grounded output ±5 V at ±100 ma, impedance less than 1 ohm), $900.

## DC—50 KC, 3-Terminal Floating Amplifier

Gain 1000 to 10 in 1, 2, 5 ratios; does not phase invert • Input impedance 100 meg. at DC • Output ±10 V ±100 ma, impedance less than 0.2 ohm • Linearity ±0.01% of 10 V output • Gain stability ±0.01% at DC at constant ambient for 40 hours • Model 860-4200, including internal power supply, $650.

## Narrow Band, Floating Input — Floating Output

Bandwidth DC to 3 db down at 100 cps • Optional plug-in output filters to limit bandwidth • Floating input isolated from floating output • Gain 1000 to 10; fixed step attenuator, gain trim and zero trim controls • Input impedance 300,000 ohms min., output impedance 75 ohms • Output ±5 V, ±2.5 ma • Linearity ±0.05% of 5 V output • Recovers from ±10 V overload in 200 ms • Common mode rejection (1000 ohms in either input lead) 130 db at 60 cps • Model 860-4300, $425.

INDUSTRIAL DIVISION
SANBORN COMPANY
175 Wyman Street, Waltham 54, Massachusetts
A SUBSIDIARY OF HEWLETT-PACKARD COMPANY

CIRCLE 109 ON READER SERVICE CARD

PRECISION PRODUCTION PROBLEMS?

Here's help from Bausch & Lomb in

TOOL DESIGN
INSPECTION
FABRICATION
MEASURING
TESTING

DR-25B OPTICAL GAGE
Fastest, easiest way to measure depth, thickness, height, diameter, taper. Read direct to 0.0001″ on bright, magnified scale.

10″ BENCH PROJECTOR
Magnifies silhouette of production part on high-contrast, wide-angle screen for measurement or comparison with template. Optional micrometer stage reads to 0.0001″.

TOOLMAKERS' MICROSCOPE
Wide field of view, bright shadow-free light and wide reticle lines for fast, easy linear measurements to 0.0001″; angular, to 1 minute of arc.

SCRATCH DEPTH GAGE
With this simple hand-held instrument you can measure the depth of any scratch to 0.0001″, with a range of 0″ to 0.015″.

STEREOZOOM® MICROSCOPES
Big, bright 3-D views of tiny parts. Zoom to any magnifications you need for assembly, inspection. Dust-proof, shockproof—can be mounted right in machines.

DIE-WEAR MICROSCOPE
See readily if die needs sharpening, and exactly how much metal must be removed. Direct, easy-to-read measurement of die wear up to 0.020″ . . . accurate to 0.0001″.

ZOOM MACROSCOPE
Measure direct to 0.0001″ — at any magnification from 10x to 30x — with constant focus throughout.

BAUSCH & LOMB INCORPORATED
61435 Bausch St., Rochester 2, N. Y.

Please send literature on optical production aids checked below:
☐ DR-25B Optical Gage ☐ Toolmakers' Microscope ☐ StereoZoom Microscopes ☐ Zoom Macroscope ☐ 10″ Bench Projector ☐ Scratch-Depth Gage ☐ Die-Wear Microscope

NAME ....................
TITLE ....................
COMPANY ....................
ADDRESS ....................
CITY .................... ZONE .... STATE ....................

BAUSCH & LOMB

sible without ambiguity within −30 degrees of the forward axis. This spacing is one wavelength, and it should be used because it results in the largest error signal for a given error angle.

Since the largest unambiguous element spacing results in the greatest phase delay for a given target angle, this spacing eases required accuracy in measuring phase. The one-wavelength spacing also provides the required degree of isolation between spiral antennas having the same sense of polarization. Also, coupling between elements is constant as the elements are rotated.

## Pulse Response Is Used For Airborne Prospecting

OPERATIONAL airborne prospecting system is based on transient responses of the ground to pulses of electromagnetic energy. Extensive investigations of this principle were reported from Canada at the Second Symposium on Remote Sensing of Environment, sponsored by the Institute of Science and Technology, University of Michigan.

Pulse lengths varying between fractions of a microsecond to 1.5 milliseconds are being used, according to A. R. Barringer of Barringer Research Ltd., Toronto. The pulses contain both a-f and r-f components. In the airborne system, the receiving equipment is designed to measure characteristics of the transient decay of eddy currents in the underlying terrain.

Additional research has been carried out using unipolar pulses ranging in duration from 1 to 40 microseconds. The transient responses to these pulses are a function of both conductivity of the ground and its dielectric constant.

## High-Pulse-Rate Laser Will Weld Exotic Metals

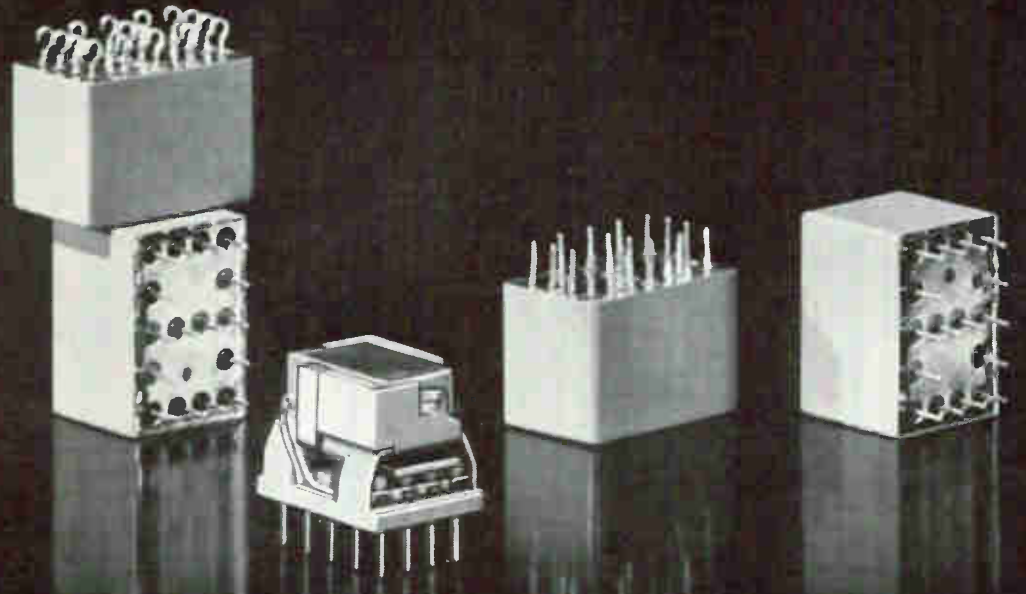
LASER now undergoing tests is expected to be able to machine and trim any material. High power is combined with a high pulse rate in the new ruby laser developed by General Dynamics/Convair.

To achieve sufficiently high pulse rates for effective welding and cut-

# New

**micro-miniature**

# 4-pole latching relay has sealed coils for greater reliability



**TL SERIES** This new latching relay's high inherent reliability is due to hermetically sealed coils, bifurcated gold plated silver alloy contacts and a unique magnetic structure.

**Other features:** Fast operate time, virtually no bounce, high shock (in excess of 100g) and vibration (30g to 2000 cps) resistance, small size (0.56 cubic inch). This relay meets or exceeds all applicable sections of MIL-R-5757D and PD-R 187.

Engineering samples are now available from Potter&Brumfield. Call your P&B representative for complete information.

**TL ENGINEERING SPECIFICATIONS**

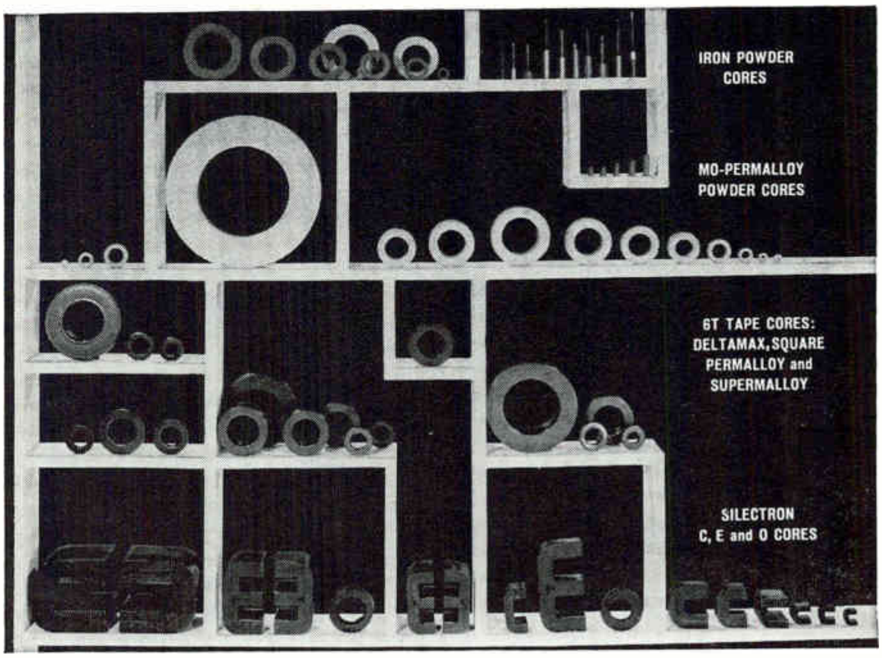
**Size:** 1.031" long, .725" wide, .750" high max.
**Weight:** Approx. 1¼ ozs.
**Contact Arrangement:** 4PDT (bifurcated, gold plated silver alloy).
**Rated:** Dry circuit to 3 amps at 28 v dc res.
**Life:** 100,000 operations at max. rated load.
**Coil Power:** For two-coil relays: Approx. 1 watt (nominal at 25°C). For single coil relays: Approx. 0.5 watt (nominal at 25°C).
**Operate Time:** 6 milliseconds max. at nom. voltage at 25°C coil temp.
**Transfer Time:** 0.5 milliseconds approx. at nom. voltage at 25°C coil temp.
**Temperature Range:** −65°C to +125°C.

P&B STANDARD RELAYS ARE AVAILABLE AT YOUR LOCAL ELECTRONIC PARTS DISTRIBUTOR

**POTTER & BRUMFIELD**

DIVISION OF AMERICAN MACHINE & FOUNDRY COMPANY • PRINCETON, INDIANA
IN CANADA: POTTER & BRUMFIELD, DIVISION OF AMF CANADA LIMITED, GUELPH, ONTARIO
CIRCLE 111 ON READER SERVICE CARD

# 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 and technical material are available—write for data.

ADDRESS DEPT. E-11

**ARNOLD**
SPECIALISTS in MAGNETIC MATERIALS

THE ARNOLD ENGINEERING COMPANY, Main Office: MARENGO, ILL. 2998 RIA
BRANCH OFFICES and REPRESENTATIVES in PRINCIPAL CITIES


ting, eight xenon flash lamps on a revolving drum are used. The lamps can be fired individually or in sequences of two, four or eight.

Repeat firing of lasers at rapid rates is presently restricted by the cooling-off time required for the xenon lamp. The use of multiple lamps will enable pulse rates to be increased while providing the cool-off time needed for each lamp. After additional testing, the firm expects to be able to determine and control energy level and output required for welding and cutting.

In industrial applications, laser beams will provide a means for melting small controlled areas of the pieces to be joined without contamination. Similarly, they will enable materials to be cut and vaporized. The accurate straight line of the laser beam is also promising for optical tooling and could be used to produce almost perfectly aligned missile assemblies and aircraft wing sections.

## Heat Waves Reveal Moon Is Colder Than Supposed

LUNAR night gets at least 30 degrees colder than has been supposed. Also, hot spots on the moon remain warm several days after the lunar sunset. These and other conclusion are based on observations made using a new infrared telescope.

The instrument is said to be 20 to 50 times more sensitive than previous systems for measuring temperatures of comparitively cold celestial obejects. It is operated by California Institute of Technology at a site 13,000 feet above sea level. The telescope senses radiation through a window in the earth's atmosphere that passes infrared having a wavelength of about 0.01 millimeter. The project, sponsored by the Caltech Division of Geological Sciences, receives support from the National Science Foundation and the National Aeronautics and Space Administration.

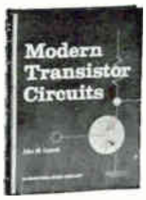
Sensitivity of the telescope results partly from the use of gold-surfaced mirrors, which are very effective in reflecting infrared waves. Also, a special germanium crystal detector is used that is doped with mercury atoms and cooled by liquid hydrogen to about


Electronic Switching, Timing, and Pulse Circuits, by J. M. Pettit. Publisher's Price, $8.50. Club Price, $7.25


Information Transmission, Modulation, and Noise, by M. Schwartz. Publisher's Price, $11.75. Club Price, $9.95

Mathematics for Electronics with Applications. Nodelman & Smith. Publisher's Price, $7.00. Club Price, $5.95


Digital Computer and Control Engineering, by R. S. Ledley. Publisher's Price, $14.50, Club Price, $12.35



Modern Transistor Circuits, by J. Carroll. Publisher's Price, $9.00. Club Price, $7.65

Magnetic Recording Techniques, by W. E. Stewart. Publisher's Price, $9.00. Club Price, $7.65


Wave Generation and Shaping, by L. Strauss. Publisher's Price, $12.50. Club Price, $10.65

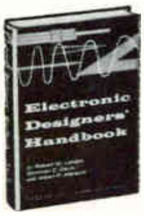
SPECIAL INTRODUCTORY OFFER

# Take ANY ONE for only $1.00

SAVINGS UP TO $21.50

To NEW MEMBERS of the

## Electronics and Control Engineers' Book Club



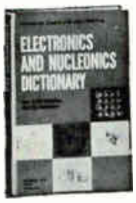
Electronic Designers' Handbook. Landee, Davis, & Albrecht. Publisher's Price, $17.50. Club Price, $14.95.


Control Engineers' Handbook, ed. by J. C. Truxal. Publisher's Price, $22.50. Club Price, $19.10

Elements of Servomechanism Theory, by G. Thaler. Publisher's Price, $9.50. Club Price, $8.10

Instrumentation in Scientific Research, by C. S. Lion. Publisher's Price, $10.75. Club Price, $9.15


Basic Feedback Control System Design, by C. J. Savant, Jr. Publisher's Price, $10.50. Club Price, $8.95



Electronics and Nucleonics Dictionary. Cooke & Markus. Publisher's Price, $15.00. Club Price, $12.75

Electronic and Radio Engineering, by F. Terman. 4th Ed. Publisher's Price, $15.50. Club Price, $13.25


Management for Engineers, by R. C. Heimer. Publisher's Price, $8.95. Club Price, $7.60

MAIL COUPON AT RIGHT TODAY

### *How many of these books do you wish you had at Club savings?*

Select one for JUST A DOLLAR! Choose from *Electronic Designers' Handbook, Modern Transistor Circuits, Magnetic Recording Techniques, Wave Generation and Shaping,* and eleven other valuable books . . . your introduction to membership in the *Electronics and Control Engineers' Book Club.*

If you're missing out on important technical literature, if today's high cost of reading curbs the growth of your library—here's the solution to your problem. *The Electronics and Control Engineers' Book Club was organized for you,* to provide an economical technical reading program that cannot fail to be of value to you.

All books are chosen by qualified editors and consultants. Their thoroughgoing understanding of the standards and values of the literature in your field guarantees the authoritativeness of the selections.

### HOW THE CLUB OPERATES

You regularly receive free of charge *The Electronics and Control Engineers' Book Bulletin.* This gives complete advance notice of the next main selection, as well as a number of alternate selections. If you want the main selection you do nothing; the book will be mailed to you. If you want an alternate selection . . . or if you want no book at all for that two-month period notify the Club by returning the postpaid card enclosed with each *Bulletin.*

### SAVES YOU TIME AND MONEY

We ask you to agree only to the purchase of three books in a year. Certainly out of the large number of books in your field offered in any twelve months there will be at least three you would buy anyway. By joining the Club you save yourself the bother of searching and shopping, and save in cost about 15 per cent from publishers' prices. Send no money now. Just indicate any two books you want—one for only $1.00 and one as your first Club selection—in the coupon below. Take advantage of this offer *now,* and get two books for less than the regular price of one.

## CLIP AND MAIL THIS COUPON TODAY

**The Electronics and Control Engineers' Book Club, Dept. L-11-30**
**330 West 42nd Street, New York 36, N. Y.**

Please enroll me as a member of the Electronics and Control Engineers' Book Club. I am to receive the two books I have indicated below. You will bill me for my first selection at the special club price and $1 for my new membership book, plus a few additional cents for delivery costs. (The Club assumes this charge on prepaid orders.) Forthcoming selections will be described to me in advance and I may decline any book. I need take only 3 selections or alternates in 12 months of membership. **(This offer good in U. S. only.)**

**Show 2 numbers: #1 for dollar book and #2 for Club selection**

- ☐ Elec. Switch., Tim., & Pulse Cir., $7.25
- ☐ Info. Trans., Mod., & Noise, $9.95
- ☐ Math. for Elec. with Appl., $5.95
- ☐ Dig. Comp. & Ctl. Enrg., $12.35
- ☐ Modern Transistor Circuits, $7.65
- ☐ Magnetic Recording Techniques, $7.65
- ☐ Wave Generation and Shaping, $10.65
- ☐ Elec. Designer's Hdbk., $14.95
- ☐ Elem. of Servomech. Theory, $8.10
- ☐ Basic Feedback Ctl. Sys. Des., $8.95
- ☐ Electronic & Radio Enrg., $13.25
- ☐ Control Engineer's Hdbk., $19.10
- ☐ Instrumentation in Sci. Res., $9.15
- ☐ Elec. & Nucleonics Dict., $12.75
- ☐ Mgmt. for Engineers, $7.60

**PLEASE PRINT**

Name ..........................................................

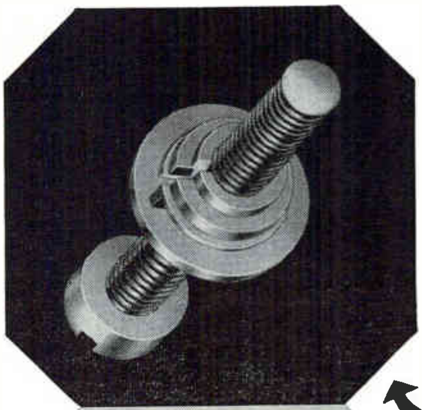
Address ..........................................................

City ................................ Zone...... State.............

Company ..........................................................

**NO RISK GUARANTEE:** If not completely satisfied, you may return your first shipment within 10 days and your membership will be canceled. L-11-30


**you can solder directly to the solid metal electrode bands of ROANWELL PRECISION PISTON TRIMMER CAPACITORS**



There's improved reliability in Roanwell piston capacitors — improved stability, linearity, accuracy, ruggedness — because of its new construction approach. Its design features . . .

**solid brass, gold plated, electrode bands:**

- Permits soldering directly to metal electrode band with no effect on capacitance.
- Ideal for high frequency application.
- Eliminates built-in stresses since there is no firing process of silver to glass.
- Unit becomes inherently more rugged since solid brass bands act as main support for the dielectric.

**new drive mechanism (pat. applied for):**

- Eliminates gold flaking.
- More uniform torque.
- Backlash eliminated radially and transversally.

**more capacitance per size:**

- Because both I.D. and O.D. of dielectric are controlled.

**will meet or exceed applicable requirements of spec. MIL-C-14409A.**

Write for catalog E-11

*For Your Custom Needs...*

we can either modify standard units or create new trimmer designs. It all depends on what best suits your specific applications.

**ROANWELL CORPORATION**
ELCOM DEPARTMENT
ROANWELL BUILDING
180 VARICK STREET, NEW YORK 14, NEW YORK
TEL: (212) YUKON 9-1090 • TWX: (212) 640-4791

−423 degrees F.

In measuring temperatures, radiation from the spot of interest is compared to that from a nearby spot in the sky. Only the difference signal is amplified, which enables small amounts of radiation to be measured despite strong emissions from the earth's atmosphere and the surroundings.

To measure lunar temperatures, the telescope scans across the moon from bright to dark and back again in 5 minutes. The output signal, which is proportional to infrared radiation, is supplied to a strip chart recorder. Simultaneously, photographs are taken through a small finder telescope to aid in locating the points where radiation is being monitored.

OBSERVATIONS—The coldest temperature during the lunar night, which is 30 times as long as night on earth, has been accepted as −243 degrees F. After five nights, however, measured temperature was below −270 degrees, which is the coldest temperature that the infrared telescope can record. Temperatures measured at other times after the lunar sunset were: −206 degrees after 6 hours, −220 degrees after 12 hours, −242 degrees after 24 hours and −260 degrees after 48 hours.

The telescope permits an area of only about 20 square miles to be observed at a time. This characteristic enabled four spots to be located that cooled much more slowly than the rest of the lunar surface. Temperatures of these areas did not fall below −270 degrees until 10 days or so after the lunar sunset.

One warm area was located near the crater Tycho and another near the crater Copernicus. The other two warm spots did not seem to be associated with any visible features of the moon. Retention of heat in these areas suggests that bare rocks may be exposed in some places on the surface of the moon, which is usually assumed to be covered with dust.

The infrared telescope was also used to measure mean temperature during 12 different nights on the planet Jupiter, which was −229 degrees F. Since heat radiated from Saturn could not be detected, its temperature was concluded to be below −270 degrees F.

# BIPCO® LOGIC is the new approach to microelectronics

# BIPCO® LOGIC is low cost and reliable

# BIPCO® LOGIC solves the interconnection problem

# BIPCO® LOGIC yields highest component density

# BIPCO® LOGIC permits circuit design flexibility

# BIPCO® LOGIC yields multi-component uniformity

# BIPCO® LOGIC is applicable to any circuit

# BIPCO® LOGIC is available now

*Typical 96 diode BIPCO Module.*
*(Measures 5⁄16" x 1⅛" x 15⁄16")*

BIPCO Logic represents an entirely new approach to microelectronics. Batches of identical components are "Built-In-Place" at one time in patterns determined by the logical function to be performed. Individual component handling is eliminated, interconnections are simplified, and electrical uniformity is achieved. For the first time, the cost barrier inherent in other approaches has been eliminated so that reliability *and* low cost can be obtained.

Functional diode logic is now available in individual BIPCO Modules or in printed circuit packages including: Decimal Counters, Binary and Alpha-Numeric Decoders, Encoders, and Distributors. BIPCO Transistor, Resistor, and Capacitor Modules will be available soon.

*Write for* **complete technical information on the growing BIPCO Module line.**

**CIRCLE 115 ON READER SERVICE CARD**

ANOTHER ELECTRONIC CONTRIBUTION BY
**Burroughs Corporation**
ELECTRONIC COMPONENTS DIVISION
PLAINFIELD NEW JERSEY

# Creating for Genuine Quality

## *Origin Electric Strives For Material & Personal Improvement*

"A company grows as men grow, and men grow first", is a guiding principle at Origin. The company's program of training is based on Education, Engineering and Economy. Education for personal growth, Engineering for production, and Economy for Wealth. Each point of the company triangular trademark (Origin) is symbolic of the company's three aims.... Machinery, Character Development and Wealth. The company's operation is literally "Democracy in Action"—teamwork, which is the by-product of individual growth.

Established in 1938, the company has developed into one of the leading makers of rectifiers in Japan. At present more than 45% of the total rectifiers used by the Japan Telephone and Telegraph Public Corporation is supplied by Origin.

A continual program of advanced research produces Selenium, Germanium and Silicon Rectifiers, Condenser Type Spot Welder, Synthetic Enamel and Miniature Ball Bearings.

**ORIGIN Silicon Diodes**

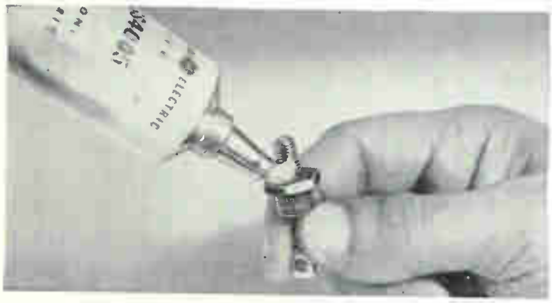
**SW-05** **SM-150** **SE-1.5**

**ORIGIN ELECTRIC CO., LTD.**
1-195 Takada Minami-cho, Toshima-ku, Tokyo
Cable Address "ORIGINELE" TOKYO

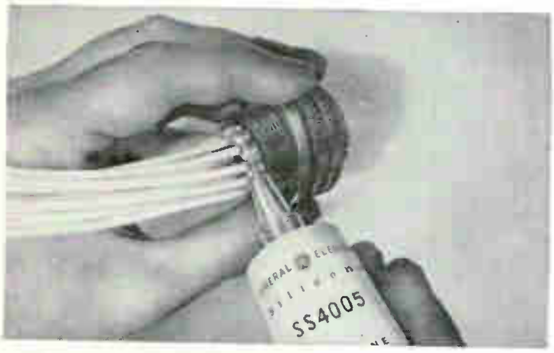

**Electric fry pan at 400°F melts solder** while G-E silicone compound adheres without melting to the tilted surface.

# Even at 400°F G-E Silicone Dielectric Compound won't melt!

*(or noticeably bleed, evaporate or dry out)*



**HEAT TRANSFER MEDIA** G-E silicone dielectric compounds improve heat transfer from electronic components.




**CORROSION INHIBITORS** Silicone compounds protect against sticking, moisture, corrosive atmosphere.

General Electric silicone dielectric compounds won't melt at 400°F or solidify at —65°F. These greaselike materials have excellent dielectric properties. They are easily applied, chemically inert, non-corrosive and water repellent.

G-E silicone compounds adhere tenaciously to almost everything, without being subject to oxidation, evaporation or excessive bleed losses. A free sample tube is yours on request, to test as a corrosion inhibitor, release agent, water repellent, insulator, protective coating or heat transfer media. Ask for SS-4067 (general purpose), SS-4005 (meets MIL-1-8660), or SS-4006 (inhibits copper oxidation). Write on your letterhead, describing your proposed application, to Section N1178, Silicone Products Department, General Electric Company, Waterford, New York.

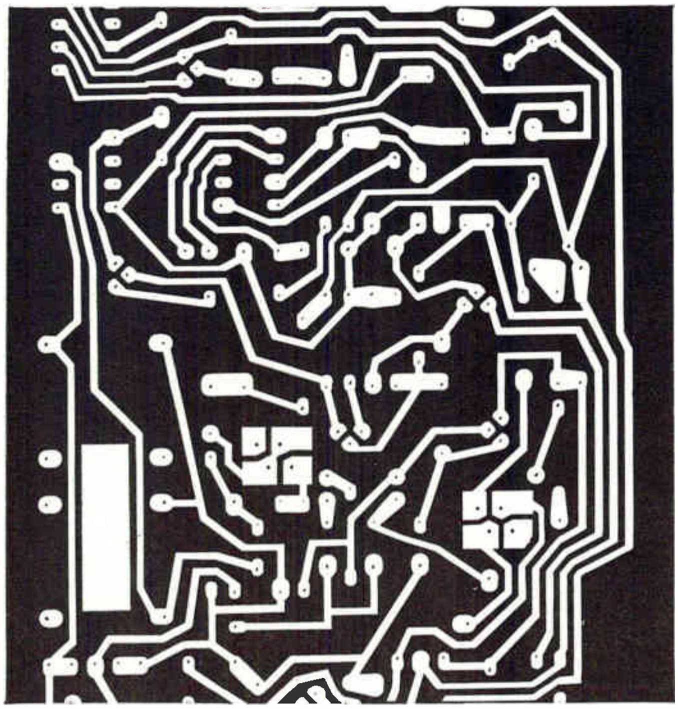
**G-E silicone insulating products available from these distributors:** San Francisco, Electrical Specialty Co., 158 11th St.; Chicago, Federal Insulation Co., 549 W. Randolph; Detroit, Insulation & Copper Sales, 15605 Woodrow Wilson; Floral Park, N.Y., Punt, Inc., 160 Woodbine Ct.; Philadelphia, Smith of Phila., 1024 Race St.; Chagrin Falls, Ohio, Electrolock, Inc., 28 N. Main; Washington, D. C., Read Plastics, Inc., 317 Cedar St., N.W.

**GENERAL ELECTRIC**



CIRCLE 117 ON READER SERVICE CARD

# Copper-clad laminate should be WORTH the circuit printed on it



Most printed circuits require a high-quality, reliable copper-clad laminate. Synthane goes to extremes to check foil quality, adhesives and the laminate. We test peel strength at room temperature *and* at 500°F, using a newly-developed peel tester. Synthane checks blister resistance and heat resistance, and measures the thickness of the entire sheet (not merely the edges) with a new Synthane-designed instrument. Synthane prints and checks test patterns. Be sure the laminate is worth the circuit *you* print on it. Write for Copper-clad Bulletin.

**SYNTHANE**

CORPORATION OAKS, PENNA.

GLendale 2-2211 TWX Valley Forge 735U

Synthane-Pacific, 518 W. Garfield Ave., Glendale 4, Calif. TWX GLDL 4417U

Synthane Corporation, 36 River Rd., Oaks, Pa.

Gentlemen:

Please send me new bulletin, "Synthane Metal-clad Laminated Plastics"

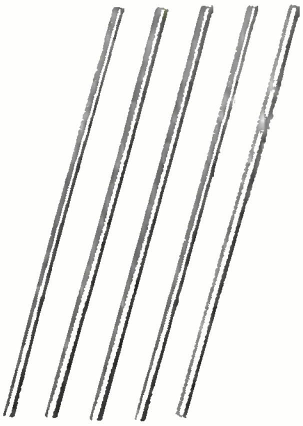
Name____________________

Address____________________

City__________ Zone____ State__________



# HOW TO CUT YOUR COSTS ON WIRE STRAIGHTS



Wire straights produced on precision automatic machines, in all diameters from .005 to .125, lengths to 8 feet, with all dimensions held to closest tolerances. Square-cut ends, virtually burr-free, with minimum surface markings. Our production economies save you money on bead wires, leads for hermetic seals, semi-conductors and other applications. In ferrous, non-ferrous, and precious metal alloys. Non-standard diameters and alloys supplied on special order.

***Send Prints or Specifications for Estimates***

**ART WIRE AND STAMPING CO.**

18 Boyden Place, Newark 2, N. J.

**CIRCLE 205 ON READER SERVICE CARD**



# SMK ELECTRONIC COMPONENTS

The SMK components are exported in large quantities to foreign markets at the lowest possible prices with the highest quality available.

We are always making strenuous efforts to make a new design and improve every product in quality.

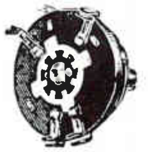
We are proud of our production capacity which is claimed to be the largest in the Orient. Catalogue available on request.

S-G1101 S-H1101
Miniature Plugs and Jacks

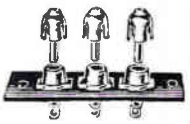
S-I 5201
S-I 5202
U.S. Connector

S-I 5701
S-I 5702
Plug Socket

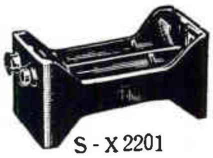
S-I 7901
Connector for microphone



S-J 2801
Rotary Switch



S-Q 2501
Pin Jack Terminals for amplifier



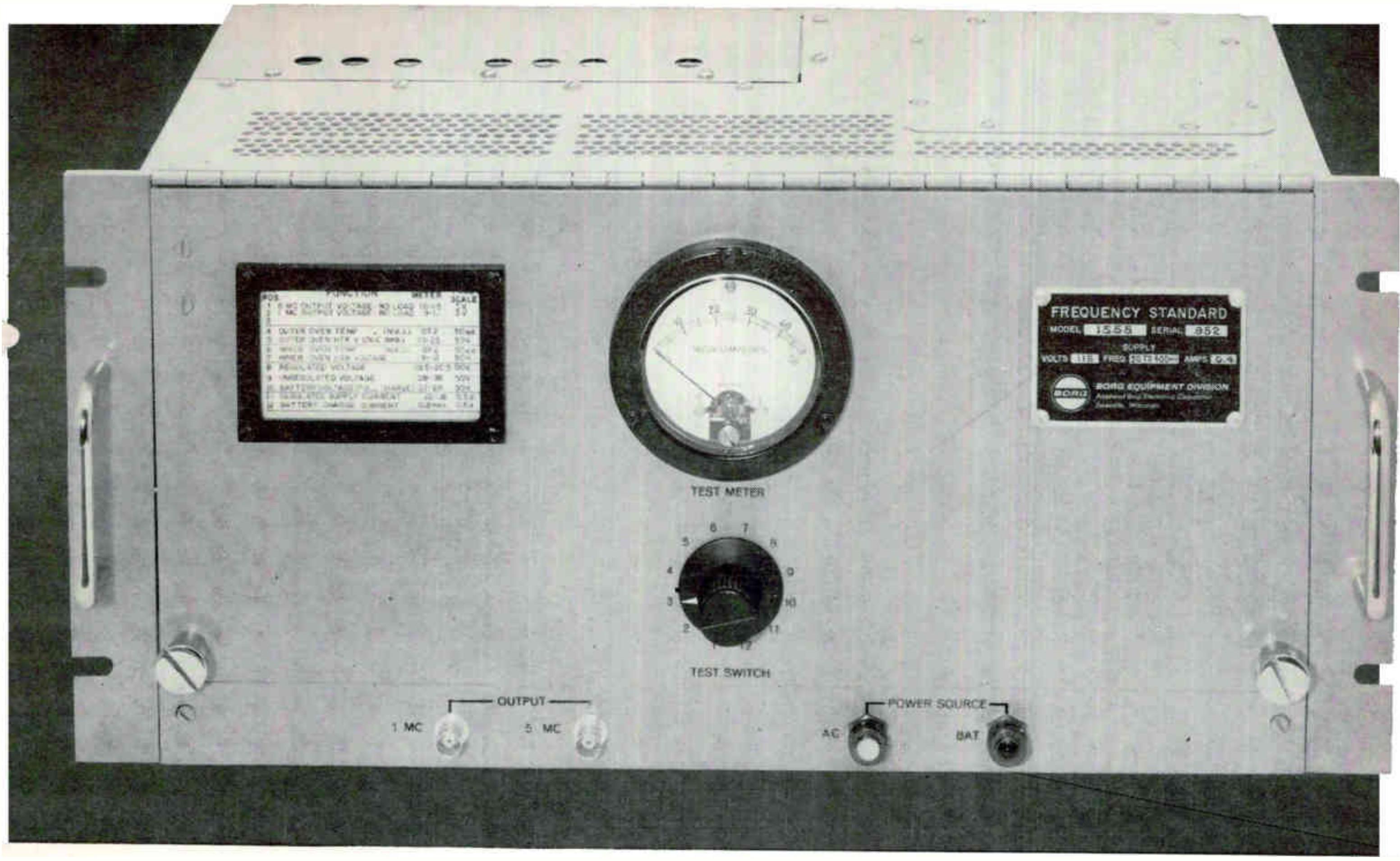
S-X2201
Battery Holders

TV Adapter

**SHOWA MUSEN KOGYO CO., LTD.**

24 Higashitogoshi 5-chome, Shinagawa-ku, Tokyo, Japan

**CIRCLE 206 ON READER SERVICE CARD**




# MTBF > 10,000 Hours

Better than 10,000 hours, mean time between failure—this is the performance you can expect from the new transistorized Borg Frequency Standard, Model 1555.

Why won't you find another frequency standard like it?

Reliability is only one reason.

Take stability. Stability of the Borg 1555 is assured by the 5 mc overtone crystal, and is maintained by dual ovens which hold crystal temperature to within ±0.003°C. Short-term stability is better than 5 parts in $10^{11}$; long-term better than 5 parts in $10^{10}$ per day.

You get more than six hours standby operation from batteries which are an integral part of the unit. You can plug in two extra frequency modules, dividers or multipliers. An external status indicator gives you quick read-out. And there are frequency outputs front and rear.

Need a militarized model? The Borg 1555 can be supplied to meet military specifications, including MIL-E-16400D. Special project engineering assistance is also available from Borg, leading designer-producer of militarized frequency/time standards. For complete information, write to H. H. Seaver:

**BORG EQUIPMENT DIVISION**
*Amphenol-Borg Electronics Corporation,*
*Janesville, Wisconsin.*

## SPECIFICATIONS Transistorized Frequency Standard, BORG MODEL 1555

**FREQUENCY STABILITY**
Long Term: 5 parts in $10^{10}$ per day; 1 part in $10^{8}$ per 60 days; after 21 days of continuous operation
Short Term: rms deviation of 1000 successive 0.2 second measurements; better than 5 parts in $10^{11}$

**OUTPUT FREQUENCY**
5 mc: output of 1 volt minimum rms into 50 ohm load

**HARMONIC DISTORTION**
Less than 1%

**FREQUENCY ADJUSTMENT**
Coarse: adjustable with range of 500 parts in $10^{9}$
Fine: adjustable with range of 1000 parts in $10^{10}$ readable to 1 part in $10^{10}$

**LINEARITY OF FINE FREQUENCY ADJUSTMENT**
Over any range of 500 parts in $10^{10}$ shall be within ±20 parts in $10^{10}$

**METERING**
Front panel with 12-position switch to meter all critical circuits and provision for remote metering of output

**TEMPERATURE RANGE**
0°C to 50°C

**DELIVERY**
60 days; if military specifications required—90 to 120 days

**CIRCLE 119 ON READER SERVICE CARD**

# More Watts, Longer Life for Solar Cells

*Push for space power goes on, emphasis lies in two areas*

TWO solar cell developments emphasize the need for solar conversion devices with more watts per pound of system weight at more watts per dollar of cost[1], and improved radiation resistance[2]. Work in both areas was described at the Space Power Systems Conference, sponsored by American Rocket Society.

Major progress towards the first objectives has been achieved with a CdS film cell, vacuum evaporated onto a metal foil substrate. Such cells are now being made in sizes up to 3 in. by 3 in., at conversion efficiencies of 2 to 3 percent. They can be laminated in plastic envelopes to form arrays delivering 10 to 15 watts per pound. These cells can be made economically, according to Harshaw Chemical Co. spokesmen.

A new construction was developed, that is simpler than that of the conventional rearwall cell, common to solar cells. Called a frontwall cell, light is incident directly on the barrier surface, and a metal foil substrate acts as negative collector.

GREATER OUTPUT—Frontwall cell shows promise of still higher efficiencies, larger areas and greater power outputs per unit of weight.

Response of this cell extends into the ultraviolet, since the CdS itself is not filtering out the shorter wavelengths as it does in the case of the rearwall cell. In spite of broader response, the frontwall construction usually gives less output, and the reasons for this are presently being studied.

Excluding secondary effects, such as loss of electrical contacts and atmospheric degradation, CdS single crystal cells, rearwall film cells on glass substrates, and frontwall cells on molybdenum substrates all seem to have similar temperature performance characteristics.

It appears that CdS film arrays can possess appreciable resistance to damage by radiation of the types normally associated with the Van Allen belts. More data, particularly on higher efficiency cells are needed according to Harshaw. Arrays are stored in inert gas atmospheres, dry atmospheres and in vacua have shown no degradation during storage periods up to 200 days.

The process for fabricating CdS evaporated film solar cells is essentially a simple one, and should be amenable to automation. And availability or cost is not a problem.

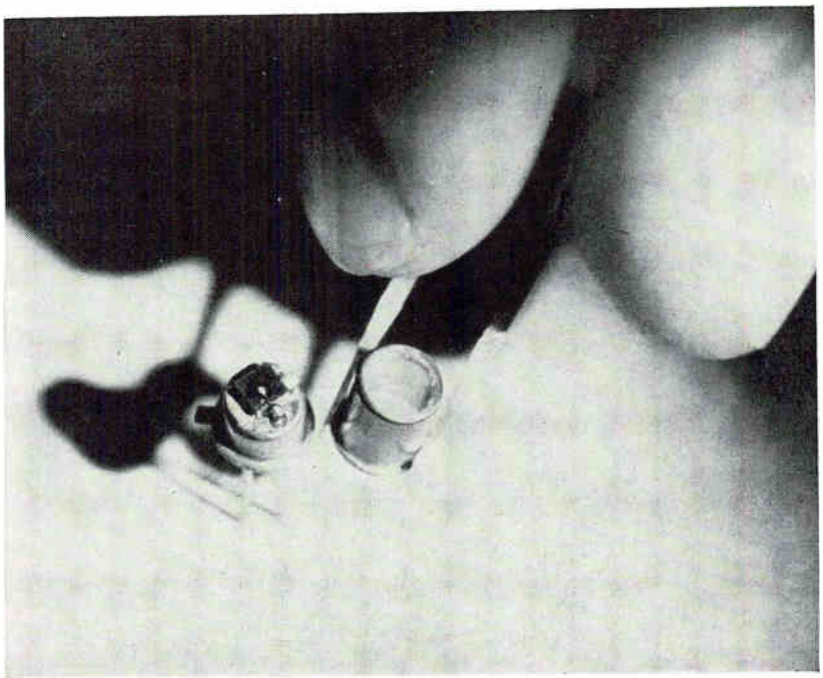
At present 3 in. by 3 in. film cells give an active cell area of 50 to 55 cm$^2$, and cells as large as 6 in. by 6 in. could probably be made with essentially the same characteristics.

