June 8, 1962

electronics

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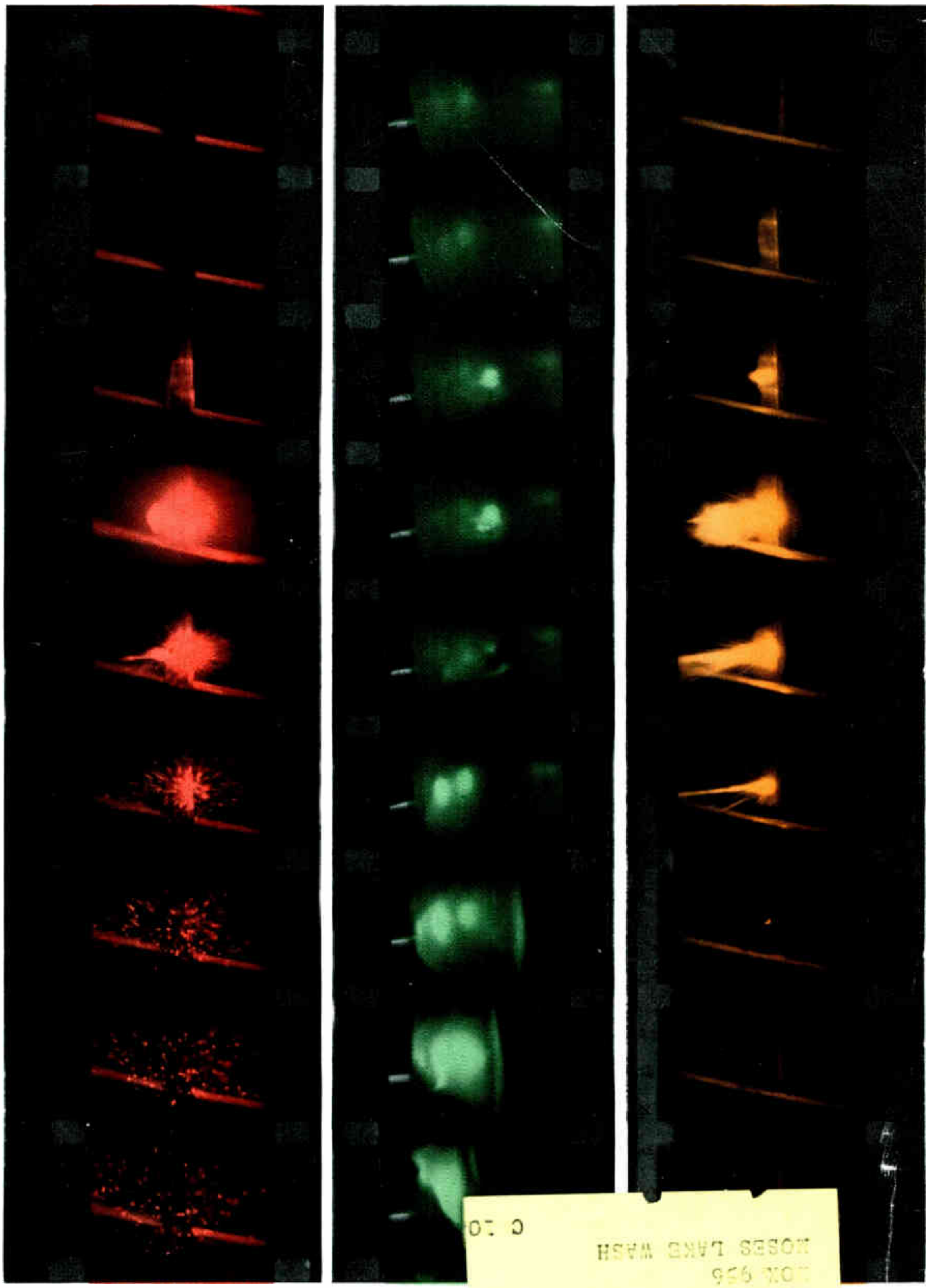
(Photo at right)

THE POWER OF A LASER

burns razor blade, balloon and graphite



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forecasts control behavior, p 35

LOCK-IN AMPLIFIERS

recover signals in high noise level, p 40

FUNCTION GENERATOR

glass disk lets it duplicate any waveform, p 44

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W. W. MacDONALD, Editor

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electronics

June 8, 1962 Volume 35 No. 23

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

Indexed Annually in Buyers' Guide and Reference issue.

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

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

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DEPARTMENTS

What Shortage?

THERE IS NO SHORTAGE of engineers, and there is no such thing as a design engineer. There is, rather, a shortage of good technicians and a shortage of good engineers, just as there is a shortage of good architects, good physicians or good any other kind of professional man.

As for the so-called "design" engineer: there are two jobs here, one for the engineer who essentially creates new devices, circuits and systems and the other for the man who is a high-grade technician regardless of his academic pedigree, and who handles the electrical and mechanical details of a new device, circuit or system. Not many men successfully perform both functions long term.

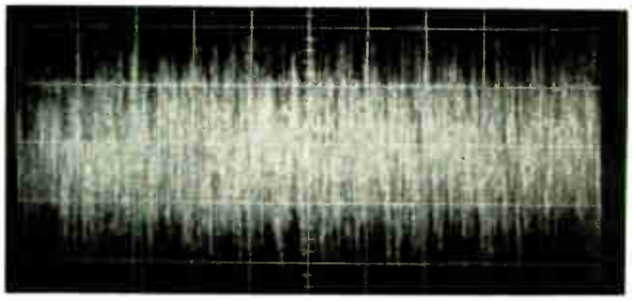
The difference between an engineer and a technician is one of task emphasis: the engineer emphasizes the theoretical, although he must also be knowledgeable about the practical side of his work, while the technician emphasizes the practical side and must, similarly, possess theoretical knowledge. Educators understand this, and the relative course content of the better engineering schools and technical institutes demonstrates it. The top engineering schools teach subjects such as transform analysis, fields and waves, solid-state and electrical discharges. The technical institutes teach radio, television, microwave equipment and industrial electronics.

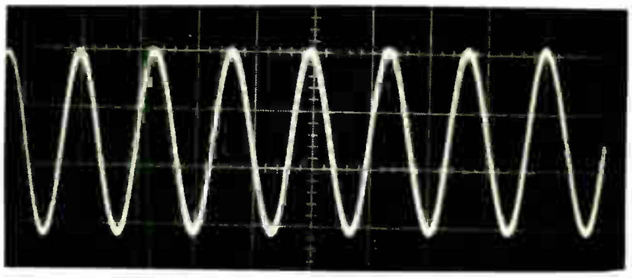
The prevailing practice, in the electronics industry, of putting a young engineer on the test bench or using him as a wireman is a waste of trained manpower. It guarantees mediocrity in design of the company's products because by the time the engineer advances from the test bench, drawing board or model shop to truly creative engineering work, he has often forgotten most of what he learned in college. Or it is out of date.

It is high time this industry recognized that it really takes two or even three kinds of technically trained men to make the wheels go round. First, the truly creative engineer, well grounded in theory and up to the minute on the very latest advances in the field. Second, the good technician, a man who can take the engineer's schematic and whip up a breadboard that works, convert it to a chassis or circuit board that can be repetitively manufactured, handle the testing and debugging and perhaps even take care of installation, maintenance and repair.

Finally, we need the businessman who understands technical electronics. For him, there should be developed concentrated survey courses so that he can concentrate his major academic effort on specialized fields such as marketing, finance and management.

Let's hire technicians to do technician's work and businessmen to do businessmen's work and stop inflating the requirements of engineering schools so they can get down to their primary job of training engineers.





THE WHEAT FROM THE CHAFF. Human sense organs are usually regarded as remarkably versatile since they can encompass an amazingly wide range of intensity in what they sense. The ear, for example, spans some 130 db from the threshold of hearing to a painful noise level.

Yet when it comes to interpreting what it hears, picking out signals from a noisy background, say, the ear is way behind modern electronic techniques. Could you listen to a symphony on your portable hi-fi set (70 db) while operating a pneumatic drill at full blast (110 db)?

Robert D. Moore, of Princeton Applied Research, this week describes a sophisticated receiver lock-in amplifier that, in effect, can do just that. The system will dig out a useful signal 40 db below the noise.

The illustrations give some qualitative idea of the receiver's performance. The upper scope photo shows a typical noisy signal input. A 4-Kc signal is buried in this noise spectrum at a level of approximately 6 mv peak-to-peak. The lower photo shows that 4-Kc signal, on an expanded vertical scale.

COMMENT

Ultrasonic Delay Lines

I feel that the solutions given for Equation 2 in the article, Ultrasonic Delay Line Equation Is Evolved, by H. Mack Thaxton, (p 80, April 27), are in error even after the typographical error in the solution of Eq. 4 is corrected.

[Editor's note: To make Eq. 4 parallel with Eq. 3, an x should be inserted in Eq. 4, just before the slash-bar preceding the last C, so that the last part of the equation reads ρ exp—$C^{\frac{1}{2}}\omega^2 x/C_o^{\,2}$.]

Perhaps author Thaxton or the editor would be willing to give me a reference to the "standard methods" alluded to.

James D. Easton
La Jolla, California

Author Thaxton replies:

Below are a few of the basic techniques which are applicable to mathematical problems involving variable cross section delay lines. The present state of this art, excluding highly classified projects, requires no particular ingenious devices of either a mathematical or physical type. Such techniques, therefore, as those of the outline below, will adequately solve the problems encountered in this work.

Listed here are only a *few* of the techniques which may be applicable. Our specific problems involving this subject have not required the use of other techniques.

The methods listed here, one may say, are the elementary straightforward techniques. Techniques required in applying Laplace transformation theory, Fourier transformation theory, operational analyses and analytic continuation processes are numerous. These techniques may be simple and much more elegant than the straight-forward techniques presented below.

H. Mack Thaxton
Englehard-Hanovia, Inc.
Newark, New Jersey

Method 1:

$$d^2y/dx^2 = Y \quad (1)$$
$$dy/dx = 2\int Y dy + c$$
$$x = \int dy/(2\int Y dy + c)^{1/2} + c_1 \quad (2)$$

Method 2:

$$\text{Let } d^ny/dx^n = f(d^{n-1}y/dx^{n-1}) \quad (3)$$
$$\text{If } z = d^{n-1}y/dx^{n-1}$$
$$dz/dx = f(z)$$
$$x = dz/f(z) + c \quad (4)$$
$$\text{If } z = \psi(x, c),$$
$$\text{then } d^ny/dx^n = \psi(x, c)$$

Example: suppose:
$$(ad^2y/dx^2)(d^3y/dx^3) = \sqrt{1 + (d^2y/dx^2)^2}\ .$$
$$\text{Let } d^2y/dx^2 = z$$
$$\text{Then } azdz/dx = \sqrt{1 + z^2}$$
$$\text{or } x = a\sqrt{1 + z^2} + c \quad (5)$$
$$\text{and } z = d^2y/dx^2 = \sqrt{(x - c)^2 - a^2}/a$$
$$\text{or } y = \sqrt{(x - c)^2 - a^2}/aD^2$$
$$\text{and } dy/dx = \int az^2\,dz/\sqrt{1 + z^2}$$

Hence,
$$y = a^2z^3/6 - (a^2\sqrt{1 + z^2}/2)\log(z + \sqrt{1 + z^2}) + a^2z/2 + ac_1\sqrt{1 + z^2} + c_2 \quad (6)$$

Eliminating z from (5) and (6) gives the solution.