ELECTRICAL FIELD — Electro-Optical Systems' radiation damage resistant solar cell[2], an experimental unit, incorporates an electrical field on the base region.

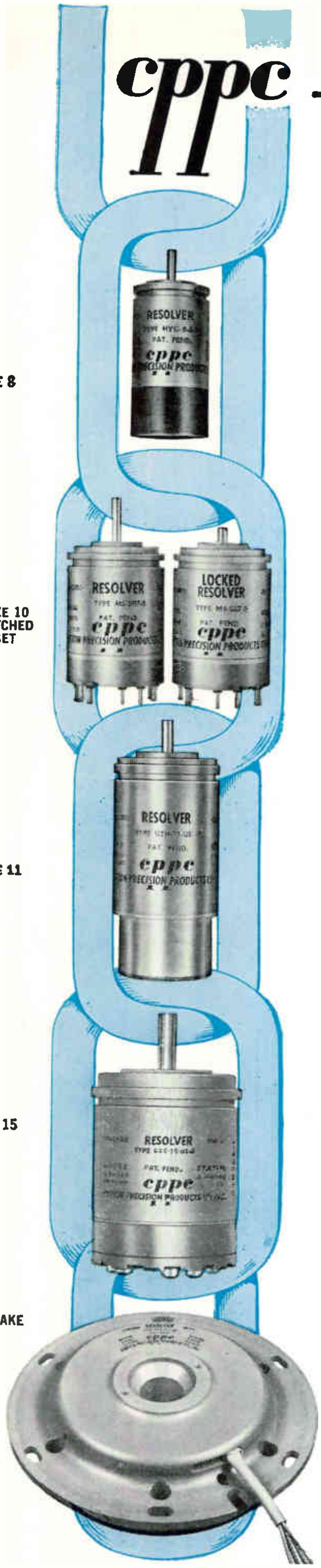
Results of both proton and electron irradiation indicate increased radiation resistance over $n$ and $p$ cells produced by shallow junction diffusion into one-ohm/cm material. The existence of an electric field in the base region has been demonstrated by transient time experiments; but influence of other factors on the improved radiation resistance has not been ruled out.

Electro-Optical's cell has an $n$-type surface layer and has an impurity gradient in the $p$-type region. The gradient is such as to

# Infrared Crystal Response Topped



NEW DEVICE *is claimed by Philco to be first indium arsenide single crystal available for operation in the 1.5 to 4-micron region. Up to recently only lead salt detectors have been available for application in this region, and they can not be produced as uniformly as crystal detectors, it was reported. Response time of indium arsenide device is less than one microsecond, a reported improvement of one to two orders of magnitude*




# cppc — Your Specialist for

# CASCADED AMPLIFIERLESS RESOLVER CHAINS

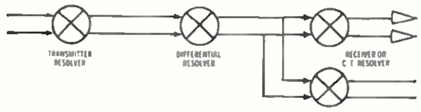
Why not take advantage of the years of pioneering experience which Clifton Precision has gained in cascaded resolvers?

Not only have we designed and developed the widest variety of these resolvers, but we have also become extremely well versed in the attendant systems engineering.

Thus you can have two important advantages by dealing with Clifton: top quality components and wide systems experience.

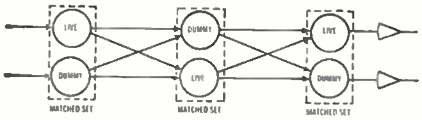
For further information, contact: Sales Dept. 5050 State Rd., Drexel Hill, Pa. Area 215 MAdison 2-1000 • TWX 215 623-6068—or our Representatives.

### Simple Follow-Up Chains—No Compensation



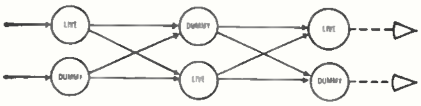

The above chain uses simple production tolerances on the components and represents a four wire data transmission system used in servo work. Variations of the above system can utilize several receivers if necessary by proper impedance matching.

### Simple Amplifierless Chains With Matched Sets of Live and Dummy Resolvers



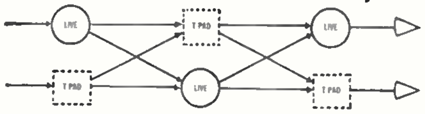

The above concept can be supplied as matched sets of live and dummy resolvers either as independent components or built into a single integral case. Matched sets can be constructed that will be all the same for a system or matched sets for different impedance levels (e. g. matched set #1, set #2, set #3, etc.). No compensation resistor, thermistor or capacitor is used in the above concept.

### Intermediate Chains With Interchangeable Components—Some Compensation



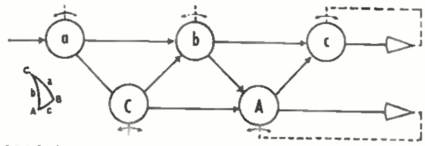

In the system above only one electrical type is utilized for both dummy and live resolver. All live resolvers are interchangeable with any other live resolver and any dummy resolver is interchangeable with any other dummy resolver. Units are compensated for constancy of transformation ratio and phase shift over temperature as well as unit to unit. No capacitors are used in the above system to reduce phase shifts.

### Completely Compensated Interchangeable Amplifierless Chains With Thermal Stability




The illustrated system employs the use of completely compensated resolvers. These units are compensated for T.R. and phase shift over temperature with a characteristic impedance concept. T-Pads are shown which are utilized with this system but dummy type transformer units completely compensated will yield better system accuracy and symmetry. The above system is frequency sensitive due to the use of timing capacitors.

### Chains For Different Frequencies, Voltages and Environmental Conditions




CPPC has developed cascaded chains for different voltages and different frequencies (e.g. 400 ~, 800 ~, 900 ~, 1600 ~, 3200 ~, 5000 ~, 10V., 15V., 26V., 50V., 115V.,) employing the use of standard components, pancakes (with and without gymbal bearings), as well as components in aluminum, stainless steel and beryllium. Some chains have been developed which must be calibrated at three different temperature levels.

cppc

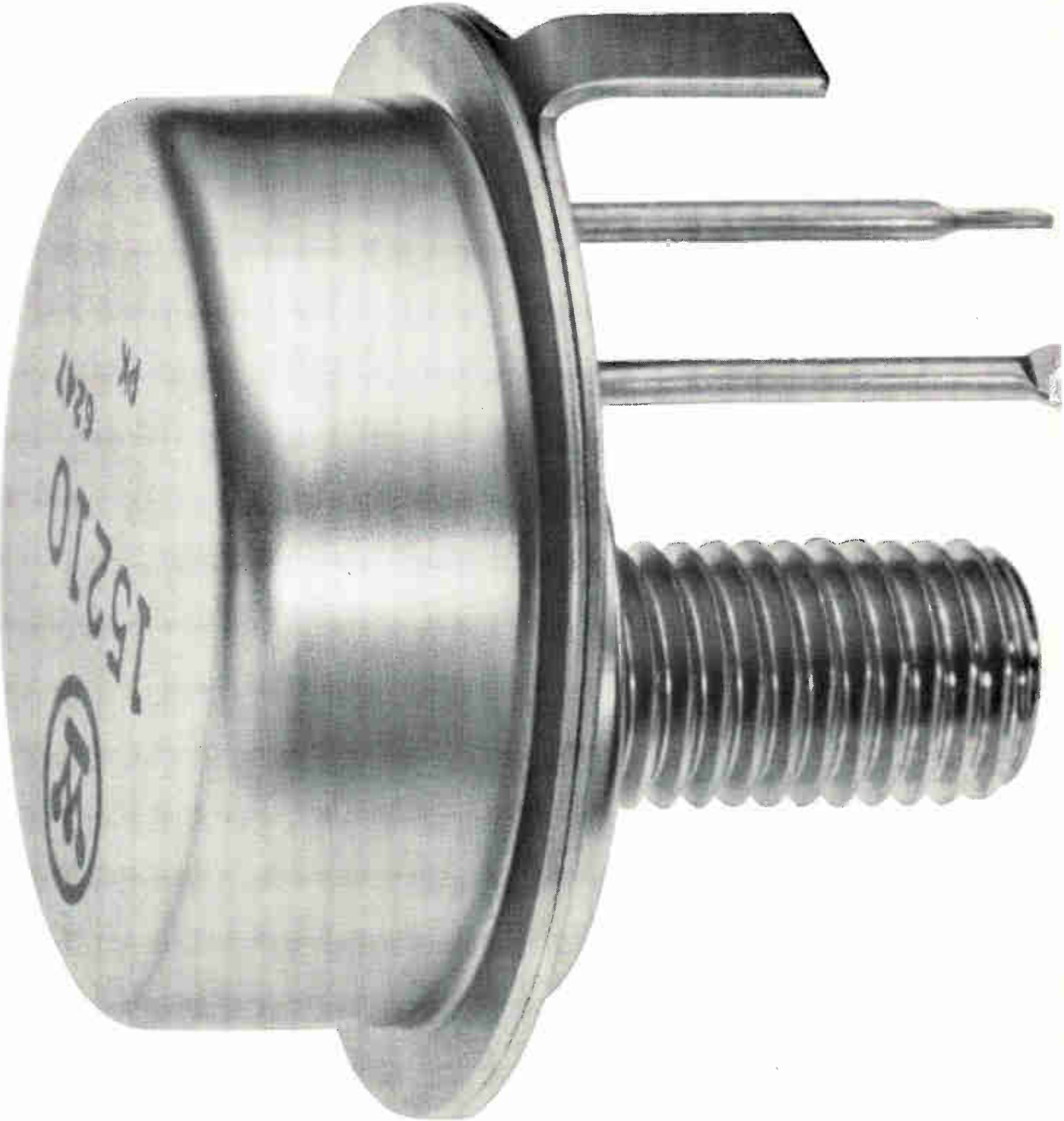
## CLIFTON PRECISION PRODUCTS CO., INC.

Clifton Heights, Pa. • Colorado Springs, Colo.



CIRCLE 121 ON READER SERVICE CARD

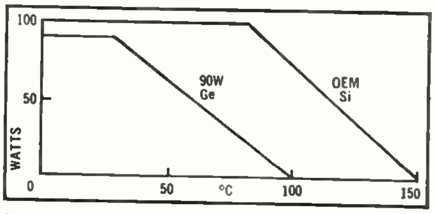
# SILICON PERFORMANCE—GERMANIUM PRICE



# New 100 watt silicon transistors for lower system costs

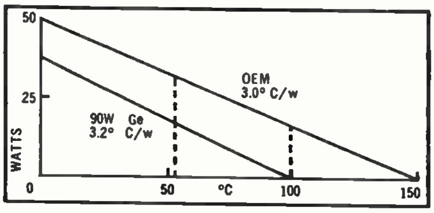
Compare the OEM silicon transistor with a 90 watt germanium transistor. On a system basis, the Westinghouse silicon transistor costs less, it gives design flexibility, it gives a more reliable performance. Here's why.

## Higher temperature operating capabilities



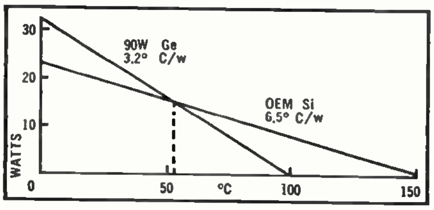

Check the stud temperature derating curves above. The OEM silicon transistors work in engine compartment temperatures and crowded, hot equipment chassis. You'll have greater design latitude.

## One silicon transistor can replace two or more germaniums




Compare the performance on a typical heat sink. One silicon transistor has the dissipation capability of two germanium transistors at 55°C ambient temperature. And compare ratings at 100°C. The silicon transistor still packs a punch. The germanium unit? It died out.

## Lighter, smaller, more reliable equipment




Compare 15W heat sink requirements at 55°C. The 6.5°C per watt heat sink would be about 50% smaller than the germanium transistor heat sink. Thus, equipment can be smaller and lighter. Also, the equipment is more reliable . . . the silicon gives a higher temperature margin. SC-1084

**FREE!** Write for an important booklet, Design Considerations for the OEM Line. It features detailed comparisons between germanium and silicon power transistors for commercial applications. Westinghouse Electric Corp., Semiconductor Div., Youngwood, Penna. You can be sure . . . if it's

**Westinghouse**

CIRCLE 123 ON READER SERVICE CARD


provide an electric field in the base which will accelerate photoelectrons into the vicinity of the *pn* junction. In this way, the dependence of the short circuit current upon the minority carrier lifetime is reduced. Since the latter parameter is the one most effected by bombardment of the cell by energetic charged particles, the tolerance of the cell to damage by such particles is considerably enhanced. Data has been presented on the performance of these cells as a function of high energy electron and proton bombardment.

REFERENCES

(1) F. A. Shirland, T. A. Griffin and G. H. Dierssen, Thin Film CdS Front Wall Solar Cells, Harshaw Chemical Co., Cleveland, Ohio, paper presented at Space Power Systems Conference, Sept. 25-28, 1962.

(2) S. Kaye, I. Weiman and W. V. Wright, A New Radiation Damage Resistant Solar Cell, Electro-Optical Systems, Inc., Pasadena, Calif., paper presented at Space Power Systems Conference, Sept. 25-28, 1962.

## Better Thermal Overcoat For Silicon Devices

HIGH temperature qualities of silicon are fully utilized by commercial development of oxide passivation, and even higher temperature performance is now within grasp.

Thin silicon slices containing large numbers of unseparated diodes are exposed to an atmosphere that combines some of the silicon at the surface, with oxygen from an external source.

This reaction forms a thin quartz layer over silicon zener diodes, offering greater protection against contaminants.

Warren Eriksen, Director of Hoffman Electronics' Semiconductor Division, announced that at 25 C, passivated diodes exhibit 50 percent greater heat dissipation. The standard glass package, which formerly had a heat dissipation rating of 400 milliwatts, has been upgraded to 600 milliwatts.

Oxide passivation technique has extended low-temperature storage capability to minus 196 C, according to Eriksen, who added that storage specifications have been extended to 250 C.

Leakage specification approaches the zener knee (50 percent), and is about 100 times higher than older typical values. If an older unit was specified at 900 ohms, the new passivated counterpart would be rated at 600 ohms.

In effect Eriksen says the passivated diffused zener diodes have low-level advantages of alloyed types, and long-term stability of diffused types.

## Torque Motor Holds Sensors on Course

INERTIAL *vertical reference, capable of holding a camera platform within 0.05 second of arc per second of time. System operates as a Schuler-tuned pendulum, uses brushless torque motor*

NO BRUSHES, commutators, slip rings or mechanical connections between rotor and stator are required in brushless d-c torque motors, now used in space probes.

Brushless motor was developed originally for a gimbal drive element in stable platforms for aerial cameras and other sensors.

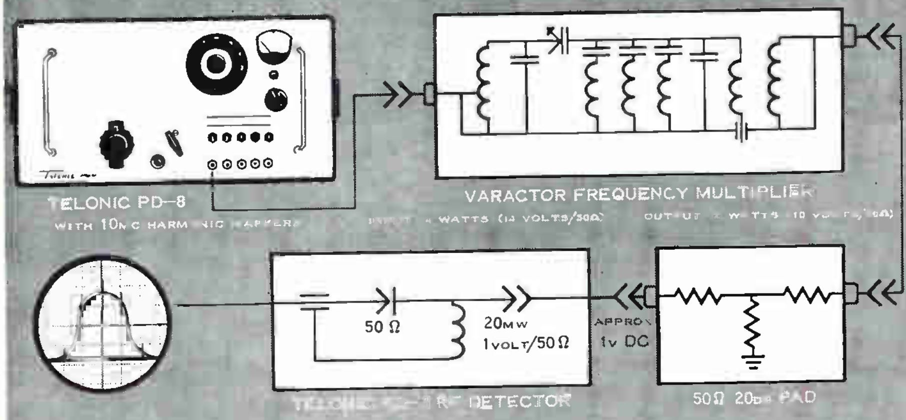
Limited rotation motors of this type produce displacement through an arc of up to 120 degrees and eliminate mechanical feedback from the driven member. Motor service life is limited only by the shaft bearing life, the manufacturer says.

The Aeroflex d-c torque motor has a permanently-magnetized rotor and a special toroidal-wound stator. Motor develops a smooth, step-free torque, and the stator eliminates motor ripple. Mounting techniques can be varied to suit most applications, it was reported.

In Mariner space-probe vehicles,

From the
TEST BENCH

CHECKING OUTPUT OF A FREQUENCY MULTIPLIER AT ITS NORMAL OPERATING LEVEL




Most varactor frequency multipliers are used in actual service with 2, 3, or 4 watts of input power — and therefore should be tested at comparable levels. Till now many engineers have kluged equipment to provide high power signals for this application — result: *costly and inadequate test set-ups.*

A much easier — more reliable — and less costly approach is shown in the diagram — simply using a Telonic PD-8 Sweep/Signal Generator. Why? — the PD-8 provides

- Four (4) watts of output power
- Covers 375 to 1000 mc frequency range
- RF & CW modulated or unmodulated output
- Wide or narrow linear sweep
- Precise measurement via crystal controlled markers
- 3 to 62 db attenuation in 1 db steps

Note: The PD-8 is not made exclusively for testing varactor circuits. If you have *any* application problem necessitating wide attenuation or high power frequency response such as checking attenuators, klystron amplifiers, RF filters, antennas, etc., you can find a quick solution in the PD-8 Sweep/Signal Generator. For lower frequencies use the PD-3 with a center range of 100 to 250 mc.

**SPECIFICATIONS**

Center Frequency — 375-1000 mc
Frequency Range — 330-1010 mc
Sweep Width — 0.05 to 15%
Flatness — ±7.5%
Source VSWR — Below 1.2:1
Display Linearity — Better than 1.2:1

Telonic® INDUSTRIES, INC.
60 North First Avenue
Beech Grove, Indiana
Phone — STate 7-7241, DDD Code 317

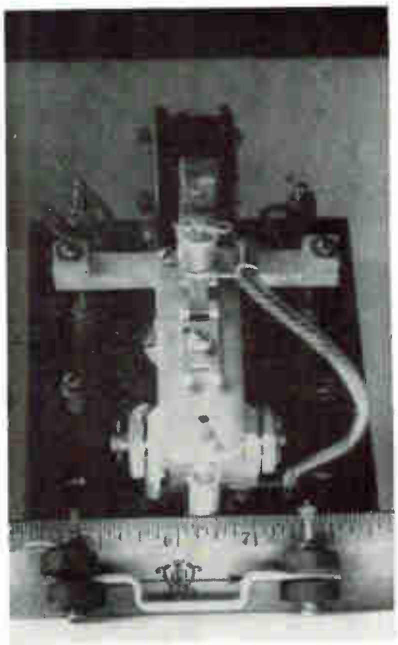
*Representatives in principal cities throughout the world*

these brushless motors move jet vanes against full blast of mid-course correction rocket motor from a standing start, and hold a position within two degrees in a total swing of 50 degrees.

A torquer, modified for the Ranger space probe, operates at 500 deg F.

Applications include use as gimbal drive; low-speed, high sensitivity tachometer, direct-drive servo motor, aerospace positioner control and actuator, and multi-input summing transducer.

## Connector Arm Solves Terminal Lead Problems

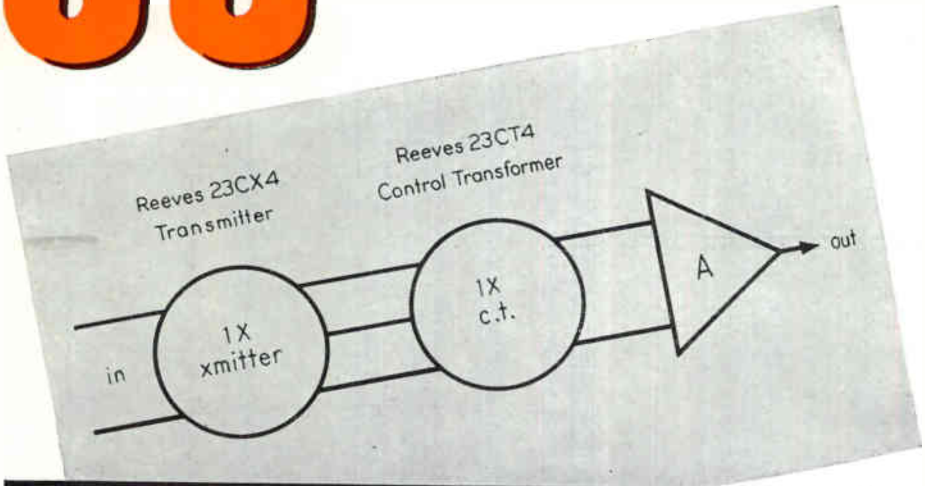


HAZARDS *of fire and shock were eliminated by replacing conventional metal connector arm, shown on ruler, with insulated connector arm, shown installed on switch above*

TWO or more wires can be connected by the simple process of clamping the wire terminals between an insulating material. Wire ends are secured by a spring screw, eliminating need for lock washers. Connections are made by merely stripping the wires and clamping. Contact arms have been developed to protect current surges of over 1,200 volts.

Sample terminal connectors with 20 connection slots are under evalu-

# 30 SECOND synchros & resolvers
## in BuOrd size 23 configuration




CONTROL TRANSFORMERS

TRANSMITTERS

3-WIRE SYNCHROS

4-WIRE RESOLVERS

***Simplify Data transmission instrumentation — Eliminate gear boxes component duplication crossover network***

**DESIGN FEATURES**

- 30 second accuracy on production runs
- 20 second accuracy units available on special order
- Stainless steel housings
- High thermal stability
- Compensated and uncompensated resolver models
- Conform to MIL-S20708A requirements

Reeves

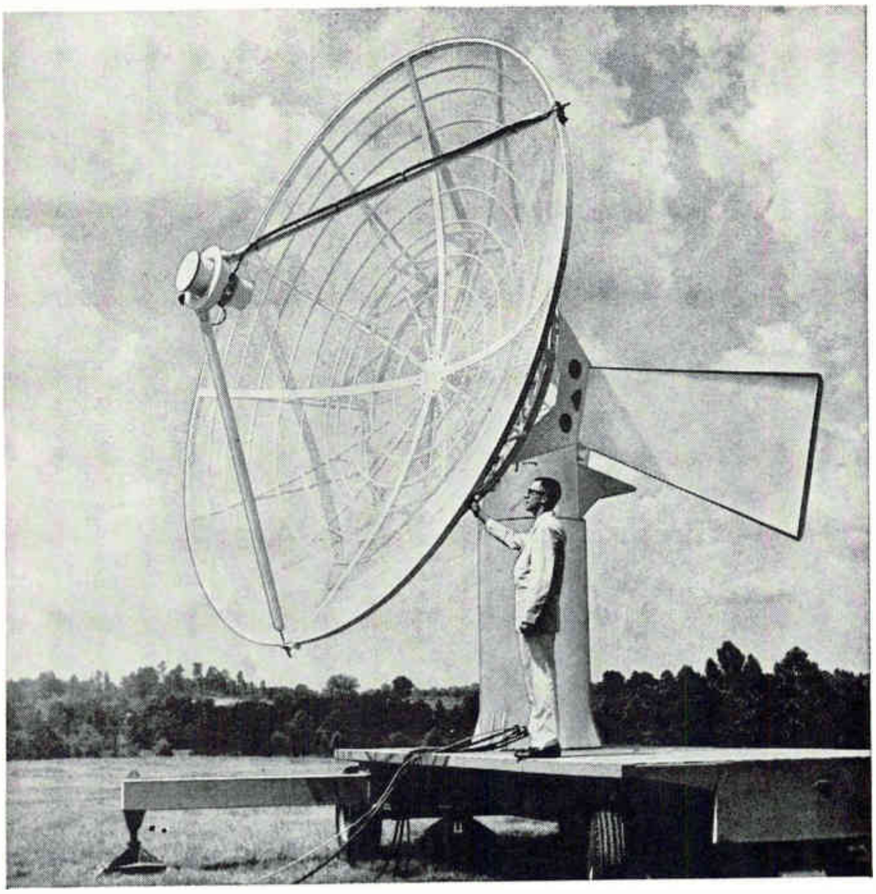
Reeves high precision size 23 synchros and resolvers represent a major design breakthrough. Their extreme accuracy enables the design engineer to develop data transmission systems with a greatly reduced number of components for an equivalent over-all system accuracy.

Compare the circuit diagram shown above with conventional instrumentation for a basic data transmission system. Two synchros, two gear boxes, and the crossover network have been eliminated. Weight and space have been reduced by a factor greater than 2, and the system accuracy will directly reflect the superior synchro accuracies. Reliability is improved immeasurably and field maintenance reduced to a minimum.

The new Reeves Synchros are the only 30-second accuracy instruments currently available in BuOrd size 23. The series includes both transmitters and control transformers, available for either 60 or 400 cycle input. Write for Data File 111.

**REEVES INSTRUMENT CORPORATION**
*A Subsidiary of Dynamics Corporation of America*
**Roosevelt Field, Garden City, N.Y.**

CIRCLE 125 ON READER SERVICE CARD




# Why S-A Tracking Antenna Pedestal Systems Offer THE BEST PRICE/PERFORMANCE RATIO

Versatility, MIL SPEC compatibility, reliability, state of the art manufacturing techniques, quick delivery, and full system capability, you get them all from Scientific-Atlanta.

**VERSATILITY.** For antennas up to 30 feet diameter, Scientific-Atlanta offers three basic pedestals with output torques from 500 to 10,000 ft.-lbs., velocities to 30°/sec, accelerations to 30°/sec$^2$, and accuracies to 0.08° static and $\pm$0.05°/rpm. Multiple mode operation; automatic, slave, manual or pre-programmed tracking. A full range of optional extras and accessory equipment is available to meet virtually any operational requirement.

**MIL SPEC COMPATIBILITY.** Scientific-Atlanta pedestals are designed to operate under MIL SPEC environmental and RFI conditions.

**RELIABILITY.** Scientific-Atlanta pedestal systems use solid state servos, printed circuit dc motors for long life and quick response, large parallel mounting surfaces for adaptability plus rigidity of antenna mounting, fail-safe brakes, electrical and mechanical limit stops.

**MANUFACTURING.** Assembly of tracking pedestals from standardized modules allows Scientific-Atlanta to meet a wide variety of customer requirements and pass along the cost benefits of mass production.

**QUICK DELIVERY.** Most TPS units are available 6 to 8 weeks ARO.

**SYSTEM CAPABILITY.** Scientific-Atlanta offers its customers a unique and proven capability to provide complete telemetry tracking systems, special antenna systems, and servo-control systems.

**FOR MORE INFORMATION,** please address Scientific-Atlanta, Inc., P.O. Box 13654, Atlanta 24, Georgia, phone: (404) 938-2930.

**SCIENTIFIC-ATLANTA, INC.**

20


ation for military applications. Connectors are said to surpass detail spec for terminal boards, MIL-T-55164, and take care of unusual shock and vibration problems.

Insulating material of the connector is made of Melamine. Metal inserts in the bed of the slots carrying the wire leads pass through the arm of the connector, and complete the circuit through the contact pins.

Interest in the Loudin connector device for electronics was suggested as the result of its application on an air-conditioned relay for a railway train, where a short through the metal contact arm of a switch caused a serious fire.

Connector was developed by Loudin Electrical Company, Stamford, Connecticut.

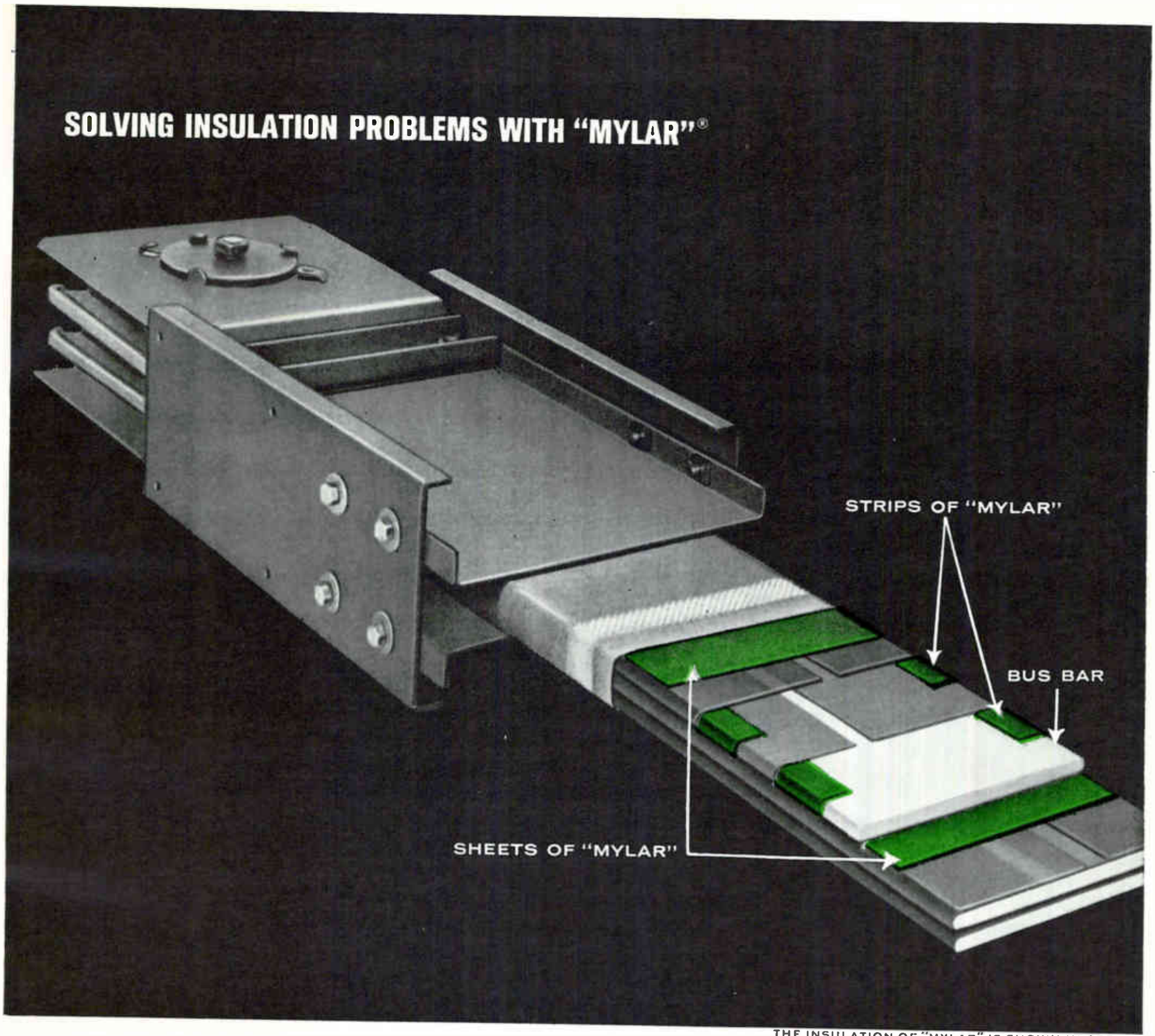
## Instant Photography

PHOTOGRAPHIC film based on photopolymerization could produce a visible image on exposure to light by the chemical change in a monomer-polymer system. Problem is to develop nonsilver halide systems capable of reacting with photographic speed.

Task now interesting Air Force Systems Command, Wright Field, includes design and evaluation of efficient visible light absorbing activators for polymerization. Investigation will cover methods of dry fixation, and efficiency of such systems as film coatings.

## Aerospace Gets First Call On Liquid Hydrogen Source

HIGH-PURITY hydrogen for semiconductor manufacturing applications may soon be supplied conveniently, and economically by a new line of on-site storage equipment engineered by Linde Company, Division of Union Carbide Corporation. Until recently, electronics firms had to depend on purchase of gas to rigid specifications or on their own purification systems. But with the sizable build-up of liquid hydrogen capacity for the nation's aerospace program, this ultracold (minus 423 degrees F) cryogenic fluid is be-



THE INSULATION OF "MYLAR" IS SHOWN IN GREEN

# High dielectric and thermal properties of "Mylar" make busway smaller...at lower cost

The outstanding performance of "Mylar" polyester film in thin gauges allowed the Square D Company to design a more compact busway at lower cost. "Mylar" provided an insulation material that was both strong and durable, with higher dielectric and thermal properties that eliminated the air space needed for cooling between the bars. Unlike many conventional insulating materials, heat can be dissipated directly through the "Mylar" without causing any breakdown of the insulating value.

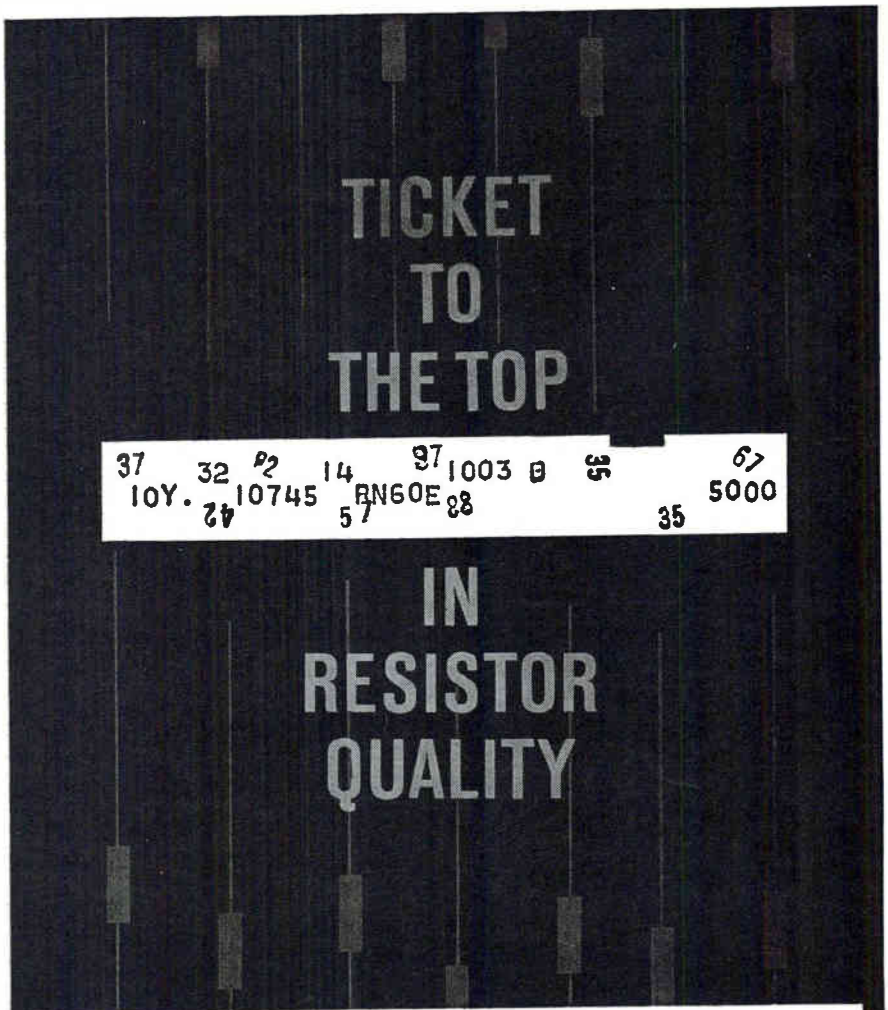
While the Square D busway operates within Class A temperature limits, the unit was subjected to a Class B test (130°C.). "Mylar" withstood this test, giving a 25° safety factor—and an expected insulation life of four times Class A insulation.

The combination of properties of "Mylar" offers you added benefits that can lead to product improvement. "Mylar" is resistant to solvents, easy to work with as compared with other insulation materials. "Mylar" has excellent volume resistivity even at elevated temperatures. It has low moisture permeability.

You may be able to reduce your costs through design modifications and manufacturing economies, using "Mylar" to replace your present insulating material. Why not investigate its unique combination of properties in your applications? Save time and money now by writing to Du Pont Company, Film Dept., Wilmington 98, Delaware.

only DU PONT makes
MYLAR®
POLYESTER FILM

DU PONT
REG. U.S. PAT OFF.
Better Things for Better Living
...*through Chemistry*




Every resistor going through the new Ward Leonard plant at Hagerstown, Md. rides a quality control ticket . . . and every resistor produced in this unique, air-conditioned, humidity-controlled plant is a METAL FILM PRECISION Resistor.

When the trip is over, the ticket looks like this—loaded with imprints. The completed ticket records the identity and integrity of each technician and engineer who performed each operation—and made every inspection. The ticket will have the history of 18 manufacturing stages, 7 inspections, 8 quality-control checks, and another 7 tests for conformance to MIL-R-10509D.

The new Ward Leonard plant for Metal Film Precision Resistors produces just one line of resistors (1/10 to 1/2 watt) and that's the *top quality.* WARD LEONARD METOHM® and other metal film precision resistors are built to be the Best Resistor for Demanding Applications. They unvaryingly exceed all specifications, and hold well within the permitted tolerances . . . otherwise, they never leave the Hagerstown plant.

Demand this top-performance quality for your own resistor requirements. Ask for new Catalog 50A on METOHM Metal Film Precision Resistors—and the entire line of Ward Leonard resistors stocked by leading Authorized Industrial Distributors. Please write or call—Ward Leonard Electric Co., Metal Film Division, 30 South Street, Mount Vernon, N. Y.

8-27

METAL FILM DIVISION
WARD LEONARD
ELECTRIC CO. MOUNT VERNON NEW YORK
RESISTORS • RHEOSTATS • RELAYS • CONTROLS • DIMMERS

coming available for industrial use. Liquid hydrogen is an excellent source of high purity gas since it normally contains only a few parts per million of impurities.

New on-site storage equipment is similar to standard Driox system which have been used since 1932 for liquid oxygen, nitrogen and argon supply requirements. However, units are now constructed with special insulation to minimize evaporation loss. Capacity range spans a small individual cylinder to 1.5 million cubic feet and can handle up to several million cubic feet per month of hydrogen gas.

## Silicon Sheets Eliminate Waste

SEVERAL types of semiconductor devices have been made by growing materials in sheet form. Material minimizes handling and eliminates many standard cutting and sizing operations which can waste as much as 90 precent of the starting material.

This technique is different from ribbon growth, where the ribbon is formed by a complicated mechanism below the surface of a supercooled melt. Sheets grow above the surface of the melt by a mechanism similar to Czochralski growth being pulled up by surface tension.

Sheets can be grown wider than dendrites, and can be grown without twin planes. The growth mechanism and characteristics of the sheets and ribbons are different.

Single widths up to 0.5 in. and thickness from 0.5 to 35 mils have been grown. Studies show it can be grown as single crystal essentially dislocation free. Surfaces can be used without further treatment for device fabrication.

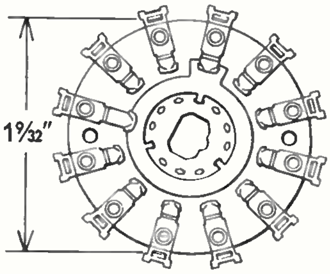
A number of physical properties of the material remain to be investigated, however a general picture of its quality can be obtained by using it in devices.

Diodes, transistors, Trinistors, and solar cells of low power level have been constructed. S. N. Dermatis and J. W. Faust Jr. of Westinghouse in Pittsburgh say performances of these devices indicate that the sheets are as good as, if not better than the best material made by conventional techniques.

*Newest*...in the industry's most extensive line of rotary switches

# CENTRALAB SERIES 600 $1\frac{9}{32}$" DIAMETER SWITCH

WITH $1\frac{1}{32}$" STRUT CENTERS




P-6209

**SPECIFICATIONS**

**INSULATION:** 1500V RMS, Steatite, Grade L-5A, MIL-I-10
1000V RMS, Phenolic, Type PBE, MIL-P-3115
1500V RMS, Mycalex, Grade L-4B, MIL-I-10

**TORQUE:** Per MIL-S-3786A.

**CONTACT RESISTANCE:** 3 milliohms.

**CURRENT RATING:** 5.5 amps at 12 VDC. 500 ma at 115 VAC.

**LIFE TEST:** 25,000 cycles minimum.

Designed to meet MIL-S-3786A, this switch is available with ceramic, phenolic or Mycalex sections. It can be supplied with adjustable or fixed stops with 30° or 60° indexing. The Series 600 switch has up to 12 terminals on each side of the stator of which 8 can be insulated.

Sample delivery is seven days. Production delivery, 4-5 weeks.

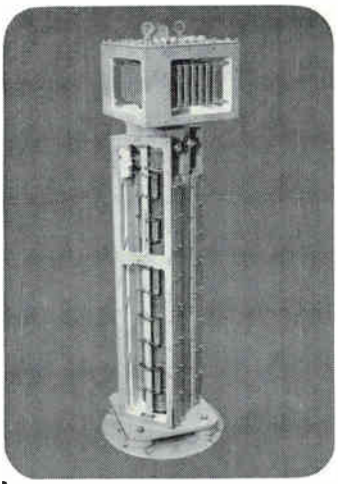
For detailed specifications, write for EP-1152.

Many types in stock at CENTRALAB distributors as Series PA-6000 Switches.

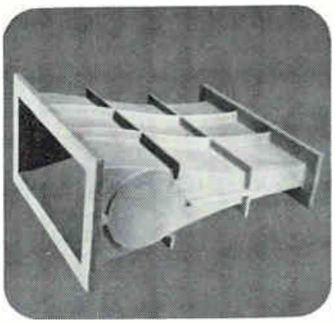
**Centralab**

THE ELECTRONICS DIVISION OF GLOBE-UNION INC.
914L E. KEEFE AVENUE • MILWAUKEE 1, WISCONSIN
In Canada: Centralab Canada Ltd., P.O. Box 400, Ajax, Ontario

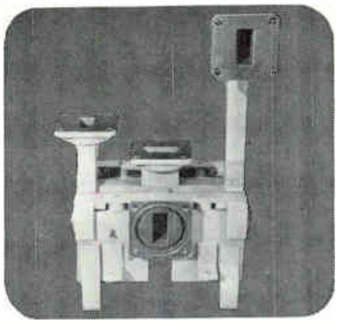
**ELECTRONIC SWITCHES • VARIABLE RESISTORS • CERAMIC CAPACITORS • PACKAGED ELECTRONIC CIRCUITS • ENGINEERED CERAMICS**



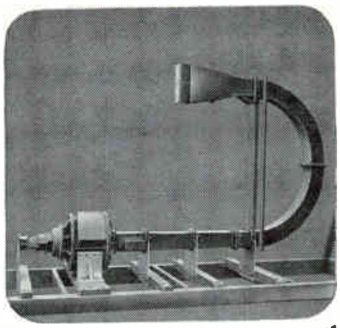
360 RING SLIP RING ASSEMBLY
Slip Ring Assemblies—Our new concept of button type spacing eliminates moisture and dust traps, gives maximum ring capacity within minimum space requirements. Dynamic characteristics are improved because of lower torque, heat dissipation is better and capacitance is reduced.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



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



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



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

# PRODUCTS OF PROVEN RELIABILITY

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

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

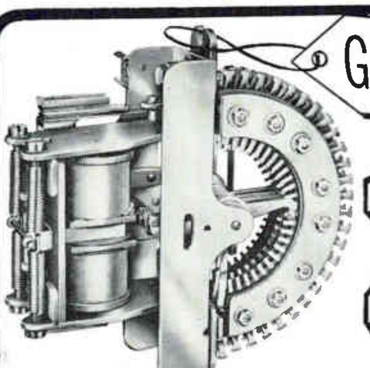
**GORHAM ELECTRONICS**
DIVISION OF GORHAM CORPORATION
333 ADELAIDE AVENUE, PROVIDENCE 7, RHODE ISLAND
Tel. Area Code 401 Williams 1-1000

ENGINEERING DESIGN • FOUNDRY • MODEL SHOP • MACHINE SHOP • PLATING & PAINTING • ASSEMBLY • TEST

CIRCLE 207 ON READER SERVICE CARD



GENALEX



2way

**PRECISION STEPPING SWITCH**

for circuits which require a switch that steps positively, in either direction, around a bank of 25 contacts. **FEATURING:**

- self-cycle or remote control operation
- 65 steps per second on self-interruption
- bridging or non-bridging wipers
- 20 steps per second from external impulses

*Over 10,000,000 steps in each direction without replacement.*

for complete data on this and other unique GENALEX switches, write:

IMTRA CORPORATION
11 UNIVERSITY ROAD, CAMBRIDGE 38, MASS.
U. S. AGENTS FOR THE GENERAL ELECTRIC COMPANY, LTD. OF ENGLAND



**The Best Miniature Soldering Iron In The World . . .**

**ANTEX-*Precision***
**MINIATURE SOLDERING IRON**


Low Wattage . . . 110-120 volts . . . no transformer!

Weighs 1 ounce

JUST 6½ INCHES LONG
Model C115

$4.35 EACH in lots of 6
Tips extra

- Life of element and ease of handling are superior to any other miniature iron.
- Sealed element maintains constant temperature around 626°F.
- Ultra-flexible 3-wire cord — grounded — 50 megohms between element and tip protects components and operator.
- Bright "safety" yellow handle stands more than 1000°F . . . stays cool.
- Easy slide-on tips stay hot under production speeds . . . made of tungsten-copper alloy; nickel or iron plated; diameter from 3/64" to 3/16"; spade or chisel ends.

Irons furnished less plugs: heavy duty 2 or 3-pronged plugs available.

**M. M. NEWMAN CORPORATION**
Dept. 3 — 79 Clifton Avenue, Marblehead, Massachusetts

CIRCLE 208 ON READER SERVICE CARD




CIRCLE 131 ON READER SERVICE CARD →

**SCIENTISTS AND ENGINEERS:** At Motorola today, formidable new problems are calling for resourceful and highly original solutions... the kind of creative mindpower that has been successfully applied to the design and development of electronic systems such as the NASA/Goddard Range & Range Rate Satellite Tracking System...the Air Force data acquisition and relaying system at the Edwards AFB high speed flight corridor...and the RADAS random access, discrete address system.

If you are interested in participating in these stimulating areas of systems research, write today describing your background and training in:

*Mindpower and Manpower...shaping the future in* **SYSTEMS RESEARCH**

**Applied Systems Research** • conceptual design and equipment development, communications theory, coding theory, logic systems design, systems and analysis, and operations research as applied to both military and non-military systems.

**Systems and Sub-Systems Design** • antenna and microwave design, integrated circuit applications, stress analysis and heat transfer, digital and voice communications, command and control, telemetry and tracking systems design, data processing and display, ultrareliability design techniques, radar and guidance equipment.

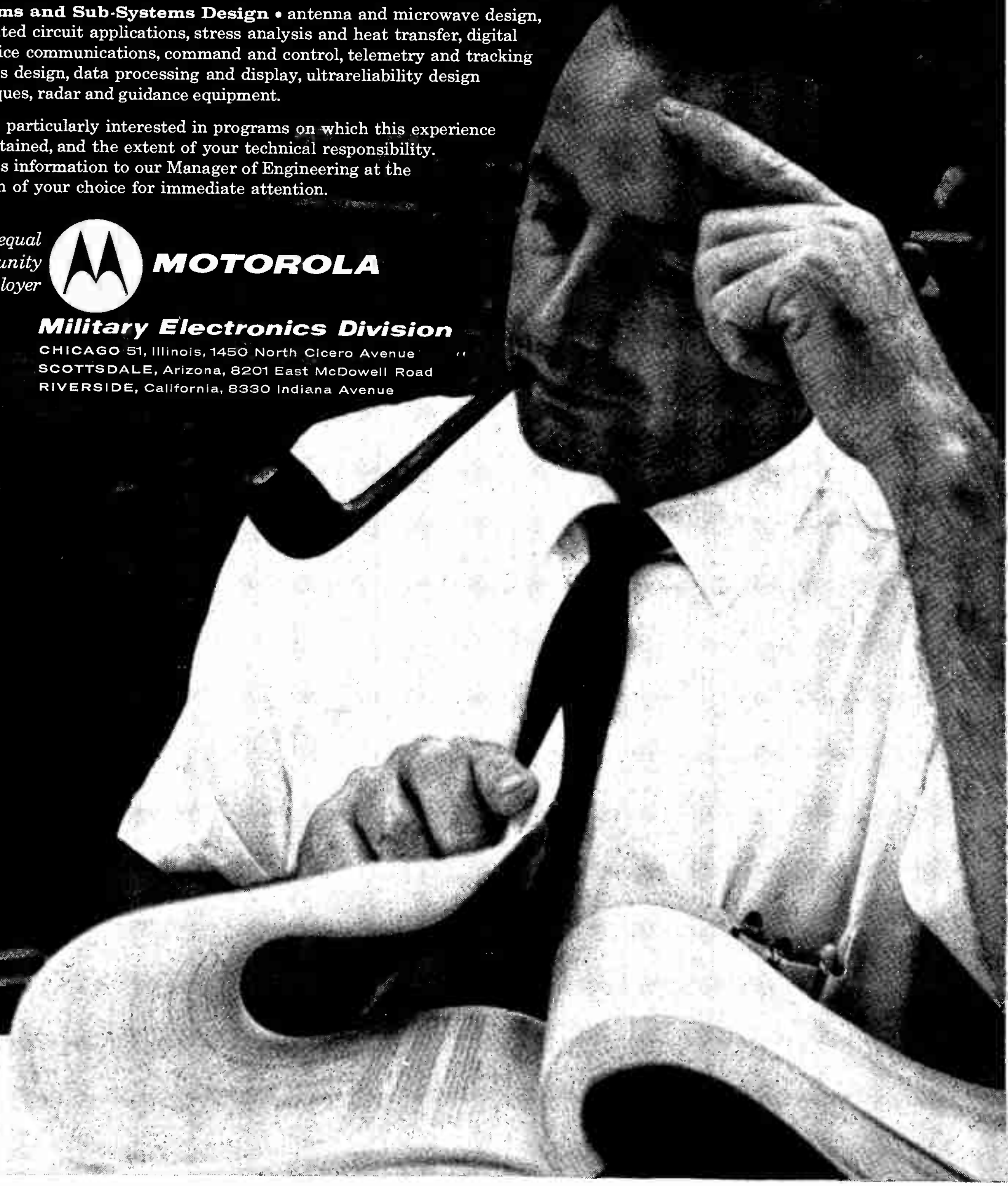
We are particularly interested in programs on which this experience was obtained, and the extent of your technical responsibility. Address information to our Manager of Engineering at the location of your choice for immediate attention.

*An equal opportunity employer*

**MOTOROLA**

***Military Electronics Division***

CHICAGO 51, Illinois, 1450 North Cicero Avenue
SCOTTSDALE, Arizona, 8201 East McDowell Road
RIVERSIDE, California, 8330 Indiana Avenue




**Very large measuring range:**

from 100 μV (f.s.d.) up to 1,000 V
from 10 μμA (f.s.d.) up to 10 μA

**Very high input resistance, low input capacitance**
**Automatic polarity indication of measuring voltage**
**Simple calibration by built-in calibration voltage**
**High stability, no zero drift**
**Overload protected**

# PHILIPS *electronic measuring*

**Sold and serviced by Philips Organizations all over the world**

*Further information will gladly be supplied by:*

**N.V. Philips' Gloeilampenfabrieken, EMA-Department, Eindhoven, the Netherlands**

*For Canada: Philips Electronic Equipment Ltd., 116 Vanderhoof Ave., Toronto 17, Ont.*

# DC microvoltmeter

### *Measuring ranges*

**Input I:** 0 – 100 μV, 0 – 300 μV, 0 – 1 mV, 0 - 3 mV...
0 – 10 V; input impedance 1 MΩ // 15–20 pF

**Input II:** 0 – 10 mV, 0 – 30 mV ... 0 – 1,000 V
input impedance 100 MΩ // 10 pF

With the aid of diode probe GM 6050
VHF voltages (0.1 – 800 Mc/s) from 1 mV up to 16 V can be measured

### *Overall accuracy*

0 – 100 μV: 5 % of f.s.d.
All other ranges : 3 % of f.s.d.

### *Pre-deflection*

<5 μV

### *Calibration Voltage*

3 mV (± 0.5 %)

### *Polarity of measuring voltage*

A pair of luminous columns automatically indicate the polarity of all readings above 10 % of f.s.d.

### *Mains supply*

110 ... 245 V, 50 ... 100 c/s; power consumption 32 W

### *Hum filter*

Input filter attenuates 50 cycle hum x 1000

### *Overload protection*

Automatic circuit protection using neon tubes

### *Cabinet*

Sturdy metal cabinet, grey finish; dimensions
250 x 360 x 220 mm.

**...some proved applications**

**there are hundreds more...**

**for D.C.:**

measurements of transistor and tube bias voltages, leakage currents in electron tubes, capacitors, diodes and transistors, ion currents in transmitting tubes, relay contact resistances, field strengths (using Hall plates), voltages and currents of photo multipliers, temperatures by means of thermocouples - as zero-indicator in compensation and bridge circuits - as indicator for wave measurements on microwave equipment, electro-analytical work, the adjustment of discriminators.

**for A.C.** *(with VHF probe)*:

measurements of RF voltages in the UHF bands, UHF tuners, oscillator voltages (AM and FM), RF output voltages of signal generators up to 1,000 Mc/s, the RF load on crystals from 80–800 Mc/s, RF voltages in IF amplifiers from 30–40 Mc/s – as indicator in tuning coil adjustments from 30–40 Mc/s.

***instruments:*** **quality *tools* for industry and research**

PHILIPS

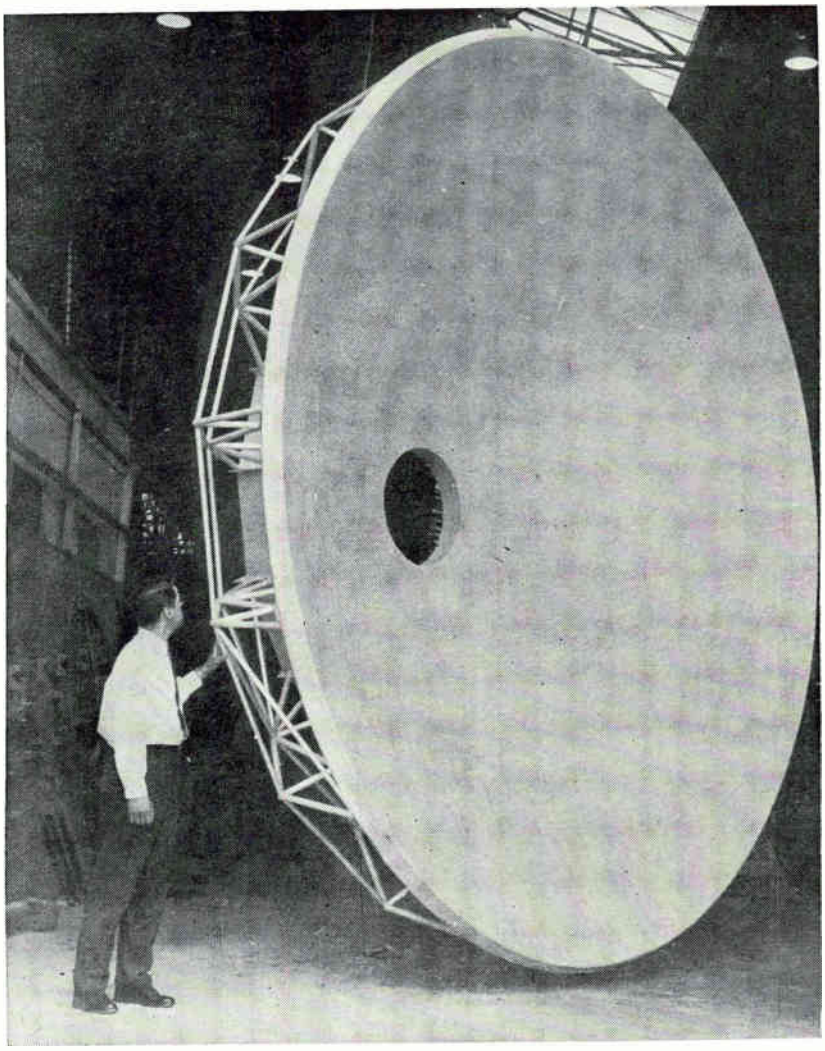
# Spuncast Plastics Achieve Reflector Precision

*Spinning of liquid synthetic resins under servo control reduces antenna costs*

By JOHN W. DAWSON
Kennedy Antenna Division
Electronic Specialty Company
Cohasset, Massachusetts

SPINCASTING, a process for obtaining high precision paraboloidal plastic surfaces, may be applicable to many of the immediate antenna reflector requirements of microwave engineers. It appears likely to greatly enhance use of frequencies heretofore restricted by lack of suitable propagating equipment.

The spincasting approach is based on a well-known physical principle: liquid spun in a dish about a vertical axis will automatically form a symmetrical parabolic surface because of the joint action of gravity and centrifugal force. Kennedy has adapted this principle to achieve stable precision-surfaced reflectors of large size—up to 30-ft diameter.



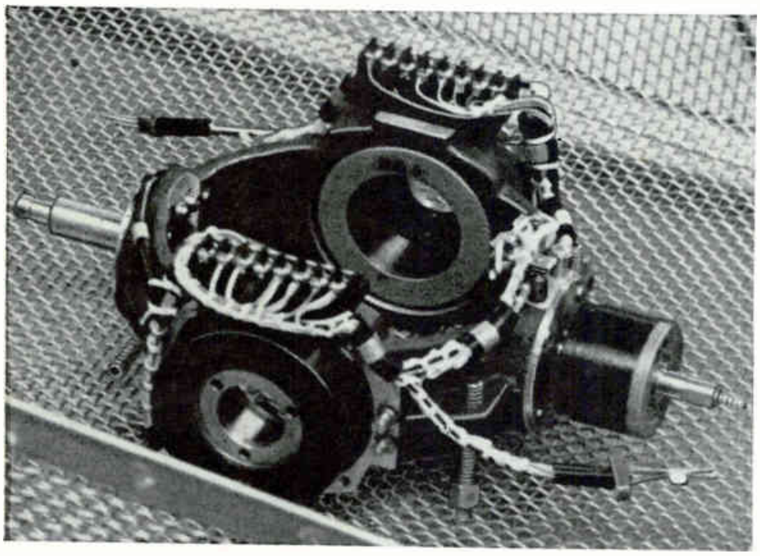
ANTENNA *reflectors up to 30-foot diameters have been spuncast. One 24-hour test showed only one minute of arc distortion due to solar heat.*

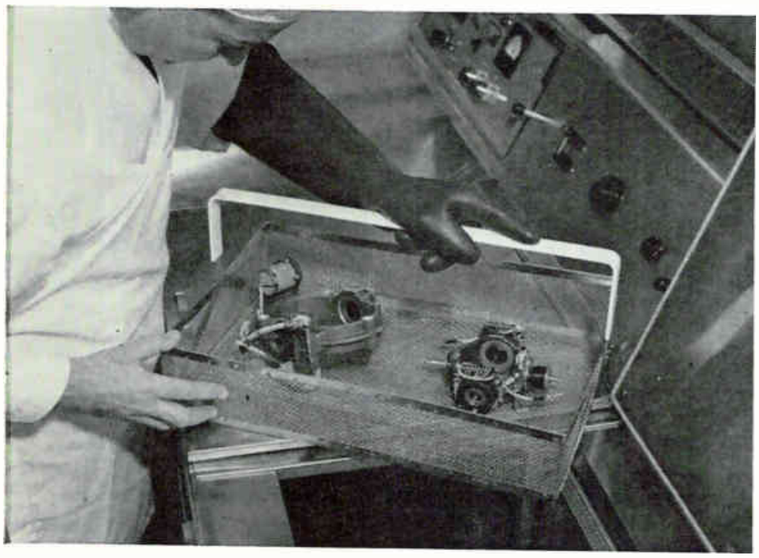
LARGE REFLECTOR—The spincasting process starts with the feeding of selected synthetic resin formulations, in liquid form, into a specially designed strong metal dish structure. These are maintained spinning under precise servo velocity control until the plastic sets. The supporting and backup structures for the dishes are several times more rugged and stable than conventional microwave antenna structures. For example, the 28-foot reflector of an antenna with an effective diameter of 1,000 wavelengths now in operation at the MIT Lincoln Laboratory has a concave supporting surface formed from 24 panels of 6-inch thick fiberglass-over-paper-core honeycomb. These panels are triangular and approximately 8 feet on a side. They are individually adjustable with respect to a massive backup structure.

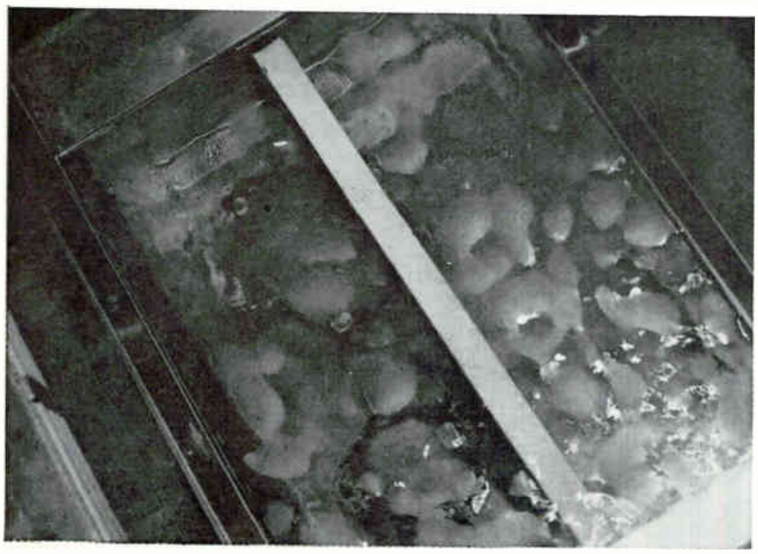
A sweep template was used to adjust the supporting surface (or dish) to form a paraboloid within a tolerance of 0.125 inches. The entire structure was then placed on a rotating table with the paraboloidal axis vertical and coincident with the table's spin axis. While rotating at a constant speed of 11 rpm, a liquid exothermic-setting polyurethane elastomer was poured into the dish. The paraboloid formed by the liquid had a focal length determined by the rotation speed; the 11 rpm speed matched the 12-foot focal length required by the 28-foot reflector to form a uniform coating approximately ⅜ inch thick. When the plastic had setup to its normal hardness (approximately that of a red rubber eraser) and while the entire unit slowly rotated, a zinc coating was applied by a flame spray technique. A final thin coating of urethane plastic was then added to protect the zinc conductive surface from weather corrosion.

To achieve a given tolerance on a given spincasting size, compliance must be made with a minimum summation value for the product quantity $h^2 \Sigma F \Delta t$, where h is the fluid film thickness, F is fluidity, $\Delta t$ rep-

# 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-2420E11, Wilmington 98, Del.

**Du Pont trademarks.*

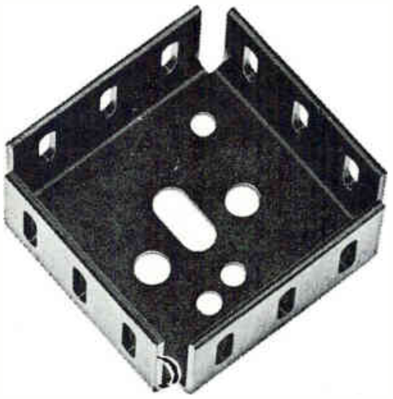
**FREON®**
solvents

DU PONT
REG. U.S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING...THROUGH CHEMISTRY

*for maximum reliability*

**SPECIFY BIRTCHER HEAT RADIATORS**

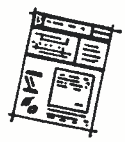


# LOW-COST HEAT RADIATOR FITS 75% OF SEMICONDUCTORS

Birtcher's new compact, low-cost 3AL-771 heat radiator has a universal hole pattern for mounting 75% of most popular semiconductors including TO-3, TO-36 and all ¼-in. stud mounted cases. You don't have to stock a variety of heat radiators for different case sizes now—one design, from stock does the job of keeping junction temperatures well within safe limits at highest wattage dissipation even in free-air mounting. No protruding fins or fingers to get in the way. A total of 15 sq. in. of effective radiating surface in a clean design. Material is .063 aluminum alloy 1100-H14 per QQ-A-561c and black anodize finish per MIL-A-8625A Type II.

*Available from authorized distributors*

**Write today for certified comparison test reports**



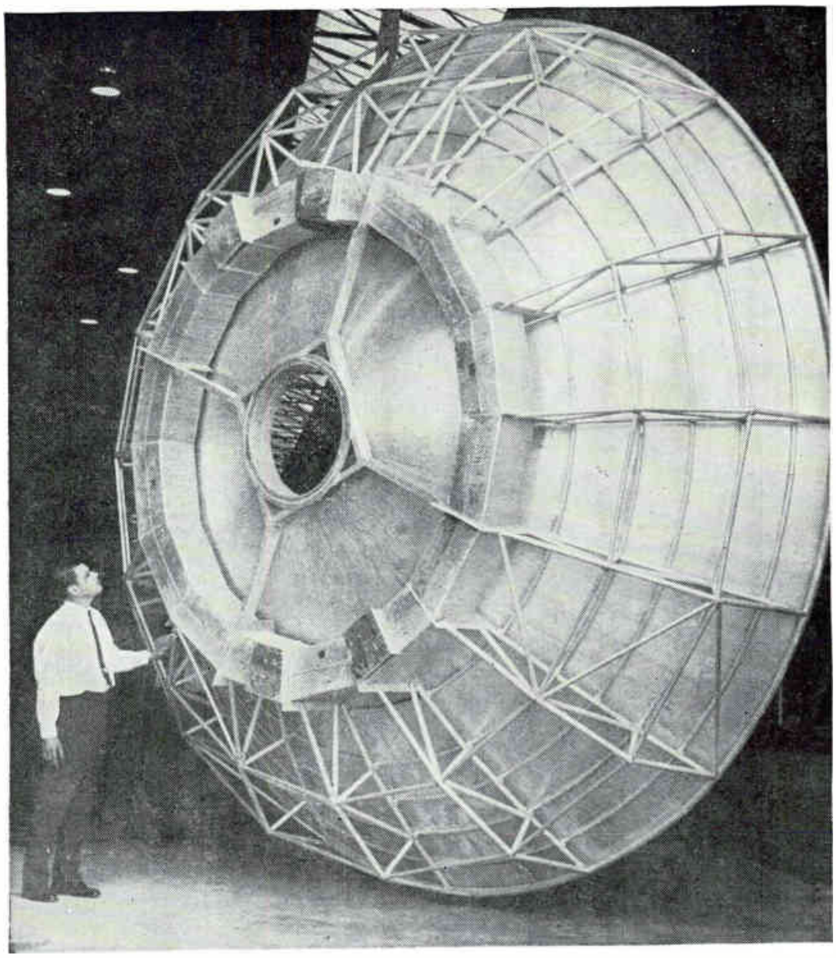
**THE BIRTCHER CORPORATION**

INDUSTRIAL DIVISION

745 S. Monterey Pass Road, Monterey Park, Calif.

ANgelus 8-8584

**TUBE/TRANSISTOR/COMPONENT COOLING AND RETENTION DEVICES**



RADIAL *truss design provides strong support needed for reflector during spinning process and operation*

resents time increments during setup of plastic.

MATERIALS—Selection of suitable "hardenable liquids" is very important in the development of spuncast reflectors. Those which have appeared to best satisfy the below-listed requirements are certain formulations of synthetic resins in the urethane and epoxy families. Epoxy resin plastics have been found admirable for applications such as smaller sized millimeter waveband reflectors and parabolic mirrors. Current work on elastometers is showing high promise for use in larger sizes and for lowest operating temperatures (−60 degrees F.)

Ideal qualities of the plastics used may be listed as:

A. Environmental Resistance:
   No creep from sunlight heating.
   Shock resistant at all operating temperatures.
   No deforming of support structure with temperature change.

B. Low specific gravity.

C. Low viscosity in liquid phase.

D. Long pot-life.

E. Good adhesive bond to metal or fiberglas panels.

F. Thermal expansion coefficient to match the support panel, or:

G. "Rubbery" character—low strength modulus—through entire temperature range.

H. Non-toxic during processing.

I. Moderate temperature range during processing.

J. Smooth gravity-cast surface.

K. Good bonding to conductive coatings.

L. Low cost.

Compared to aluminum present spincasting materials have a modulus of elasticity several thousand times less and a coefficient of thermal expansion several times greater. Their specific gravities range from 10 to 15 percent greater than water. No creep was detected on flexible urethanes after 16 months weather exposure and on

## 99.99 PERCENT RELIABLE*

*Confidence level: 90 percent


This is Filtors' Blue Ribbon Relay. The probability that this relay will operate 10,000 times without a single miss is 99.99 percent. If it does not miss in 10,000 operations, the probability that it will operate another 10,000 times without a miss is still 99.99 percent. Documentation for this claim for both dry circuit and 2 ampere contact loads can be obtained by writing to:

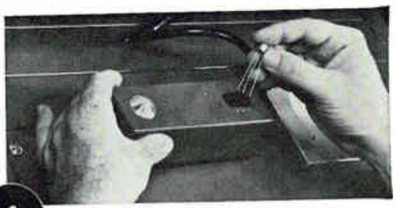
**FILTORS, INC./ RELAYS**

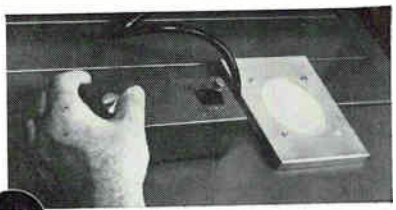
**EAST NORTHPORT, NEW YORK (516) AN 6-1600**

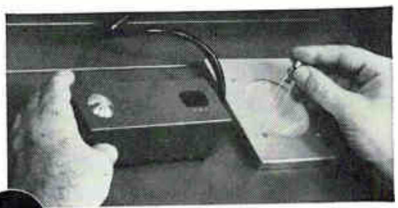
Subsidiary of General Battery & Ceramics Corp.

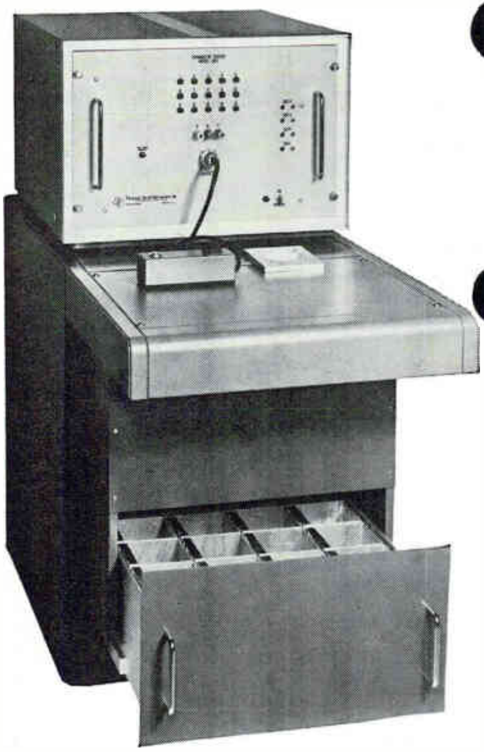
CIRCLE 137 ON READER SERVICE CARD

Fast, foolproof production testing and sorting of 2 and 3 terminal devices


1 Insert Device


2 Press Button


3 Drop in Chute



15 tests in less than a second

Automatic sorting to 16 categories

No operator decision

**Texas Instruments Model 654 Transistor and Diode Tester** with 16-Bin Automatic Sorter provides production-speed testing and accurate automatic grouping of two- and three-terminal devices.

Operation requires only three simple manual steps, completely eliminating operator decision. Sorting logic determined by printed plug-in circuit boards in the tester automatically routes the component to the proper bin. At the conclusion of the test, the operator merely drops the device into the entry chute. Sorting logic is held during the testing of the next device.

The Model 654 combines speed and accuracy with flexibility of circuit board programming. The Automatic Sorter and other accessory equipment insure continued maximum effectiveness of the basic instrument.

**Write for complete information.**

INDUSTRIAL PRODUCTS GROUP
STRIP CHART RECORDERS
TEST EQUIPMENT
DATA SYSTEMS
TRANSDUCERS

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

550

epoxys for nearly as long. Shock resistance of epoxies as used in the reflector configuration was found to be good except at temperatures below −20 degrees F, while elastometers were excellent at all operating temperatures. Water and chemical resistance of materials were excellent.

SURFACE TOLERANCES—Surface finishes of 5 microinches or less are achievable. Although, up to this time mirrorizing of reflectors larger than 4-foot diameters has not been worked-out. Sizes up to 4-foot are often vacuum aluminized. Also, for microwave use, the plastic surface is *ordinarily* molten-zinc sprayed and protected by a synthetic varnish coat. Optical testing on 4-foot sizes has indicated surface slope tolerances of approximately 2 minutes of arc or less.

REFLECTOR STRUCTURES—Customarily, *spincastings* are formed in reinforced spun-aluminum "dishes" in sizes up to and including 10-foot diameter. Smaller dishes of this class are typically reinforced using a heavy cylinder section serving as mounting ring and as structural support of a brace cone extending between mounting point and the reflector rim.

HIGH REFLECTION *is displayed by plastic surface immediately after spinning process*

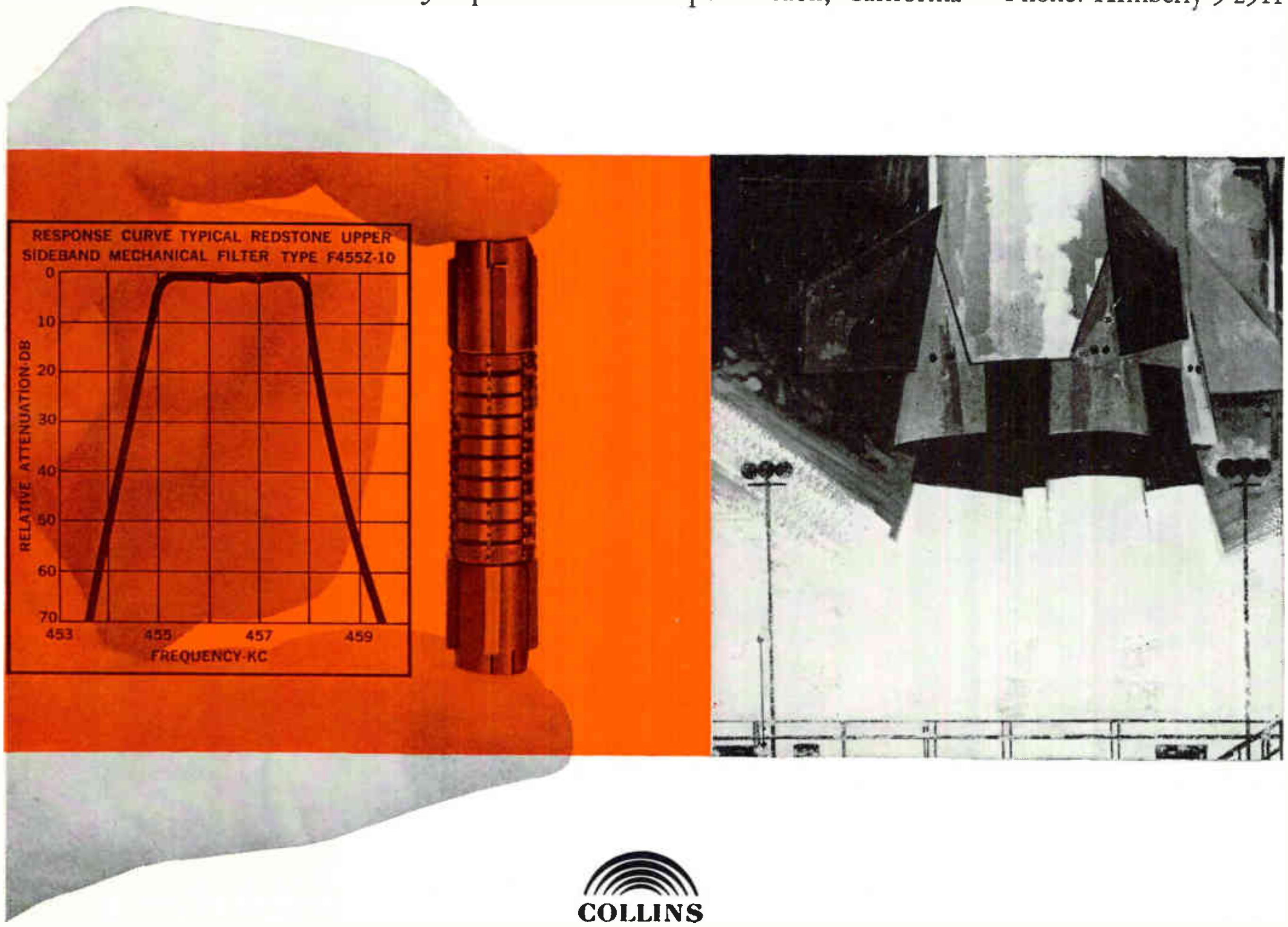
The 10-foot diameter size is similarly reinforced, but uses 16 brace channels instead of the cone.

An aluminum radial truss design typical of many strong structures has been developed by Kennedy applicable to a variety of f/d ratios and for dish diameters of 5-20 feet. The radial trusses are surfaced by successively larger tubular rings welded to the girders. The rings are, in turn, "shingled" with radial overlapping wedge-shaped alumi-

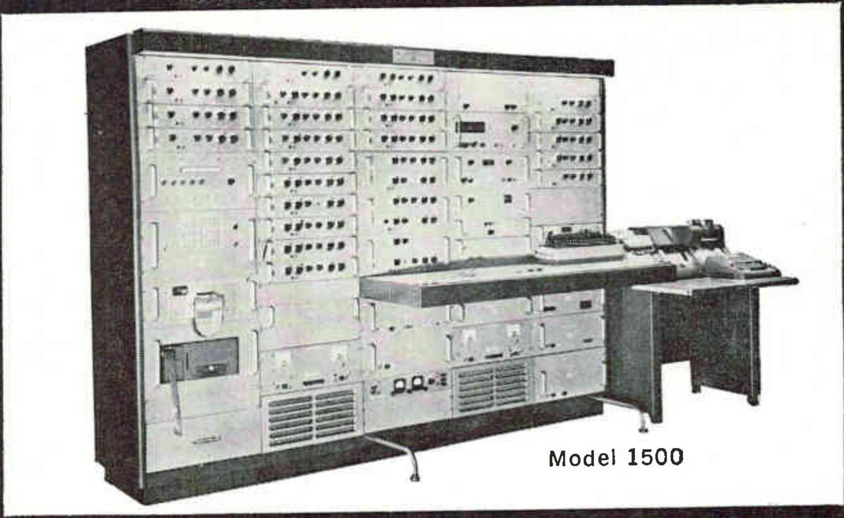
# LIKE HAPPY ENDINGS?

Here's one from the Saturn program about a new telemetry technique — and a Collins Mechanical Filter.

The Saturn missile brought up a tough telemetry question: How to provide adequate transmission capacity for wideband data such as vibration measurements. □ Bandwidth capacity of available telemetry systems was too low. A new kind of transmission, using single sideband modulation of an AM subcarrier and providing 10 times the equivalent bandwidth, had been proposed. □ Filters were key factors in the system's operation. In addition to the extreme selectivity demanded of the bandpass filters, they had to be tough enough to operate under 20 G's vibration from 50 cps to 200 cps without modulation and spurious signals. They had to withstand a 100 G shock. And they would have to reduce insertion loss and passband ripple to new minimums. □ Because of these rigorous requirements, the logical answer was a Collins Mechanical Filter, but with significant state-of-the-art improvements. For the transducer, Collins developed a new ferrite material, increasing the mechanical strength of the filter and reducing insertion loss. Another benefit of the ferrite transducer was a 3 db to 1 db drop in passband ripple. □ Specs for frequency stability of the filters under radical temperature changes sounded impossible at first. But with new heat treatment techniques for the nickel-alloy discs that are the filter's resonant elements drift was held to within 1 ppm/C° temperature change. □ This Collins Mechanical Filter, packaged in less than ⅓ cubic inch, was a key to development of this new SS-FM telemetry technique at NASA's George Marshall Space Flight Center. The new technique has been invaluable in transmitting the avalanche of vibration data and other wideband information through two successful Saturn launchings. □ More than 100 standard mechanical filters for the 60 kc to 600 kc range are in the Collins catalog today, and if one of these won't do, the industry's *only* mechanical filter design staff is ready to help you with special designs. Call Collins today or write for Data File 202. □ COLLINS RADIO COMPANY • Components Division • 19700 San Joaquin Road • Newport Beach, California • Phone: KImberly 9-2911

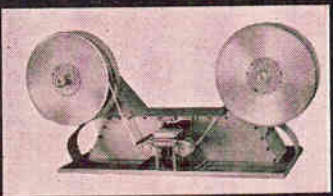



COLLINS





TEST MODULES


AXIAL LEAD HANDLER


TURRET ADVANCE


TAPE PROGRAM MODULE


LOGGED-DATA

Automatic semiconductor tester provides

**MODULAR ANSWERS**

to parameter testing problems

For incoming inspection . . . production testing . . . reliability testing . . . engineering studies . . . component sorting . . . the multi-parameter Model 1500 Testing Station has fast become recognized by leading transistor/diode producers and users as the most versatile and accurate instrument in its field.