Method 3:
$$d^2y/dx^2 + f(x)dy/dx + F(y)(dy/dx)^2 = 0 \quad (7)$$

Integrating once, neglecting the last term, gives
$$dy/dx = ce^{-\int f(x)dx}$$

Let c vary with y, then
$$d^2y/dx^2 = (dc/cdy)(dy/dx)^2 - f(x)dy/dx$$

and (7) becomes:
$$dc/cdy - F(y) = 0$$

Thus, the general solution is:
$$\int e^{\int F(y)dy}\,dy = B\int e^{-\int f(x)dx}\,dx + E \quad (8)$$

Method 4: Equations of the form:
$$[f(x)D^2 + (a + bx)D + (c + dx + ex^2)]\,y = 0 \quad (9)$$

are reducible to a solvable form:
$$[f(x)D^2 + (g + hx)D + k]\,z = 0 \quad \text{by } y = ze^{\alpha x}e^{\beta x^2/2}$$

Method 5: Equations of the form:
$$P(p,q,r,s,t) = (rt + s^2)^n\,Q(x,y,z) \qquad n > 0 \quad (10)$$
$$\text{Let } q = \psi(p), \text{ then}$$
$$s = \psi'(p)r \qquad t = \psi'(p)s = [\psi'(p)]^2r \quad (11)$$

Substituting (11) in (10) gives an equation in p, $\psi(p)$, and $\psi'(p)$, which, when integrated gives a relation between p and q and an arbitrary constant. Integrating the last equation gives the solution.

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ELECTRONICS NEWSLETTER

Washington Rejects Transistor Import Quota

WASHINGTON—The Office of Emergency Planning last week announced rejection of the 2½-year-old request by the Electronic Industries Association for import quotas on Japanese transistors to protect U. S. defense production capability. E. A. McDermott, OEP director, said the petition was rejected after long study because the U. S. industry appears capable of meeting defense requirements for the forseeable future.

EIA, acting in behalf of several U. S. transistor manufacturers, had applied for a ruling in September, 1959. McDermott's report admitted that there has been a considerable increase in transistor imports, especially in the small radio field, but said that the U. S. industry was rapidly expanding anyway. U. S. electronics producers will continue to get the lion's share of defense contracts and the industry seems in good condition to fulfill these and any future orders that might come from an emergency, the report said.

Digital Process Control Computer Line Introduced

PITTSBURGH — Westinghouse Electric and Sperry Rand's Univac division have teamed up to produce a new line of digital industrial process control computers, called the Prodac 500 Series. Univac makes the central computer and some peripheral equipment. Westinghouse supplies the system, installation and related services.

The computers feature a priority interruption system permitting simultaneous off-line computation and on-line process control. The 510 is for single-process systems, data logging, monitoring and computation. The 580 has more flexibility and capacity. Core memories range from 4,096 to 16,384 18-bit words, drums hold 32,768 or 65,536 words. Access time is 1.8 μsec and cycle time, 4 μsec. Input-output capabilities include 2,048 analog inputs and 1,024 digital inputs and outputs.

Gulf States Paper has ordered a 580 to control a pulp digester. Another will go to Arizona Public Service as part of an automatic digital dispatch and processing system that will include a solid-state analog circuit to regulate generators, and telemetry.

Double Tunneling Might Lead to Decimal Diodes

SECONDARY TUNNELING, recently observed and controlled in experimental diodes at RW division, Thompson Ramo Wooldridge, could lead to a decimal diode, with 10 stable states permitting computers to operate directly in a decimal code. The experimental diode, dubbed a "camel diode," has a double-humped I-V characteristic.

According to an RW spokesman, conventional tunnel diode theory postulates a forbidden energy gap, through which the passage of electrons cannot be controlled. RW found that by diffusing the impurity atoms in this forbidden gap, empty states were created which enhanced tunneling either through the intermediate states to the valence band or directly through the empty states created in the band gap. Which of the two effects occurs depends on the concentration of impurity atoms within the band gap that can be achieved by the state of the art, the spokesman said.

Russians Want Japanese Transistor Plant Gear

TOKYO—Informed sources here report that a USSR trade delegation is attempting to purchase equipment or plants to manufacture transistors for radio and television sets.

One Russian indicated that some Japanese companies do not wish to sell. Some companies promise catalogs, but never send them. Others have agreements with U. S. companies which prevent sales to the USSR.

Among purchases the USSR has made in Japan are electron microscopes and automatic recording type spectrometers. The USSR purchasing office in Tokyo is staffed by about 30 people.

Court Rejects Plea to Keep Incentive Profits

WASHINGTON—U. S. Tax Court has rejected again Boeing's appeal from a Renegotiation Board ruling on excessive profits (ELECTRONICS, p 12, May 18). The court affirmed that $13 million of Boeing's earnings on Air Force contracts in 1952 must be repaid to the government.

Over 80 percent of Boeing profits that year were derived from incen-

Tokyo Tightens Foreign Technology Screening

TOKYO—The Science and Technology Agency last week decided to establish tighter screening criteria for introduction of foreign technology, to protect domestic industries from electronics to manufacturing instant coffee. Screening had been relaxed recently in anticipation of foreign trade liberalization.

The agency is expected to refuse approval of applications to introduce foreign techenology in the following cases:

When production has started on the basis of similar domestic technology; when foreign technology is likely to obstruct development of similar domestic technology expected to be adopted for commercial production; when the company seeking approval will be unable to develop the technology; when terms for introduction are considered unreasonable, unduly unfavorable or less favorable than terms for introduction of similar technology tive contracts. The use of such contracts is being expanded under a new Pentagon policy. In its appeal, Boeing argued that the board's recapture of incentive profits would undermine industry confidence in this type of procurement.

The Defense Department denied this, claiming that the new type of incentive contracts will differ from those awarded Boeing in 1952. The new policy, the Pentagon says, will stress the establishment of more precise target cost estimates, on which incentives will be based, and will reward quality of product and accelerated delivery schedules as well as cost control.

Varying Voltage Scans Radar Antenna Array

WORKING MODEL of an electronically scanned, circular antenna array that permits a radar beam to be pointed in any direction has been developed by James D. Tillman, Jr., and associates at the University of Tennessee. The concentric array consists of 12 quarter-wave monopole elements in an outer circle, 8 in the next, 4 in an inner circle, and one in the center. Beam direction is controlled by a d-c control voltage that varies voltage output amplitudes of two amplifiers connected to each ring. Funded by the Air Force, the system will be demonstrated next month at the Air Force Cambridge Research Laboratory.

Nonlinear Interactions Point to Laser Advances

BOSTON—Availability of optical masers as an intense light source is spurring research into nonlinear interactions at optical frequencies. At a meeting of the New England section, Optical Society of America, Perry A. Miles, of MIT, reported on a neodymium glass optical maser with primary output of 1.06 microns and harmonic generation at 0.53 micron. At power level of only a few microwatts, little significance is seen for applications at this stage, but experimentation is expected to yield important information about nonlinear processes in crystals. Nicolas Bloembergen, of Harvard, said that the theory of interaction between light waves in nonlinear media predicts not only harmonic generators but mixers, modulators and demodulators, limiters and "all the things which radio engineers have done at radio and microwave frequencies."

Storage Tubes Provide Stop-Motion Television

ROCHESTER—Television system employing storage tubes is being used by Eastman Kodak as a portable monitor for checking operation of high-speed manufacturing processes.

The last 12 frames of the picture taken by a tv camera are stored by 12 Raytheon storage tubes. During normal operation, the frames change at the frame speed. If the process breaks down, the monitor stops and holds the last 12 frames, allowing Kodak engineers to analyze what happened just before the breakdown.

Japanese Transistors Sought by Hong Kong

TOKYO—The British embassy here warned the Japanese Foreign Office last week that the Japanese embargo of transistors to Hong Kong be lifted or imports of Japanese cotton cloth will be shut out.

The Crown Colony Authority is said to be sympathetic with the Chinese manufacturers on the issue because electronics is now a growth industry in Hong Kong. At the same time, Hong Kong textile manufacturers are now being restricted in their exports to the U. S.

With an export trade council scheduled for mid-June, MITI, the trade ministry, will soon send a mission to Hong Kong to talk things over with the Chinese manufacturers and ask them "to make some kind of adjustment" in their transistor radio exports to the U. S. similar to that of the Japanese.

MITI last week suspended temporarily transistor exports to Hong Kong and Okinawa on the ground that they are exporting six-transistor radios to the U. S. $6 cheaper than those of the Japanese.

In Brief . . .

FEDERAL AVIATION AGENCY is centering materiel and contracting functions, formerly dispersed among several facilities, in a new Installation and Materiel Service office.

LATIN AMERICAN Free Trade Area members are meeting in Montevideo to coordinate development of the electronics industry in Latin America.

NASA and the Swedish Committee on Space Research have agreed on a cooperative space research program. Four Nike-Cajun sounding rockets will be launched from the Vidsel Range, in Sweden, to investigate noctilucent clouds and energetic particles.

TROPSCATTER f-m radio transmitters providing hops of 393 and 341 miles have been delivered by Radio Engineering Labs to Western Electric under a $5.6 million contract. The three-station net will be used by the Air Force in the outer Aleutians.

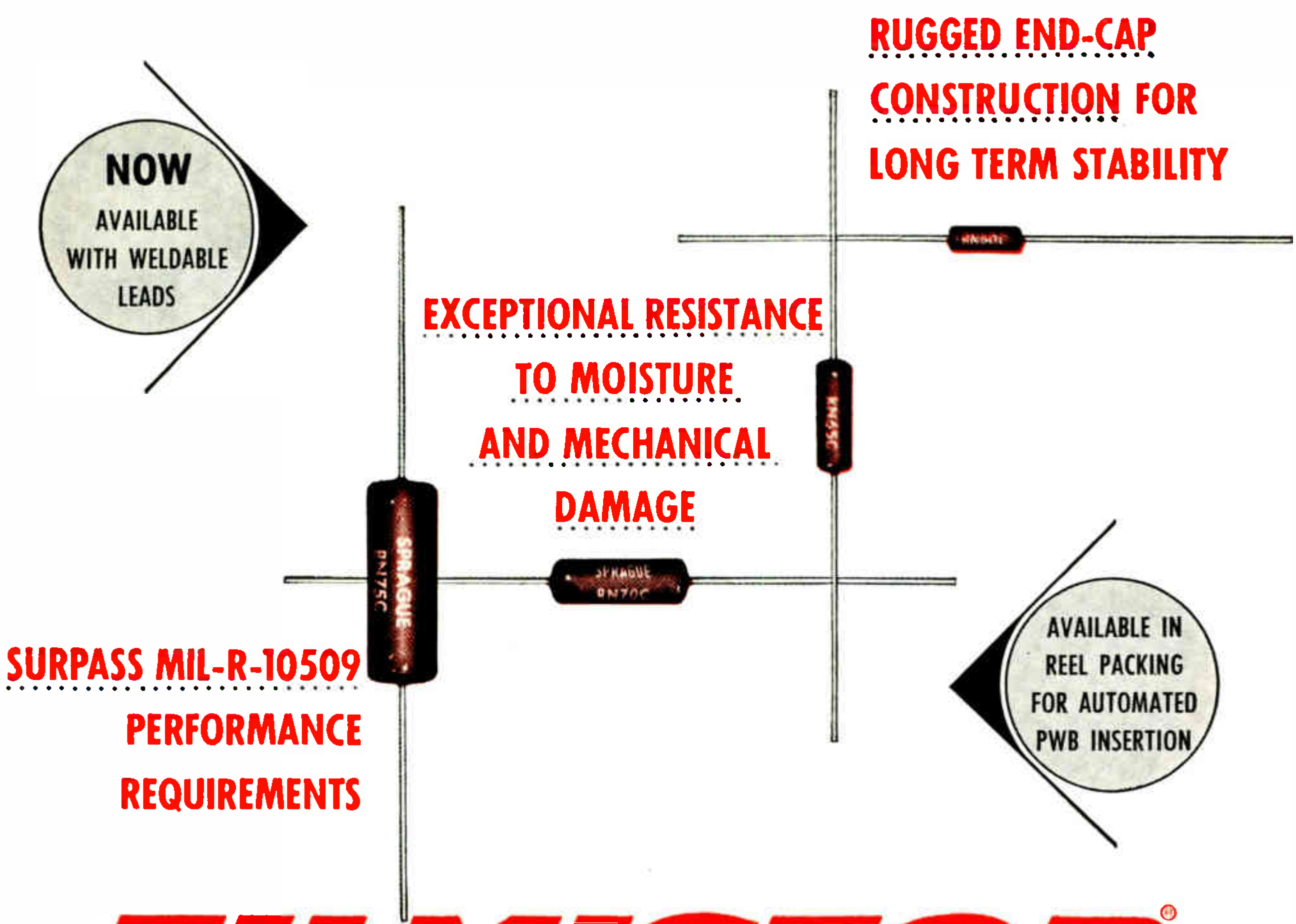
FOUR GE 225 computers have been ordered by NASA for engineering analysis of the Saturn booster. One has a special input-output buffer to scan 1,000 gages on the vehicle at a rate of 0.1 msec.