**Programming:** Automatic and direct reading manual program modes are available. Punched Tape provides an unlimited number of sequential tests to be performed on any device. Self-Instruction permits new programs to be prepared directly from the precision dials and panel selector switches on the test modules. Test type, bias conditions, hi-lo limits and delays are all included in the program.

**Measurements:** All DC, small signal (grounded base and emitter), pulse, and diode tests are available. The TEST MODULE concept permits complete measurement flexibility. Over 30 standard test modules are available. Field installation of new modules is easily accomplished.

**Ranges:** Currents 0.1 nanoampere to 10 amperes
Voltages 1 millivolt to 1000 volts
AC or DC Ratios (gain transfer ratios) 0.1 to 1000.

**Accuracies:** 1% on DC tests; 3% on AC and Pulse tests.

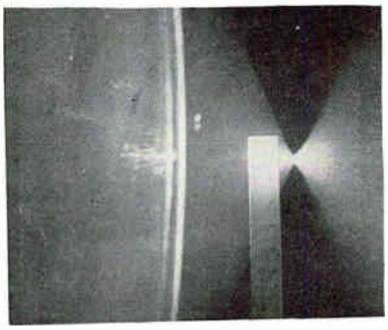
**Readouts:** GO, NO-GO; digital indication; printout; summary punch; classification and automatic bin selection.

**Input Devices:** Scanners; Axial Component Handlers; Conveyor Systems.

**OPTIMIZED DEVICES INC.**
PLEASANTVILLE, NEW YORK
ROgers 9-6100


num sheets fixed to the circular tubing support by rivets.

MEASUREMENT — Reliable surface measurement is a problem of some magnitude. A simple and reliable method for measuring circular errors of the paraboloid is performed while the reflector is still mounted on the spin-machine. Dial indicators are mounted from a steel cross-beam and applied against the plastic surface. Successively larger "rings" are measured at various angular positions while the reflector is slowly rotated. Accurate measurements can be made within .001 inch. Such measurements provide no direct information on accuracy of parabolic cross-section. However, with proper control of the forming process cross-sectional errors are compatible with the "circular" errors.



ILLUMINATION *of smoke particles outlines circle-of-least-confusion at reflector's focal point*

A similar method measures both radial and angular errors. This method requires accurate location of the axis of symmetry—"bore sight." A measuring rod of pre-set length is gimbal-supported at one end on the bore sight line, while the other end bears a dial indicator which applies against the reflector surface. Primary advantage of this method is that it measures both parabolic and circular errors. A practical advantage is that the dial indicator need not be tracked precisely at a particular radius because the rod projects normal-to-surface.

Optical measurements and beam pattern tests have also been used. A circle-of-least-confusion optical test method requires mirrorized reflector surfaces. Parallel light rays are projected into the mirror face. Size of the focal spot may be directly observed and roughly meas-

PUMPS • VALVES • BAFFLES • GAUGES

# VACUUM COMPONENTS

## DIFFUSION PUMPS

Only NRC offers a full line of high-speed diffusion pumps with all these important advantages:

- No super-heating ... minimizes pump fluid decomposition.
- Fractionating jet assembly ... constantly purifies pump fluid ... lower pressures can be held longer.
- Patented Cold Cap* ... an NRC exclusive ... cuts back-streaming 98%.

Available now in 4", 6", 10", 16" and 32" sizes for all your high vacuum testing and production applications, where performance and reliability really count.

**Licensed exclusively from Edwards High Vacuum Limited. U. S. Patent No. 2919061.*

## SLIDE VALVES


New NRC Slide Valves (HC Series) are *very-high* and *ultra-high* vacuum valves at *conventional* prices. Pressures of $10^{-8}$ to $10^{-10}$ torr range have been produced ... without baking ... in vacuum systems using these valves. 100% clear opening and low height provide highest conductance. Double-pumped stem seal cuts gas bursts 99%. They're available in 4" and 6" sizes, either hand or air operated.

## CRYO AND MOLECULAR BAFFLES

Now, your high vacuum system can be operated at lowest pressures for extended periods of time *with no detectable trace of hydrocarbons reaching the chamber!* The reason: NRC's Circular Chevron Cryo Baffle and the all-new NRC Molecular Sorbent Baffle (which utilizes three full trays of zeolite) virtually eliminate back-migration of pump fluid vapors. Yet, they provide exceptionally high conductance for maximum *useful* pumping speed.

## VACUUM GAUGES

Get accurate, reproducible direct-readings to $10^{-13}$ torr with the new NRC Model 752 Redhead Magnetron Gauge! The only really satisfactory gauge commercially available for measurements below 1 x $10^{-9}$ torr. Increased current readings provide 50 times the sensitivity of hot-wire ionization gauges. Because there's no hot filament, it's magnitudes less "gassy", can't become contaminated by vaporizing of gauge elements. And the 752 Gauge is not X-ray limited.

NRC's full line of vacuum gauges and controls also includes an improved Bayard-Alpert type gauge, Model 751, for accurate, reliable measurement in the 1 x $10^{-3}$ to $10^{-10}$ torr range.

NRC
NRC EQUIPMENT CORPORATION

A Subsidiary of National Research Corporation

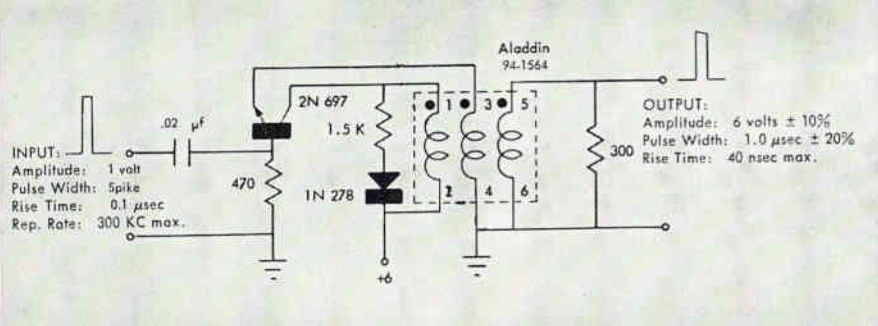
160 Charlemont St. Dept. 4K
Newton 61, Massachusetts
Area Code 617, DEcatur 2-5800

All of the above components are stock items. Write today for product data sheets. Let us show you how NRC components can improve the performance of your high vacuum system.

MANUFACTURING PLANTS IN NEWTON, MASSACHUSETTS AND PALO ALTO, CALIFORNIA

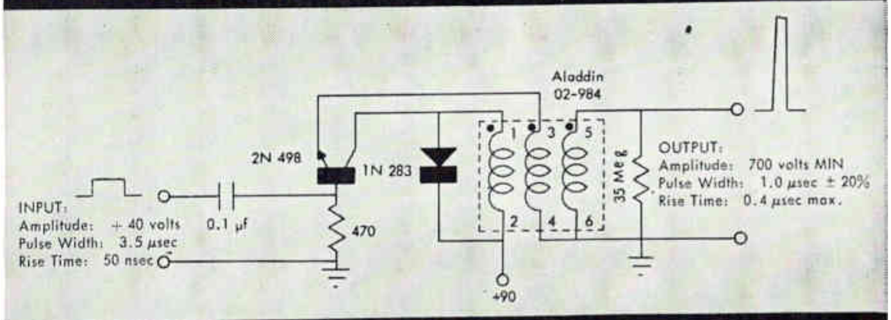
*APPLICATION ENGINEERING NOTE*
FROM ALADDIN ELECTRONICS

# Blocking oscillator circuits




## for 40 nanoseconds rise time

Shown above is a common base transistor blocking oscillator using the popular 2N697 transistor. This circuit offers a rise time of 40 nanoseconds maximum as well as a duty cycle of 30%.




## for 700 volt amplitude

A look at the output characteristics of the circuit above indicates it will produce a one microsecond wide pulse with an amplitude of at least 700 volts. Ideal for circuits where high voltage is needed and the current drain is low—e.g., igniting a thyratron.

Using other transistors or transformers in the circuits shown above, it is possible to get many combinations of performance characteristics. For information to assist you in the design of circuits involving pulse transformers, wide band coupling transformers or inductors, write for your free copy of our "Product Directory."

*Write Department IM*

*where the magic of magnetics is a science...*™

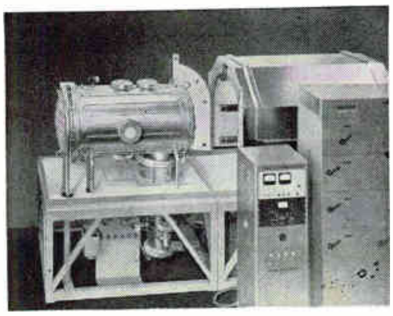
Aladdin® electronics

nashville 10, tennessee phone: 242-3411, code 615
twx: 615-244-1534

ured in a smoke-filled atmosphere. More accurate measurement is easily made using a partially masked (.010 inch hole) photo cell traversed through the focal area. Recent tests of a four-foot diameter reflector showed a circle-of-confusion diameter, at the half-power point, of only .070 inch.

A grid image optical test method measures surface slope errors. This method requires mirrorized surfaces. The reflector is illuminated from its focal point, thru an accurate grid using an appropriate lens system. A perfect reflector will then project a true grid pattern onto a white screen. Imperfections of slope show as waves in the projected grid lines. These waves are measured and translated into slope error. Typically, slope deviations are within 15 seconds of arc.

## Space Simulation Chamber Has Fast Pump Down



A LABORATORY space environment chamber able to produce a vacuum of $5 \times 10^{-9}$ mm Hg has been developed by Vacuum Specialties, Inc., Somerville, Mass.

The chamber uses elastometer "O" ring seals and a 10-inch diffusion pump with an integral water-cooled optical baffle. The 20 cubic-foot cylindrical chamber has fast pump down and a minimum of vapor evolution.

For degassing to reach lowest pressure, the chamber is heated by a tunnel-type bakeout oven which can be rolled by hand over the chamber. The oven has radiant heaters with polished reflectors and is capable of operating up to 250 C.

Stainless steel coils on the outside of the chamber are used for cooling after bakeout. Four ports facilitate making connections and fulfill other purposes.

# MNEW FROM MNEMOTRON!*

*We are silent about the "M" in Mnemotron but not about our new 700 Series Data Recorder. With good reason. For one, it brings the size and cost of data recording systems down to sensible proportions if your data is analog voltage from DC to 5000 cycles per second. And its features would not embarrass even the costliest instrumentation recorder. Here are a few:*

**COMPACTNESS.** A complete 7 channel record/reproduce system uses less than two feet of rack space. A 14 channel system adds less than seven inches more.

**ACCURACY.** Input-output characteristic is linear within 0.2 per cent with Mnemotron unique Pulse Frequency Modulation (PFM) data conversion technique.

**FLEXIBILITY.** As many data channels as you need with a choice of channel format. For greatest operating economy, choose up to 7 channels on ¼ inch magnetic tape, 14 channels on ½ inch tape, standard IRIG spacing and track width of 7 channels on ½ inch tape.

**INTEGRATED RECORD/REPRODUCE MODULES.** A single solid-state PFM Data Converter has all the record/reproduce electronics for each channel. Simple rotary switching lets you select data conversion for 3 tape speeds. No additional plug-ins needed.

**ISOLATED INPUT CIRCUITS.** Input terminals of each channel are isolated from all the others to readily accept data from floating, unbalanced or differential sources.

**VERSATILITY.** 700 Series plug-in accessories expand instrumentation capability. Typical: Electrocardiogram pre-amplifiers for recording directly from electrodes. Pulse Record unit for recording trigger pulses, time markers, or stimulus pulses in medical research . . .

**PRICE.** 7 Channel System from $6,495

**COMPLETE SPECIFICATIONS.** Send for your copy today.

* To answer the many inquiries, Mnemotron comes from Mnemosyne, Greek Goddess of Memory.

## MNEMOTRON CORPORATION

45 South Main St., Pearl River, New York, 914 PEarl River 5-4015, Cables: Mnemotron, TWX: H99

Subsidiary of Technical Measurement Corporation, North Haven, Conn.

## WANTED TO PURCHASE

Supplies and equipment of every type for commercial fishing by prominent firm of ship chandlers. *Genoa, Italy*

**(One of thousands of typical export opportunities for American businessmen)**

The world is your market place. From South America to South Asia there's an immediate need for furniture, construction equipment, appliances, aluminum. The list is endless and so are the business opportunities.

To help U.S. businessmen take advantage of these opportunities, the U.S. Department of Commerce sponsors specialized Trade Missions to countries throughout the Free World. Each Mission is composed of specialists in particular industries who volunteer to carry abroad hundreds of specific business proposals from American manufacturers to their opposite numbers overseas. One Result: A Trade Mission recently helped a Chicago manufacturer fill an order to ship a million dollars' worth of goods.

The United States Department of Commerce can help stimulate export trade in many other ways: It can help you find agents abroad, survey your best markets, and exhibit your products at International Trade Fairs and Trade Centers.

To find out more about how to get your share of profits in growing world markets, contact the U.S. Department of Commerce—field offices in 35 major cities. Or write: Secretary Luther H. Hodges, U.S. Department of Commerce, Washington 25, D.C. You'll get a prompt reply.

**BUILD YOUR BUSINESS BY BUILDING AMERICA'S EXPORTS**

Published as a public service in cooperation with The Advertising Council and the United States Department of Commerce.

Your Present Temperature Controlled Units

# TROUBLESOME?

install BLUE M POWER-O-MATIC 60

REACTOR CONVERSION PACKAGE

LOW COST

NO AMPLIFIERS • NO CONTACTS

CHANGE FROM OLD-FASHIONED ON-OFF CONTROLS TO PROPORTIONAL STRAIGHT-LINE RESULTS

• ALL VOLTAGES • ½ KVA to 10 KVA

EFFICIENCY • RELIABILITY • SAFETY

3 RANGES: -20°F. to 650°F.

®

BLUE M Electric Company

BLUE ISLAND, ILLINOIS

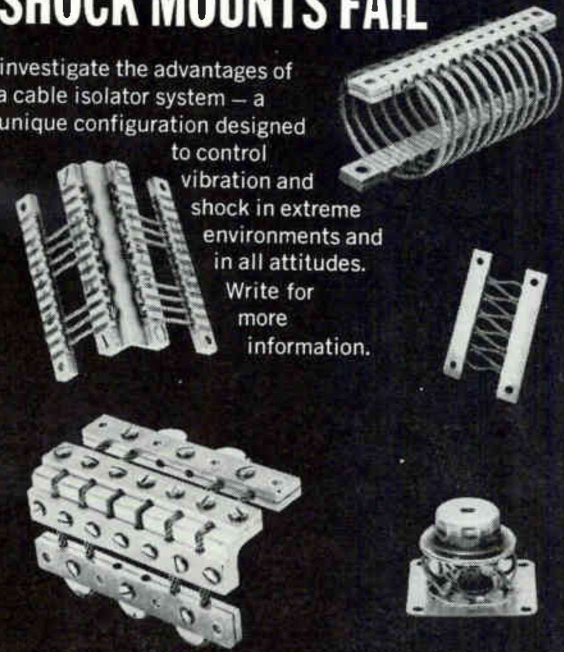
DIVISION: BLUE M ENGINEERING COMPANY

2312 So. Main Street, Los Angeles 7, California

CIRCLE 209 ON READER SERVICE CARD


# WHEN CONVENTIONAL SHOCK MOUNTS FAIL

investigate the advantages of a cable isolator system – a unique configuration designed to control vibration and shock in extreme environments and in all attitudes. Write for more information.



AEROFLEX LABORATORIES

INCORPORATED

Dept. JL-66 • 48-25 36TH STREET • LONG ISLAND CITY 1, N. Y.

CIRCLE 210 ON READER SERVICE CARD



Pardon the "Variety" headline but Lel's new Mixer-Preamp models just plain deserve the full treatment . . . klieglights, fanfares and all. The new K-BAND Models are sure to win applause from the most exacting users.

Plenty of features in this spectacular . . . most notable are the full wave-guide range and the high isolation LO to signal port. Here are some of the others

| | |
|---|---|
| Frequency Range | 12.4-18 Gc |
| Gain | 20 db |
| IF | 30, 60 or 70 Mcs. |
| Noise Figure | |
| KET-2 (tubes) | 10.0 db (max.) |
| KET-6 (transistors) | 12.0 db (max.) |
| KET-8 (Nuvistors) | 10.5 db (max.) |
| Isolation (L.O. Port—Sig. Port) | 15 db (Typ.) |
| Size | 3 11/16" L x 1 5/16" W x 1 5/8" D |
| Weight | 11 oz. |

The program lists 20 basic models, with a wide choice of IF and bandwidth, each one a star. Like all LEL products, they are certain to be hailed throughout the microwave field for sure-fire performances of the highest merit. Here's another important plus, these attractions aren't just coming soon . . . they're here now! Make your reservations early.

Write for Comprehensive Illustrated Catalog

LEL INC.

AKRON STREET
COPIAGUE, L.I., N.Y.
AMityville 4-2200
PYramid 9-8200

CIRCLE 145 ON READER SERVICE CARD

## *The New Legislation Is Only One Of The Steps Required...*

# To Fulfill The Promise Of The Trade Expansion Program

In securing unprecedented powers to negotiate mutual tariff reductions with other countries — especially those of the European Common Market — President Kennedy has scored a notable political victory for his Administration. Also, and of much more abiding importance, he and his trade advisers have devised and secured command of new machinery for making international tariff adjustments which have the **potential** of providing highly beneficial stimulation to U.S. and Free World trade.

**However, if this potential is to be realized in anything like full measure, the President's acquisition of power to negotiate large reductions in U.S. tariffs in exchange for comparable concessions abroad is only the first of a series of adjustments that must be made in the prevailing economic arrangements in the U.S.A. The purpose of this editorial is to indicate something of the nature of the follow-through that will be required.**

In successfully seeking the authority to bargain for sweeping reciprocal tariff cuts, the Kennedy Administration has stressed primarily the proposition that we must get tariff barriers lowered abroad to increase our exports. It is axiomatically true that lower tariff barriers abroad would help our exports. And it is also true that we need larger exports to keep our international balance of payments in reasonably good and safe order.

### It's A Two-Way Operation

But bargaining to get the tariff barriers of other countries lowered on a grand scale is a two-way operation. We've got to give — in lowering our own walls against competition from abroad — for what we "git."

**Here another axiomatic proposition emerges. If we as a nation are going to benefit from the razing of our tariff walls, in exchange for similar concessions abroad, we must first be sure that our economy is in rugged enough condition to compete successfully with the greatly intensified foreign competition we will be inviting. Otherwise, on balance, we stand to take an economic beating.** The fact of the matter is that much of our economy is not in this robust condition.

### Subsidized Exports

**Take the case of our agricultural exports. Last year, we sold almost $5 billion of food and other farm products abroad. This was almost 25% of our merchandise exports. But about a third of these exports was channelled through our foreign aid program, was paid for in foreign currencies, or even given away, and got us no dollars to help our balance of international payments. Another fourth of these exports was subsidized by the U.S. government, some as much as 25%. The subsidies were vivid testimonials to the fact that our national policy of restricting output and jacking up the prices of the products in question has priced them out of world markets.**

The subsidizing of exports of farm products also has the grossly unfair effect of penalizing American processors of them. They must pay more, sometimes far more, for their raw materials than do their overseas competitors. The domestic manufacturers of textiles, for example, must pay up to 25% more for U.S. grown cotton than their Japanese competitors.

Hence a basic step in a successful trade expansion program is a return to something approaching economic sanity in the government's farm program.

### A High Wage Haven

**Take also our capacity to compete in industrial products with overseas competitors, particularly those of the Common Market and Japan. Wage rates in the U.S. are about twice as high as they are in Western Germany. Much the same wage differential favors the rest of the major industrial countries with which we propose to enter a broad tariff-cutting program.**

Historically, we have competed successfully in international markets for industrial products, despite extremely high wages, for two basic reasons. First, we have had the great cost- and price-reducing advantages of mass production, made possible by our own continental tariff-free common market. Second, we have had the advantage of especially efficient industrial plants and equipment.

Now our competitive advantages in world markets through mass production of industrial products are clearly on the way out. The European Common Market will give its participating countries opportunities for mass production which previously only the U.S. has enjoyed.

### Antique Industrial Plants

**Our advantages in superior industrial plant and equipment have already disappeared in large degree. It is a grimly ironic fact that the bombs dropped on Western Europe and Japan were an economic boon of sorts. They destroyed a lot of aging or obsolete industrial equipment which has now been largely replaced by up-to-date producing facilities. For example, McGraw-Hill's recent survey of Overseas Operations of U.S. Industrial Companies discovered that less than 25% of U.S. firms' foreign plants and equipment antedates 1950.**

In what should be to us a most alarming contrast, a large part of our industrial plant and equipment in the U.S. properly belongs in an antique shop. The McGraw-Hill Department of Economics has found through another survey that 40% of the productive facilities of the U.S. date back to 1950.

### Signs Of An Awakening

Recently, there have been some important indications of awareness of the necessity of facing up to these harsh realities of our international competitive position. They are the administration's tax credit plan and the upward revisions of depreciation allowances to speed up the process of modernizing the industrial plant of the U.S.

**But thus far nothing has been done to reduce perhaps the greatest single deterrent to a speedup of the modernization of our industrial producing facilities. This is the 52% bite the federal government takes out of corporate profits. Until this bite is reduced, the chances of getting our industrial facilities reasonably well modernized will remain slim.**

### Booby Traps Ahead

In many lines U.S. companies can compete successfully almost anywhere for many different reasons — product originality, better design, better packaging, better selling. Yet our foreign competitors are not backward; they are quick to learn any improvements and advances that U.S. companies introduce, and they carry out research and development of their own that sometimes helps them get the jump on our products. And their governments, long pressed to help increase their countries' exports, know well which economic policies help their competitive position abroad and which ones hinder. They are in excellent condition to meet the challenge of U.S. competition. But until a lot of basic overhauling and strengthening is done — key parts of it governmental — much of the American economy will not be in such rugged shape.

The success of the trade expansion progam does not, of course, rest solely with the U.S. government. American businessmen have heavy responsibility for its success. They must intensify their search for new and better products and more efficient methods of production; and our salesmen must continue to expand overseas markets for U.S. made products.

The goals of a great free trade area embracing all of the free world which have been envisaged by the eloquent proponents of the Kennedy trade program are shining and alluring goals. But, unhappily, the route toward these goals for the U.S. is replete with pitfalls and booby traps. To avoid them, **we must see that we have rugged international competitive strength when we invite sweeping tests of it by deep reciprocal tariff cuts. Without such a follow-through the trade expansion program can prove bitterly disappointing.**

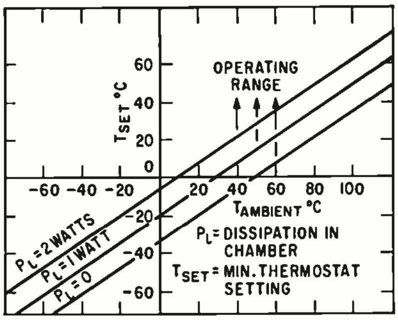
This message was prepared by my staff associates as part of our company-wide effort to report on major new developments in American business and industry. Permission is freely extended to newspapers, groups or individuals to quote or reprint all or part of the text.

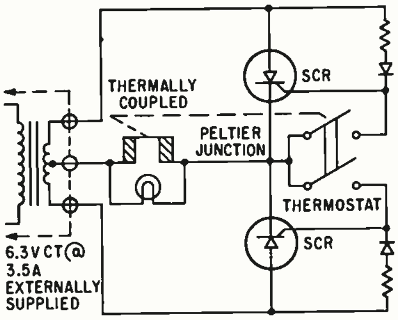
Donald C McGraw

PRESIDENT

McGRAW-HILL PUBLISHING COMPANY

# DESIGN AND APPLICATION




## Stabilizing Temperatures Below Ambient

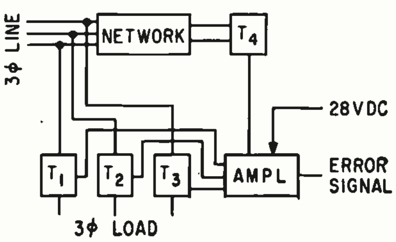
### *Circuit components can be tested at temperatures between 0 and 25 C*

RECENTLY announced by Energy Conversion, Inc., 336 Main St., Cambridge 42, Massachusetts, the model 1700 uses a thermoelectric module powered by 6.3 v, 50 to 400 cps to maintain a 2.5 cubic inch chamber to ±1 C within the range between 0 and 25 C. Electrical connections to components within the chamber are by 12-lead connector. Free convection heat sinks are used on the package exterior. Internal chamber temperature is controlled by precision bimetallic thermostat that switches a low-power scr gate circuit. Although temperature stability of ±1 C is used, a number of set temperatures are available. Minimum set temperature, as shown in the accompanying graph, is determined by highest expected ambient and power dissipation $P_l$ of component being stabilized. Temperature control up to 50 C below the ambient is possible. Typical applications include stabilization of any temperature-sensitive component, but special advantages are obtained with respect to lowered aging effects and reduced temperature sensitivity in quartz crystals, zener diodes or standard cells when low temperature stabilization is to be used.

CIRCLE 301, READER SERVICE CARD

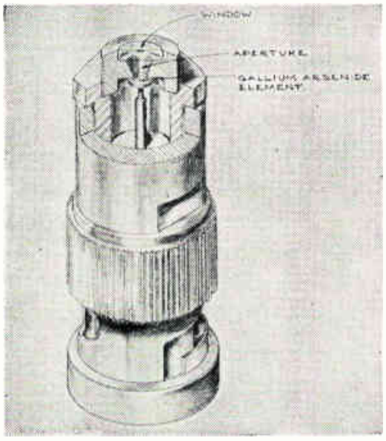
## Detecting Phase Loss or Improper Rotation

ANNOUNCED by Transonic, 808 16th St., Bakersfield, California, the model TNW-10002 phase loss detector also indicates improper phase rotation. Voltage drop per line is 6 v rms at 0.075 ampere per line, maximum current is 400 ma for less than one minute per line, and maximum allowable continuous load is 0.17 ampere rms per line. Error indicator output is 26 v at 0.1 ampere. Loss of one phase or phase reversal produces less than 1 v output. Power requirement is 26 to 30 v at 0.1 ampere. The unit has no moving parts, requires no neutral line, is hermetically sealed and has a minimum estimated life of 10,000 hours. (302)




## Light Emitting Diode For Optical Communications

MANUFACTURED by Philco Corp., Tioga and C Sts., Philadelphia 34, Pa., the GAE-402 is a diffused junction GaAs diode which, when forward biased, emits monochromatic light near 9,000 A. Intensity of emitted radiation can be varied by suitable variation of bias current making it possible to obtain monochromatic light modulated at frequencies extending into the microwave region. Modulation power is a few tenths of a watt and radiated power output is approximately 1 mw at room temperatures to more than 25 mw at 77 K. Efficiency is 5 percent at room temperature and near 100 percent at 77 K. Light is through a 60-degree cone of the UG-88/U package. (303)




## Subminiature Ceramic I-F Transformer

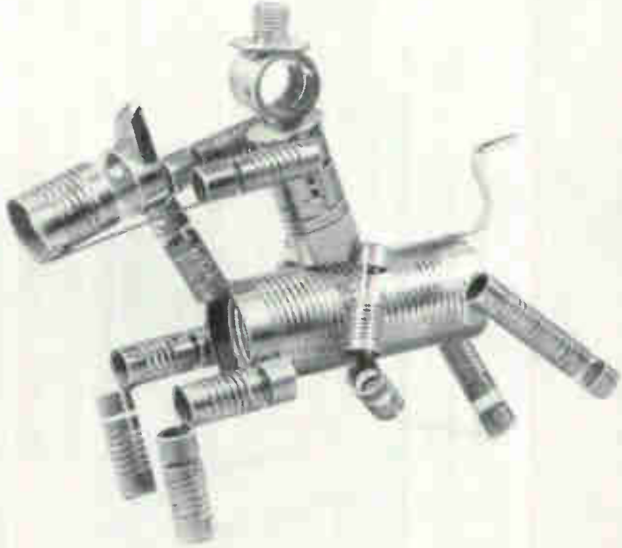
INTRODUCED by U. S. Sonic Corp., 63 Rogers St., Cambridge 42, Massachusetts are a series of subminiature ($\frac{5}{16}$ × $\frac{1}{4}$ inch) ceramic i-f transformers having a frequency

New Miniature Metalized Inductors. LF3P and LF4W Series

Ranges: Available in 22 values from 0.05 to 1.0 μhy.
Q: Over 125.
Lengths: Panel Mounts—up to 1½ inches.
Wire Mounts—up to 1¼ inches.
Frequency of Operation: below 10 mc over 900 mc.
O.D.: 0.290 inches.

ACTUAL SIZE

# when your miniature metalized inductor specs demand the "impossible"... rely on JFD and see!



Compactness...reliability...stability...are a few of the vital advantages you get when you specify JFD Miniature Metalized Inductors. Now up to 45% smaller in size and higher in Q, they help meet and beat critical packaging and environmental demands.

Special JFD processing permanently fuses a pure silver film to a low loss dielectric cylinder for a practically indestructible assembly that is impervious to moisture, corrosion and withstands temperature changes from −55°C to +125°C. Because of this unique construction JFD Inductors are inherently rugged, entirely moisture resistant and highly vibration resistant.

If you prefer, inductances, windings, size, Q and other parameters of JFD Miniature Metalized Inductors can be adapted to match your specs. Catalog T172 gives you full details. Contact your local JFD sales office or your JFD franchised distributor for action.

**FEATURES:** 1. Rugged construction affords unusually high stability under conditions of severe shock and vibration.
2. Use of glass dielectric assures low temperature coefficient of inductance and operation without derating over extremely severe environmental conditions.
3. Low distributed capacity.
4. Special alloy plating protects metal parts from corrosion.
5. A high Q over a broad frequency range.
6. Silver plated copper leads.
7. Available in panel mount and printed circuit mount types.
8. JFD Variable Inductors can also be supplied to order. Write for questionnaire or contact the JFD sales office or representative nearest you.

JFD

AT WORK IN THE NEW FRONTIERS OF ELECTRONICS

**JFD ELECTRONICS CORPORATION**

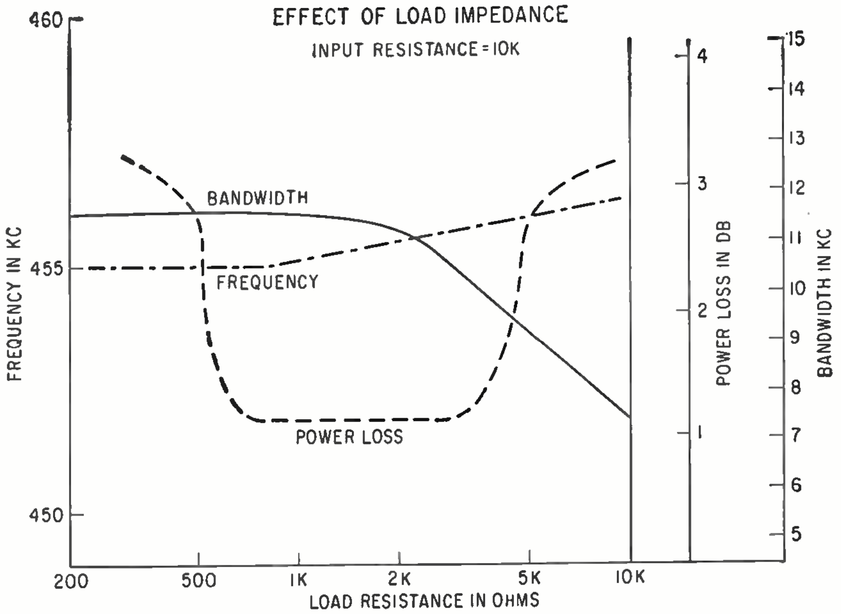
Components Division • 6101 16th Avenue, Brooklyn, New York • Phone DEwey 1-1000 • TWX-NY25040 • Cable—JEFDEE NY

| JFD WESTERN | JFD NORTHEASTERN | JFD MIDWESTERN | JFD CANADA |
|---|---|---|---|
| P. O. Box 3416, Van Nuys, Calif. | Ruth Drive, P. O. Box 228, Marlboro, Mass. | P. O. Box 588, Skokie, Illinois | 51 McCormack Street, Toronto, Ontario, Canada |
| Phone: EMpire 4-4131 | Phone: HUntley 5-7311 | Phone: 675-1140 | Phone: ROgers 9-1129 |

VARIABLE TRIMMER PISTON CAPACITORS • FIXED METALIZED INDUCTORS • LC TUNERS • DIPLEXERS
FIXED AND VARIABLE. DISTRIBUTED AND LUMPED CONSTANT DELAY LINES • PULSE FORMING NETWORKS

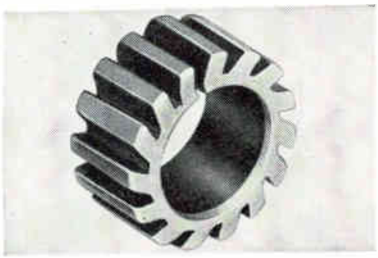


CIRCLE 149 ON READER SERVICE CARD




range from 100 Kc to 1 Mc, bandwidth at the 6 db point can be 1- to 20-percent of center frequency and impedance of 50 to 15,000 ohms input and output. Typical specifications for a communications filter are: center frequency 455 ± 1 Kc, 6 db bandwidth of 6 Kc, 60 db bandwidth of 30 Kc, input impedance of 10,000 ohms, output impedance of 1,000 ohms and power loss of 3 db. The transformer ratio depends on both input and load resistances over a wide range and may be connected in a circuit in either direction regardless of direction of flow and can be regarded as a step-down transformer in either direction. A typical production unit may be used with output impedances from 200 to 5,000 ohms without appreciable change in power loss or resonant frequency. The illustration shows the effect of varying the load on a typical transformer.

CIRCLE 304, READER SERVICE CARD

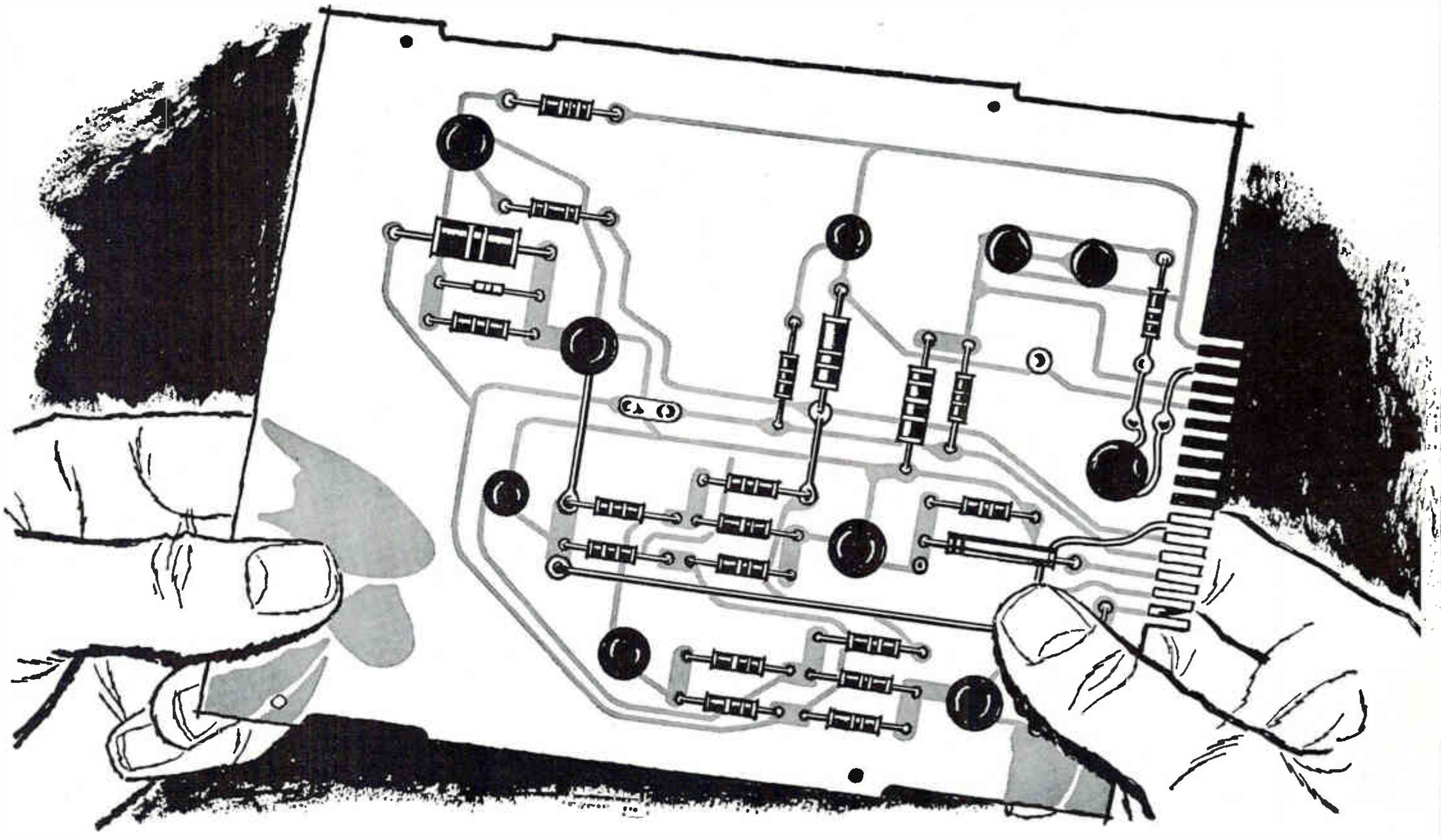


## Heat Sink Offers Gear Design

ASTRO DYNAMICS, INC., Second Ave., Northwest Industrial Park, Burlington, Mass. Model 2201 gear design heat sink has, by virtue of its angled fins, increased the area which can be used in natural con-



# Taylor works magic



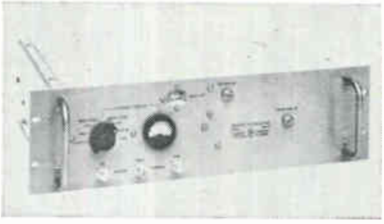
vection. This additional area results in more efficiency, an increase of approximately 10 percent without increasing the overall size of the heat sink. Unit is made to fit most TO outline cases. (305)

Using scr circuitry with transistorized controls, the units have no moving parts or aging characteristics. (306)

and 100 Kc are also provided. Transistorized, compact and rugged, model 104AR is priced at $3,250. (307)

## Static Inverter Has No Moving Parts

RAYTHEON CO., Hooksett Plant, Manchester, N. H. Efficiently converting d-c standby power into a-c power, the static inverter can produce any output up to 600 v and any power up to 6,000 w. Frequency can be provided from 20 to 100 cps. Harmonic distortion of the standard models' sinusoidal waveshape is not more than 20 percent. Line regulation is within ±1 percent and load regulation from no load to full load is within ±3 percent.



## Quartz Oscillator Offers High Stability

HEWLETT-PACKARD CO., 1501 Page Mill Road, Palo Alto, Calif. Model 104AR quartz oscillator has a long-term stability of 5 parts in $10^{10}$ per day. Typical short-term stability, based on a 1-sec average and reasonably constant environment is 5 parts in $10^{11}$. Unit provides a 5 Mc output of extreme spectral purity. This makes it particularly useful for microwave spectroscopy and for obtaining accurate doppler measurements. Outputs of 1 Mc

## Ceramic Capacitors Rated 6 to 40 Kv

SPRAGUE ELECTRIC CO., 35 Marshall St., North Adams, Mass. Doorknob ceramic capacitors for use in high voltage applications ranging from 6 to 40 Kv are available. They have the ceramic slug elements housed in a special epoxy casting for moisture and mechanical protection. They are equipped with tapped terminals so that the units may be easily connected in series for applications at high voltages or for use in series parallel connections. A series of six terminal adapters is also available to meet mechanical


# with glass-base laminates

**Which grade has the unusual combination of properties you need?**

Almost magical combinations of resin formulations and glass reinforcements have enabled Taylor to develop a number of glass-base laminates that have outstanding characteristics for electrical and mechanical applications. For example, the glass silicone grades offer very high heat resistance combined with excellent mechanical and electrical properties plus the highest arc resistance. If you require extremely high strength, excellent chemical resistance, low moisture absorption and high strength retention at elevated temperatures select one of the glass epoxy grades. These grades are ideally suited for high reliability printed circuitry. Other grades have equally important characteristics.

Write to us for complete technical data.

**Taylor corporation**
ENGINEERED PLASTICS
Valley Forge 40, Pa. • West Coast Plant: La Verne, Calif.
(Formerly Taylor Fibre Co.)

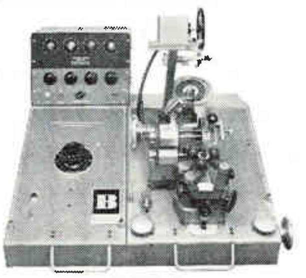
**TAYLOR GLASS-BASE LAMINATES**

| Taylor Grade | NEMA Grade | Military Specification | Resin Used | Principal Characteristics |
|---|---|---|---|---|
| GSC | G-7 | MIL-P-997 Type GSG | Silicone | High heat resistance. Excellent electrical properties, highest arc resistance. Will not support combustion. |
| FIREBAN 1011 | G-10 G-11 FR-4 FR-5 | MIL-P-18177 Types GEE and GEB | Epoxy | Combines all desirable properties of G-10 (GEE) and G-11 (GEB), plus flame retardance in one grade. |
| GEC-500 | G-10 | MIL-P-18177 Type GEE | Epoxy | Extremely high flexural, impact and bond strength. Low moisture absorption. High insulation resistance. |
| FIREBAN 600 | FR-4 | MIL-P-18177 Type GEE | Epoxy | Self extinguishing. Excellent electrical properties under high humidity conditions. Extremely high flexural, impact and bond strength. |
| GEC-111 | G-11 | MIL-P-18177 Type GEB | Epoxy | High mechanical strength retention at elevated temperatures. Will not support combustion. |
| G-5 | G-5 | MIL-P-15037 Type GMG | Melamine | High mechanical strength. Excellent arc resistance and electrical properties. Will not support combustion. |
| G-3 | G-3 | None | Phenolic | Good mechanical strength. Good heat resistance. |

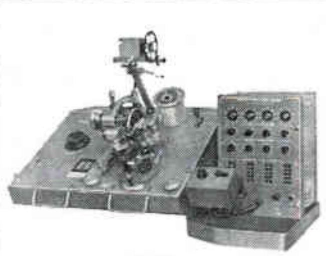
NOTE: Taylor Glass-Epoxy, Copper-Clad Grades are available to meet MIL-P-13949B, Types GE, GB and GF.

CIRCLE 151 ON READER SERVICE CARD

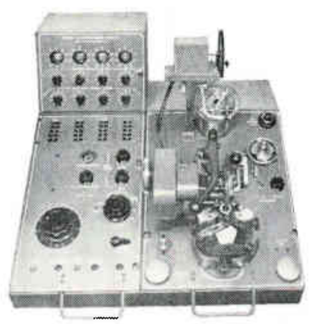
# WANTED



T-100 A
PERFORMANCE AT LOW PRICE



T-100 B
OUTSTANDING COMBINATION OF ECONOMY AND FLEXIBILITY



T-100 C
FULLY COMPLEMENTED WITH AUTOMATIC AND PREDETERMINED CONTROLS

## THE BEST TOROID WINDER FOR THE JOB

**DESCRIPTION**

ALL THE MACHINES SHOWN ABOVE UTILIZE QUICK CHANGE INTERCHANGEABLE SHUTTLE HEADS AND ARE WELL KNOWN FOR THEIR MODUS OPERANDI IN THE FOLLOWING AREAS:

★ RANGE OF COIL SIZES: 1/32" (.035) I.D. to 5" O.D.
★ RANGE OF WIRE SIZES: #16 through #50 AWG
★ WINDING SPEED: Variable ... 0 to 2000 Turns/Minute (for 4" shuttle)

**REWARD**

INCREASED PRODUCTION, LOWER COSTS, UNIFORM PRODUCT QUALITY - WITH GREATER FACILITY AND FLEXIBILITY TO MEET CHANGING REQUIREMENT

By the most exacting standards . . . the new Boesch T-100 series of machines deliver value . . . whether the measure be productivity or cost reduction, uniformity or quality of product, range of application, price or economic life. And there is a model in the T-100 series that can meet virtually any price and performance requirement. Attachments and accessories can be added when necessary to extend the range of capabilities of the simpler models to meet changing needs.

Some of the Available Features of Boesch Winders:
Two Knob Core Positioning System . . . positions cores during operation • Electronic Controls for Predetermined Footage and Turns Count • Built-in Deceleration for Winding to Exact Turn • Dynamic Braking • Built-in Shuttle Loader • Precision Control for Core Rotation

*Write for bulletin T-100*

B
BOESCH

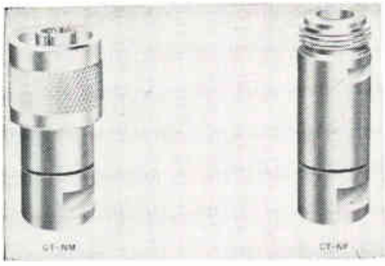
BOESCH MANUFACTURING DIVISION
WALTHAM PRECISION INSTRUMENT COMPANY, INC.
DANBURY, CONNECTICUT / Telephone: Pioneer 3-3886 / Teletype: DANB 468


requirements for making connections or mounting in h-v applications.

CIRCLE 308, READER SERVICE CARD

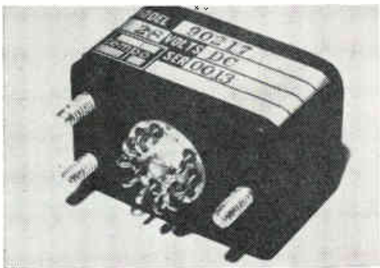
## Proximity Tachometer Adapted for Industry

LECTROLOGIC OF FLORIDA, 4165 S.W. 11th Terrace, Broward County Airport, Fort Lauderdale, Fla., announces a proximity tachometer that has outputs covering the standard industrial d-c current signals. It has filtered output. This allows the actuating of an electronic controller and/or a potentiometer recorder. Another feature is its heavy cast aluminum all weather case with conduit threaded pipe terminations. (309)



## Coax Termination Rated 1 W Average

WEINSCHEL ENGINEERING, 10503 Metropolitan Ave., Kensington, Md. The Blueline model CT-N is a 50 ohm termination covering the frequency range from d-c to 10 Gc. It is rated for 1 w average power and 1 Kw peak. Price is $25. (310)



## Solid-State Timer For Cryogenic Uses

TEMPO INSTRUMENT, INC., Plainview, L. I., N. Y., has introduced a solid state, electronic timer for cryogenic applications, where temperatures range as much as −196

# NEW TEFLON MICRO-LOGIC ELEMENT SOCKETS

*Actual size shown*

MADE OF TEFLON* TFE, these tiny sockets are designed to be used with the new Fairchild micro-logic elements (molectronic-type semiconductor networks employed in computer and other critical circuits). Designed in collaboration with Fairchild engineers, the Garlock sockets are the only micro-logic element sockets on the market. Through the use of Teflon insulating material and silver-plated, gold-flashed Beryllium copper contacts, these sockets exhibit unusually low dielectric loss and outstanding pin retention. For immediate availability, *New Garlock Micro-logic Element Sockets are stocked in your locale.* Contact the Garlock Electronic Products distributor or representative nearest you for full information. Or, write GARLOCK ELECTRONIC PRODUCTS, GARLOCK INC., Camden 1, New Jersey.

**DuPont Trademark*

75TH Anniversary Year

# GARLOCK
## ELECTRONIC PRODUCTS

THE MOST-USED ELECTROLYTIC RECORDING PAPERS

ARCHIVAL QUALITY ? ? Sharp Definition ?
Reproducibility Dense Black Marking
? Extensive Gray Scale
HIGH SPEED MARKING ? High Contrast ?

**No "QUESTION" about it...when you specify**

**HOGAN FAXPAPER®**

Whatever the application, HOGAN FAXPAPERS have the characteristics you are looking for in electrolytic recording: high contrast, sharp definition, high-speed marking, dense black marking, extensive gray scale, archival quality, reproducibility by office duplicators. HOGAN FAXPAPER is used for event and data recording, operations monitoring, press service news pictures and weather-map recording, spectrum analysis, ceilometering, data retrieval readout, plotting and printer plotting, facsimile recording. HOGAN FAXIMILE also makes equipment for such uses.

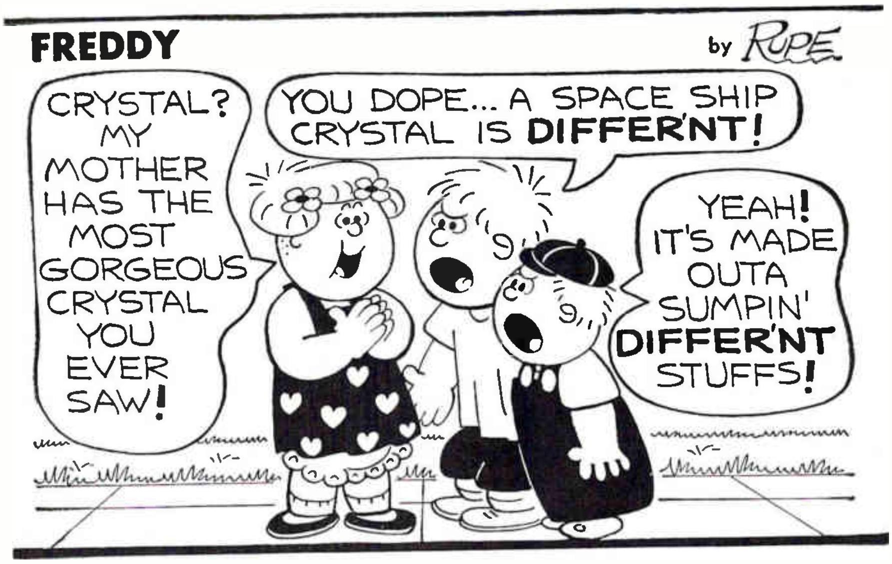
*Write for Facts on Faxpaper to...* **Dept. E-6**

® Faxpaper is a registered trademark of Hogan Faximile Corp.

121
122

**HOGAN FAXimile Corporation • 635 Greenwich St., New York 14, N. Y.**
A SUBSIDIARY OF TELAUTOGRAPH CORPORATION

CIRCLE 211 ON READER SERVICE CARD



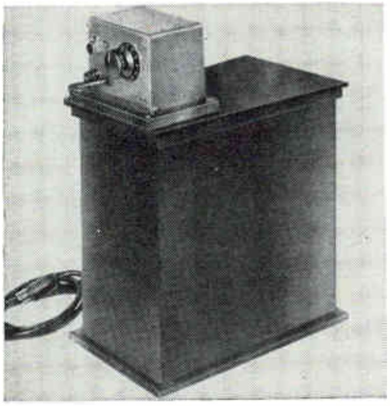

Yeah! Anybody knows that! Although it may not be as pretty as the one Charlene's mother has, a **REEVES-HOFFMAN QUARTZ CRYSTAL** has a lot more utility. Standard crystals are available from 1 kc to 100 mc for all commercial and military applications. Precision crystals are available in a frequency range of 1 kc to 5 mc. Write for complete information on some of the most gorgeous crystal designs you've ever seen! Ask for bulletin QCI.

**REEVES-HOFFMAN**
CARLISLE, PENNSYLVANIA
*DIVISION OF DYNAMICS CORPORATION OF AMERICA*

PRODUCERS OF PRECISION FREQUENCY CONTROL DEVICES... crystals • crystal-controlled frequency sources, standards, filters • component ovens.

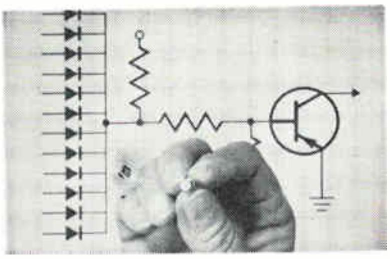
to +55 C. Unit is designed for use in such applications as rocket fuel systems, where components must function at or near the temperature of liquid oxygen, or in severe environments encountered by satellites or space probes. It provides time intervals from 0.05 to 1 sec, is adjustable by means of an external timing resistor, and operates from 20 to 31 v d-c. It incorporates a static output switch capable of delivering up to 500 ma to an external load.

CIRCLE **311**, READER SERVICE CARD



## Power Supply Has 0-100 Kv D-C Output

SPELLMAN HIGH VOLTAGE CO., INC., 1931 Adee Ave., Bronx 69, N.Y. Power supply features all solid state circuitry and complete encapsulation. Output is continuously variable from 0-100 Kv d-c at 25 $\mu$a. It is suited for electrostatic paint spraying, precipitating, de-tearing, powder separation, and as a system component. **(312)**



## Logic Transistor Used in H-V Switching

TEXAS INSTRUMENTS INC., 13500 North Central Expressway, Dallas, Texas. The 2N2635 is a high-voltage germanium mesa epitaxial logic transistor. Specifications include: $BV_{CEO}$ of 12 v; $BV_{CBO}$ of 30 v; $t_T$

(total switching time) as low as 240 nsec in a typical circuit; plus the extremely rugged mesa construction capable of withstanding forces in excess of 35,000 g in the critical $Y_1$ plane. (313)

## Tiny Delay Line Suited for P-C Use

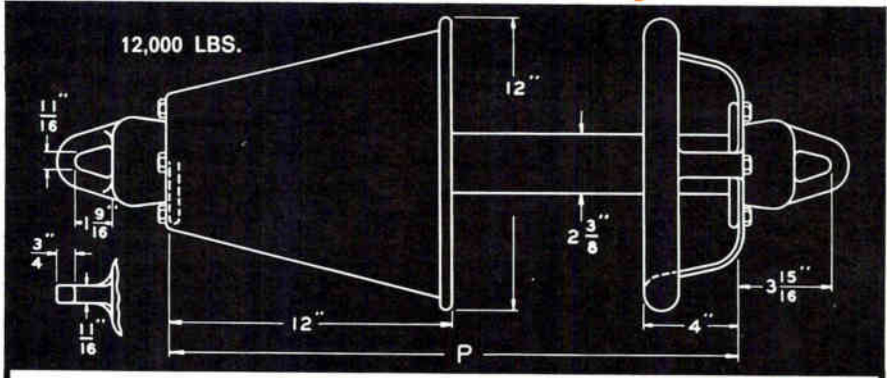
PARADYNAMICS, INC., 10 Stepar Place, Huntington Station, N. Y. Variable delay line measures only 3¾ in. long, 11/16 in. high and ½ in. wide. Model V835, particularly suitable for mounting in printed circuits, features a continuously variable delay time of 1 to 80 nsec with a resolution of less than ±0.5 nsec, and a 3 db bandwidth of 30 Mc minimum. It has an impedance of 100 ohms and an operating temperature range of −55 C to +125 C. (314)

## Scope Control Has Improved Circuits

ACME ELECTRIC CORP., Cuba, N. Y. Completely redesigned Scope-O-Trol is particularly useful in connection with oscilloscope observations, in that it provides an opposing potential which cancels out the d-c increment of a circuit being checked so that both d-c and a-c steady state and transient voltage changes can be observed on the scope in their true form. Unit operates from a 115 v 60 cps circuit and provides an output from 0 to 50 v d-c. Input regulation ±0.005 percent for ±15 percent line change. Output voltage adjustable and sta-


# LAPP HEAVY-DUTY ANTENNA INSULATORS

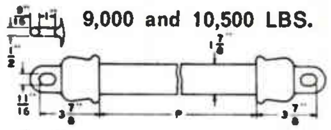
***...in all these standard sizes to save you time and money***



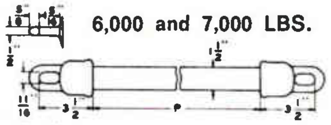

**No. 9171**, without ring or shield, for most high-strength applications. Standard "P" dimensions: 12, 16, 20, 24, 30 inches.

**No. 9172**, with two grading rings to raise voltage at which corona starts, and to distribute voltage to reduce heating of porcelain. Standard "P" dimensions: 20, 24, 30 inches.

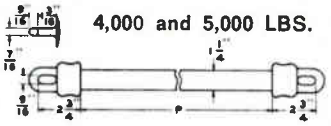
**No. 9173**, with corona ring and rain shield, preferred for vertical installations. Standard "P" dimensions: 24 and 30 inches.




**No. 43812** in porcelain (rated at 9,000 lb. average ultimate strength) or **No. 43813** in steatite (10,500 lbs.), in standard "P" dimensions of 12, 14, 16, 20 inches.




**No. 43810** in porcelain (rated at 6,000 lb. average ultimate strength) or **No. 43811** in steatite (7,000 lbs.), in standard "P" dimensions of 10, 12, 14, 16 inches.




**No. 43808** in porcelain (rated at 4,000 lb. average ultimate strength) or **No. 43809** in steatite (5,000 lbs.), in standard "P" dimensions of 8, 10, 12, 14 inches.

### FLASHOVER AND RADIO RATINGS

| | WET FLASHOVER 60 ∾ KV eff. | | | RADIO RATING KV eff. | | |
|---|---|---|---|---|---|---|
| "P" Inches | All except No. 9172 No. 9173 | No. 9172 | No. 9173 | All except No. 9172 No. 9173 | No. 9172 | No. 9173 |
| 8 | 45 | | | 21 | | |
| 10 | 54 | | | 22 | | |
| 12 | 62 | | | 23 | | |
| 14 | 70 | | | 24 | | |
| 16 | 77 | | | 24 | | |
| 20 | 88 | 88 | | 25 | 34 | |
| 24 | 96 | 96 | 60 | 27 | 37 | 34 |
| 30 | 108 | 108 | 108 | 28 | 40 | 38 |

Steatite Insulators will have the same Flashover but twice the Radio Rating.

Lapp

WRITE for Bulletin 301-R.
Lapp Insulator Co., Inc.,
198 Sumner Street, LeRoy, N. Y.

CIRCLE 155 ON READER SERVICE CARD


# BF SERIES
## BATTERY HOLDER

Literally, BF Series Battery Holders are powerhouses . . . designed for use as highly stable, panel mounted cell sources of power. They will accommodate batteries and cells up to 1 3/8" diameter and lengths from 1 19/64" to 7 3/16", enabling use of different battery combinations to obtain wide selection of voltages. Batteries are exchanged simply by unscrewing holder cap. Designed for mounting up to a 1 5/8" diameter hole and 3/8" panel thickness.
Inquiries for special battery holder lengths are invited. Complete data available on request.

300 SERIES: • Designed to accommodate batteries up to 11/16" diameter and lengths 1.300 to 5.850.

●

400 SERIES: • Accommodates batteries 1" to 1 1/8" diameter and lengths from 1 11/16" to 6 3/16".

●

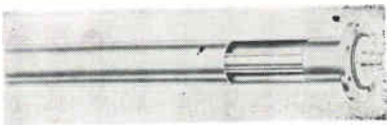
500 SERIES: • Accommodates batteries ranging from 1 3/16" to 1 3/8" diameter and lengths from 2 3/16" to 7 3/16".

SDL

SECURITY DEVICES LABORATORY
ELECTRONICS DIVISION OF SARGENT & GREENLEAF, INC.
ROCHESTER 21, N. Y.

bilized ±0.015 percent at any selected voltage. Ripple 0.002 percent peak to peak.

CIRCLE 315, READER SERVICE CARD



## Rigid Line Cable Provides Low Loss

PHELPS DODGE ELECTRONIC PRODUCTS CORP., 60 Dodge Ave., North Haven, Conn., announces rigid line coaxial cable designed for broadcast and tv transmission installations. It provides extremely low loss and high power capability. Available with either aluminum or copper sheathing, it incorporates a copper inner conductor, supported by Teflon plugs. Rigid line is available in 50 and 75 ohm ratings and in the following diameters: 7/8 in., 1 5/8 in., 3 1/8 in. and 6 1/8 in. These sizes are shipped in standard mill lengths of 20 ft. (316)


## Accelerometers Are Gas Damped

GENISCO, INC., 2233 Federal Ave., Los Angeles 64, Calif., announces a series of gas-damped accelerometers for a wide variety of applications. Featuring high a-c or d-c output, infinite resolution, 1 percent accuracy and withstanding 100 g shock, the series 2397 accelerometers meet the most rigid environmental requirements, provide exceptional performance from −100 to +125 F. (317)

## Computer Trainer

DIGITAL ELECTRONICS, INC., 2200 Shames Drive, Westbury, L.I., N.Y. The DIGIAC 3010 desk top digital training computer, designed for use

new


CONCEPT
in
ac voltmeters

- 10 cps to 100 megacycles ± 3 db
- 20 cps to 50 megacycles ± 2%
- 70 microvolts to 300 volts
- 12 full reading ranges
- peak responding, cal. in rms
- 1 megohm input impedance
- 200 mv ac amplifier output
- 6 nsec amplifier response
- price: $775

*Send for four-page Engineering Note on Model 120 Wideband Voltmeter—Amplifier*

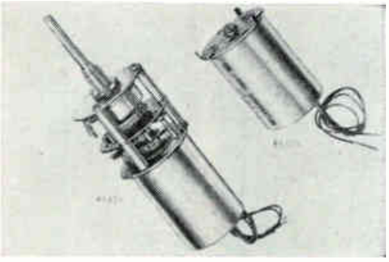
latest catalog available upon request

KEITHLEY INSTRUMENTS
12415 Euclid Avenue • Cleveland 6, Ohio

CIRCLE 212 ON READER SERVICE CARD

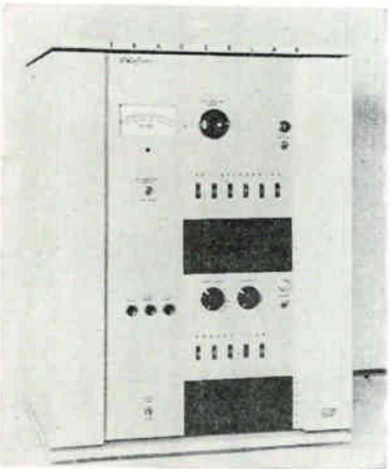
 CIRCLE 156 ON READER SERVICE CARD

as a teaching aid for various scholastic and technical levels as well as an error proving device for OEM logic R&D, has also found direct applications for on-the-line usage in automatic processing industries. (318)



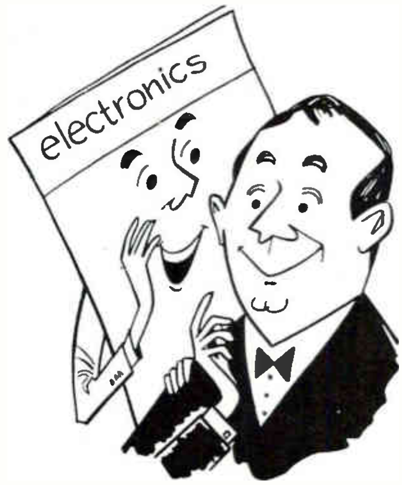
## Motorized Controls Have Low Noise Level

THE LIONEL CORP., Hoffman Place, Hillside, N. J., has developed the 4425 a-c hysteresis motor, the 4429 a-c hysteresis motor and gear train and 4428 a-c motorized potentiometer controls to meet the requirements of the electronics industry for motorized controls, with low level of mechanical and electrical noise. Presently in production and used in the tv industry, they have application in the industrial control and instrumentation fields. (319)



## Scaler Eases Data Handling

TRACERLAB, 1601 Trapelo Road, Waltham 54, Mass., announces a scaler designed to more fully automate multiple sample analysis. Counting results are presented in the form of a net count ratio for each sample as compared to a standard reference. The Ratio/

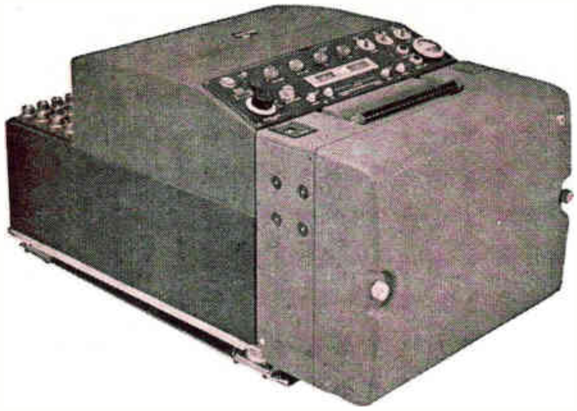

**electronics IS EDITED TO KEEP YOU FULLY INFORMED**

***—a "well-rounded" engineer***

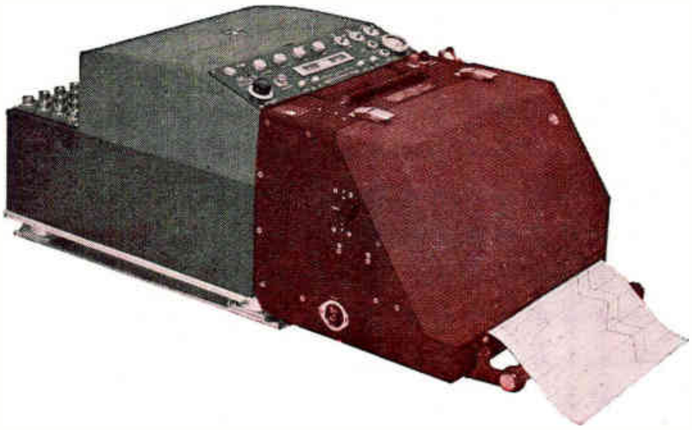
What's your *present* job in electronics? Do you work on computers? (**electronics** ran 158 articles on computers between July, 1961 and June, 1962!) Are you in semiconductors? (For the same period, **electronics** had 99 articles, not including transistors, solid-state physics, diodes, crystals, etc.) Are you in military electronics? (**electronics** had 179 articles, not including those on aircraft, missiles, radar, etc.)

In all, **electronics'** 28-man editorial staff provided more than 3,000 editorial pages to keep you abreast of all the technical developments in the industry. No matter where you work today or in which job function(s), **electronics** will keep you fully informed. Subscribe today via the Reader Service Card in this issue. Only 7½ cents a copy at the 3 year rate.

**electronics**



# Own a CEC 5-119 Recording Oscillograph?



# Add Datarite for instant records

CEC's 5-036 Datarite Magazine provides the shortest continuous record access time of any known oscillographic process. Oscillograms are automatically developed and dried within the magazine as quickly as data is recorded. Records are characteristically of high trace contrast and permanency. Recording speeds are from 0.1 to 25 ips. And capacity is 400 feet of commercially available (see opposite page) photographic papers. Full facts? Call your CEC office or write for Bulletin 5119-X11.

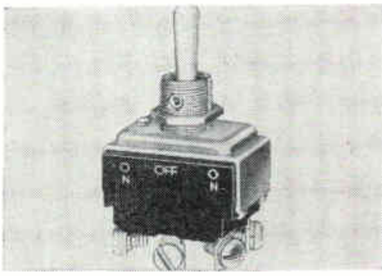
CEC
Data Recorders Division
**CONSOLIDATED ELECTRODYNAMICS**
PASADENA, CALIFORNIA • A SUBSIDIARY OF BELL & HOWELL

Matic scaler offers provision for setting any time integer from 0.01 minute to 999.99 minutes as the counting time, and automatic subtraction from the total count registration of any fixed number of counts.

CIRCLE 320, READER SERVICE CARD

## Transponder Beacon Spans 5.4 to 5.6 Gc

TELERAD DIV. of The Lionel Corp., Route 69, Flemington, N. J., announces a C-Band transponder beacon that measures only $6\frac{3}{4}$ in. in length. The triggering sensitivity of the receiver is $-45$ dbm min for a 0.50 $\mu$sec pulse. Frequency range of the model 745C-20 is 5,400 to 5,600 Mc. (321)

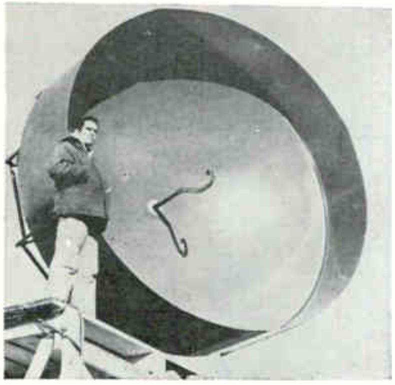


## Toggle Switches Are Lever Sealed

CUTLER-HAMMER INC., 315 N. 12th St., Milwaukee 1, Wisc., has added lever sealed, full throw momentary contact toggle switches to its line of two pole aircraft devices. Included among design features are: hot tin dipped screw terminals, corrosion resistant metal parts, and a silicone rubber lever seal. (322)

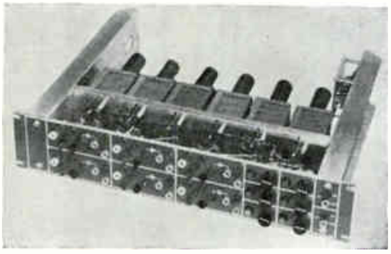
## Terminal Block Rated at 600 V

K&B ELECTRICAL PRODUCTS CO., 2504 N. California Ave., Chicago 47, Ill. Model C-1552 low cost terminal block is rated at 600 v, 25 max working amperes and can withstand ambient temperatures from $-65$ F to $+800$ F. Use of specially molded plastic as the material permits terminal block to flex and fit tightly on curved surfaces or bend in arc for cable hook-ups. The compact C-1552 will not break or chip, accepts up to No. 12 Awg solid wire and has chamfered hole which guides wire into place. (323)



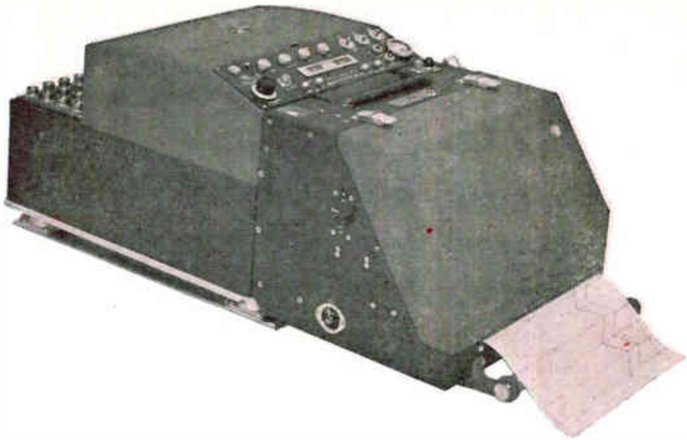
## Parabolic Antenna Covers 5.9 to 8.2 Gc

ANDREW CORP., P. O. Box 807, Chicago 42, Ill. A guaranteed 65 db front to back ratio in both E and H planes from 90 deg through 270 deg is available in the new 10-ft microwave antenna. Covering the band from 5,900 to 8,200 Mc, the vswr of this antenna does not exceed 1.03 over any 600 Mc band. (324)



## D-C Amplifiers Packaged as 6 Plug-Ins

EMBREE ELECTRONICS CORP., 10 No. Main St., West Hartford 7, Conn., has introduced an operational six-pack for analog simulation applications. Model 1501/06P/3.5 holds up to six metal case plug-in model 1501 Nuvamp stabilized operational d-c amplifiers. Input and output jacks on the front panel permit connecting operational amplifiers as summers, integrators, or for other special purposes. Input requirement is ±300 v d-c and 6.3 v a-c. Output capability is 3 ma to ±150 v d-c, 15 ma to ±100 v d-c, with a

# Own a CEC Datarite?


# Use these Recording Papers for perfect records

CEC Datarite Recording Papers are expressly designed for use in CEC's Datarite Magazine. Type 22 Recording Paper produces excellent oscillograms at low writing speeds. Type 33 is suitable for all applications from the highest writing speeds down to the medium low range, due to its wide latitude of exposure. Both papers yield records of high trace contrast with light background and are practically stain resistant. Full facts? Call your CEC office or write for Bulletin CEC 1639-X39.

CEC

Technical Supplies Department

CONSOLIDATED ELECTRODYNAMICS

PASADENA, CALIFORNIA • A SUBSIDIARY OF BELL & HOWELL

CIRCLE 159 ON READER SERVICE CARD


# (Formerly the DTS 400)

Now, in full production, this amazing new silicon power transistor is available in quantity under its new number 2N2580. ■ Because of its high voltage and high temperature capabilities, the 2N2580 makes possible dramatic weight and space saving advantages to designers of missile, aircraft and commercially used equipment. Operation of 400 cps equipment from transformerless power supplies connected directly to 115v., 60 cps mains is just one practical application. Other applications include: frequency conversion and regulation, auto ignition systems, voltage regulators, electronic ripple filters, control circuitry and VLF amplifiers. ■ Contact us or your local distributor for prices and more data.

| | |
|---|---|
| Collector diode voltage $V_{CBO}$ ....... 400 Volts | Base current (continuous) ........... 1 Amp. |
| Emitter diode voltage $V_{EBO}$ .......... 5 Volts | Maximum junction temperature ........ 150°C |
| Emitter current (continuous) ........ 5 Amps. | Minimum junction temperature ...... −65°C |

| PARAMETER | CONDITIONS | MIN. | TYP. | MAX. | UNITS |
|---|---|---|---|---|---|
| $I_{CBO}$ | $V_{CBO}$=400V, T=125°C | — | — | 10 | ma |
| $I_{CEO}$ | $V_{CEO}$=400V | — | — | 10 | ma |
| $I_{CEX}$ | $V_{CE}$=400V, $V_{EB}$=1.5V TEMP.=125°C. | — | — | 5 | ma |
| $R_{Sat}$ | $I_C$=5 amp, $I_B$=1 amp | — | 0.15 | 0.25 | ohm |
| $h_{FE}$ | $V_{CE}$=5V, $I_{CE}$=5A | 10 | — | 50 | |
| THERMAL RESISTANCE | — | — | 0.5 | 0.7 | °C/watt |

Electrical characteristics @ $T_C$=25°C unless otherwise noted.
NPN silicon transistor furnished in TO-36 package.

Union, New Jersey
324 Chestnut Street
MUrdock 7-3770
AREA CODE 201

Detroit, Michigan
57 Harper Avenue
TRinity 3-6560
AREA CODE 313

Santa Monica, California
726 Santa Monica Blvd.
UPton 0-8807
AREA CODE 213

Syracuse, New York
1054 James Street
GRanite 2-2668
AREA CODE 315

Chicago, Illinois
5151 N. Harlem Ave.
775-5411
AREA CODE 312

General Sales Office: 700 E. Firmin, Kokomo, Indiana, GLadstone 2-8211—Ext. 500 • AREA CODE 317

DELCO RADIO
DEPENDABILITY
RELIABILITY

Division of General Motors


# DELCO RADIO SEMICONDUCTORS AVAILABLE AT THESE DISTRIBUTORS

**EAST**

**Binghamton, N. Y.**—Federal Electronics
P. O. Box 208/PI 8-8211

**Philadelphia 6, Penn.**—Almo Radio Company
913 Arch Street/WA 2-5918

**Pittsburgh 6, Penn.**—Radio Parts Company, Inc.
6401 Penn Avenue/EM 1-4600

**Newton 58, Mass.**—Greene-Shaw Distributing Co.
341 Watertown Street/WO 9-8900

**New York 36, N. Y.**—Harvey Radio Company, Inc.
103 West 43rd Street/JU 2-1500

**Syracuse 11, N. Y.**—Harvey Electronics-Syracuse, Inc.
Pickard Drive, P. O. Box 185/GL 4-9282

**Baltimore, Md.**—Radio Electric Service Company
5 North Howard Street/EL 9-3835

**SOUTH**

**Birmingham 5, Ala.**—Forbes Distributing Company, Inc.
2610 Third Avenue, South/AL 1-4101

**West Palm Beach, Fla.**—Goddard, Inc.
1309 North Dixie/TE 3-5701

**Richmond 20, Va.**—Meridian Electronics, Inc.
1001 West Broad Street/EL 5-2834

**MIDWEST**

**Detroit 3, Mich.**—Glendale Electronic Supply Company
12530 Hamilton Avenue/TU 3-1500

**Minneapolis 16, Minn.**—Admiral Distributors, Inc.
5305 Cedar Lake Road, St. Louis Park/LI 5-8811

**Indianapolis 25, Ind.**—Graham Electronics Supply, Inc.
122 South Senate Avenue/ME 4-8486

**Cleveland 14, Ohio**—Main Line Electronics Division
1260 East 38th Street/EX 1-4944

**Chicago 30, Ill.**—Merquip Electronics, Inc.
4939 North Elston Avenue/AV 2-5400

**Cincinnati 10, Ohio**—United Radio, Inc.
1308 Vine Street/MA 1-6530

**Kansas City 11, Mo.**—Walters Radio Supply, Inc.
3635 Main Street/VA 1-8058

**WEST**

**Dallas 1, Texas**—Adleta Company
1914 Cedar Springs/RI 1-3151

**Phoenix 20, Ariz.**—Astronics, Inc.
9130 North Central Avenue/944-1551

**Houston 2, Texas**—Harrison Equipment Company, Inc.
1422 San Jacinto Street/CA 4-9131

**Monrovia, Cal.**—Lynch Electronics, Inc.
1818 South Myrtle Avenue/EL 9-8261

**San Diego 1, Cal.**—Radio Parts Company
2060 India Street, Box 2710/BE 2-8951

**Los Angeles 15, Cal.**—Radio Products Sales, Inc.
1501 South Hill Street/RI 8-1271

**San Jose 13, Cal.**—Schad Electronic Supply, Inc.
499 South Market Street/CY 7-5858

**Denver, Colo.**—L. B. Walker Radio Company
300 Bryant Street/WE 5-2401

**Tacoma 2, Wash.**—C & G Electronics Company
2502 Jefferson Avenue/BR 2-3181

Ask for a complete catalog

DELCO RADIO
DEPENDABILITY RELIABILITY

**CIRCLE 213 ON READER SERVICE CARD**

bandwidth over 700 Kc. Amplifier drift is under 100 $\mu$v per 24 hr.

CIRCLE 325, READER SERVICE CARD


## Magnetic Modulator Has Two Isolated Inputs

TRANSMAGNETICS INC., 40-66 Lawrence St., Flushing 54, N. Y. Model 245 magnetic modulator features 1 percent linearity d-c to a-c conversion, 5 percent distortion, $\pm 5$ deg phase shift and 1 percent drift over $-55$ to $+85$ C operation. Applications are in algebraic addition of d-c and 400 cps a-c inputs, the latter typically from a synchro, resolver, tachometer or induction potentiometer. Other characteristics include: $3\frac{1}{2}$ v 400 cps output, null 30 mv max. **(326)**


## Tapped Delay Lines Require Less Circuitry

MICROSONICS, INC., 60 Winter St., Weymouth 88, Mass., has added new versatility to ultrasonic quartz delay lines through the development of processes which can add multiple inputs and outputs to these units without increasing attenuation or decreasing bandwidth. These devices may be operated up to 70 Mc for max bandwidth. No longer is the design engineer forced to compromise his system requirements or use many delay lines to

# COMPUTER RESEARCH ENGINEERS & LOGICAL DESIGNERS

Rapid expansion of the Computer Laboratory at Hughes-Fullerton has created several attractive professional opportunities for qualified Computer Research Engineers and Logical Designers. These positions require active participation in broad computer R & D activities in connection with Army/Navy computer systems and *new* large-scale, general-purpose computers. These multiple processor computers utilize advanced solid-state circuitry, gating and resolution times in the millimicrosecond regions; combine synchronous and asynchronous techniques for maximum speed and reliability.