TEXAS INSTRUMENTS has an Air Force contract to develop for the Vela program a seismograph that will convert ground movement signals directly into digital format for computer analysis.

TRACKING MALFUNCTION caused a 30-mile-high nuclear blast to be aborted at Johnston Island, postponing for two weeks a test of such a blast's blackout effects on communications.

MISSILE CONTRACTS include $4.7 million to GE for Sidewinder guidance control systems and $5.3 million to General Dynamics for missile site communications.

REPUBLIC AVIATION has $1.5 million in Navy contracts for a submarine control system and a control training system.



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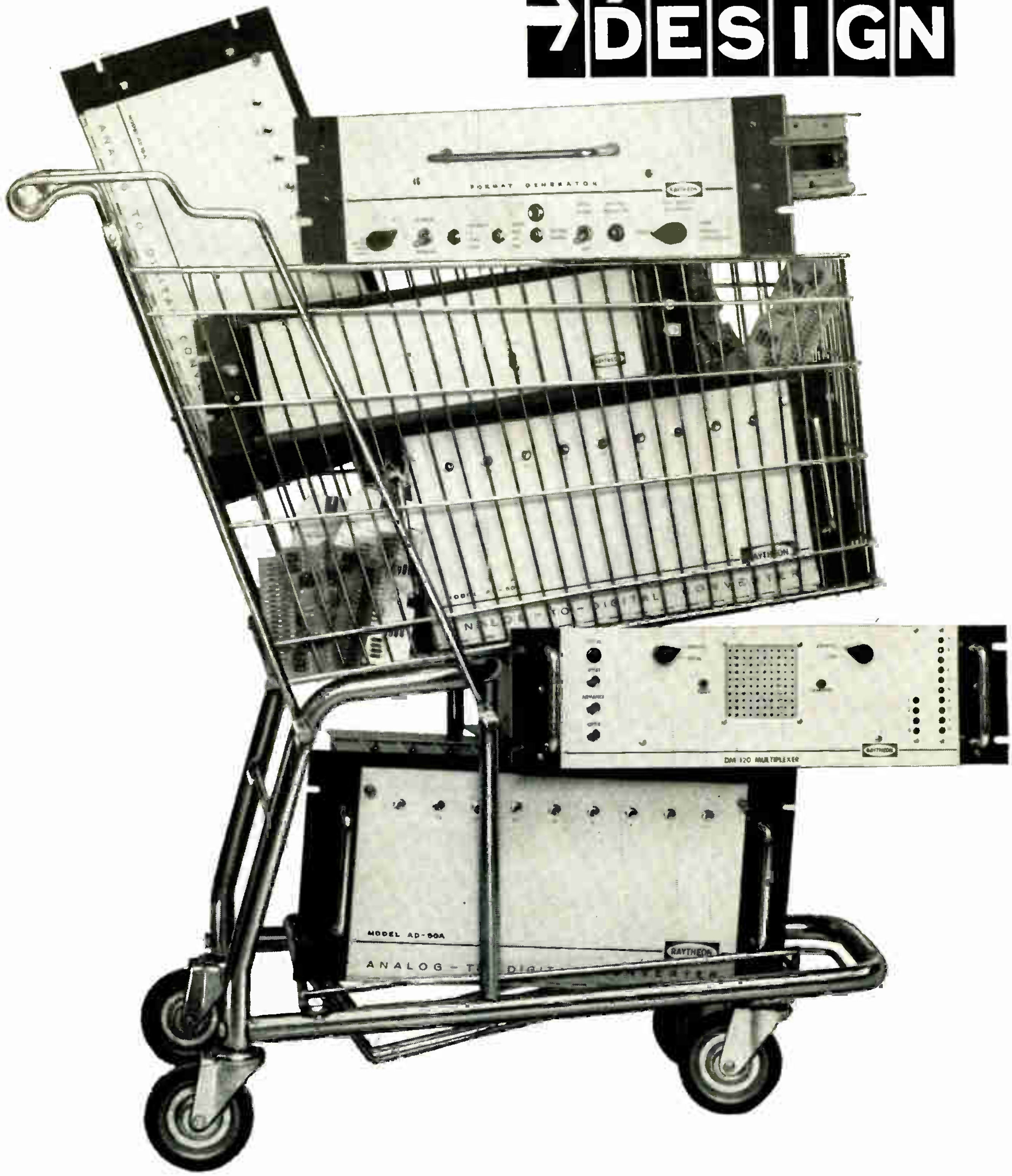

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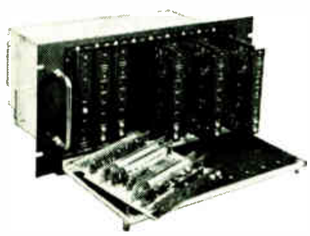

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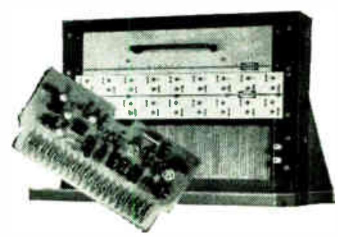

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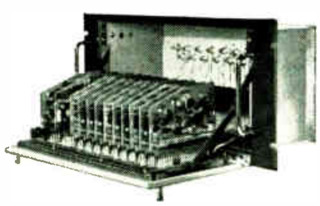

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WASHINGTON OUTLOOK

DOD WANTS PARLEYS REDUCED

DEFENSE INDUSTRY ADVISORY COUNCIL is being formed by the Pentagon as a single, formal, industry-Pentagon forum to discuss pending changes in procurement regulations and other matters of concern to defense industries. Up to 25 representatives of a wide range of military contractors will meet periodically with Defense Department officials. Secretary McNamara and his top aides are annoyed by what they consider excessive demands on their time in sitting down to discuss such matters with at least seven different trade associations, including EIA.

TAXPAYERS TO FINANCE SATELLITE PROFITS?

INTEREST OF BIG INVESTORS in the proposed communications satellite system is puzzling—and worrying—some officials.

This is what they fear: many small investors will be lured by the aura of government sponsorship. If government aid through minimum-cost boosters and access to technology isn't enough to make the system pay during a long shakedown period, political pressure on Congress to vote dividends could develop. Its insistence on public participation would put the administration in an embarrassing position.

To large investors, the possibility of small stockholder pressure for early returns adds to the stock's luster as a long-term proposition.

Officials who believe Kennedy should have let common carriers own the system claim its immediate earning potential is overrated, no matter how bright its long-term prospects. Satellite tv, for instances, faces varying time zones; overseas cable communications is today a relatively small market. There is still fear that limitations on common carrier participation in the satellite system will crimp their incentive to shift traffic quickly from cable to satellite.

FCC AIDES TO DECIDE RADIO CASES

FEDERAL COMMUNICATIONS COMMISSION has hopefully established a short-cut procedure to deal swiftly with routine radio cases. A four-man staff review board headed by Donald J. Berkemeyer, chief of the opinions and review office, will make final decisions.

The commission can still review cases raising policy questions, but normally contests of review board decisions will go directly to federal courts.

Chairman Minow and other commissioners expect the board to relieve them of time-consuming routine actions, giving them more time for policy planning and major regulatory problems. Broad delegation of commission duties was authorized by Congress last year.

ARMY WILL CENTRALIZE BUYING

FORT MONMOUTH, N. J., has been designated as headquarters for the Electronics Command of the New Army Materiel Command. Maj. Gen. Stuart S. Hoff, now chief of R&D in the office of the Army's Chief Signal Officer, will head the new agency.

The Electronics Command will be responsible for both R&D and procurement of Army communications equipment, electronic warfare systems, combat surveillance systems, automatic data-processing equipment, and radar. It will absorb the Army's Signal R&D Agency and Signal Materiel Support Agency, already at Fort Monmouth, Signal Materiel Management and Procurement Agency in Philadelphia, Air Defense Engineering Agency at Fort Meade, Md., and the electronic test ranges at Fort Huachuca, Ariz., and White Sands, N. M.

These Army field agencies will continue operating, but under Fort Monmouth's centralized management.

CIRCLE 13 ON READER SERVICE CARD →

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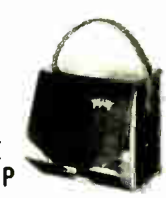
Handle also serves as tester stand.



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SOLAtron LINE VOLTAGE REGULATOR