These professional assignments involve broad areas of logical design, programming and system conception. Fields of interest include:

**▪ Distributed computers ▪ Advanced arithmetic processing techniques ▪ Mechanized design ▪ Asynchronous design techniques ▪ Utilization of parametrons in computers ▪ Studies in the utilization of multiple processor computers.**

These professional assignments involve such R & D areas as:

**▪ Solid state digital circuitry involving millimicrosecond logic**
**▪ Microwave carrier digital circuits**
**▪ Sub-microsecond core memory**
**▪ Thin film storage techniques**
**▪ Functional circuit concepts**
**▪ Micro-miniaturization concepts**
**▪ Tunnel diodes ▪ Microwave parametrons ▪ Circuit organization for maximal-speed computing.**

Located in Southern California's Orange County (the nation's fastest growing electronics center), Hughes-Fullerton offers you: a stimulating working environment; private or semi-private offices; long-term stability.

**CALL COLLECT TODAY!**
For complete information on these challenging assignments, call us collect **today!** Ask for:
**Mr. J. E. TENNEY at: TRojan 1-4080, ext. 3741.**

Or, airmail resume to: HUGHES-FULLERTON R & D, P. O. Box 2097, Fullerton 1, California.

An equal opportunity employer.

HUGHES
HUGHES AIRCRAFT COMPANY

# GREEN

## PRINTED CIRCUIT DRILL for versatility at LOW COST

**NEW...** *Spindle feed control provides infinite range of controlled feed rates.*

For prototype panels or high production work, drill quickly and easily without specialized labor or expensive tooling. The Green D2 Pantograph Engraver with D2-201 Pneumatic Attachment provides manufacturers with a Printed Circuit Drill having unlimited application flexibility. Check these features:

drills up to **100** holes/min.

- Spindle speeds to 26,000 R. P. M.
- Drill speeds and feeds independently adjustable
- May be used for profiling and engraving
- Boards can be stacked 4 deep for fast production
- Operates on "In Plant" compressed air or tank air (very small volume required)

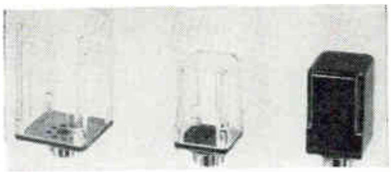
Whatever your requirements, the Model D2-201 is the answer — complete and ready to operate. Write or call today for full details.

**GREEN INSTRUMENT COMPANY, INC.**

**Dept. 63 • 295 Vassar Street**
**Cambridge, Mass. • ELiot 4-2989**


obtain a variety of delay times. This ability enables the company to provide taps which are any submultiple of the total delay time up to 1600 $\mu$sec.

CIRCLE 327, READER SERVICE CARD

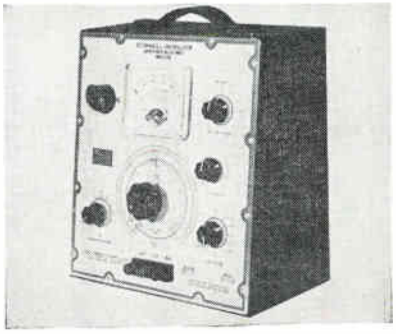


## Plug-In Housings Have Molded Bases

CATON INDUSTRIES, 646 W. First Ave., Roselle, N. J., offers a line of plug-in housings with fully molded octal, 9, 11 and 20 pin bases. Housings are available in a variety of colors and materials including Nylon, Lexan and Polystyrene. The enclosures are suited for relays, amplifiers, filters, logic packages or any assembly requiring dust and dirt protection. (328)

## Crucibles

MATERIALS ASSOCIATES, Box 126, Butler, Wisc., announces availability of molybdenum disilicide, titanium diboride, boron nitride, silicon nitride and other rare materials for electronic crystal growing. ((329)



## Capacitor Analyzer Tests 1 to 500-V Units

CORNELL - DUBILIER ELECTRONICS DIVISION, 118 E. Jones St., Fuquay Springs, N. C. Capacitor analyzer tests units with voltage ratings of 1 to 500 v. Model BF-71 measures capacitors with values ranging from 10$\mu\mu$f to 2,000 $\mu$f. Its resist-



# ultra-high precision capacitors

**Southern Electronics** high-precision capacitors are demonstrating their **proven** reliability today in twelve different missiles, analog computers, and many radar and communications applications.

**SEC high-precision capacitors** utilize polystyrene, providing .01% tolerances, and mylar and teflon to meet .5% requirements. They show excellent stability characteristics over an extended temperature range, and tolerances are unaffected even at extreme high altitudes.

The unusual accuracy, stability and reliability of **SEC capacitors** are the result of engineering experience concentrated on the design and manufacture of precision capacitors only, plus rigid quality control standards subjecting each capacitor to seven inspections during manufacture, plus final inspection.

Our engineering experience enables us to meet **your** size requirements, while holding to exact capacitance and tolerance specifications.

**SEC capacitors** are manufactured in a wide range of capacitance to meet your needs from 100 mmfd. to any higher value, and meet or exceed the most rigid MIL-SPECS.

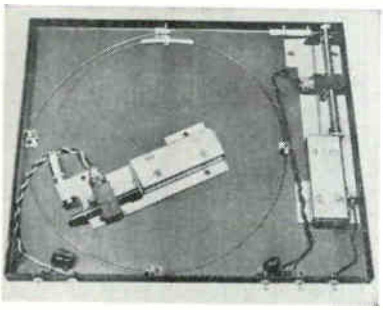
**Write today for detailed technical data and general catalog.**

**SOUTHERN ELECTRONICS** *Corporation*

150 WEST CYPRESS AVENUE
BURBANK, CALIFORNIA

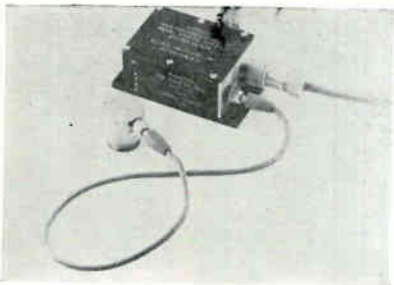
**CIRCLE 214 ON READER SERVICE CARD**

ance measurement range is 2.5 ohms to 25 megohms, and its current measurement range is 2 $\mu$a to 100 ma. Measurements are within 3 percent accuracy. Analyzer can also measure power factors up to 50 percent. **(330)**



## Delay Lines Have 20:1 S/N Ratios

ANDERSEN LABORATORIES, INC., 501 New Park Ave., West Hartford 10, Conn., announces a 250 $\mu$sec, 2 Mc magnetostrictive delay line that is capable of storing 500 bits of information in a return to zero mode of operation or 1,000 bits in a non-return to zero mode. With a 10-v drive pulse this line has an output voltage of 12 mv into 2,000 ohms termination. Signal to noise ratios of better than 20 to 1. Temperature coefficients of ½ ppm per deg C. **(331)**

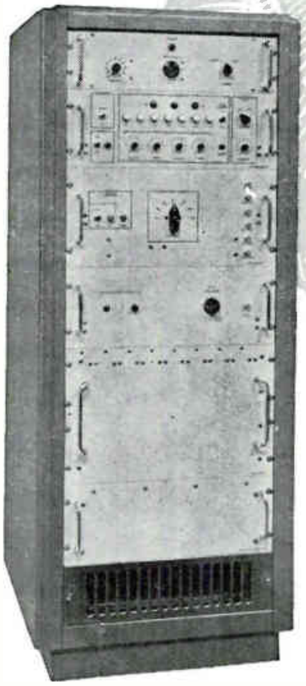


## Airborne System Measures Vibration

GULTON INDUSTRIES, INC., 212 Durham Ave., Metuchen, N. J., has developed a miniature airborne system for general purpose measurement of vibration and low g shocks. It weighs less than 5 oz. Operating in temperatures ranging from −40 F to +185 F over the frequency range of 15 cps to 5 Kc, model KA-1079 system has a quiescent noise level of less than 50 mv peak to peak max. Frequency response is


*I am the seeker incessant,*
*Endless avenues I roam, ravelling*
*Slender threads toward logical conclusions,*
*Splintering the thrum of inaudibility*
*To halt the hereafter with heartbeats,*
*Combing the static deep for denizens*
*Of stingered steel and polarized petards,*
*Slicing through quake and classic crust*
*To wrench the secrets of antiquity*
*From the very bowels of earth, so man,*
*Perhaps, can stir a step nearer heaven.*
*To sing the song of truth and amplify*
*Its message. My mission this, my task eternal—*
*I am sound.*

**TO HALT THE HEREAFTER WITH HEARTBEATS**



The very low frequency phenomena of heartbeats, like those of underwater sounds, speech, structural or geological shock and vibrations, no longer defy real time, high resolution analysis. Focussing broad scientific background and intensive research talents on the problem, General Applied Science Laboratories, Inc. has developed the SA-12 Spectrum Analyzer – capable of 1 second analysis time for 500 line resolution in frequency ranges from 0-250,000 cps.

A major component of GASL's MASSDAR (Modular Analysis, Speedup, Sampling and DAta Reduction) System, the SA-12 is compatible with GASL Probability Distribution Analyzer ND-501 and Spectral Density Analyzer DI-11.

*Other outstanding characteristics include:*

- **Six scales (Frequency ranges in cps):**

| | | |
|---|---|---|
| 0-5 | 0-250 | 0-5000 |
| 0-62.5 | 0-1000 | 0-250,000 |

- **Analysis of both real and recorded inputs**
- **Analysis of periodic, random and transient data**
- **Simultaneous digital and analog output**

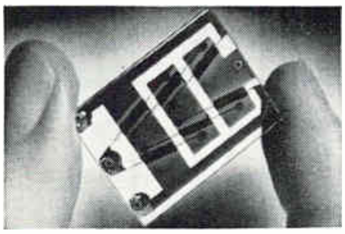
SEND FOR ILLUSTRATED BROCHURE OR
CALL TO MAKE ARRANGEMENTS FOR A DEMONSTRATION

***Pathways to Progress from the Ageless Truths of Technology***

**GENERAL APPLIED SCIENCE LABORATORIES, INC.**
**Merrick and Stewart Avenues, Westbury, New York**
**(516) EDgewood 3-6960**

# Straits Tin Report

**Tin oxide** film resistors afford guaranteed maintenance of tolerance for a given working life under all expected operating conditions, because of the power handling properties of tin oxide, its reliability and stability. This "total excursion" stability is particularly advantageous in computers and electronic equipment which use many components and are required for continuous use in situations inaccessible to maintenance and where operational failure is costly.



Experimental model of computer "brain cell" —a 6-cryotron circuit of tin and lead vaporized and deposited as thin films on glass.

**Superconductivity** results when tin and lead are exposed to very low temperatures. They lose all resistance to the electric current, allowing it to flow indefinitely without loss of power.

**Cryogenics** and the application of superconductivity, according to physicists, may lead to a new era in electrical technology. Tin and lead, still vital in electrical solders today, are important metals in cryogenic superconductivity.

**"Cold soldering"** wires to heat-sensitive electronic devices such as transistors is possible with gallium alloys which are soft at room temperature and harden in two hours. Adding 24% tin to an alloy of 44% copper and 32% gallium delays hardening time as long as 24 hours, permitting fabrication. This particular "cold solder" alloy will resist heat up to 650°C.

**Free Bulletin**

Write today for a free subscription to TIN NEWS—a monthly bulletin on tin supply, prices and new uses.


**The Malayan Tin Bureau**

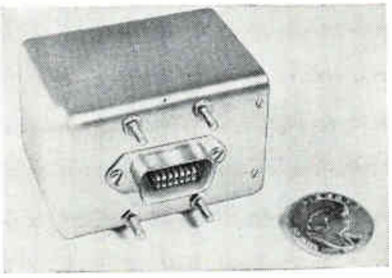
Dept. T-25L, 2000 K Street, N.W., Washington 6, D.C.


±10 percent from 15 cps to 5 Kc, relative to 100 cps. Linearity is +3 percent of best straight line.

CIRCLE 332, READER SERVICE CARD

## Time Delay Module For P-C Mounting

ELECTRONIC PRODUCTS CORP., 2315 Cecil Ave., Baltimore 18, Md. Model 500 (Mil-Spec) offers a wide variety of parameters with adjustable time delay ranges from 10 millisec to 225 sec. Features 0.400 grid-space terminals and slim configuration for mounting on p-c cards with 0.700 max height. Offers either a positive or negative solid state output, or relay contacts. Price is $55 each (in 100 quantities). (333)



## Frequency Standard Is Stud Mounted

MONITOR PRODUCTS CO., INC., 815 Fremont Ave., S. Pasadena, Calif., announces its 60 cps frequency standard. Short term stabilities are available up to ±5 parts in $10^7$ depending on temperature controller. Oscillator input is + and −12 v d-c. Oven input is 115 v a-c or 28 v d-c. Unit measures 2[illegible] in. by 3 in. by 2 in., is stud mounted and has a connector for input and output. Prototype price is $500 to $650 depending on stability required. (334)

## Conductivity Bridge

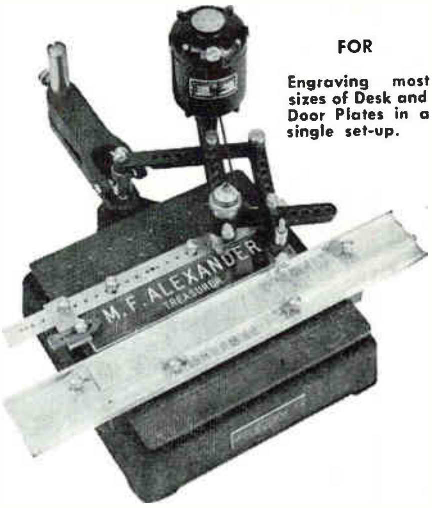
INDUSTRIAL INSTRUMENTS INC., 89 Commerce Road, Cedar Grove, N. J.


# MICO

**DESK AND DOOR PLATE ENGRAVER**

**FOR**

Engraving most sizes of Desk and Door Plates in a single set-up.




**FEATURES**

1. Six pantograph ratios—from 1.5:1 to 4:1.
2. Spindle has integral micrometer depth control of .250".
3. Uses standard tapered-shank engraving cutters.
4. New 19" Copy carriers hold 17" of master copy; Permits engraving about 11" line of characters in one set-up at the 1.5:1 ratio.
5. Three sizes of copy carriers available. Each positioned separately.
6. Work-holding fence speeds set-up and engraving time.

**Send for *illustrated Catalog***

**MICO INSTRUMENT CO.**

77 Trowbridge St. Cambridge 38, Mass.

CIRCLE 215 ON READER SERVICE CARD

*Angelica's* **SUPER IV CLEAN ROOM UNIFORMS**

**"Packaging People to Protect Products"**

Angelica's engineer-designed uniforms meet Air Force recommendations . . . prevent Clean Room contamination and insure product reliability.

Static-free, non-linting, acid resistant. Coveralls, smocks, head covers, gloves, boots, wiping cloths.

Contact your nearest Angelica office for help in determining your garment needs . . . or write for FREE CATALOG.

*Angelica*®

**Uniform Co.**

1427 Olive St., St. Louis 3, Mo.
107 W. 48th St., New York 36, N. Y.
445 N. LaSalle St., Chicago 10, Ill.
1900 W. Pico Blvd., Los Angeles 6, Calif.
317 Hayden St., N. W., Atlanta 13, Ga.

CIRCLE 216 ON READER SERVICE CARD

Model RC-18 conductivity bridge, a laboratory instrument that measures electrolytic conductivity and resistivity in $\mu$mhos and ohms to $\pm$0.1 percent accuracy, provides internal generator frequencies of 1,000 and 3,000 cps. (335)

## Chart Recorder Has Lightweight Design

BAUSCH & LOMB INC., Rochester 2, N. Y. The VOM-5 strip chart recorder can record multiple inputs directly: for example, resistance, milliamperes, or d-c volts, without use of external converters. Built into the design of the basic unit is an event marker pen (used together with the recording pen) that permits the technician to mark important passages. This device can be used both manually, in keeping a time-factor record, or in conjunction with related equipment to chart such data as opening and closing of relays, pilot light action, and other functions. (336)

## Low Noise Traveling-Wave Tube

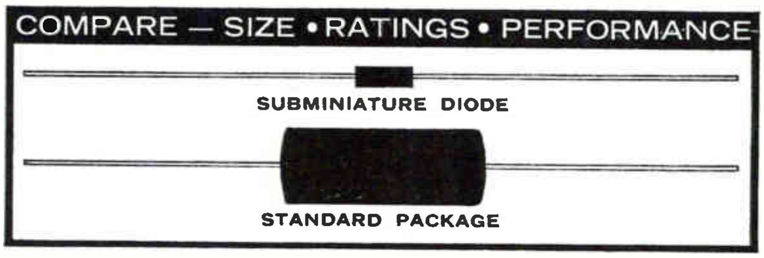
WARNECKE ELECTRON TUBES, INC., 175 West Oakton St., Des Planes, Ill., offers a rugged compact, lightweight, permanent magnet focusing traveling wave tube with less than 6.5 db noise figure, more than 27 db gain, collector voltage of 300 v and helix voltage of 260 v. Frequency range is 2,900 to 3,300 Mc. Type RW 101 operates at high efficiency because no special cooling is

actual size

# 4000 VOLT

# SUBMINIATURE SILICON DIODE

**Meets or exceeds the environmental requirements of MIL S-19500C and associated specification MIL Standard 750**




NAE TYPE NSS 1026, shown actual size above, is a high voltage rectifier in a subminiature diode package capable of delivering up to ¼ ampere average forward current and up to 4000 volts peak reverse voltage . . . and a maximum operating voltage of 2800 Volts RMS! It's just one of a family of six NAE subminiature diode types designed to be used where space, weight and/or environmental extremes are critical.

These units are constructed with high temperature, fatigue-free solder and encapsulated in a subminiature insulated housing. They withstand thermal shocks of $-65°$C to $+150°$C and cycling with temperature excursions up to 573°C. They offer ¼ ampere power at 25°C ambient temperature, despite their small size, with a derating factor of only $-2$ ma/°C. Operating and storage temperature range: from $-65°$C to $+150°$C.

**WRITE FOR DATA SHEET #4750.**

**ELECTRICAL CHARACTERISTICS**

| TYPE | Peak Recurrent Inverse Voltage (volts)† | Maximum RMS Voltage (volts) | Maximum Average Forward Current @ 25°C (ma) | Maximum Forward Voltage @ 25°C (volts @ ma) | Max. Avg. Inverse Current @ 125°C ($\mu$a)† |
|---|---|---|---|---|---|
| 1N3643 | 1000 | 700 | 250 | 5.0 @ 250 | 100 |
| 1N3644 | 1500 | 1050 | 250 | 5.0 @ 250 | 100 |
| 1N3645 | 2000 | 1400 | 250 | 5.0 @ 250 | 100 |
| 1N3646 | 2500 | 1750 | 250 | 5.0 @ 250 | 100 |
| 1N3647 | 3000 | 2100 | 250 | 5.0 @ 250 | 100 |
| NSS 1026 | 4000 | 2800 | 250 | 5.0 @ 250 | 100 |

† Measured at 10 $\mu$Adc. @ 25°C

† Full cycle average with device operating at maximum rated inverse voltage and average forward current.

**NORTH AMERICAN ELECTRONICS, INC.**
West Lynn, Mass.
SUBSIDIARY OF LRK
nae



CIRCLE 165 ON READER SERVICE CARD

# VITREOSIL®


## PURE FUSED QUARTZ TAKES MORE SHOCK, HEAT AND ACID

THAN GLASS OR PORCELAIN —

RESISTS TEMPERATURES TO 1050°C —

HANDLES MOST HOT ACIDS WITHOUT ETCHING —

WITHSTANDS CONSTANT THERMAL SHOCK —

EXCELLENT ELECTRICAL AND OPTICAL PROPERTIES —

LABORATORY AND INDUSTRIAL WARE —

SPECIAL FABRICATION —

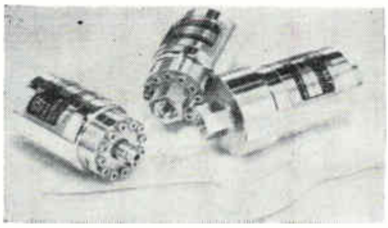
SPECTROSIL® FOR PURITY

ASK FOR 32 PAGE FREE CATALOG — 10

**THERMAL AMERICAN**
FUSED QUARTZ CO.
RT. 202 AND CHANGE BRIDGE RD.
MONTVILLE, N. J.

required. For input tube applications, it improves a radar receiver's signal/noise ratio and adapts easily to any radar in service.

CIRCLE 337, READER SERVICE CARD



## Airborne Transducer Provides 5-V D-C Signal

TABER INSTRUMENT CORP., 107 Goundry St., North Tonawanda, N.Y. A Teleflight bonded strain gage pressure transducer/amplifier model 185/290-1 is designed for space vehicle and rocket applications where reliability, weight and size are most important. It delivers an amplified, 5 v d-c signal in proportion to the applied pressure. It is designed to operate at temperatures from −65 to +250 F. (338)

## D-C Amplifier Has High Power

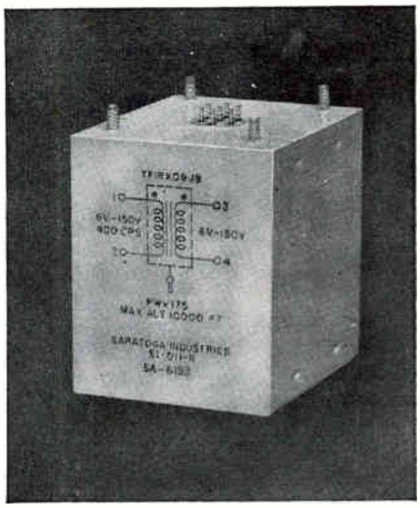
SOLID STATE INSTRUMENTS CORP., Cambridge, Mass. An all solid state high power d-c amplifier can deliver 300 w continuous power at 50 C. It is integrally packaged with a power supply for operation from 115 v a-c, 60 cps. The power supply features scr overcurrent protection so that the output can be shorted with no damage to the amplifier. Applications include drive for direct drive torque motors and voice coil type actuators encountered in gyro test equipment, and vibration test equipment. (339)

## Meter Calibrator

TWINCO, INC., 9 Erie Drive, Natick, Mass. There are no rms/average,

## SARATOGA INDUSTRIES REPORT

**A Precision Ratio Transformer for Military Applications — SI-011-R**



Custom designed and manufactured to meet the rigorous requirements of electronic checkout systems.

**FEATURES**—low phase shift—high transformation accuracy—high input impedance—hermetically sealed to meet requirements of MIL-T-27A, grade I, class R.

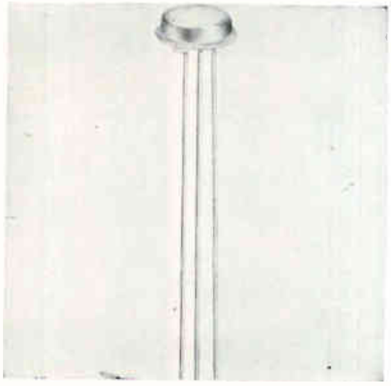
**SPECIFICATIONS —**
Input Voltage: 150 V RMS
400 cps±2 cps
Input Impedance: 6-30 V 1 meg min.
30-60 V 1.5 meg min.
60-120 V 2.0 meg min.
Input Current: 6 ua max. @ 6 V 400 cps
20 ua max. @ 30 V 400 cps
30 ua max. @ 60 V 400 cps
Load Impedance: 10 meg min.
Phase Shift: primary to secondary ± .15 milliradians
Turns Ratio: primary to secondary
max. 1.00006
min. .99994

For full information about Saratoga Industries complete design, engineering and production facilities, write —

**SARATOGA INDUSTRIES**
A Division of Espey Mfg. & Electronics Corp.
Saratoga Springs, N. Y. • Telephone 4100

CIRCLE 217 ON READER SERVICE CARD

loading, friction or parallax errors when using model MC5500 meter calibrator which provides high power output on all 54 a-c and d-c voltage & current ranges. (340)



## Planar Transistors Come in Four Models

SPERRY SEMICONDUCTOR DIVISION, Norwalk, Conn. The 2N2590-2N-2593 series of complementary *pnp* silicon planar transistors are designed for high-frequency, high-voltage linear amplifier, oscillator and nonsaturating switching circuits. Four restricted beta ranges, two-point control of $h$ parameters and typical $f_T$ of 100 Mc insure superior performance in small signal applications. (341)

## Pressure Sensor for Cryogenic Service

TRANS-SONICS, INC., Burlington, Mass., has available a series of pressure potentiometers designed for cryogenic service. They have a temperature sensitivity of less than 0.005 percent/deg F through their operating range of −320 F to +160 F. A time constant of 3 millisec and ability to withstand 50 g to 2,000 cps vibration make the units ideally suited for airborne missile applications. (342)

## Coaxial Adapters

OMNI SPECTRA, INC., 8844 Puritan Ave., Detroit 38, Mich. Coaxial


# EIC MODEL H-1000 SERIES MAGNETIC HEADS

AM • FM • AM / FM combination

EIC magnetic recording head components are now available for any recording or playback system. Originally designed for use in EIC recording systems, these heads are now proved and offered as industrial electronic components. Their wide range of electrical and mechanical adaptability makes them your best buy for laboratory and industrial applications in recording, control, and data analysis.

**Features:**

- Vacuum impregnated and potted in epoxy resin.
- Mu-metal shielded.
- Precise mechanical tolerances.
- Available in single or multi-head blocks.
- Blocks available in permanently imbedded or individually replaceable heads.

**Applications:**

- Drum, reel, or disc recording.
- Sound or seismic recording.
- Process instrumentation and control computers.

**Specifications**

| Type No. | Track Width (In.) | Gap Width (In.) | Over-All Width (In.) | Inductance (mh) | Resistance (Ohms) |
|---|---|---|---|---|---|
| A- 12 | 0.012 | 0.00025 | 0.125 | 6.7 | 6.75 |
| A- 40 | 0.040 | 0.00025 | 0.125 | 600 | 215 |
| A- 50 | 0.050 | 0.00025 | 0.125 | 750 | 220 |
| B- 50 | 0.050 | 0.00025 | 0.125 | 65 | 30 |
| C- 50 | 0.050 | 0.0010 | 0.125 | 325 | 220 |
| A- 60 | 0.060 | 0.0010 | 0.207 | 3 | 200 |
| A- 90 | 0.090 | 0.00025 | 0.207 | 100 | 30 |
| A-100 | 0.100 | 0.00025 | 0.187 | 1200 | 265 |
| B-100 | 0.100 | 0.0010 | 0.187 | 500 | 265 |
| C-100 | 0.100 | 0.00025 | 0.187 | 375 | 265 |
| A-125 | 0.125 | 0.0020 | 0.207 | 29 | 34 |
| B-125 | 0.125 | 0.0050 | 0.207 | 1.17 | 1.9 |
| C-125 | 0.125 | 0.0050 | 0.207 | 0.224 | 0.7 |
| A-140 | 0.140 | 0.0010 | 0.207 | 500 | 230 |
| B-140 | 0.140 | 0.0010 | 0.207 | 7 | 10 |
| C-140 | 0.140 | 0.0030 | 0.207 | 235 | 230 |
| A-30-3 | 0.030 | 0.001 | 0.145 | 7.0 | 14.5 |

EIC

**ELECTRODYNAMIC INSTRUMENT CORPORATION**
SUBSIDIARY OF REED ROLLER BIT COMPANY
TWX 713-571-341 / RI 8-2760 1841 Old Spanish Trail — Houston 25, Texas
Cable: EICORP — Houston

EIC REPRESENTATIVES

CLYDE M. SALISBURY CO., San Francisco, 1453 Seventh Ave. — MO 4-0586 • REPCO SALES, Miami, 401 N.W. 71st Street — PL 7-2911 • ELECTRONIC SALES, INC., Denver 22, 2641 S. Ivy Street — SK 6-4148 • WALLACE AND WALLACE, Los Angeles 15, 1206 Maple Ave. — RI 7-0401 • BRANCH OFFICE: P. O. Box 30201, Dallas 30 — EM 1-0174.

CIRCLE 167 ON READER SERVICE CARD



**YOUR POSTMASTER SUGGESTS:**

Avoid the Last Minute
Christmas Holiday Rush

**MAIL EARLY**

To Out-of-Town Points, by December 10th
For Delivery in your Local Area, by December 15th

**WRAP PACKAGES SECURELY**

ADDRESS PLAINLY—INCLUDE POSTAL
ZONE NUMBER AND YOUR RETURN ADDRESS

**SHOP AND MAIL EARLY!**

# AUGAT
HEAT DISSIPATORS FOR SEMICONDUCTORS

## Now... an expanded line!

9016

Approx. radiating surface 83 sq. in.

9015

Approx. radiating surface 1.9 sq. in.

Augat's extensive line now includes these new heat dissipators. The 9016 Series will handle the power requirements of the largest semiconductors. The 9015 Series, designed for the TO-5 and TO-9 cases, effectively increases the surface area by a factor of six. The Augat line includes:

| Model Number | for Semi-conductor | Thermal Res (Natural Conv.) |
|---|---|---|
| 9006 | TO-3 | 6.5°C/Watt |
| 9008 | MT-1 and Stud Mounts | 5.2 |
| 9009 | TO-36 | 5.0 |
| 9014 | TO-8 and Stud Mounts | 11.0 |
| 9015 | TO-5 and TO-9 | 40.6 |
| 9016 | TO-3, TO-36, MT-1 and Stud Mounts | 2.1 |

Dissipators are also made to customer specifications. Write today for Catalog HD 462 describing the Augat line in full detail.

**AUGAT INC.**
30 Perry Avenue, Attleboro, Mass.


adapters only 1¼ in. long, and with vswr under 1.15:1 up to frequency of 11.0 Gc provide convenient transition between type N and TNC connectors and the new OSM and BRM miniature connectors.

CIRCLE 343, READER SERVICE CARD


## Solid State Switch Features Low Offset

WESTERN ELECTROSYSTEMS, INC., 1041 E. Seventh St., Long Beach 13, Calif. Miniature solid state switch features low offset, high speed and low cost. Driving signal characteristics are very flexible; the Ministat can be driven from a square wave from 0 to 50 Kc and typically requires 6 to 12 v at 3 to 8 ma to operate. Switching properties are such that 0 to ±12 v signals may be switched at currents up to 10 ma. Nominal forward resistance is 3 ohms; a max offset voltage of not greater than ±50 μv from −25 C to +70 C is guaranteed. (344)

## Parametric Amplifier Designed for C-Band

FERRANTI LTD., Hollinwood, Lancs., England. Type VCA/C/III amplifier has been designed for the frequency range 4-5 Gc as a simple compact addition to a receiver to improve its noise figure. The circuitry is waveguide throughout enabling it to be readily incorporated in an existing system. The parametric amplifier operates in a nondegenerate reflection type mode with an idler frequency of 6,000 Mc, a three-port circulator being used to separate input and output signals. (345)

## Voltage Comparator

PHILCO CORP., Lansdale Div., Lansdale, Pa. A d-c voltage comparator


for **INSULATING CONDUCTING PROTECTION** in RESEARCH and INDUSTRIAL APPLICATIONS

HumiSeal®

Synthetic Materials

- General purpose anti-corrosive weather resistant coatings
- Coatings for electronic applications
- Impregnants and encapsulants
- Adhesives and cements
- Potting and casting compounds

Our Engineers and Chemists will develop special materials to meet your requirements.

Write for data

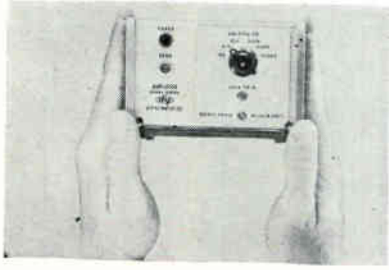
COLUMBIA TECHNICAL CORPORATION
Woodside 77, N.Y. • YE 2-0800

CIRCLE 218 ON READER SERVICE CARD

that exhibits differential sensitivity of 50 μv will accept inputs of any parameter that can be reduced to a d-c voltage and compare the unknown voltage to an external d-c limit reference voltage. **(346)**

## Telemetry Oscillator

SONEX, INC., Twenty East Herman St., Philadelphia 44, Pa. The TEX-3107, an all solid state high environmental millivolt controlled oscillator developed for the telemetering of millivolt signals in aircraft and missile applications, eliminates the need for a costly high gain d-c amplifier in addition to a subcarrier oscillator. **(347)**



## D-C Amplifier Covers Wide Band

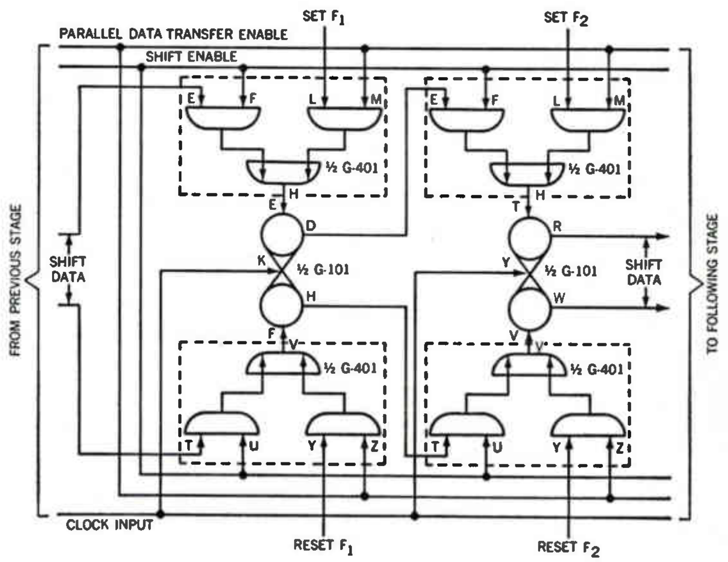
DYMEC, a division of Hewlett-Packard Co., 395 Page Mill Road, Palo Alto, Calif. The DY-2460A high-gain d-c amplifier for systems and bench use features a photoconductive chopper and solid state circuitry for long life and exceptional reliability on low-level measurements. The instrument will supply an output of ±10 v peak at 10 ma. Zero drift is less than 1 μv per week, noise less than 4 μv peak-to-peak and gain stability is 0.01 percent per week. Fast settling time and rapid overload recovery make the unit ideal for systems use. **(348)**

## Dry Reed Relays

LINE ELECTRIC DIVISION, Industrial Timer Corp., U. S. Highway 287, Parsippany, N. J. Dry reed relays that provide fast acting, reliable switching at low cost in transistor testing equipment are available in various packages including plug-in, p-c and solder lug, with from one to 12 reeds in the package. **(349)**


EECo G-Series Circuit Applications

# THIS 10 MC SHIFT REGISTER




**10 Mc Shift Register with synchronous data entry followed by synchronous serial shifting, with true logic levels enabling the logic inputs of the JK flip-flops, and with data entered or shifted at clock time.**

Clock Input
Max. rise time: 25 nanoseconds
AC noise: reject at least 2 volts peak to peak
True level: −6 VDC (nominal)
False level: 0 VDC (nominal)

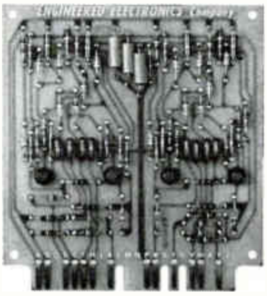
EECo Modules/Bit
One G-401 universal logic gating package
One-half G-101 dual JK flip-flop

Power
−12 VDC: 2F/F=60 Ma, each 401=32 Ma
−6 VDC: each 401=32 Ma
+6 VDC: 2F/F=6 Ma

Logic Input
True level: −6 VDC (nominal)
False level: 0 VDC (nominal)
Logic transfer frequency: up to 10 Mpps

# COSTS LESS THAN $68/BIT

Yet, it utilizes the most reliable circuits you can buy today—EECo G-Series extended-service digital-circuit modules. Every EECo module is guaranteed reliable and will be repaired or replaced under conditions defined in the company's written warranty. In addition, every module is a catalog item, available from stock. You can select from the 10 Mpps, 500 Kpps, and 25 Kpps basic frequency groups. No matter what your choice, three major benefits will always be yours—reliability, economy, availability.

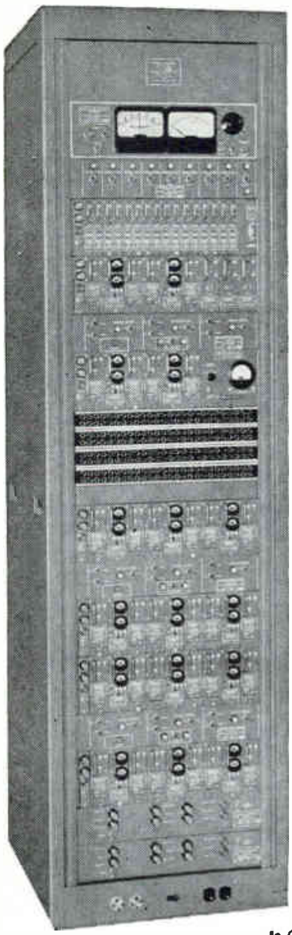


This is just one of the many practical applications of this versatile new series. Perhaps another will be of direct interest to you. Write, wire, or phone today for details; ask for the new G-Series catalog or a call from one of our experienced staff of applications engineers.

ENGINEERED ELECTRONICS Company

***ENGINEERED ELECTRONICS Company***
1441 East Chestnut Avenue, Santa Ana, California
Telephone: 547-5651 Cable Address: ENGELEX

CIRCLE 169 ON READER SERVICE CARD



NEW BETTER-THAN-EVER

# RELIABILITY

for long-distance point-to-point communications

NORTHERN RADIO

NEW 16-CHANNEL TRANSISTORIZED VOICE FREQUENCY DIVERSITY CARRIER TELEGRAPH TERMINAL TYPE 235 MODEL 3

**MIL DESIGNATION AN/FGC-61A**

NEW

. . . All units militarized: components and design approved by U.S. Military.

. . . Converters have equalized gain and adjustable time delay in each channel for better diversity performance and interchangeability.

. . . Switching Panels provide "local" or "remote" selection of 2-channel or 4-channel diversity modes.

. . . Combiners have adjustable gains in each channel, for complete switching flexibility, and the combining follows an ideally modified square law function for both 2-channel space or frequency and 4-channel space plus frequency diversity.

. . . Keyers have adjustable "threshold" sensitivity control and simplified input circuit selection.

. . . Dotter and Delay Indicator provides test keying signal source for keyers and delay equalizers in all channels.

Write for complete literature.

*Pace-Setters in Quality Communication Equipment.*

NORTHERN RADIO COMPANY, inc.
147 WEST 22nd ST., NEW YORK 11, NEW YORK
In Canada: Northern Radio Mfg. Co., Ltd., 1950 Bank St., Billings Bridge, Ottawa, Ontario.

CIRCLE 219 ON READER SERVICE CARD



# INDUSTRIAL COLORADO

*PRIME SITE FOR ELECTRONIC INDUSTRIES!*

Locate in the middle of the great new industrial west... right between the giant west coast and expanding midwest markets... Locate in Colorado, the transportation hub west of the Mississippi. Many of the nation's leading electronic companies have Colorado addresses... enjoy Colorado's year 'round Pleasant Living bonus. Discover the advantages for your company in Colorado.

*WRITE TODAY FOR FREE EXECUTIVE PORTFOLIO..."INDUSTRIAL COLORADO"*

9-booklet portfolio containing the latest data on Colorado's industrial assets, sites, markets, labor and of course... Pleasant Living. All inquiries are strictly confidential.