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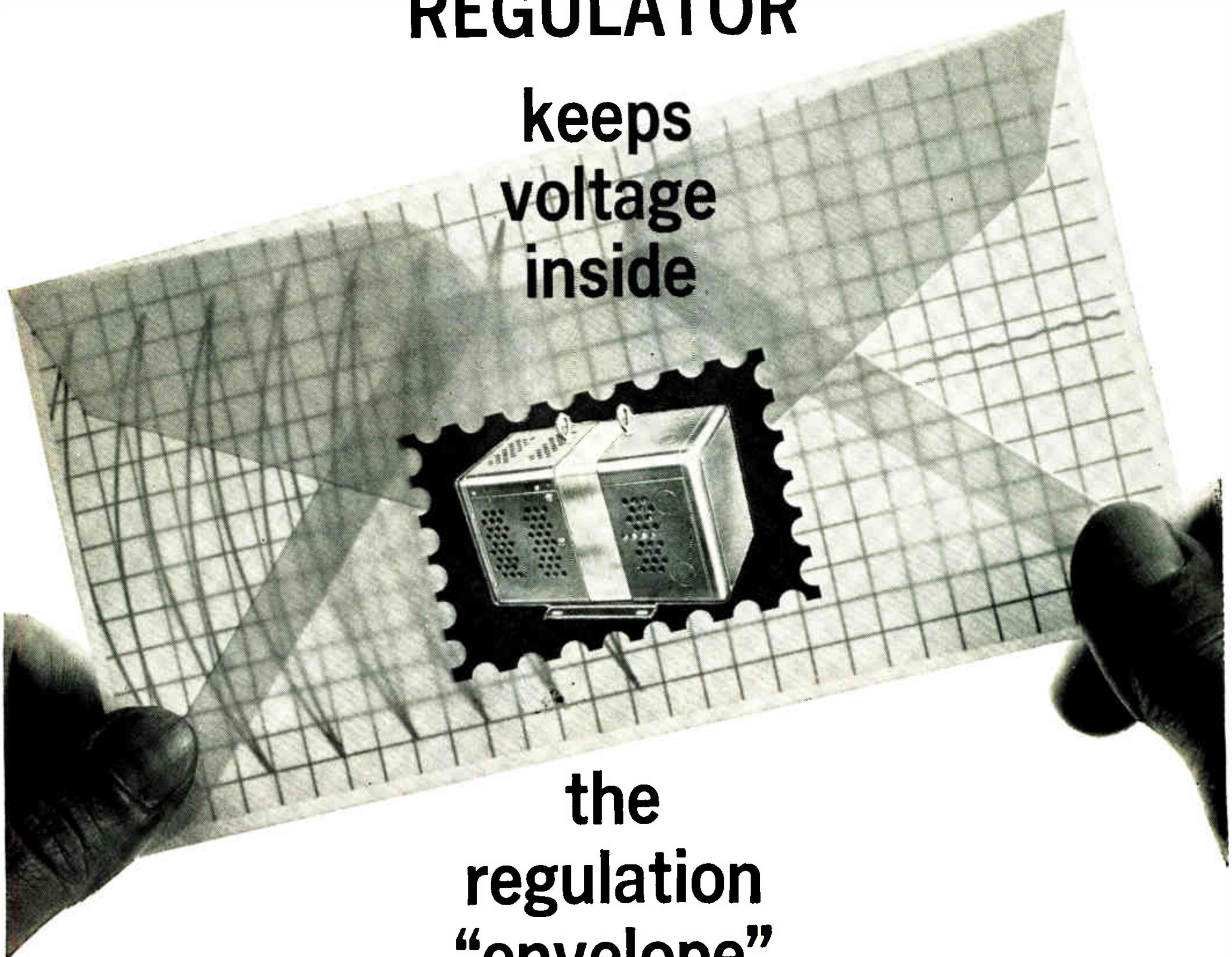
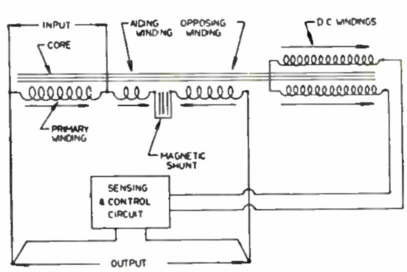


the regulation "envelope"

Starts corrective action the instant output departs from nominal... long before voltage even approaches the boundaries of the regulation envelope. In fact, response is *10 times faster* than mechanical regulators. Even under extreme conditions, return to nominal will *never* exceed 10 cycles. And no moving parts means no electro-mechanical wear. Maintenance is reduced to insignificant static-design proportions. A solid-state sensor triggers a magnetic flux "valving action" to maintain nominal voltage.



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Variation in magnetic cores can halt your whole production with a high reject rate and can multiply the engineering burden through product redesigns and adjustments.

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electronics

Editorial Opportunity

IT DOESN'T HAPPEN OFTEN, but electronics, "bible of the industry" and a McGraw-Hill publication, has an opening for an Assistant Editor.

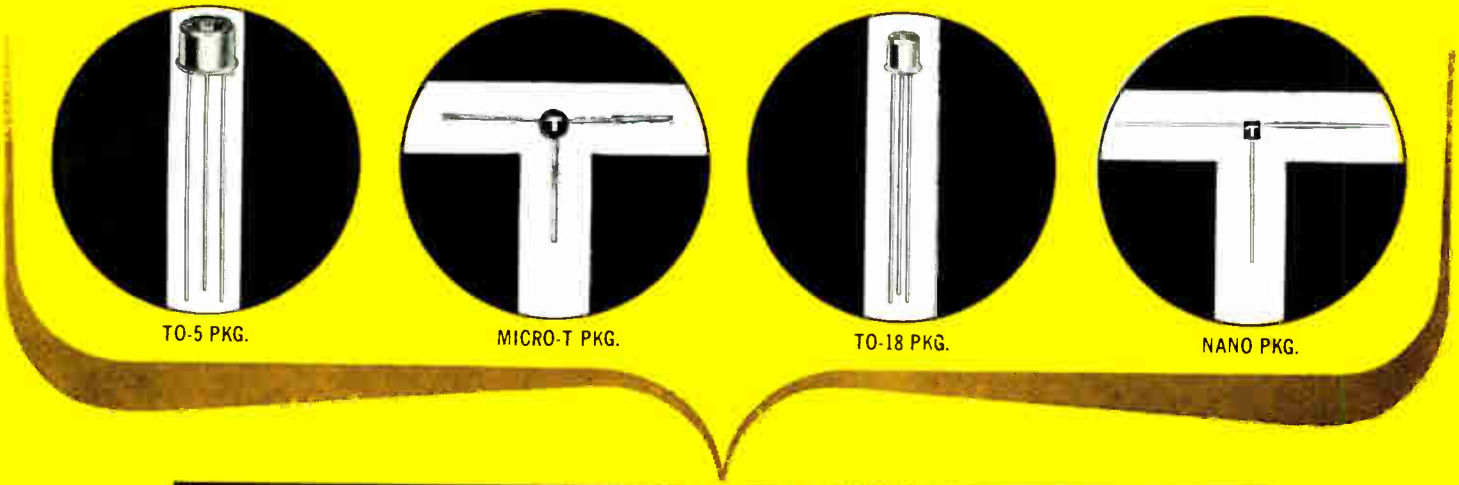
Ideally, the man we are looking for and to whom a post on our New York staff could be a long-term challenge, would have an electrical engineering degree or technical equivalent, practical experience in our field and a demonstrated aptitude for editing, writing, reporting. He probably lives somewhere in the metropolitan area and therefore would have no relocation problem.

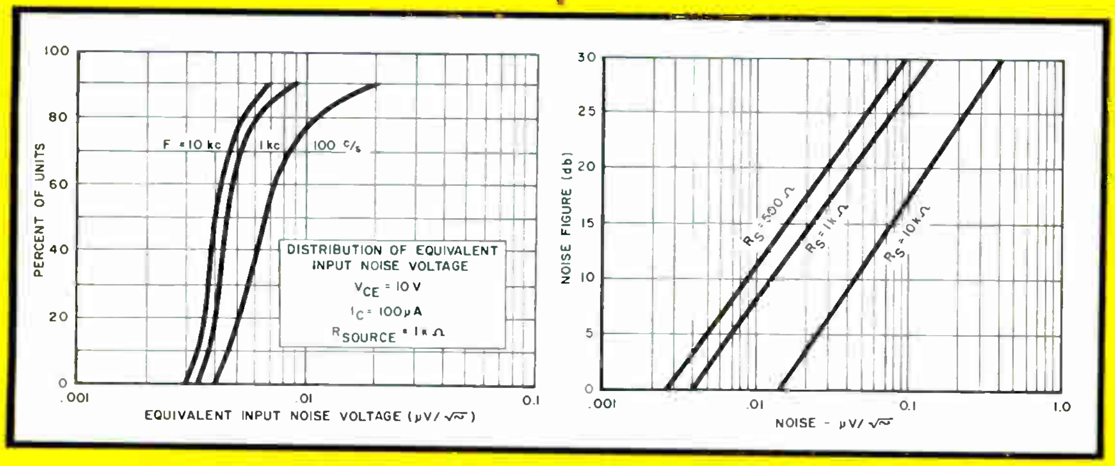
Write **The Editor, electronics, 330 W. 42nd St., New York 36,** stating experience, aspirations and past earnings. Mark the envelope "Confidential" and it will be kept that way.

NEW LOW LEVEL MESA TYPES

AUGMENT TRANSITRON'S COMPREHENSIVE LINE OF

SMALL SIGNAL SILICON TRANSISTORS





TRANSITRON'S newest addition — the 2N2427 — further demonstrates why the firm continues to be the industry's most versatile and dependable source for small signal silicon devices. This new low level diffused mesa type — available in any of the four packages illustrated on this page — is typical of a wide variety of silicon transistors designed to serve a comprehensive range of small signal applications.

Type	Minimum Collector to Base Breakdown Voltage (Volts)	Maximum Collector to Base Leakage Current (nA)	Minimum Forward Current Transfer Ratio (β @ 10µA)	Maximum 1/f Equivalent Input Noise Voltage (µvolts)
2N2427	40	10	20	2

TRANSITRON engineers also invite your inquiries concerning specific applications requiring noise levels down to tenths of micro-volts, leakage currents down to 1nA and betas greater than 50 at 5µA.

Historically, TRANSITRON was the first semiconductor firm to thoroughly investigate low level amplifier requirements. With the subsequent introduction of the grown junction 2N1247-48 types, TRANSITRON was the first to design silicon transistors specifically for this demanding category of applications.

TRANSITRON today offers a full range of types and characteristics from which to select. Popular series in this line are:

- 2N839-45 and 2N754-5 (both exclusive to TRANSITRON)
- 2N1564-66
- 2N1572-74
- 2N734-6 and 2N738-40
- 2N756A-60A

All types are optionally available in any of the four packages shown here. All are available for immediate delivery in production quantities.

For complete specifications and characteristics, write to TRANSITRON'S Wakefield facility. And remember . . . TRANSITRON know-how has developed a reliable silicon transistor for every small signal application.

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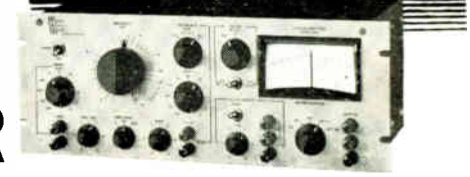
RECOVER SIGNALS FROM NOISE

NEW LOCK-IN AMPLIFIER



Now you can recover signals 40 db below 1 kilocycle bw ambient white noise.

This new signal processing instrument is designed to recover signal information from noise. It is a narrow band detection device, the center frequency of which is locked to the frequency at which the signal information has been made to appear. Therefore, extremely narrow detector band widths can be obtained with complete freedom from drift between the detector center frequency and the characteristic signal frequency. Consequently, it is applicable to situations where narrow band operation will enhance signal-to-noise ratio. Lock-in amplifier techniques are being used in radio astronomy, nuclear and electron magnetic resonance experiments, carrier life time studies in semiconductors, experiments in special and general relativity, and optical pumping.

Pertinent specifications include: **frequency range** 15 to 15,000 cps continuously tunable; **equivalent band width** 0.12 cps min. (2 sec. max. RC integrating time). 6 or 12 db per octave selectable roll-off; gain RMS AC in to push-pull DC out — approx. 9,000. Completely transistorized. Price: $990. *Write for Bulletin 103*

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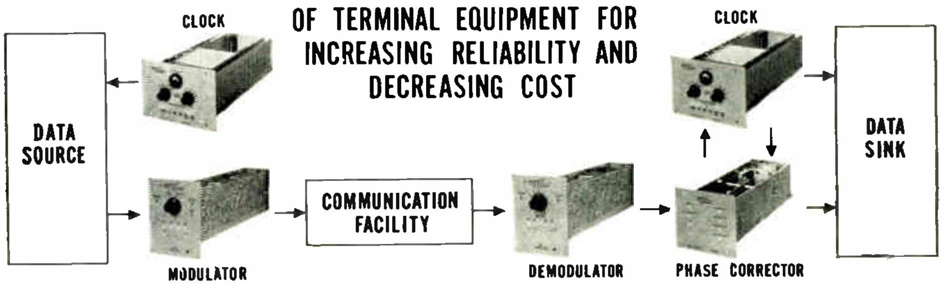
CIRCLE 203 ON READER SERVICE CARD

ANOTHER EXAMPLE OF RIXON'S SERVICE TO ITS CUSTOMERS

THE DOUBLE D LINE

A SIMPLIFIED MECHANICAL DESIGN OF TERMINAL EQUIPMENT FOR INCREASING RELIABILITY AND DECREASING COST



The Problem:

Many data communications systems today are either experimental forerunners of possible major systems of the future or part of an overall experimental program which may or may not be repeated. Because of the uncertainty about the future requirement for the hardware, it is not practical to develop special equipment for each application. This leaves us with the problem of constantly redesigning equipment to fit ever-changing requirements, or having to purchase superfluous equipment to meet the requirements. If a device is needed for development of various timing signals, to be compatible with existing equipment, then the logical answer would be to procure only a timing device — not a complete deck of equipment just to get a timing generator. There should be a solution to any requirement of this type — a solution which would provide complete functional units, each one performing one of the common functions in a data communications system. Incidentally, Rixon has the solution!

The Solution:

Rixon's solution is a new hardware approach based on simple, low-cost functional units with common mechanical features, which has eliminated the heretofore sacred mechanical design features. This naturally has resulted in a drastic reduction of manufacturing complexity, and an equally important improvement in reliability. Mechanical features, whose sole purpose was to provide quick access for mechanical service have now, through redesign, been eliminated — a cost-saving factor. Improved reliability is then achieved by eliminating potential mechanical failure points and by devoting more careful consideration to circuit and component design margins. Therefore, Rixon can furnish you with basic functional units which offer greater flexibility, increased reliability, and at lower cost.

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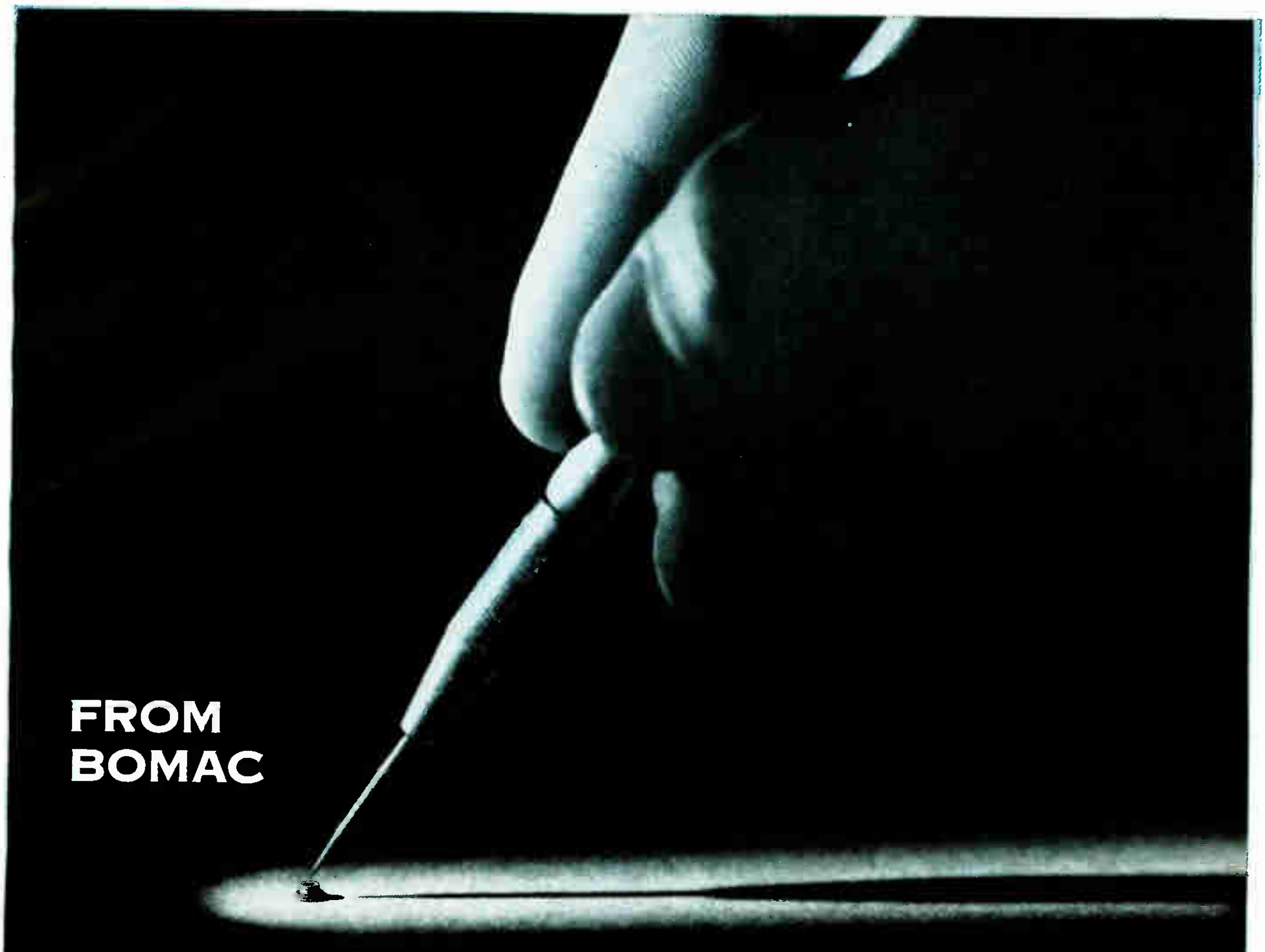


A NEW SUBMINIATURE VARACTOR DIODE

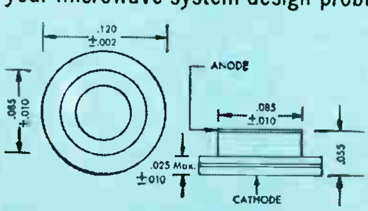
Bomac Laboratories' new ThermoBond* silicon varactor diode provides the microwave designer with a subminiature silicon component offering great reliability, uniformity, packaging simplicity, and size advantages.

Reliability is achieved through matching metal-to-ceramic seals and welded construction. There is no C-spring to work loose from environmental shock, and extreme temperature; an important noise source is eliminated. Uniformity is assured through heat bonding and batch process manufacturing techniques. Packaging simplicity is evident in the extremely small size of the ThermoBond diode. It easily withstands normal soldering temperatures. In addition, hermetically-sealed case construction provides long-life stability, independent of environmental conditions. Retrofit packaging is available. A single case dimension covers 252 electrical values.

Bomac ThermoBond silicon varactor diodes are designed for use in microwave limiters, sideband modulators, harmonic generators, low-noise parametric amplifiers, as tuning elements in voltage control oscillators, and in solid state duplexers.

Write for technical data on the ways in which ThermoBond diodes by Bomac can aid your microwave system design problems.

*Trademark



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CIRCLE 19 ON READER SERVICE CARD

Self-Organizing Systems Near Hardware

By CLETUS M. WILEY
Midwest Editor

CHICAGO—More blackboard than breadboard, self-organizing system theory is only beginning to evolve into hardware, according to 26 invited papers presented at a conference on self-organizing systems, cosponsored by the Office of Naval Research and Armour Research Foundation.

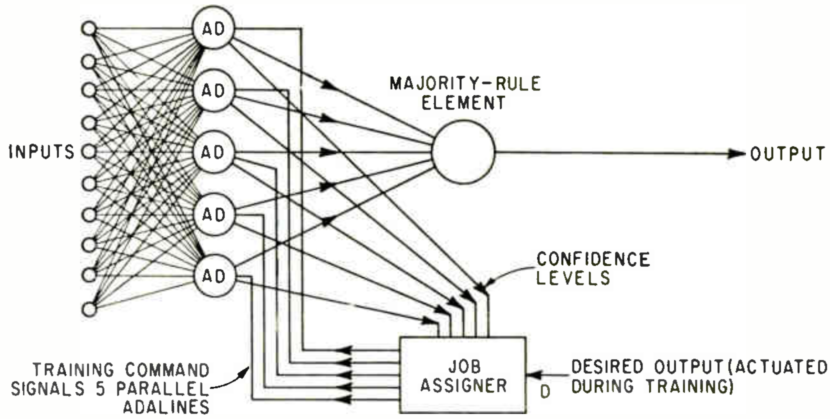
"We now appear somewhat closer to successful creation of useful artificial self-organizing systems," ONR's Marshall Yovits told the international group of more than 300 scientists and engineers from industry, government and foundations. It is still too early to expect significant applications, he said, but hopes are strong that some feeling for these will emerge from the examination-in-depth of progress made during the three years since the last conference.

Exploitation of connecting pathways for storage between elements was urged by D. M. MacKay, University of Keele, England, to increase versatility and enhance reliability of self-organizing circuits.

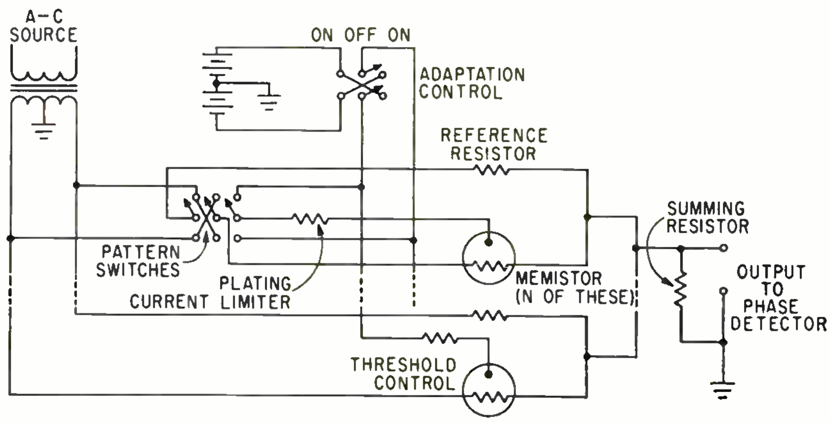
MacKay suggested using capillary tubes, or narrow grooves, as paths for silver nitrate in readily mass-produced network links. Impedance could be varied continuously by electrolytic growth of conducting paths. The combination of such variable transmission lines with nonlinear or metastable elements could serve as a detector of temporal coincidence, he said. Delay line network paths could provide transient storage for running analyses and short term correlations.

Control of propagation speed could cause radical changes in activity without altering surface connections. Different specific responses could be elicited by specific input rhythms through built-in sensitivity to temporal pulse patterns. Temporal coded broadcasts of signals over a wide area could be tuned out of a welter of other activity by subsystems alert to them.

Use of the entire element, adding enormous amounts of interconnecting pathways and eliminating more lumped constants, could easily reduce the scale of machines by a whole order of magnitude, MacKay suggested.



Madeline configuration of five Adalines with parallel-connected inputs. This system could be trained by adapting Adalines (AD) until majority-rule element output is the desired response



Circuit of a memistor Adaline. Memistors are electrochemical cells in which information is stored as thickness (resistance) of metal film plated or stripped by d-c. A-c is used for nondestructive sensing

Bernard Widrow brought conferees up to date on work at Stanford University on adaptive linear neuron systems called Adaline, using electrochemical cells called memistors (ELECTRONICS, p 20, Sept. 15, 1961). Unlike conventional computer systems, these generalize. Information is stored diffusely and the system can be trained to react to stimuli.

Madeline 1, containing six independently adaptable Adalines, has just been put under control of an IBM 1620 computer. The computer stores patterns and desired responses and controls neuron training. This combination, Widrow said, is three times faster than digital simulation of the same neurons on the computer alone.