COLORADO DEPARTMENT OF DEVELOPMENT
11 STATE CAPITOL DENVER 2, COLORADO


# Literature of the Week

AUTOMATED BOBBIN CORE: Infinetics, Inc., Electro-Magnetic Div., 1601 Jessup St., Wilmington 2, Del. Catalog 21-1 introduces bobbin cores manufactured by automation. It explains the process and resultant advantages.
CIRCLE 350, READER SERVICE CARD

NOISE FIGURE Hewlett-Packard Co., 1501 Page Mill Road, Palo Alto, Calif. *Application Note* No. 57, defining noise figure and how it may be measured, is available. (351)

D-C POWER SUPPLY Perkin Electronics Corp., 345 Kansas St., El Segundo, Calif., offers a technical engineering data sheet on a 0-40 v, 0-5 amp d-c power supply. (352)

ELECTRONIC VOLTMETERS Metronix Division of Assembly Products, Inc., Chesterland, O. Panel-mounting voltmeters with multi-range accuracies of $\pm$ 0.5 percent are among the instruments described in a 16-page catalog. (353)

SCIENTIFIC COMPILER SYSTEM Honeywell Electronic Data Processing, 60 Walnut St., Wellesley Hills 81, Mass., has published a bulletin describing Automath, its scientific compiler system. (354)

TRANSISTORS Amelco, Inc., 341 Moffett Blvd., Mountain View, Calif. A 16-page folder gives technical data on a line of silicon planar transistors, field effect transistors, and special assemblies. (355)

ENCAPSULATED CIRCUITS Clevite Transistor, Waltham 54, Mass., has available bulletin TB-300 covering technical data on "milli-pak" encapsulated circuits. (356)

SEMICONDUCTOR STRAIN GAGES Baldwin-Lima-Hamilton Corp., 42 Fourth Ave., Waltham 54, Mass. Features and advantages of self-temperature-compensated semiconductor strain gages are described in a data bulletin. (357)

AEROSPACE PRODUCTS Transco Products Inc., 4241 Glencoe Ave., Venice, Calif. Booklet summarizes the company's lab and engineering facilities for production of aerospace components and systems. (358)

HIGH POWER VARACTOR DIODE Bendix Semiconductor Division, Holmdel, N.J. An engineering data sheet describes and illustrates a high power silicon varactor diode. (359)

ACTIVE FILTER NETWORK Guillemin Networks, Inc., 381 Eliot St., Newton 64, Mass. Booklet describes notch filters that are said to be 20 to 50 times sharper than conventional twin-tees. (360)

SYNCHROS AND RESOLVERS Kearfott Division, General Precision Aerospace, Little Falls, N. J. A recent catalog sheet discusses a series of size 11 industrial synchros and resolvers. (361)

DIGITAL STEPPING RECORDER Digi-Data Corp., 4908 46th Ave., Hyattsville, Md. Catalog sheet illustrates and describes model DSR 1400 digital stepping recorder. (362)

TEST EQUIPMENT Precision Apparatus Co., Inc., 70-31 84th St., Glendale 27, N. Y. A 20-page booklet contains features, specifications and prices of a complete line of precision test equipment. (363)

DIFFUSION FURNACES Hevi-Duty Equipment Co., Watertown, Wisc., has issued a bulletin describing diffusion furnaces for processing semiconductor products. (364)

NYLON PRECISION PARTS Cosmo Plastics Co., 3239 West 14th St., Cleveland 9, O. Catalog 1062 provides specifications on Nylon bobbins, washers, and other precision parts now available from stock. (365)

INFRARED PRODUCTS Barnes Engineering Co., Opti-therm Division, 30 Commerce Road, Stamford, Conn., has available data sheets on an infrared thermometer and an infrared micrometer. (366)

COAXIAL CABLE Phelps Dodge Electronic Products Corp., 60 Dodge Ave., North Haven, Conn., has published bulletin CT3 illustrating and describing Spirafil coaxial cable. (367)

LOW TORQUE CAPACITORS National Radio Co., Inc., 37 Washington St., Melrose, Mass., offers a specification sheet covering four types of low torque capacitors. (368)

PRINTER SYSTEM Anelex Corp., 150 Causeway St., Boston 14, Mass., has published a four-page brochure describing the model 300 high speed printer system. (369)

MOTOR SPEED CONTROL Vectrol Engineering, Inc., a subsidiary of Sprague Electric Co., 85 Magee Ave., Stamford, Conn. Versatile adjustable speed scr shunt motor drives are described in technical paper VTP-2. (370)

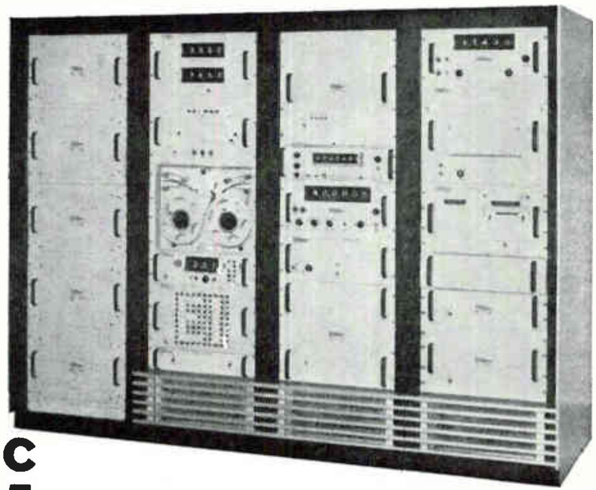
VIBRATION TRANSDUCERS Consolidated Electrodynamics Corp., 360 Sierra Madre Villa, Pasadena, Calif. Bulletin covers types 4-102A and 4-103 vibration transducers. (371)

SIGNAL SIMULATOR Correlated Data Systems Corp., 1007 Air Way, Glendale, Calif. Two-page brochure 211 describes model SS1000 pcm telemetering simulator. (372)

DIGITAL TRANSDUCERS Diginamics Corp., 2525 E. Franklin Ave., Minneapolis 6, Minn., has available a condensed catalog on the complete line of its digital transducers and data handling equipment. (373)

R-F DIODE American Micro Devices, Inc., 10888 N. 19th Ave., Phoenix 20, Ariz. Data sheet covers the AM600 r-f diode that can operate as either a rectifier or switch from 1 to 50 Mc. (374)


*Better Measuring from* EI



# COST CUTTING AUTOMATIC SYSTEM TESTER

*built for* RAYTHEON

*by Electro Instruments*

Key to the speed, accuracy, high reliability and *cost-saving* features of this automatic system tester created for Raytheon is the EI *all solid state* Digital Multimeter.

Combining simplified circuitry, fewer parts, improved packaging and *lower price*. EI D.V.M's. can swiftly and accurately evaluate any component or complete assembly which can be checked by the measurement of a DC voltage, AC voltage, DC ratio, resistance, capacitance, inductance, or impedance.

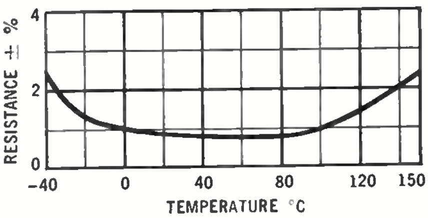
The automatic system tester built for Raytheon, for example, measures up to 1000 signal inputs programmed for a random scan of AC or DC voltages, AC and DC voltage ratios, frequencies and resistances. Measurement mode and tolerance limits are programmed by punched paper tape. The measured data and in or out-of tolerance information are recorded on an output punched paper tape and strip printer. The system also includes an auxiliary stimuli control which provides up to 100 closures for external circuit control on command of the program tape.

*For full details on EI's individual instruments in the digital measuring field, or our complete systems capability in data acquisition, display and control — call the EI office nearest you or write direct.*

**Electro Instruments, Inc.**
8611 Balboa Avenue, San Diego 12, California


# new low cost precision THERMISTORS

*match standard curves -40° to 150° C.*




Resistance Tolerance
30K thermistor No. 44008

■ YSI precision thermistors can now be stocked by the thousands, used interchangeably. The high cost problems of matching, padding, auxiliary resistances or individual calibration have been eliminated.

■ Stock base resistances at 25° C. of:

| | | |
|---|---|---|
| 100 Ω | 1K | 10K |
| 300 Ω | 3K | 30K |
| | | 100K |

■ For 5 years YSI has manufactured precise, interchangeable thermistors for laboratory instrumentation.

■ Now we offer as components a family of precision thermistors which match the same Resistance-Temperature curves to within ± 1% over a wide temperature range.

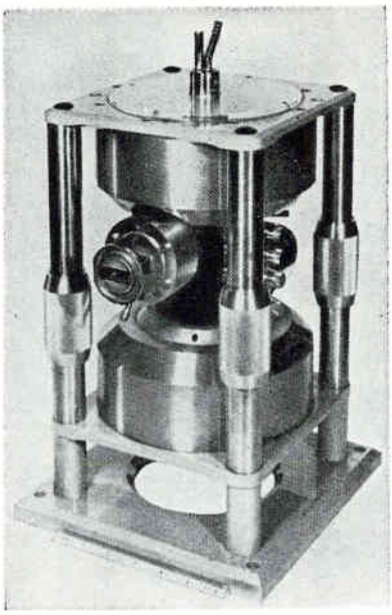
■ $4.90 each, with substantial discounts on quantity orders.

■ Quantities under 100 available from stock at Newark Electronics Corporation and its branches.

**For complete specifications and details write:**

**YSI—COMPONENTS DIVISION**
Yellow Springs, Ohio


## NEW BOOKS



*Doppler radar water-cooled klystron in focusing magnet assembly*

### Permanent Magnets and Magnetism

Edited By D. HADFIELD

*John Wiley & Sons, New York,* 1962, 556 *p*, $16.50.

A collection of thirteen authoritative articles, this book should prove a useful reference volume.

The brief historical chapter makes fascinating reading; subsequent chapters establish magnetic theory and deal with selection of materials and design procedures in enough detail to serve as a working manual. Further chapters deal with manufacturing techniques, magnetizing procedures, magnetic stability, magnet metallurgy and contemporary research in the field, with prediction of future trends.—G. V. N.

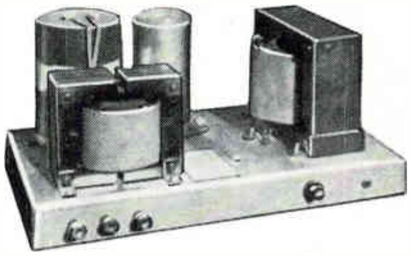
### Linear Electric Circuits

By Z. HENNYEY

*Addison-Wesley Publishing Company, Inc., Reading, Mass.,* 1962, 330 *p*, $14.

While this text is "intended for those who are already experts", it


**LOW VOLTAGE POWER SUPPLY MODULES**



**Model 287:** 28 Volt, 7 Amps Heavy Duty $96.00
**(FOB Houston)**

A complete line of fixed low voltage power modules, designed for operation where only a SLIGHT RISE ABOVE AMBIENT TEMPERATURE can be tolerated. These units feature CONTINUOUS OPERATION; they may be rack mounted, or employed in any position.

**Voltages:** 10-12-20-24-28-32 or 36 volts.
**Amps:** 2- 5- 7- or 10 amperes.
**Filtered:** To .02, capacitive, inductive, capacitive.
**Rectifiers:** PRV ratings 2, 5 to 6 X above E output. 1 output specs of rectifiers, 1.5 to 4.2 X full output amperage rating of power supply.
**Size:** 13" x 7". 6" high.

Units are supplied with A.C. cord, are fused, have reversible ground polarity, removable mounting brackets, are shipped READY TO WORK.

**LOSHACK ELECTRONICS**
1010 QUITMAN • FA 3-9812
HOUSTON, TEXAS

**CIRCLE 231 ON READER SERVICE CARD**

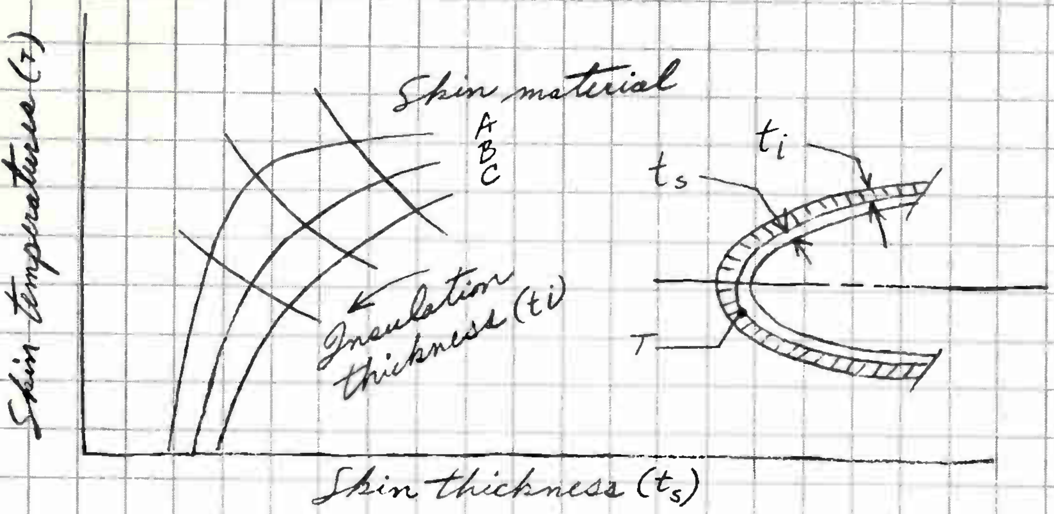
**NIMS**

**NATIONWIDE IMPROVED MAIL SERVICE PROGRAM**

**For Better Service Your Post Office Suggests**

That You Mail Early In The Day!

*Of interest to engineers and scientists*




# RE-ENTRY STRUCTURES

*. . . among the more than 500 R&D programs underway at Douglas*

Douglas is engaged in an intensive program to further development of high temperature structures for re-entry vehicles.

Research is being conducted on super alloys, refractory metals, ceramics, graphites, and high temperature insulative and ablative materials. Representative structural components are being manufactured and tested in our laboratories. Theoretical analysis is being developed and compared with the experimental research data. The need is emphasized by the inadequacy of conventional materials and structures at the temperature levels of re-entry flight.

Other areas of current structures research include: development of titanium and fiberglas tankage for cryogenic and storable propellants; analysis of sandwich domes, cylinders and cones under load and thermal gradients; stability of landing legs for lunar touchdown; meteoroid and radiation shielding; and development of inflatable structures.

**Of career interest to engineers and scientists**

Stimulating work assignments and wide professional growth are available at Douglas for men who can integrate the requirements of structural design with strength and load analysis, thermodynamics, guidance and control, weight optimization and manufacturing.

Also urgently needed are qualified engineers and scientists in the wide variety of other areas related to missile and space systems. Scholarships and financial assistance are available for you to continue your studies in such fine universities as Cal Tech, U.C.L.A., and Southern California.

Send us your resume or fill out and mail the coupon. Within 15 days from the receipt of your letter, we will send you specific information on opportunities in your field at Douglas.

**DOUGLAS**

**MISSILE & SPACE SYSTEMS DIVISION**

An equal opportunity employer

**Mr. F. V. Edmonds** F-14
**Missile and Space Systems Division**
**Douglas Aircraft Company**
**3000 Ocean Park Boulevard**
**Santa Monica, California**

Please send me full information on professional opportunities in my field at Douglas.

Name ____________________

Engineering or scientific field ____________________

Address ____________________

City ____________________ State ____________


CIRCLE 220 ON READER SERVICE CARD

WANTED

Thermoelectric materials suppliers and potential suppliers for the following materials:

Lead telluride
Zinc antimonide
Bismuth telluride
Silicon Germanium alloys

Send detailed specifications to Box 101
c/o electronics
330 West 42nd Street
New York 36, N. Y.

DON'T CUT CORNERS on vital parts! Buy the best .....

SHIZUKI CAPACITORS

Paper, Metallized Paper, and Plastic Film (Polyethylene) Tubular Capacitors. Mylar, Metallized Lacquer Film and Thin Film Capacitors.
C-R Part, Electrolytic Capacitors, Paper and Metallized Paper Capacitors by MIL Spec.

SHIZUKI ELECTRIC WORKS CO., LTD.
HEAD OFFICE: 1, TAISHA-CHO, NISHINOMIYA, JAPAN
CABLE ADDRESS: "CAPACITOR" NISHINOMIYA.
TOKYO FACTORY: 10-7, ARAIJYUKU, OTA-KU, TOKYO.

CIRCLE 230 ON READER SERVICE CARD

will probably be found equally useful by engineering senior and postgraduate students. It develops linear circuit theory from basic ideas through two-, four- and three-terminal networks to wave filters and circuits such as the negative-impedance transformer and equalizers. Separate chapters deal with the relevant topology, and an appendix on operational calculus provides the necessary mathematical background. The book is sufficiently self-contained to be useful in its field without extensive references to other literature.

## Instrumentation for Engineering Measurement

By R. H. CERNI and L. E. FOSTER

*John Wiley & Sons, Inc., New York,* 1962, 456 *p*, $12.50.

This book is designed to acquaint the engineer, student or manager with the many types and applications of measuring devices, transducers, amplifiers, indicators, recorders and other devices that are available so that he may make an intelligent and efficient selection in any given measurement situation. The approach is illustrative rather than analytic.

Basic measurements are described first, and then specific types of instruments are covered from primary sensors all the way to telemetry, data reduction and computer data processing. The principles are later illustrated by several instrumentation systems representative of advanced contemporary practice.—G. V. N.

## Digital Information Processors

(Selected Articles on Problems of Information Processing)

Editor: WALTER HOFFMANN

*Interscience Publishers, John Wiley & Sons, New York,* 1962, 740 *p*, $27.

Only computer specialists will want this multiple-language text. Of 22 papers, 8 are in German, 14 in English; all are summarized in German, English and French.

Rather than attempting a comprehensive view of computer developments, the papers aim at going

MICRO
MINI
ATURE

ETI

**tiniest timer for reliability studies**


This A. W. Haydon ETI is essential for applications where space is critical. We don't know of any other ETI that can touch it for size—only ¼ cubic inch. It records hours to 999.9 or 9999, with over 99.9% accuracy... runs on a half watt, 115 v, 400-cycle input...weighs 0.75 oz....exceeds requirements of MIL-M-26550. Temperature range, −65° to +250°F... altitude 80,000′...20g vibration up to 2,000 cycles. The microminiature ETI is designed for reliability test engineering. For full details on this, and its companion events counter, write The A. W. Haydon Company today.

THE AW HAYDON COMPANY
235 NORTH ELM STREET, WATERBURY 20, CONNECTICUT

CIRCLE 221 ON READER SERVICE CARD

into depth in selected areas—these include Automata and Thought Processes, Interrelations between Computers and Applied Mathematics, Programming, and Theoretical Aspects of the Mechanization of Literature Searching; 2 Czech papers discuss a self-correcting computer and the numerical system of residual classes (in English). A group of 7 papers from Japanese experts, also in English, treats many aspects of digital computer development in that country, including the famous Parametron. The majority operation circuit above comes from "The Parametron" by Takahasi and Goto.

Combined bibliographies are enormous—the literature survey by W. Hoffmann, concluding the book, alone contains 697 items.—N. L.

## Handbook of Chemistry and Physics

CHARLES D. HODGMAN, Editor-in-chief

*The Chemical Rubber Publishing Co, Cleveland, Ohio,* 1962, *over* 3,500 *p*, $12.

The forty-fourth edition of this immensely useful volume has been brought up to date once more, with the addition of a good deal of information pertinent to the electronics field.

Some of these additions are: tables of velocity of sound in various substances, lists of superconducting elements and of other superconducting materials, emissivity of tungsten, secondary electron emission, and data on elementary particles. Other existing tables have been revised with data based on recent work.

## Proceedings of the Third International Conference on Medical Electronics

*Charles C. Thomas, Springfield, Ill.,* 1962, 535 *p*, $34.50.

On a Himalayan peak at 19,150 feet sits a transistorized electrocardiograph left there on a 1959 expedition—anyone who "cares to go and get it can have it for noth-

SUB
MINI
ATURE

ETI

**workhorse of reliability testing**


This A. W. Haydon ETI is ideal for applications where space is a problem. Less than 3″ long, 1¼″ dia, it's production-test-proved to record up to 9,999.9 hours at better than 99.9% accuracy—much more reliability than what it's testing. The 23200 series for 60-cycle, or the 25200 series for 400-cycle run on 3 watts of 115 v., exceed requirements of MIL-M-7793. These ETI's are tested for service from −65° to +250°F... altitude to 80,000′...20g vibration up to 2,000 cycles. To get full details, write The A.W. Haydon Company today.

THE AW HAYDON COMPANY
235 NORTH ELM STREET, WATERBURY 20, CONNECTICUT

CIRCLE 175 ON READER SERVICE CARD

***Are you a***

***COMPLETELY INFORMED***

***electronics engineer?***

Today you may be working in microwaves. But on what project will you be working tomorrow? You *could* have read **electronics** this past year and kept abreast of, say, microwave technology. *There were 96 individual microwave articles between July, 1961 and June, 1962!*

But suppose tomorrow you work in some area of standard electronic components, in semiconductors, in systems? Would you be up-to-date in these technologies? Did you read the more than 3,000 editorial pages that **electronics'** 28-man editorial staff prepared last year?

**electronics** is edited to keep you current *wherever* you work in the industry, *whatever* your job function(s). If you do not have your own copy of **electronics**, subscribe today via the Reader Service Card in this issue. Only 7½ cents a copy at the 3 year rate.

**electronics**

ing". Is there still a gulf between engineers and medical scientists? Who cares about methods of analyzing and transforming neurophysiological information, radio pills or cephalic bruits? Engineers now evidently do, in increasing numbers. Says V. K. Zworykin, ". . . electronics will have a radical effect in changing the practice of medicine. . ."

Tidbits must suffice here to speak for a volume of fascinating scope and richness. Nearly 150 papers comprise three major sections: Measurements in Medicine and Biology; Research and Clinical Application; Equipment, Techniques and Safety. These include papers on all types of medical instrumentation, research on the motor and nervous systems, on the circulatory and respiratory systems, and on electronic aspects of sight, hearing and locomotion, etc.

This book demonstrates impressively how varied and important the work in medical electronics has become. It should be a required reference for engineers who now work with the medicinemen. The purchaser will also find important clues in his search for the Himalayan electrocardiograph.—N. L.

## The Weapons Acquisition Process

By MERTON J. PECK and FREDERIC M. SCHERER, *Division of Research, Harvard Business School*, 1962, 736 *p*, $10.

Primarily an economic and analytic study of the nature of the weapons acquisition process in this country. It is based on historical case studies of 7 commercial products as well as of 12 weapon system programs in aircraft and missiles. This book should interest administrators and officials who plan and execute weapons development programs, in which the electronics industry is naturally heavily involved.

Future volumes in this series will cover actual cases, contractual and competitive incentives, and recommendations on administrative problems that are unique to this period of history when weapons acquisition is such an all-encompassing activity.—N. L.


# General RF Fittings, Inc.

702 BEACON STREET, BOSTON 15, MASSACHUSETTS
Telephone: 617 267-5120

**CIRCLE 222 ON READER SERVICE CARD**

---

*The Finest Compliment from People Who Know*

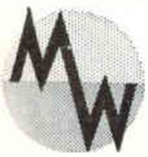
## PRECIOUS METALS PLATING

M-W Laboratories receives volume orders from firms which ordinarily do their own plating—but preferred to turn over jobs requiring the application of specialized techniques to M-W Laboratories.

**The more exceptional the job—the more definitely we demonstrate our superiority.**

| | |
|---|---|
| Gold<br>Silver<br>Rhodium<br>Albaloy<br>Indium<br>Nickel<br>Platinum | Quality Control for Precious Metals Plating of Electronic Components |

Write for Brochure



**M-W LABORATORIES, INC.**
1824 N. Milwaukee Avenue
Dept. E-1
Chicago 47, Illinois

**CIRCLE 223 ON READER SERVICE CARD**

---

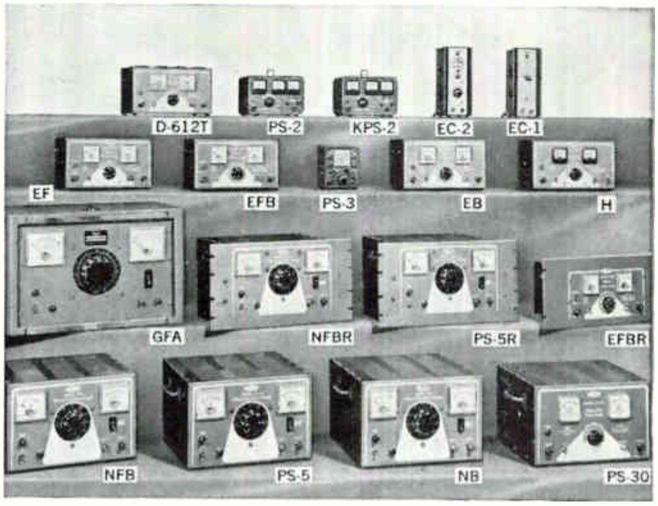
**PRODUCT NEWS from EPL**

**Low cost, reliable**

# DC POWER SUPPLIES for low voltage applications

**Variable output . . . low ripple . . . guaranteed performance . . . built to withstand 24-hour-a-day operation**

*Recognized best in their price class*




| Model | Voltage Output | Amperage Output | Regulation (V/A) | Maximum Ripple (%) | Meters | Price (net) |
|---|---|---|---|---|---|---|
| GFA | 0-125 | 0-10 | 1.6 to 10A* | 1 | 0-150V, 0-20A | $575.00 |
| PS-5 | 0-55 | 0-10 | 0.8 (0-10A) | 0.5 | 0-75V, 0-10A | 250.00 |
| PS-5R | 0-55 | 0-10 | 0.8 (0-10A) | 0.5 | 0-75V, 0-10A | 275.00 |
| NFB | 0-32 | 0-15 | 0.3 (0-15A) | 0.75 | 0-50V, 0-25A | 250.00 |
| NFBR | 0-32 | 0-15 | 0.3 (0-15A) | 0.75 | 0-50V, 0-25A | 275.00 |
| NB | 0-32 | 0-15 | 0.3 (0-15A) | 5 | 0-50V, 0-25A | 225.00 |
| EFB | 0-32<br>0-16 | 0-4<br>0-8 | 1.25 (0-4A)<br>1 (0-8A) | 0.1 | 0-40/20V, 0-10A | 140.00 |
| EFBR | 0-32<br>0-16 | 0-4<br>0-8 | 1.25 (0-4A)<br>1 (0-8A) | 0.1 | 0-40/20V, 0-10A | 160.00 |
| EB | 0-32<br>0-16 | 0-4<br>0-8 | 1.25 (0-4A)<br>1 (0-8A) | 5 | 0-40/20V, 0-10A | 115.00 |
| EF | 0-28<br>0-14 | 0-5<br>0-5 | 0.9 (1-5A)<br>0.6 (1-5A) | 1 | 0-50V, 0-6A | 98.00 |
| PS-3 | 0-15<br>15-25 | 0-200MA<br>0-100MA | 100MV | 1MV | 0-25V/100MA/<br>200MA | 79.50 |
| PS-2 | 0-20<br>0-16 | 0-75MA<br>0-5A | 1.6 | 0.15<br>0.5 | 0-20V, 0-10A<br>& 0-75MA | 56.00 |
| KPS-2 (kit) | 0-20<br>0-16 | 0-75MA<br>0-5A | 1.6 | 0.15<br>0.5 | 0-20V, 0-10A<br>& 0-75MA | 44.95 |
| D-612T | 0-16<br>0-8 | 0-10<br>0-10 | .44 (3-10A)<br>.3 (3-10A) | 0.5 @ 5A,<br>2 @ 10A | 0-20V, 0-10A | 59.95 |
| EC-2 | 0-16 | 0-5 | 1.8 | 0.5 | 0-20V/10A | 39.95 |
| PS-30 | 12 | 0-30 | 0.27 | 1 | 0-20, 0-50 | 195.00 |
| H | 12**<br>6** | 0-10<br>0-20 | .23 (3-10A)<br>.15 (3-20A) | 5 | 0-20V, 0-30A | 86.00 |
| EC-1 | 12** | 0-5 | 1.4 | 0.5 | ........ | 29.95 |

* 12% of no-load voltage @ max. output ** adjustable

**Complete Line Bulletin PS-561 gives all details**

*Stocked at Your Electronic Distributor*

2124

**ELECTRO PRODUCTS LABORATORIES**
6125-(F) West Howard, Chicago 48 (Niles), Illinois. Phone 647-6125

*Canada: Atlas Radio Ltd., Toronto*

Since 1936 . . . Pioneers in DC Power Supplies • Proximity Switches
Magnetic Pickups • Prescon Controls • Dynamic Micrometers

**CIRCLE 177 ON READER SERVICE CARD**

## Phelps Dodge Unit Opens New Plant

A NEW manufacturing plant has been opened in North Haven, Conn., to provide engineering and production facilities for the recently formed Phelps Dodge Electronic Products Corp., subsidiary of the Phelps Dodge Corp.

The one-story building has 51,500 square feet of space. Manufacturing area encompasses 39,000 square feet; classified area, 4,300 square feet; test laboratory, 1,800 square feet; office area, 4,800 square feet; other area, 1,600 square feet.

The manufacturing function will cover coaxial connectors, delay lines and bending waveguides into sophisticated configurations.

Research and development and applied engineering in systems communications is the prime purpose of the new corporation. Emphasis is being placed in the following areas: development of special components, origination of complete cable systems, custom engineering of special coaxial cable, design of waveguides, transitions and cable assemblies for exacting frequency requirements, and providing the engineering knowledge to analyze potential coaxial cable parameters to meet untested applications.

Communication Products Co., Marlboro, N.J., which manufactures and assembles a complete line of small antennas and other types of radiating equipment, will be operated as a subsidiary of Phelps Dodge Electronic Products Corp.

## Ortronix Incorporated Names Verdery V-P

LEONARD F. VERDERY has been promoted to vice president of engineering at Ortronix Inc., Orlando, Fla.

He will be responsible for all activities of the Engineering division which includes the design and development of telemetering and communications equipment, data systems and ground support equipment.

## Lear Siegler Board Elects Walsh

JOSEPH M. WALSH, president of the Instrument division of Lear Siegler, Inc., has been named a corporate vice president by the board of directors.

Walsh joined the former Lear, Inc. in 1955 and was named general manager of the Instrument division at Grand Rapids, Mich., in May 1959. Following the merger of the Siegler Corp. and Lear, Inc. in June 1962, Walsh was named president of the Instrument division.

## Victory Electronics Appoints Henderson

WILLIAM J. HENDERSON has been named executive vice president of Victory Electronics, Inc., Syosset, L. I., N. Y., manufacturer of precision power supplies, regulators and inverters for military, space and industrial uses. He was formerly with the FXR division Amphenol-Borg Electronics Corp.

Henderson will implement the expansion program for Victory Electronics into diversified electronics systems through new product research and acquisition of other companies, according to Joseph Lazar, president.

## National Electronics Hires Hoffman

DONALD C. HOFFMAN has joined National Electronics, Inc., Geneva, Ill., a subsidiary of Eitel-McCullough, Inc., as quality control manager of the Thyratron and Rectifier division. In this capacity he will be responsible for the overall quality of

Cinch ELECTRONIC COMPONENTS

## Now! New From Cinch

# UNIT CONDUCTOR RELIABILITY

### For Micro-Miniature or Standard Applications

# *ULTREKON**

ULTIMATE RELIABILITY CONNECTORS

New ULTREKON connectors were developed to answer the extreme demands of military and aerospace applications.

They function as conventional connectors during check-out and test. Then, after final test, the mating contacts are bonded together by welding or solderless wire wrapping. Bonding creates unit conductors providing ultimate reliability even in the severe environments of aerospace applications.

For further information contact your Cinch representative or local Cinch-Jones distributor or call direct.

*Patent Pending

**ULTREKON CHARACTERISTICS**

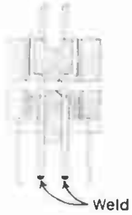
**CONTACT SPACING**—For welding: .050 in. minimum. For solderless wire wrapping: .100 in. minimum.

**INSULATORS**—Glass filled diallyl phthalate.

**CONTACT MATERIAL AND FINISH**—Phosphor bronze plated .00003 gold over copper flash.

**INDESTRUCTIBLE ENTRY**—ULTREKON design prevents oversize probes from damaging contacts.

**SERVICEABLE AND REUSABLE CONNECTORS**—Welds can be clipped or wire unwrapped from ULTREKON connectors. They then function as conventional connectors until rewelded or rewrapped.




Cross section of ULTREKON with mated contacts welded together

## CINCH MANUFACTURING COMPANY

1026 South Homan Avenue. Chicago 24, Illinois

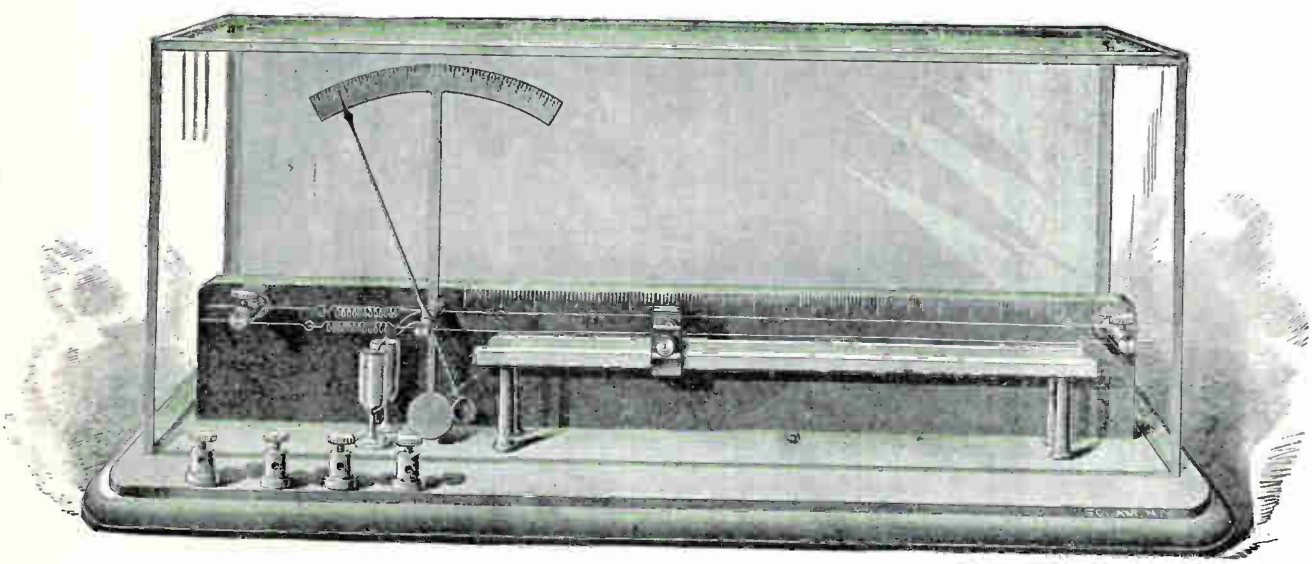
*Plants located in Chicago, Illinois; Shelbyville, Indiana; City of Industry, California; and St. Louis, Missouri.*

A DIVISION OF UNITED-CARR FASTENER CORPORATION, BOSTON, MASSACHUSETTS

DOT

**CIRCLE 224 ON READER SERVICE CARD**

---

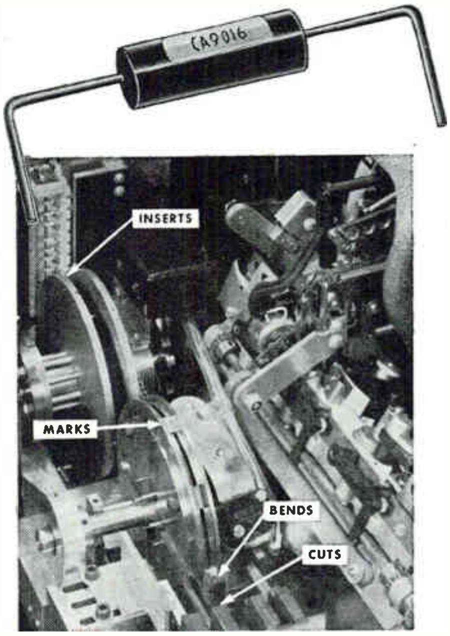


## *Is it ancient history by the time you see electronics?*

Get the facts while they're new. Don't wait for **electronics** on a route slip. Look in this issue for the Reader Service Card. Fill out and mail the "for subscriptions" section. Only 7½ cents a week.

**electronics** A McGraw-Hill Publication, 330 West 42nd St., N. Y. 36

# NEW! BRADY Component Processor
# CUTS RELIABILITY COSTS




133

***Automatically:***

**FEEDS** axial lead components individually, from taped coil or from prefilled feed tray . . .

**CUTS** leads to exact length . . .

**BENDS** leads to specification bend . . .

**MARKS** component body with a pressure-sensitive marker with preprinted serial number . . .

**INSERTS** formed and marked components into carrier stick . . .

**DELIVERS** filled component carrier stick, ready for reliability testing.

Every element of operation of the Brady Component Processor is electronically sensed . . . insures accuracy and uniformity in each process . . . saves time and rework. Speeds up to 30 components per minute. Requires work area only 3 feet square.

*For full information, write to:*

W. H. BRADY CO. • 739 W. Glendale Ave. • Milwaukee 9, Wis.

Manufacturers of Quality Pressure-Sensitive Industrial Tape Products, Self-Bonding Nameplates, Automatic Machines for Disipensing Labels, Nameplates, Masks and Tape. Est. 1914.

CIRCLE 225 ON READER SERVICE CARD

almost
# iDIOTPROOf
## TERMINAL BLOCKS

- No Lugging • No Screws
- No Special Tools • No Lost Time
- No Short Circuiting
- No Breakage • No Loose Parts

Making wire connections with Camblock terminal blocks, feed-thru connectors, and binding posts is amazingly simple: (A) strip wire, (B) insert into connector, and (C) turn cam. Quick acting and positive locking construction provides better electrical and mechanical connections . . . . . superior current carrying and insulation characteristics and high vibration values. Write for complete literature on medium and subminiature sizes.

CAMBLOCK DIVISION

WALTHAM PRECISION INSTRUMENT COMPANY, INC.
221 CRESCENT STREET, WALTHAM 54, MASS.
Tel: TWInbrook 3-4000 TWX: WALTH 1183-X

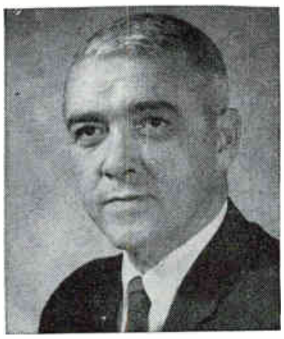

the special purpose electronic tubes manufactured by this division.

Before this appointment, Hoffman was plant superintendent of the RCA Electronic Tube division at Indianapolis, Ind.

## MCS Appoints Vought General Manager

MICROWAVE COMPONENTS AND SYSTEMS CORP., Monrovia, Calif., manufacturer of custom and standard microwave components, has appointed Richard E. Vought as general manager. In his new post, he will be fully responsible for all company operations regarding engineering, marketing, and production control of all microwave test equipment.

Vought was formerly associated with Hughes Aircraft Co., Fullerton, Calif.



## John Sefton Joins GD/Electronics

JOHN R. SEFTON has been appointed principal engineer in the Advanced Development Electroacoustics Laboratory of General Dynamics/Electronics, Rochester, N. Y., with express responsibility for management of the division's SUTEC (Seneca Underwater Test and Evaluation Center) facility.

Sefton comes to GD/Electronics from the Martin-Marietta Corp., in

***Are you a COMPLETELY INFORMED electronics engineer?***

Today you may be working in microwaves. But on what project will you be working tomorrow? You *could* have read **electronics** this past year and kept abreast of, say, microwave technology. *There were 96 individual microwave articles between July, 1961 and June, 1962!*

But suppose tomorrow you work in some area of standard electronic components, in semiconductors, in systems? Would you be up-to-date in these technologies? Did you read the more than 3,000 editorial pages that **electronics'** 28-man editorial staff prepared last year?

**electronics** is edited to keep you current *wherever* you work in the industry, *whatever* your job function(s). If you do not have your own copy of **electronics**, subscribe today via the Reader Service Card in this issue. Only 7½ cents a copy at the 3 year rate.

**electronics**

Baltimore, where for the past three years he was head of the laboratory for antisubmarine warfare research and underwater acoustic measurements.

## Elastic Stop Nut Hires R. L. Paul

THE ELASTIC STOP NUT CORP. OF AMERICA, Union, N. J., announces the appointment of Russell L. Paul to the position of chief electronics engineer of its Elizabeth division. He will have prime engineering responsibility for the division's line of solid state Agastat timing instruments and other electronic control components.

Before joining ESNA, Paul had been chief engineer at Seaboard Electronics Co. in New York City.

## Packard Bell Computer Names McDonald

J. J. MCDONALD has been named general manager of Packard Bell Computer, Los Angeles, a division of Packard Bell Electronics. He will direct engineering, manufacturing, and marketing of computers and other digital systems, equipment and components, reporting to Wendell B. Sell, vice-president and general manager of Packard Bell's Defense and Industrial Group.