A larger Madeline is being planned. When connected to the 1620, it will be faster at neuron simulation than an IBM 7090, he said. On this scale, a neuron simulation facility is 10 times cheaper than an all-digital simulation facility, he added.

Widrow said the objective of the program is to develop an adaptive computer that can be taught by men to solve the problems of men in the environment and language of men, not with a machine language. One application for such a system is a quick-learning, self-adapting industrial process controller.

Oliver Selfridge, of MIT Lincoln

Lab, said people should be included as components in experiments with self organizing systems. "Automate every function we know has to be, and by observing the adaptation that people perform with what is left, we shall be in a better position to automate that adaptation as well," he suggested.

One move in a similar direction was discussed by James Miller, of University of Michigan. The Mental Health Research Institute there is working on the adjustment processes that living systems use against information overloads.

Frog fibers simply stop responding to every input when rates increase above critical levels, Miller reported. Some of the fibers skipped, some responded only to every third or fourth impulse and others failed for long periods, after which they again fired repeatedly.

Human subjects using an Information Overload Testing Apparatus (Iota), which presented information at variable rates on a ground glass screen, responded with similar queing, omissions allowing for a fresh start, more queing and finally more omissions.

Addition of components to an information processing system apparently lowers channel capacity, Miller concluded, summing up additional experiments. The necessity to recode at the border between components inevitably results in some loss of information, he said, and no channel can be faster than its slowest components.

Satellite Communications in a Few Years?

By RAY BLOOMBERG
McGraw-Hill World News

SEATTLE — Intercontinental and worldwide satellite communications were discussed at length during the IRE Seventh Regional conference here. Such systems are seen as operational within the next few years.

So imminent is satellite communication that Great Britain is said to have abandoned plans for a submarine cable project scheduled to start in 1964. Prospects are that the United States, Russia, and the British Commonwealth will each have a system.

Robert T. Haviland, of General Electric, said three families of satellite systems will be needed: polar random, equatorial ring and synchronous systems. Synchronous systems will employ three satellites, an equatorial ring eight to 12 and a polar group 30 to 50.

Haviland said a study based on a 10-satellite ring indicated the heaviest traffic load, at noon over the North Atlantic, would use about 1,000 4-Kc channels in 1970-1975. Another 1,000 channels would serve the rest of the world. Data traffic is expected to increase faster than telephone traffic.

Of the three use classes of systems—relay, broadcast and distribution—Haviland saw the greatest traffic gain in intercontinental relay. Traffic increase was conservatively estimated at 10 to 20 percent a year, with the original system soon loaded to capacity.

There is not yet enough power available for high-quality tv broadcasts, but he thinks worldwide tv will be possible in the 1970's. Broadcasts could now be made over a restricted area, such as South America. Distribution satellites would handle weather and perhaps airways traffic.

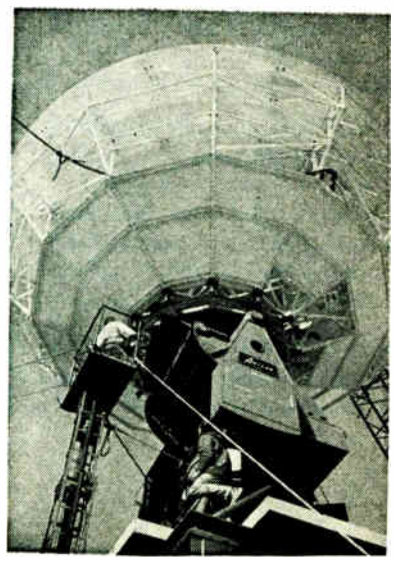
Communications satellite projects programmed by NASA and the Department of Defense were reviewed by Victor F. Evans, of DOD.

Evans said DOD believes satellites will make important contributions in these three areas of communications:

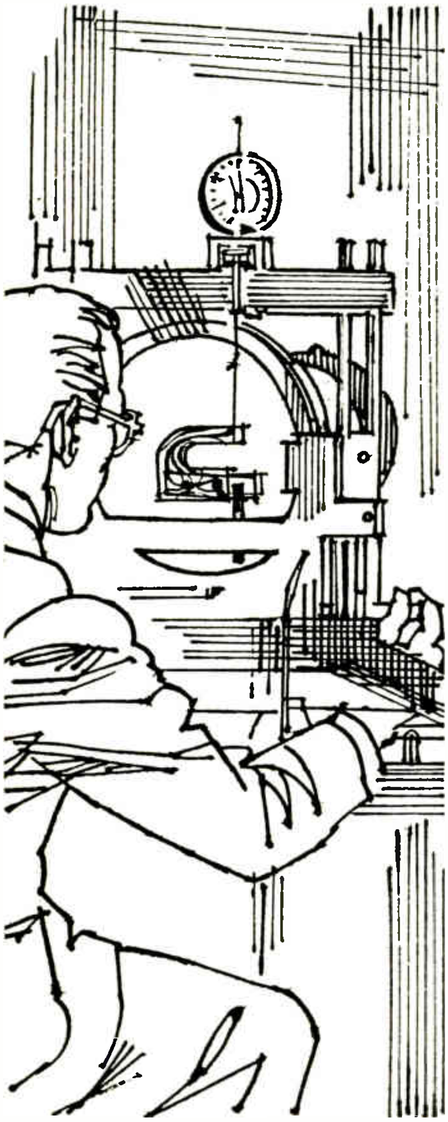
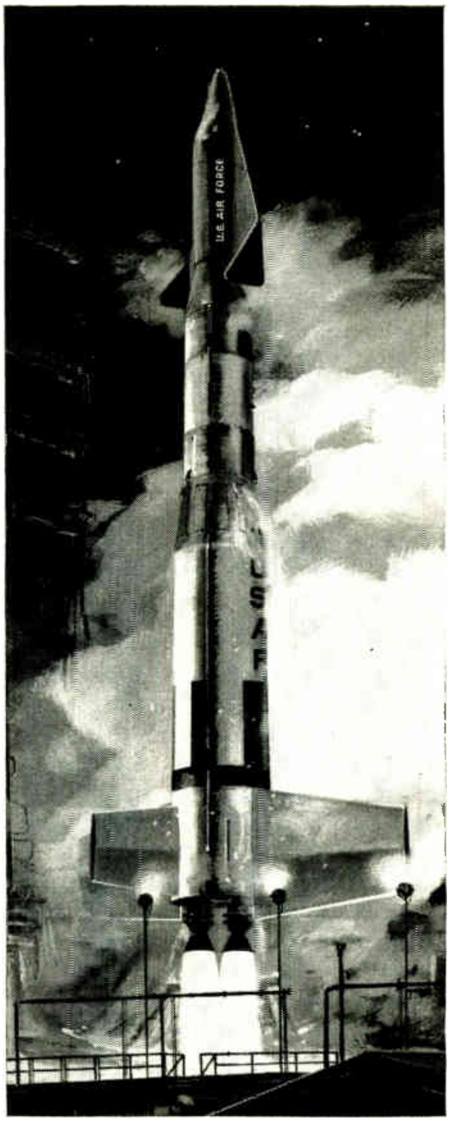
- Long-haul, point-to-point links providing few circuits to remote areas of the world having light traffic loads. Transportable ground equipment would establish new circuits on short notice.
- Fixed, long-haul, point-to-point trunks providing many circuits between major traffic nodes, such as those on the U. S. east coast, Europe, North Africa or the Middle East, and from points on the west coast to Hawaii, the Philippines and Japan.
- Mobile communications between fixed points and mobile stations, or between mobile stations.

Evans said most systems will employ satellites in high-altitude synchronous orbits, or in subsynchronous orbit.

Test Ship's Missile-Tracking Antenna



Thirty-foot C-band radar antenna with Cassegrain reflector is placed atop tower at Sperry Gyroscope's mile-long antenna range for tests and boresighting. It will go aboard Mobile Atlantic Missile Range ship (ELECTRONICS, p 22, July 28, 1961) as part of integrated L-, X- and C- band system that can gather data on three targets at once. All-aluminum antenna is designed not to distort more than 0.06 inch from heat, wind and ship motion. Sperry Rand is instrumenting two Mars ships under $60 million in Air Force contracts. The ships will be stationed in the Indian Ocean to track missiles fired 10,000 miles from Cape Canaveral. Communications, telemetry, inertial navigation, computer, meteorological and operations control systems will also be installed on the ships


From Raytheon/Rheem:

1N3730/RD750 subminiature power diodes feature high conductance—1 Amp @ 1 volt—at nanosecond switching speeds

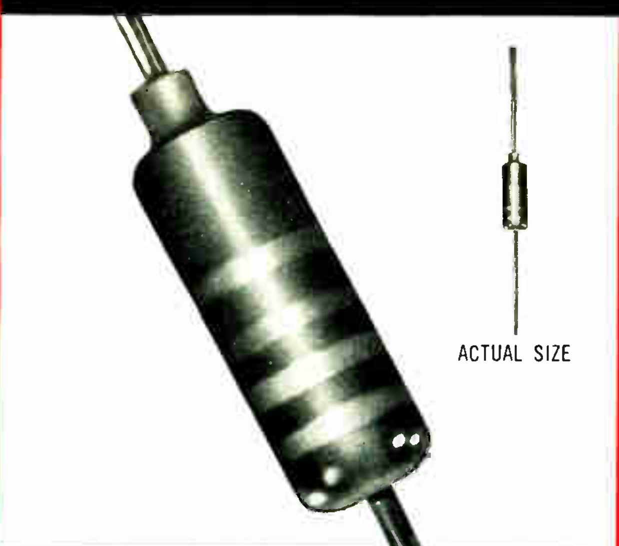
High-speed, high-current core driving This Raytheon/Rheem .107"-diameter silicon diode combines high power dissipation plus ultra-high conductance — typically 1 Amp @ 1 volt. Result: cooler junctions and more reliable operation. Switching speed is 15 nanoseconds max. at 10 mA ($V_R = -6V_f$, $R_L = 75$ ohms); power dissipation rating is 750 mW — three times that of conventional diodes. The high current capabilities of the 1N3730 provide substantial operating stability for greater reliability.

Miniaturized power supplies The 1N3730/RD750 marks a big step forward for low frequency power supply design. Extremely fast turn-on time — V_{fr} (peak) is typically 1.0 volt at $I_F = 750$ mA — prevents impulse distortion and undesirable voltage feedback. Superior turn-off results from a low stored charge (typically less than 20 picocoulombs per mA).

Computer switching This subminiature diode is ideal for a large number of computer applications because of its wide switching current range — 1.0 mA to 5 Amps. Actual specification at several current levels is your assurance of ultra-fast reverse recovery over a wide range. Direct correlation to stored charge is also provided.

For complete details, please call or write the Raytheon Field Office nearest you, or write Raytheon Semiconductor Division, 900 Chelmsford Street, Lowell, Massachusetts.