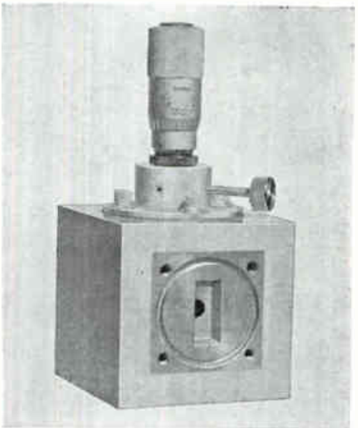
McDonald was formerly vice

**DEPENDABILITY**
**ZUVERLÄSSIG**
**CONSIANCE**
**FIDEDIGNO**
**PÅLITLIG**

In any language, the Greeks had a word for it—DEPENDABILITY. Whether you look for systems or component engineering, research and development, or straight purchasing of standard components you want and need a dependable source of supply. Try us at Telerad. DEPENDABILITY is guaranteed because our products are the result of creative research and quality control. Because we are customer-minded, we give you precisely what you require, and we give it to you when you want it.

And, while on the subject of DEPENDABILITY, a good example of practicing what we're preaching is our recent development of this . . .

CAVITY

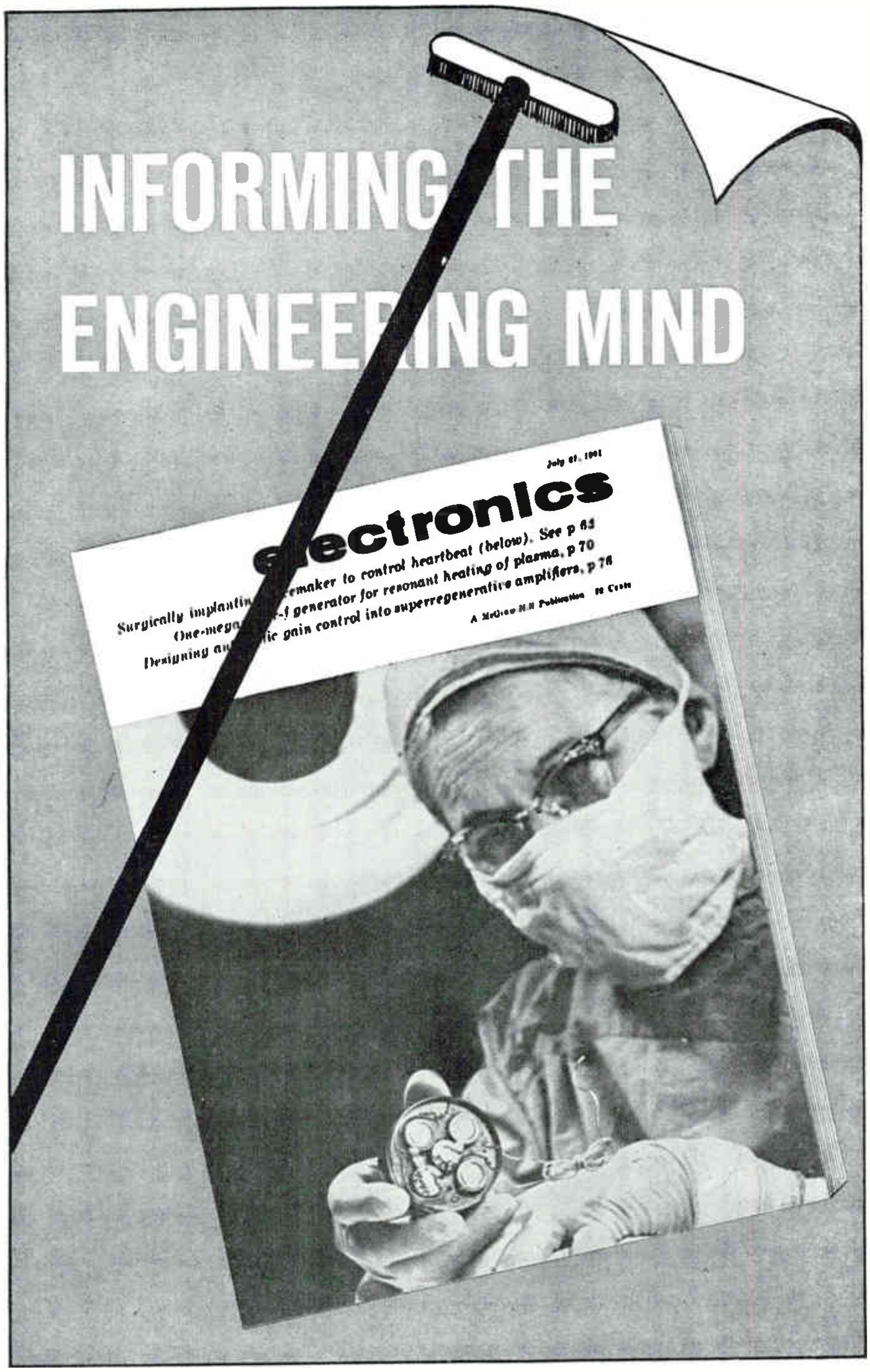


**The spherical configuration of this cavity provides the highest possible "Q" in the minimum amount of space. It is designed for use in "X" bands and has a relatively linear tracking. This cavity is especially ideal for reference application. "Q"s in the order of 10,000 are readily available. Call or write today.**

**TELERAD**
A DIVISION OF LIONEL CORPORATION
FLEMINGTON, N. J.



CIRCLE 181 ON READER SERVICE CARD




**electronics** is written and edited specifically to inform . . . and, more difficult, to keep informed . . . the engineering minds that ultimately pace and guide the vast electronics industry. To this end, the **electronics** editorial staff scours the nation and the world to report all important developments in the areas of research, design, production and management.

The result: *must reading* for anyone in these areas of the industry. Don't miss an issue; subscribe today, via the Reader Service Card in this issue, to

**electronics**

president in charge of engineering and research at Consolidated Systems Corp.

## George Mahn Joins Machlett Laboratories

George R. Mahn has joined Machlett Laboratories Inc., Springdale, Conn., producer of x-ray tubes, as chief engineer for that product line.

Before accepting his new post, Mahn was senior engineer with General Electric Company's x-ray department.

## Holtum Assumes New Andrew Post

ALFRED HOLTUM was recently appointed chief of the Andrew Corporation Antenna Design Group.

Holtum joined the Andrew organization in 1957 as chief engineer of the company's California affiliate. In 1961 he was transferred to Chicago to head the company's Government Research and Development department.

## LFE Electronics Names Rothstein

JEROME ROTHSTEIN has been named to the new post of senior staff scientist for LFE Electronics, Boston, Mass. Reporting to the vice president in charge of the Research division, he will participate in research programs and be responsible for technical liaison with other divisions of LFE Electronics.

Rothstein joins LFE from Maser Optics, Inc., where he was vice president and chief scientist in charge of basic and applied research.

## PEOPLE IN BRIEF

**Kenneth W. Peterson** promoted to mgr. of quality control at Pickard & Burns, Inc. **Clyde F. Coombs,** formerly with Hewlett-Packard, Inc., named quality assurance mgr. for the Berkeley div. of Beckman Instruments, Inc. **William E. Parkins** advances to mgr. of the Research div. at Atomics International. **Donald O. Schwennesen** moves up to exec v-p of The Arnold Engineering Co. **Edward J. Bresnen,** ex-Autonetics div. of North American Aviation Corp., joins Trimpot div. of Bourns, Inc., as mgr. of material. **William Hedge,** former engineer with Engineered Electronics Co., returns to the company as new products mgr. Three promotions within the electronics div. of Lockheed Missiles & Space Co.: **A. F. Gaetano** named mgr. of microwave applications; **Norbert J. Gamara,** mgr. of electromagnetics research; and **Lester L. Libby,** mgr. of the design techniques dept. **Harry M. Himeback, Jr.,** previously with Philco Corp., appointed chief engineer for Semtran Instruments, Inc. **Brian Dale** leaves Transitron Electronic Corp. to become mgr., advanced device research, for the Semiconductor div. of Sylvania Electric Products Inc. **Donald W. Brusch,** ex-Fenwal Electronics Inc., hired by F&M Scientific Corp. as a research engineer. **Alan G. Stanley** from General Instrument Corp. to Transitron Electronic Corp. as mgr. of the Micro-Circuitry div. Univac ups **George A. Hagerty** to g-m of its new OEM dept. **Franz C. McVay,** formerly with Raytheon Co., joins Applied Technology, Inc., as senior engineer.


QUALITY

to the Nth Degree

Fine Wire engineered to your requirements. Ultra-pure metals . . . Precise homogeneous alloys . . . Optimum physical and electrical characteristics . . . combine to give you the utmost in quality. Write for data.

Let us quote on our requirements.

CONSOLIDATED REACTIVE METALS, inc.
115 Hoyt Avenue — Mamaroneck, N.Y. — OWens 8-2300

FINE WIRE CRM

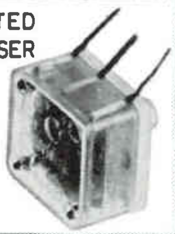
CIRCLE 226 ON READER SERVICE CARD

AM·FM Tuner

A.M. CAPACITY: MAX., 371 PF
TUBE: 6A98, 12DT8, 17EW8

PLASTIC INSULATED VARIABLE CONDENSER

Square Sizes: 15mm., 17mm., 20mm., 21mm., Single band 2 band, 3 band and for FM only



SANKAISHA CO., LTD.

Cable address, SANESVARICON TOKYO
1425, 4-chome, Higashinakanobu, Shinagawa-ku, Tokyo, Japan.

CIRCLE 227 ON READER SERVICE CARD

EICO®
PUTS THE BEST IN CREATIVE ELECTRONICS
INTO YOUR HANDS


28 pages of professional electronic equipment in kit and wired form—for Lab . . . Line . . . Home

EICO, 3300 N. Blvd., L.I.C. 1, N. Y. E-11B
☐ Send free 32-page catalog & dealer's name.
☐ Send new 36-page Guidebook to HI-FI for which I enclose 25¢ for postage & handling.
Name
Address
City Zone State

EICO® 3300 N. Blvd., L.I.C. 1, N. Y.
Export Dept., Roburn Agencies
431 Greenwich St., N.Y. 13, N.Y.

CIRCLE 183 ON READER SERVICE CARD

EMPLOYMENT OPPORTUNITIES

# electronics

## WEEKLY QUALIFICATION FORM FOR POSITIONS AVAILABLE

### ATTENTION: ENGINEERS, SCIENTISTS, PHYSICISTS

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

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

### STRICTLY CONFIDENTIAL

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

### WHAT TO DO

1. Review the positions in the advertisements.
2. Select those for which you qualify.
3. Notice the key numbers.
4. Circle the corresponding key number below the Qualification Form.
5. Fill out the form completely. *Please print clearly.*
6. Mail to: D. Hawksby, Classified Advertising Div., ELECTRONICS, Box 12, New York 36, N. Y. (No charge, of course).

| COMPANY | SEE PAGE | KEY # |
|---|---|---|
| ATOMIC PERSONNEL INC. Philadelphia, Penna. | 185 | 1 |
| BELTONE HEARING AID COMPANY Chicago, Ill. | 67* | 2 |
| CONN LTD., C. G. Elkhart, Indiana | 185 | 3 |
| DOUGLAS AIRCRAFT CO. Missile & Space Systems Division | 173 | 4 |
| PAN AMERICAN WORLD AIRWAYS INC. Guided Missiles Range Div. Patrick AFB Fla. | 66* | 5 |
| SPERRY MICROWAVE ELECTRONICS CO. Div. of Sperry Rand Corp. Clearwater, Florida | 185 | 6 |
| SYLVANIA ELECTRONIC SYSTEMS—CENTRAL Williamsville, N. Y. | 185 | 7 |
| P 1051 | 67* | 8 |
| P 1082 | 67* | 9 |

* These advertisements appeared in the Nov. 23rd issue.

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

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

**Personal Background**

NAME ..........................................

HOME ADDRESS ..........................................

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

HOME TELEPHONE ..........................................

**Education**

PROFESSIONAL DEGREE(S) ..............................

MAJOR(S) ..............................

UNIVERSITY ..............................

DATE(S) ..............................

**FIELDS OF EXPERIENCE (Please Check)** 113062

| | | |
|---|---|---|
| ☐ 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

# ATTENTION RELIABILITY ENGINEERS

***SYLVANIA ELECTRONIC SYSTEMS—CENTRAL** has immediate openings for supervisory personnel and staff specialists, trained and experienced in the field of reliability. Recently acquired long term contracts include the improved ground electronics command and control system for the Air Force's Minuteman.*

**GROUP HEAD—Reliability Research & Training Group**
to supervise and direct activities in the planning of reliability training for engineering organizations, auditing of reliability training of factory personnel, maintaining contact with national reliability organizations and providing consultation in the field of reliability mathematics. Minimum B.S.E.E. or Physics or Math equivalent. 8 years engineering experience: at least three years in a reliability organization.

**GROUP HEAD—Projects Reliability Group**
to supervise and direct proposal contributions, failure processing and analysis, preparation of reliability program plans, formulation of maintainability concepts, human factors engineering, reliability allocations and predictions and services to design groups. Minimum B.S.E.E. or Math equivalent required. 8 years engineering experience and a minimum of three years in a reliability organization.

Direct inquiries in confidence to
*Robert E. Artman*

**SYLVANIA ELECTRONIC SYSTEMS—CENTRAL**
1176 Wehrle Drive Williamsville, N. Y.
An Equal Opportunity Employer

**CIRCUIT ANALYST**
reporting to Head, Design Audit Group, will be required to perform detailed circuit analysis on designs to assure proper emphasis on reliability and make recommendations as indicated, chair and direct formal design reviews, build up documentation of reliable circuits, provide consultation in area of reliable design, audit projects to insure they are complying with reliability program plans. Minimum B.S.E.E. or Physics equivalent required. 6 years engineering experience: at least 2 years in circuit design or evaluation. Reliability experience desirable.

**SENIOR RELIABILITY ENGINEER**
reporting to Head, Design Audit Group, will be required to present reliability contributions at formal design reviews, participate in auditing of factory programs from a product assurance point of view, participate in survey of subcontractors, aid in the creation of reliability practices applicable to all projects. Minimum B.S.E.E. or Physics equivalent required. 3 years in engineering with reliability experience desirable.

**SENIOR RELIABILITY ENGINEER**
reporting to Head, Projects Reliability Group, will be required to audit failure processing and analysis on one or more programs, prepare reliability program plans, create maintainability concepts, derive reliability allocations and predictions, provide coordination between project group and reliability organization. Minimum B.S.E.E. or Physics equivalent required. 3 years in engineering work with reliability experience desirable.

*We are located ten miles northeast of Buffalo in the picturesque suburban village of Williamsville, N. Y.*

SYLVANIA ELECTRONIC SYSTEMS
Government Systems Management
*for GENERAL TELEPHONE & ELECTRONICS*

---

### POSITION VACANT

**Electronic Engineer: University Staff position.** Must handle pulse, analog computer and DC amplifier design; supervise maintenance of electron accelerator, T.O.F. mass spectrometer. Pleasant living conditions and climate. Salary $8,000. Write to DR. C. K. Mann, Chemistry Dept., Florida State University, Tallahassee, Florida.

### SELLING OPPORTUNITY WANTED

**Component Manufacturers—Are you third** best line with your New England rep? Want more effort and results? Your 10,000 line could be first with new electronic-mech. rep. firm org. by exp. O.E.M., dist. man. B.S. degree-design-mfg-exp. Robert J. Hoey Co., 17 Orchard Dr., W. Acton, Mass.

---

# E. E.'s
**for FEE-PAID Positions**
**WRITE US FIRST!**
Use our confidential application for professional, individualized service . . . a complete national technical employment agency.
**ATOMIC PERSONNEL, INC.**
Suite 1207L, 1518 Walnut St., Phila. 2, Pa.

---

**ELECTRONIC ENGINEER**
ORGAN DIVISION
Needed Electronic Design Engineer.
Work involves electronic organ.
Knowledge of transistor oscillators, amplifiers and printed circuit techniques required. Person with previous electronic organ experience preferred. Applicants furnish resume. Salary open.
**C. G. CONN, LTD.**
1101 East Beardsley Ave. Elkhart, Indiana

---

# SEARCHLIGHT SECTION
*(Classified Advertising)*

BUSINESS OPPORTUNITIES — EQUIPMENT - USED or RESALE

**OVER 2,000,000**
# RELAYS
**IN STOCK!**
*Send for Catalog SS*
**Universal RELAY CORP.**
42 WHITE ST., N.Y.13, N.Y. • WAlker 5-6900

**CIRCLE 950 ON READER SERVICE CARD**

**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!
**COMMUNICATIONS EQUIP CO.**
343 CANAL ST., N. Y. 13, WO 6-4045
CHAS. ROSEN (Fomerly at 131 Liberty St.)

**CIRCLE 952 ON READER SERVICE CARD**

**OSCILLOSCOPES**
And other types of Test Equip.
Gov't. Surplus
Send for Free Catalog to
**SELECTRONICS**
Dept. E, 1206 Napa St. Philadelphia, Pa.
Tel: HO 8-4645 HO 8-7891

**CIRCLE 951 ON READER SERVICE CARD**

**RADIO RESEARCH INSTRUMENT CO.**
AUTO-TRACK & TELEMETRY ANTENNA PEDESTALS
3 & 10 CM. SCR. 584 AUTOTRACK RADARS.
AN/TPS-1D SEARCH. AN/TPS-10 HT. FINDERS.
AN/FPN-32GCA. AN/APS-10 NAVIG. & WEATHER.
AN/APS-15B PRECISION. AN/APQ-35B PRECISION.
AN/APS-31A SEARCH. DOZENS MORE.
.5-1-2 MEGAWATT HIGH POWER PULSERS.
RADIO RESEARCH INSTRUMENT CO.
550 Fifth Ave. New York Judson 6-4691
RADAR SYSTEMS & COMPONENTS/ IMMEDIATE DELIVERY

**CIRCLE 953 ON READER SERVICE CARD**

---

# ENGINEERS SCIENTISTS

**SPERRY MICROWAVE ELECTRONICS CO.**

seeks the creative engineer and scientist to become a vital part of a rapidly expanding Engineering Department probing the vast and challenging region of microwave theory and technique. Openings exist for those men who have the imagination, resourcefulness and sufficient background in the following areas.

**CIRCUIT DESIGN ENGINEERS**
E.E. or Physics grad. with 4 or more yrs. exp. in design of electronic circuits and sub-systems. Background in transistorized pulse, grating or I.F. circuit development is required.

**SENIOR SYSTEMS ENGINEERS**
To contribute to advanced techniques in the field of electronic instrumentation. Should have at least 6 yrs. exp. including recent work in system analysis, synthesis, and integration. An advanced degree in E.E. is desired.

**SENIOR APPLICATIONS ENGINEER**
B.S.E.E.—5 yrs. exp. in ferrites—solid state or related microwave fields. Must have experience in commercial and military sales, sales objective forecasts, microwave components. Must be capable of developing sales contacts, establishing sales objectives and meeting forecasts.

**APPLICATIONS ENGINEER**
B.S.E.E. or equivalent in experience. Minimum 5 yrs. exp. in sales covering military and commercial contacts. Must be familiar with system instrumentation such as automatic check-out equipment for beacons, telemetry, etc., and spectrum surveilance instrumentation. Must be responsible for establishing sales objectives and meeting forecasts.

**SENIOR RELIABILITY ENGINEER**
Career opportunity. Head up all engineering aspects of reliability and coordinate other departments' activities in this area. Perform reliability analysis and MTBF predictions. Conduct design reviews, analyze parts, failure reports and prepare technical reports. 3 yrs. reliability engineering experience on full-fledged reliability programs plus minimum of 2 years in circuit design, derating and redundancy techniques, etc. Must have B.S.E.E. with suitable academic background in mathematics.

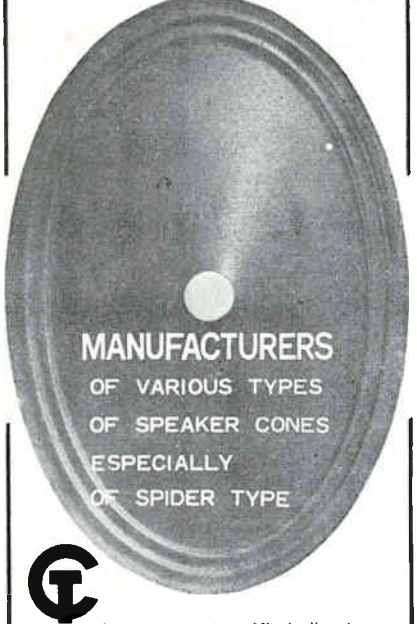
**RESEARCH**
A few unusually challenging openings are available for individuals with Ph.D. or equivalent backgrounds.

Master of Engineering degree (University of Florida) may be obtained locally under company-paid program.

SPERRY

Contact: Mr. R. C. Carroll,
Employment Supervisor
**SPERRY MICROWAVE ELECTRONICS CO.**
Division of Sperry Rand Corp.
**CLEARWATER, FLA.**
Phone 855-3311 (Tampa)
An equal opportunity employer

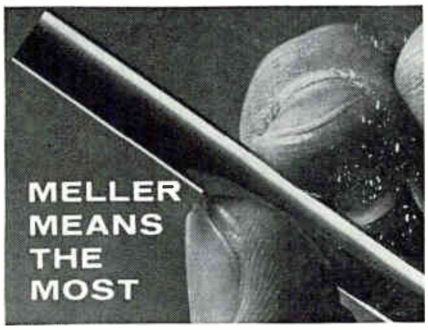
# TOYO CONES




No. 2-37, Nakano-cho, Miyakojima-ku
Osaka, Japan
phone: Osaka (351) 7791
Tokyo Office:
No. 1-589, Totsuka-machi, Shinjuku-ku
Tokyo, Japan
phone, Tokyo (341) 3522

**TOYO CONEPAPER CO., LTD.**

**CIRCLE 228 ON READER SERVICE CARD**




**Crystals of all types and sizes, guaranteed to laser!**

In stock, hundreds of single crystals. All configurations (plain flat and parallel ends, TIR configuration, Brewster's angle). Optically corrected for lowest threshold, narrowest beam divergence. Extra slow grown and annealed for minimum strain.

- NEW glass crystals w/2.0% $Nd^{3+}$
- NEW NPS1 super-uniform ruby crystals
- Ruby rods up to 12" long ● $CaWO_4$ w/.5% $Nd^{3+}$ up to 5" long ● $SrF_2$ w/.1% $Sa^{2+}$ ● $BaF_2$ w/.5% $Nd^{3+}$, or .1%$U^{3+}$
- $CaF_2$ w/.5% $Nd^{3+}$, or .1% Sa2+, or .05% $Dy^{2+}$, or .1% $U^{3+}$.

For full specifications and prices, contact Adolf Meller Company, Box 6001, Providence 4, R. I. Tel: DExter 1-3717 (Area Code 401).

**MELLER SAPPHIRE PRODUCTS**

Synthetic Sapphires • Ruby Lasers & Masers
Alumina Powder


# INDEX TO ADVERTISERS

Audited Paid Circulation

■

## CLASSIFIED ADVERTISING

F. J. Eberle, Business Mgr.



### INDEX TO CLASSIFIED ADVERTISERS



■

• See advertisement in the July 25, 1962 issue of Electronics Buyers' Guide for complete line of products or services.

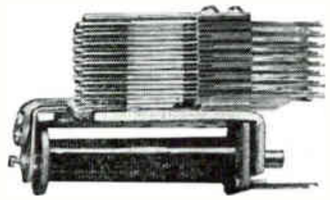
---

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.

---

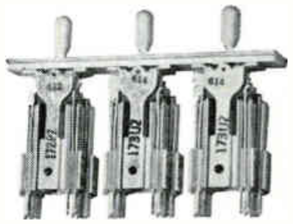
Stromberg-Carlson®
TELEPHONE-TYPE COMPONENTS
*for unfailing quality*

RELAYS



wide range, for many electromechanical switching applications. Send for Bulletin T-5000R3.

KEYS



many designs available in pushbutton, cam and twist types. Send for Bulletin T-5002R2.

TELEPHONE HANDSETS

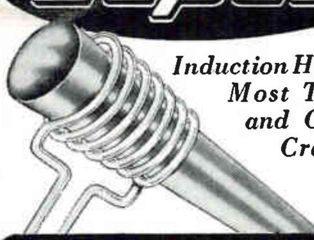
lightweight high-efficiency models. Standard or with switch assemblies. Send for Bulletin T-5017R.

Plus all other telephone switchboard components. For bulletins and more information, contact our nearest Sales Office. Atlanta: 750 Ponce de Leon Place N.E.; Chicago: 564 W. Adams Street; Kansas City (Mo.): 2017 Grand Avenue; Rochester: 1040 University Avenue; San Francisco: 1805 Rollins Road.

GENERAL DYNAMICS TELECOMMUNICATION

CIRCLE 187 ON READER SERVICE CARD

**Lepel**



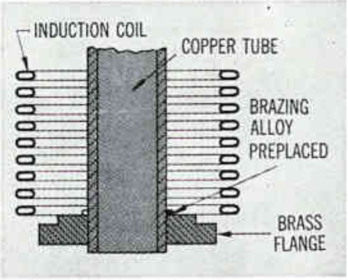
*Induction Heating's Most Trusted and Creative Craftsmen Since 1926*

HIGH FREQUENCY
## INDUCTION HEATING UNITS

for
- BRAZING • SOLDERING
- HEAT TREATING
- ZONE REFINING
- CRYSTAL GROWING
- PLASMA TORCH

*Typical Applications*

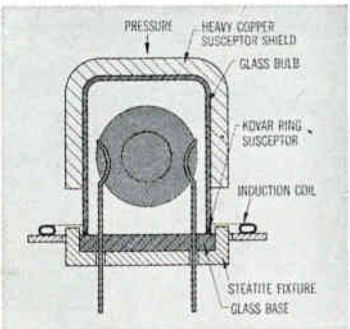
**WAVEGUIDE ASSEMBLIES INDUCTION BRAZED**




Induction brazing has proved to be an excellent method for production assembly of wave guides. In the diagram, a rectangular copper tube is joined to a brass flange using a preplaced ring of brazing alloy. Uniform localized heating minimizes distortion. Induction brazing produces consistently sound joints with smooth fillets.

**Free Application Engineering Service**

**GLASS – TO – GLASS SEALS**




Holders for quartz crystals are sealed by induction heating in an evacuated bell-jar. A glass-coated kovar metal ring is used as a susceptor between bulb and base. Steatite nest, held in plate-type induction coil positions glass base, while spring-loaded copper block locates glass bulb and also provides pressure to cause plastic flow of glass after localized heating. In production, several crystals are sealed at one time.

WRITE FOR LEPEL CATALOG

**Lepel HIGH FREQUENCY LABORATORIES, INC.**

55th ST. & 37th AVE., WOODSIDE 77, N.Y.C.
CHICAGO OFFICE: 6246 WEST NORTH AVENUE



# electronics

Audit Bureau of Circulations    Associated Business Publications

Audited Paid Circulation

**JAMES T. HAUPTLI**
Advertising Sales Manager

R. S. QUINT: Assistant Publisher Buyers' Guide and Business Manager
FRED STEWART: Promotion Manager
B. ANELLO: Market Services Manager

RICHARD J. TOMLINSON: Production Manager
GEORGE E. POMEROY: Classified Manager
HUGH J. QUINN: Circulation Manager

**ADVERTISING REPRESENTATIVES**

ATLANTA (9): Michael H. Miller, Robert C. Johnson, 1375 Peachtree St. N.E., Trinity 5-0523 (area code 404)

BOSTON (16): William S. Hodgkinson, Donald R. Furth, McGraw-Hill Building, Copley Square, Congress 2-1160 (area code 617)

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)

DALLAS (1): Frank Le Beau, The Vaughn Bldg., 1712 Commerce St. Riverside 7-9721 (area code 214)

DENVER (2): J. W. Patten, Tower Bldg., 1700 Broadway, Alpine 5-2981 (area code 303)

HOUSTON (25): Joseph C. Page, Jr. Prudential Bldg., Halcombe Blvd., Riverside 8-1280 (area code 713)

LOS ANGELES (17): Peter S. Carberry, Ashley P. Hartman, W. C. Gries, 1125 W. 6th St., Huntley 2-5450 (area code 213)

NEW YORK (36): Donald H. Miller, Henry M. Shaw, George F. Werner, 500 Fifth Avenue, LO-4-3000 (area code 212)

PHILADELPHIA (3): Warren H. Gardner, William J. Boyle, 6 Penn Center Plaza, LOcust 8-4330 (area code 215)

SAN FRANCISCO (11): R. C. Alcorn, 255 California Street, Douglas 2-4600 (area code 415)

LONDON W1: Edwin S. Murphy Jr. 34 Dover St.

FRANKFURT/Main: Matthée Herfurth, 85 Westendstrasse

GENEVA: Michael R. Zeynel, 2 Place du Port

*"Headquarters for Business Information"*

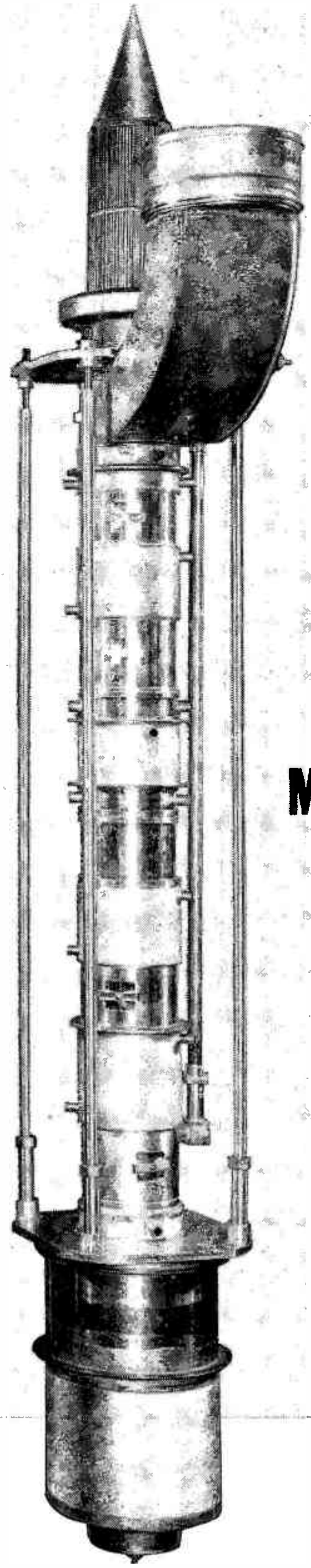
## McGraw-Hill Technical and Business Publications

American Machinist/Metalworking Manufacturing
Aviation Week and Space Technology
Business Week
Chemical Engineering
Chemical Week
Coal Age
Construction Methods and Equipment
Construction Daily
Control Engineering
Electrical Construction and Maintenance
Electrical Merchandising Week
Electrical Newsletter
Electrical West
Electrical Wholesaling
Electrical World
Electronics
Engineering Digest
Engineering and Mining Journal
E & MJ Metal and Mineral Markets
Engineering News-Record
Factory
Fleet Owner
Industrial Distribution
National Petroleum News
Nucleonics
Nucleonics Week
Platt's Oilgram News
Platt's Oilgram Price Service
Power
Product Engineering
Purchasing Week
Science Week
Textile World

Overseas only:
Automobile International (English, Spanish)
Ingenieria Internacional Construccion (Spanish)
International Management (English, Spanish Portuguese editions)
Metalworking Production (Great Britain)

Available by subscription only — to qualified persons actively engaged in the field of the publication. For subscription rates and information describing the editorial coverage of any of the above publications, write to: *Subscription Manager, Circulation Department, McGraw-Hill Publishing Company, 330 West 42nd Street, New York 36, N. Y.*

# NOW FROM SPERRY



## Megawatts at L band . . .

## A megawatt or more at X band . . .

## or in between

| TYPICAL TUBES FROM SPERRY'S MEGAWATT LINE | | | | | | |
|---|---|---|---|---|---|---|
| Type | Frequency Mc | Bandwidth Mc (1 db) | Peak Po MW | Avg Po kW | Gain db | Joules/ Pulse |
| SAL-305 | 1215-1365 | 150 | 12.5 | 60 | 36 | 375 |
| SAL-320 | 1300 | * | 20 | 60 | 50 | 600 |
| SAS-159 | 2856 | * | 25 | 24 | 50 | 62.5 |
| SAC-167 | 5400-5800 | 100 | 1.25 | 8 | 47 | 37.5 |
| SAX-151 | 9000-9500 | 500 | 1.0 | 10 | 40 | 30 |
| SAX-191 | 8830-9200 | 370 | 1.25 | 6 | 50 | 37.5 |

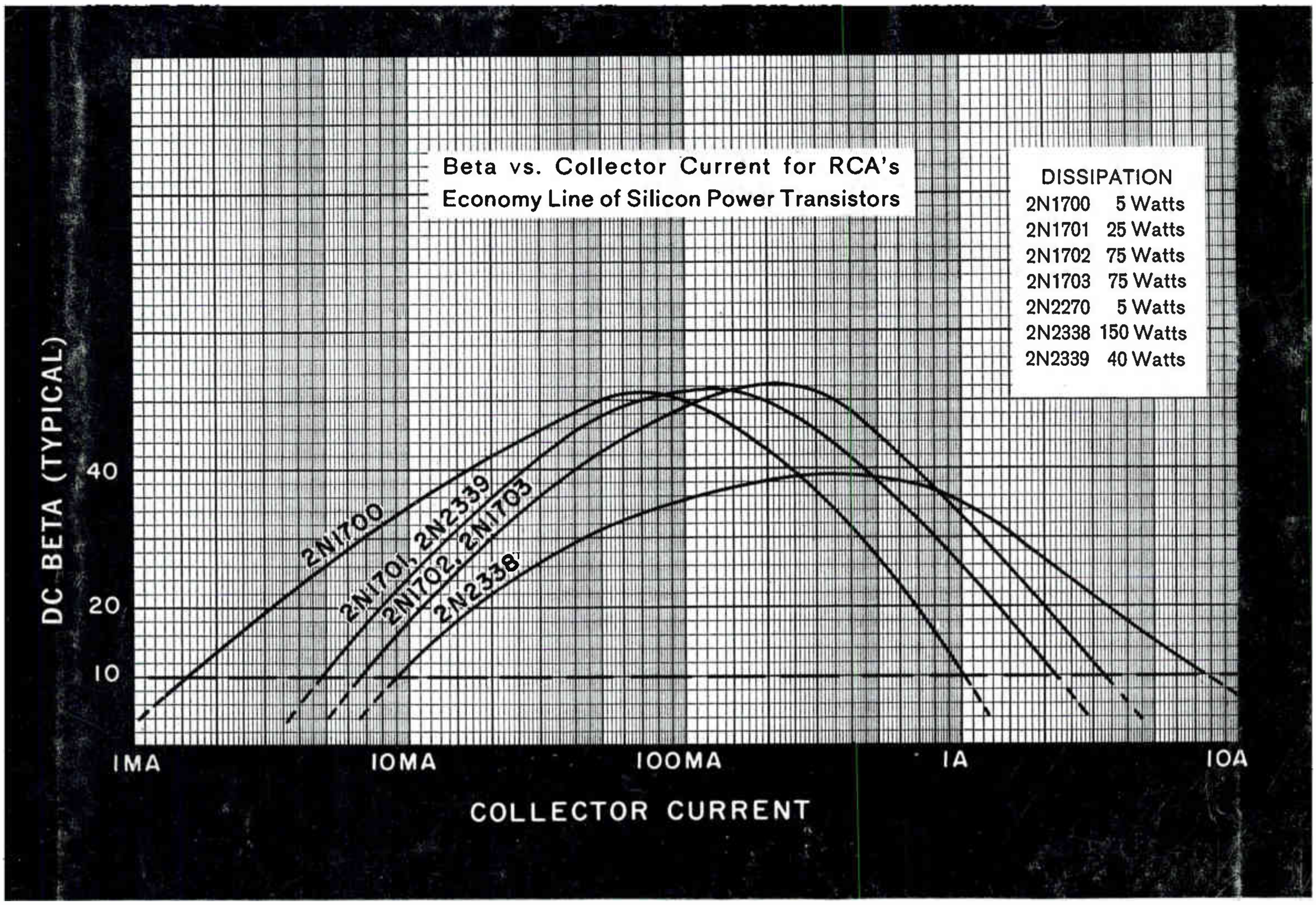
*Fixed-tuned—optimized for linear accelerator service.

For details on Sperry's broadband, high average power, phase linear, high pulse energy megawatt klystrons, write Section 168. Information about a wide selection of classified Sperry microwave tubes is available with proper security clearance and "need to know." Sperry is represented nationally by Cain & Co.

SPERRY | ELECTRONIC TUBE DIVISION

SPERRY RAND CORPORATION
GAINESVILLE, FLA. / GREAT NECK, N. Y.

CIRCLE 901 ON READER SERVICE CARD




# RCA EXPANDS ECONOMY SILICON LINE FOR LOW COST DESIGN FLEXIBILITY UP TO 150 WATTS

**Now, RCA adds 3 new types, 2N2338, 2N2339, 2N2270 to its line-up of low-cost silicon transistors at prices starting as low as comparable Germanium Power Types.**

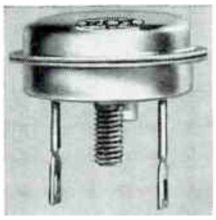
Here's RCA's answer to today's value and performance requirements for industrial and military applications...a broad new economy line of silicon transistors. This low-cost, high performance line now includes three new types, 2N2338 and 2N2339, high and medium power types, respectively, and the 2N2270, RCA's new economy version of the "Universal" triple-diffused planar silicon transistor type 2N2102. With these additions, RCA's economy silicon line now offers:

- High dissipation...up to 150 watts
- Top performance at high temperatures...up to 200°C
- Wide-range beta control...up to 10 amps

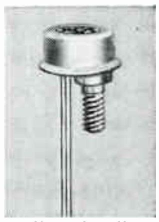
These low-cost silicon types are immediately available to bring you new economy and greater design freedom for industrial and military circuits demanding the reliability and performance of silicon transistors.

AVAILABLE THROUGH YOUR RCA DISTRIBUTOR

New RCA 2N2270 Triple-Diffused Planar



New 150-watt RCA 2N2338



New 40-watt RCA 2N2339

For new low prices call your RCA representative today. For FREE Technical Bulletin on RCA's Economy Silicon Line, write RCA Semiconductor and Materials Division, Commercial Engineering, Section IN11-5, Somerville, N. J.

**FIELD OFFICES...**
EAST: Newark, N. J., 744 Broad St., HU 5-3900 • (Camden-Philadelphia Area) Erlton, N. J., 605 Marlton Pike, HA 8-4802 • Syracuse, N. Y., 731 James St., Rm. 402, GR 4-5591 • Baltimore, Md., EN 9-1850 • NORTHEAST: Needham Heights 94, Mass., 64 "A" St., HI 4-7200 • SOUTHEAST: Orlando, Fla., 1520 Edgewater Dr., Suite #1, GA 4-4768 • EAST CENTRAL: Detroit 2, Mich., 714 New Center Bldg., TR 5-5600 • CENTRAL: Chicago, Ill., Suite 1154, Merchandise Mart Plaza, WH 4-2900 • Indianapolis 5, Ind., 2132 East 52nd St., CL 1-1405 • Minneapolis 16, Minn., 5805 Excelsior Blvd., WE 9-0676 • Denver 11, Colorado, Continental Terrace Bldg., Suite 301, 2785 N. Speer Blvd., 477-1688 • WEST: Los Angeles 22, Calif., 6801 E. Washington Blvd., RA 3-8361 • (San Francisco Area) Burlingame, Calif., 1838 El Camino Real, OX 7-1620 • Seattle 4, Wash., 2250 First Ave. S., MA 2-8816 • SOUTHWEST: Dallas 7, Texas, 7905 Carpenter Freeway, ME 1-9720 • GOV'T: Dayton, Ohio, 224 N. Wilkinson St., BA 6-2366 • Washington, D. C., 1725 "K" St., N.W., FE 7-8500 • RCA INTERNATIONAL DIV., 30 Rockefeller Plaza, N. Y. 20, N. Y. Cable Address: RADIOINTER, N. Y.

RCA®

**THE MOST TRUSTED NAME IN ELECTRONICS**

CIRCLE 902 ON READER SERVICE CARD