RAYTHEON/RHEEM 1N3730/RD750

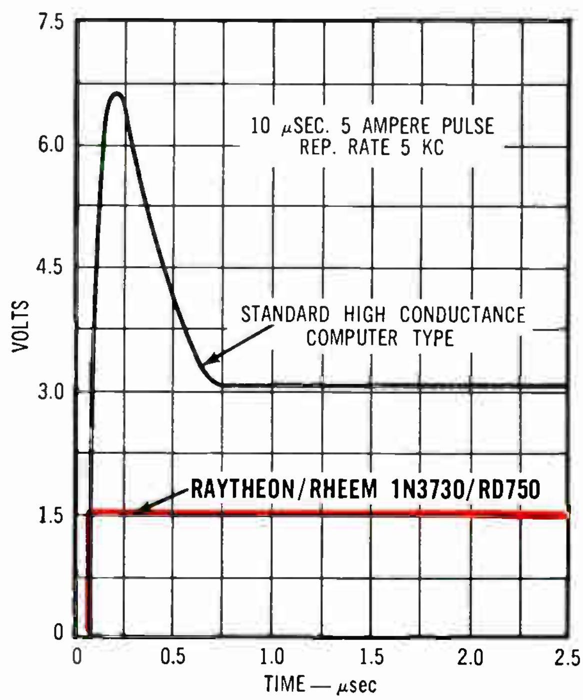


KEY PARAMETERS

- **Switching Speed** . . . . . . 15 nanosecond max.
- **Forward Conductance** . . 1 Amp @ 1 volt typical
- **Power Dissipation** . . . . . 750 mW max. @ 25°C.

FAST TURN-ON TIME

FIVE AMPERE PULSE SCOPE TEST — COMPARING TURN-ON TIME OF 1N3730/RD750 WITH STANDARD COMPUTER DIODE



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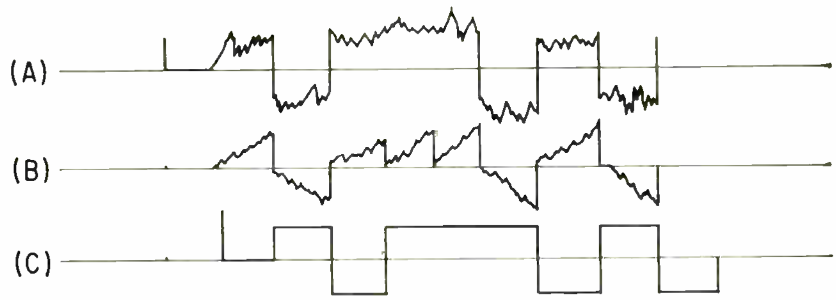


Waveforms in a pcm bit synchronization system showing typical signals with noise (A), the integrator output determining presence or absence of a pulse (B) and the detected output signal (C), inherently delayed by one bit

What to Do with All That Telemetry Data?

By LAURENCE D. SHERGALIS
Associate Editor

WASHINGTON—One of the most annoying problems facing telemetry designers is what to do about processing the volumes of magnetic tape recorded during a missile or space flight.

Vanguard III, for example, produced 6,000 2,400-foot reels of tape in its first three months of flight. All of it had to be converted into curves and other readable data. Goddard Space Flight Center is reportedly putting up new buildings to store tapes expected from future space flights.

A favored solution is processing data in the satellite before transmitting it to ground. Transmitting only essential data reduces telemetry system requirements as well as data processing effort.

One technique discussed at the National Telemetering Conference late last month is compressing bandwidth, then reconstructing the data on the ground. Another method is to process data on-board and transmit the actual curves. Reducing bandwidth by reducing data rate will also conserve the frequency spectrum.

Adaptive digital telemetry systems offer another way to filter out irrelevant material. Bernard Harris and Robert Sommer, of New York University, described a decision feedback system that notifies the transmitter when the information received is sufficient to decide on the actual message. Much redundancy is eliminated.

An adaptive system also permits control of the telemetry transmitter's power output, depending on the prevailing signal-to-noise ratio. An adaptive system in which the telemetry format may be modified is also considered possible.

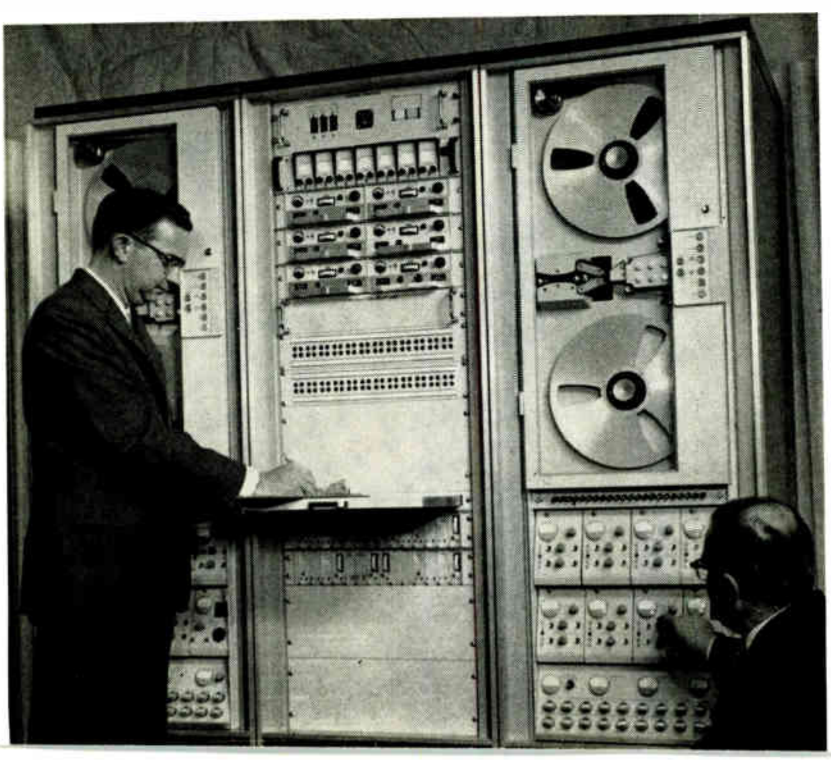
At present, almost all telemetry systems use pcm because its bit rate may be varied over an extremely wide range. Benn Martin, of Jet Propulsion Labs, claims bit rates in pcm may vary 1,000:1.

However, because pcm systems have been designed around extremely small error rates, reliability becomes a major problem to designers. Herman LaGow, of Goddard, says reliability requirements have gone up at least two orders of magnitude since Vanguard. And designers of spacecraft equipment face a unique problem—how do you get reliability statistical data from one or two samples? Essentially, equipment is one of a kind.

Two solutions are suggested: to overtest, or to put more emphasis on environmental testing and test to much higher specifications.

Consensus of many engineers at the meeting was that the major reliability problem areas include: using failure rates that are too optimistic; inaccurate derating figures, especially in load-sharing or redundant applications; ignoring interactions between subsystems: ignoring switching applications in standby applications, and ignoring transients and their effects on the systems.

One major environmental problem that tends to be overlooked is the effect of acceleration forces on satellite components. A 20-inch diameter satellite spinning at 600-rpm subjects components at the



Data-Control Systems' predetection recording equipment records i-f signals on wide-bandwidth magnetic-tape recorder. Any type of telemetry signal can be handled on similar equipment

S-BAND TELEMETRY WAITS ON HIGHER FREQUENCY COMPONENTS

WASHINGTON—*A sampling of manufacturers at the National Telemetering Conference indicates that little progress is being made toward making equipment generally available for the coming move of telemetry bands to S band (*ELECTRONICS*, p 32, March 30).*

Engineers indicated that efficient and reliable components for those frequencies are still not within the state of the art. While some equipment is being produced on special order, several firms said they have no plans at present to produce lines of S-band transmitters or receivers

outer edge to 20 g.

Predetection recording techniques are receiving more attention from system designers because wide bandwidth tape recorders are available. Ampex exhibited its FR-700, a 4-Mc wideband recorder. In the demonstration, the spectrum from 535 Kc to 4 Mc was recorded on tape without bandsplitting. One advantage of predetection recording is its ability to handle many types of data transmission with a minimum of recording equipment. According to Owen Ott, of Data-Control Systems, pam f-m and pacm f-m may be accommodated without special recording equipment or techniques. The disadvantage of predetection is the large amount of tape used during a typical run.

Data-Control Systems introduced a bit rate synchronizer that detects the presence or absence of a pulse in high noise. The device uses the integrate-and-dump technique in which the entire bit interval is integrated. If the result is positive, a pulse is present; if negative, a pulse is not present. Bit synchronization reportedly improves bit error rates.

New Power Sources Emerging from R&D

By MICHAEL F. WOLFF
Senior Associate Editor

ATLANTIC CITY—Advances toward practical hardware in fuel cells and thermal energy conversion systems (ELECTRONICS, p 35, April 6) highlighted the recent 16th Annual Power Sources Conference sponsored by the Army Signal R&D Lab.

Ion-exchange membrane fuel cells are beginning to prove practical, claimed E. A. Oster, of GE. Present programs include furnishing the Air Force 25-w batteries with 170-hour life for orbital tests, 2-Kw batteries for Gemini (p 8, May 18) and studies of fuel cells as motive power sources for submarines.

Radioactive regenerative fuel cells are potentially a long-life power source. J. Yaeger, of Union Carbide, said a prototype in which gamma radiation is applied to a ferrous sulphate solution has been built for Navy. The 5-w unit's efficiency is three percent.

A methanol-air fuel cell battery was discussed by B. L. Tarmy, of Esso Research and Engineering. Other soluble carbonaceous fuels may be used. D. H. Archer, of Westinghouse, described a cell using a ceramic electrolyte of zirconia containing 15 percent calcium oxide as an anion conductor. Electrodes are porous platinum. The cell can operate on a variety of fuels and has a nominal circuit voltage of 1.2 v.

Biochemical fuel cells, producing power with bacteria and other organisms, were surveyed by G. H. Rohrback, of Magna Corp. He reported operating a urea battery and a multiwatt magnesium sulfate cell designed for ocean use.

P. A. O'Riordan, of Navy Bureau of Ships, said that specific power of 7 w/lb has been demonstrated in portable thermoelectric generators and that efficiencies of engine-generator systems are being approached. Efficiencies of five percent and 24 w/lb could be achieved in a 300-w to 500-w generator if junction resistance can be cut to one-tenth its present value. After several hundred hours operation, power output fell 28 and 40 percent in propane-fired generators delivered to the Navy last July.

A 45-w thermoelectric generator being developed for USASRDL was described by Melvin Barmat, of General Instrument. It will have a 12-hour gasoline supply, weigh 10 lb and provide 50 w-hr/lb. Goal is a 1,000-hr front-line system.

Similar requirements were reported by W. R. Martini, of North American Aviation, for gasoline-powered thermionic converters. While these face high-temperature problems, they would be very light. A 100-w system with five percent efficiency would have half its weight in the fuel supply. He expects to demonstrate two-percent efficiency in a converter with 1,400 C cathode temperature.

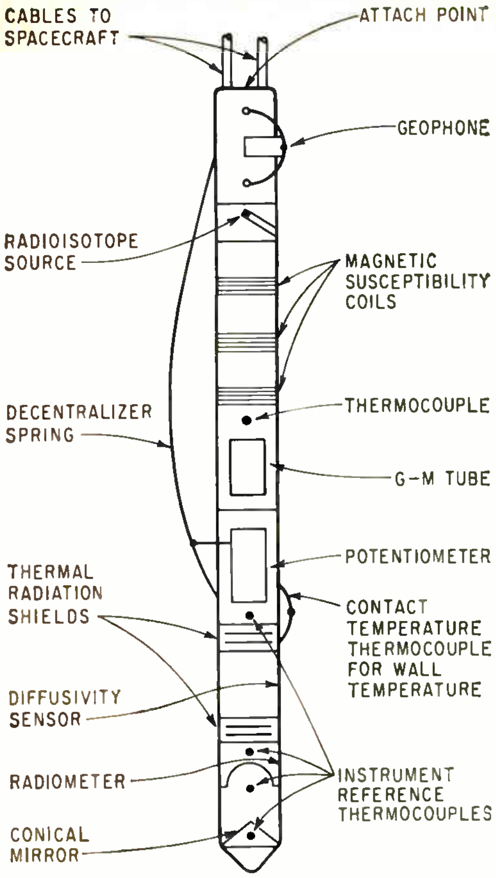
Thermo Electron Engineering is designing a 45-w portable cesium-diode thermionic generator for USASRDL. Overall efficiency is now two percent, target is four percent and system weight of 10 lb. G. N. Hatsopoulos reported that percent efficiency of the gasoline burner, now 23, may be raised to 30 or 40.

Electrochemical couples are reversible in molten salt secondary batteries, according to E. F. Uhler, of RCA. He said they could be used in space systems. The theoretical performance of these systems is 500 w-hr/lb.

In a panel discussion of radiation-resistant solar cells, J. Mandelkorn, of USASRDL, reported that *n* on *p* cells from 10-ohm-cm silicon have at least twice the resistance of the best 1-ohm-cm material. F. M. Smitz, of Bell Labs, said that annealing was observed in *n* on *p* silicon cells after several days proton bombardment.

Well-Logging Technique to

By LEON H. DULBERGER
Assistant Editor



Subsurface geophysical probe under development at JPL for lunar measurements. Case is 21 inches long and one inch in diameter

WASHINGTON—Instrumentation for measuring ionized interplanetary gas, lunar surface texture, vlf propagation in space, and an X-band radar for space rendezvous were among the equipment and techniques reported late last month at the Instrument Society of America meeting.

K. W. Linnes, of Jet Propulsion Laboratory, discussed techniques for measuring the moon's surface texture. Equipment being developed will analyze surface composition and such surface and subsurface properties as density, acoustic velocity and penetrability.

A drill boring into the surface will give texture data from drill rate as a function of thrust, acquire samples for composition analysis and also provide a hole for measuring subsurface temperature.

An instrumentation package now being breadboarded at JPL combines several measuring devices in a small-diameter probe that can be lowered from spacecraft (see illustration) into a hole.

The decentralizer spring, mechanically coupled to a potentiometer, will press the probe against the hole wall and measure hole diameter as a function of spring compression. Backscattering from a gamma ray source, measured by a g-m tube, will provide density information. An infrared radiometer and thermocouples for temperature measurement, and a geophone to determine the velocity of sound from a distantly fired squib are also included.

Satellite instruments for investigation of ionized interplanetary gas were described by R. H. Baker, of MIT Lincoln Laboratory. The detectors and instruments can measure direction, speed, density and temperature of plasma with laboratory accuracy, he said. One solid-state instrument uses a modulated Faraday cup mounted flush with the satellite skin and open to the space environment. The preamplifier at the cup employs a feedback-stabilized design so it will operate at the temperature extremes resulting from solar heating of the cup.

Among several magnetometers, was a spin-precession type reported by J. T. Arnold, of Varian Associates. It uses optical detection. Resonance radiation is supplied by a lamp and a photocell is used as a pickup. Arnold said the system can detect phenomena occurring from 20 cps to r-f and that it gives good

Defense Contracting Shifts to Incentives

CHICAGO—Department of Defense spokesmen told Electronic Industries Association members that incentive contracts for development work will be much more prevalent soon. The philosophy—expressed in a seminar at the EIA annual convention—was "something for something, nothing for nothing."

Air Force wants to "make our procurement in a highly competitive market," said Major Raymond Staley, USAF, "and we want to give our development work to the low bidder. Unfortunately we can't always use that simple method."

Staley said Air Force is now asking bidders to propose incentive contracts. The goals set in proposals will be used as ceilings in future negotiations; in effect bidders are asked to set their goals.

A Navy procurement official, Milton Jones, said cost-plus-fixed-fee contracts will be restricted to work "so nebulous that DOD can't fix concrete goals. Other work will be done on incentive contracts negotiated with risk taken into account."

"With the new incentive contracts," said Emanuel Kintisch, of Army, "the renegotiation board takes into account the contractor's efficiency when considering performance."

The board says it understands the objectives of the incentive program is to reward efficiency and penalize inefficiency. In its reports to the renegotiation board, DOD will highlight superior—or inferior—contractor performance, Kintisch said.

"Don't promise the government anything in your proposal that you aren't willing to be pinned down to," Staley said.

Jones added that contractors should propose goals which they think are reasonable and as precisely defined as they can be at the time. Goals will be pinned down during negotiation. Incentive proposals are to be much more definitive and not nearly so broad as fixed-fee proposals.

Present DOD thinking indicates that incentive development contracts will be over $1 million and run more than 18 months.

Probe Moon

sensitivities down to 10^{-5} oersteds, even with small samples.

Propagation experiments in space vehicles at 3 Kc to 30 Kc were discussed by L. H. Rorden and L. E. Orsak, of Stanford Research Institute. Absorption, time delay and other variables affecting operation in the D and E regions have been measured. The authors described receivers with sensitivity of 10^{-7} gamma (in free space, three gamma equal 1 μv/meter) and dynamic range of 90 db. Antenna impedance in space was measured with a complex Z bridge.

D. C. Enemark, University of Iowa, told how radiation in the inner portion of the Van Allen belt was measured by scintillation and solid-state detectors activated by a magnetometer sensing the earth's field. The instrumentation covers the electron energy range from 500 Kev to 1.2 Mev and proton energy from 1 Mev to 60 Mev. The work, conducted for communications satellite studies, included solar cell deterioration checks.

Several symposium speakers stressed the need for 100 percent tests of components used in space instrumentation. Many designs employ redundant subsystems within a complete major system and provide for automatic switching or doubling up of signals to an operating subsystem if a unit fails.

An orbital rendezvous guidance and control system using X-band, f-m—c-w radar was described by F. Blitzer, G. C. Bonelle and B. A. Kriegsman, of Raytheon's Missile and Space division.

A manned space ferry would be guided to boarding position alongside an orbiting space station by a radar and transponder system. The ferry, from a position ahead of the station, would automatically decrease its speed until it is close to the station and traveling at the same speed. Among reasons for choosing an X-band radar is its ability to see through the ferry's exhaust flame.

Manufacturers and distributors huddle during executive conference day

Parts Show Hosts 12,000 Conferences

CHICAGO—Unique executive conference day, providing some 12,000 individual meetings between distributors and manufacturers, was declared a successful prelude to the 25th annual Electronic Parts Show and Conference in Chicago late last month. Manufacturers and distributors used the sessions to discuss new products, programs and policies. More than 15,000 distributors attended the show and more than 300 manufacturers exhibited.

Multiplex broadcasting—claiming nearly 100 stations on the air this spring, with another 200 expected by next fall—was again a major influence this year. Emphasis has shifted from tuners and adapters to improved outdoor antennas to compensate for the estimated 20-percent decrease in signal strength which follows the shift to multiplex broadcasts in fringe areas.

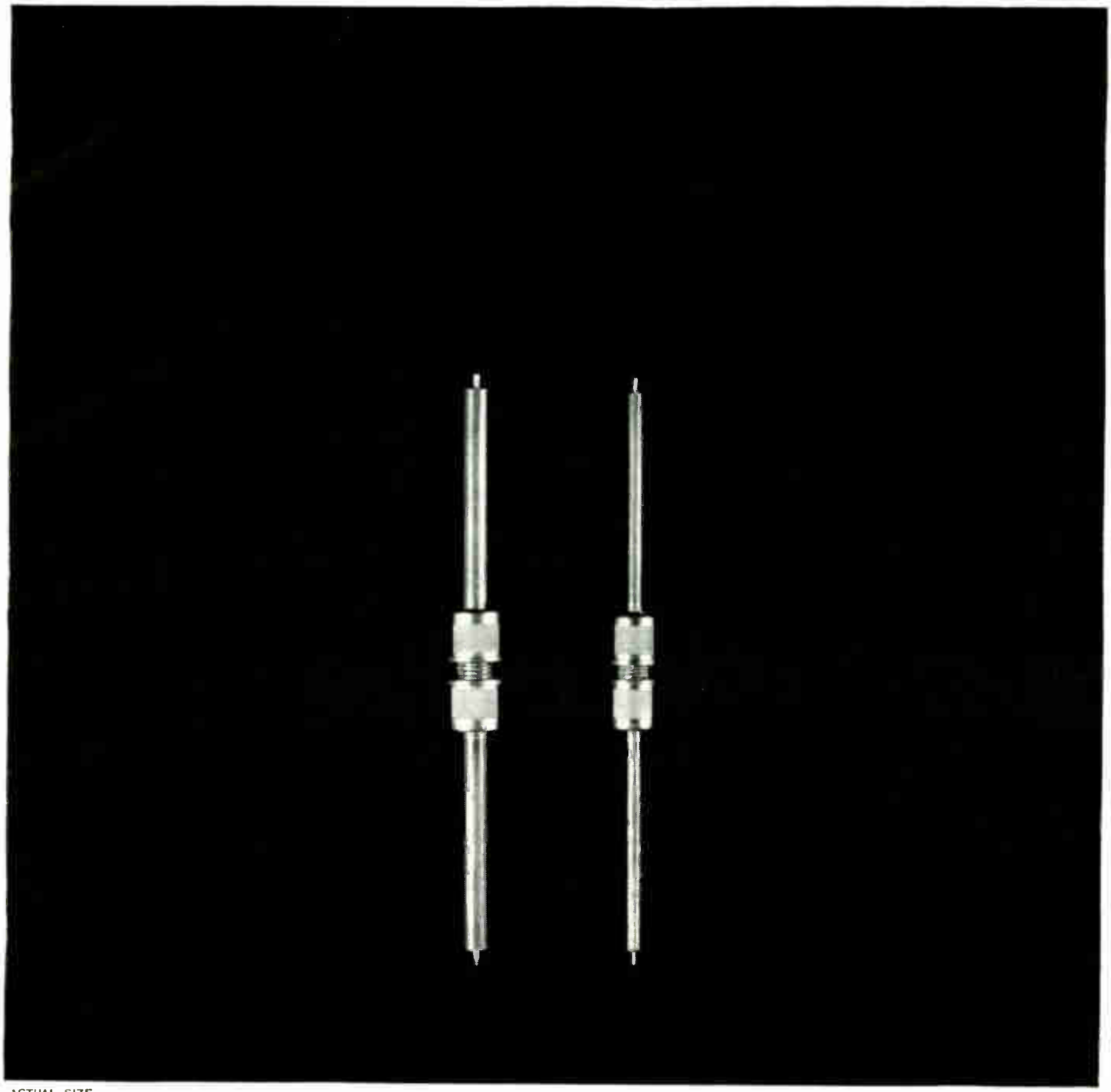
An omnidirectional, electrically-switched antenna introduced by All Channel Products is said to be comparable to nine highly directional tv antennas, plus nine full wave f-m antennas. B & G division of Dynascan Corp. exhibited an omnidirectional, seven-element, horizontally polarized antenna for multiplex. Cornell-Dubilier offered a 46-Kc ultrasonic remote control of antenna rotation, for distances up to 30 feet.

Clear Beam Antenna Corp. has developed a vertically linear arrangement of seven stacked dipoles providing high gain with flat response for f-m multiplex reception. Parabolic dish inspired by the Midwest Program for Airborne Tv Instruction (Mpati) can also be used for all-channel uhf reception. A single dipole eliminates phasing losses, according to Clear Beam.

Technical Appliance subsidiary of Jerrold also offered uhf parabolic dishes for the 800-Mc to 890-Mc Mpati translator range. Jerrold exhibited new uhf preamplifiers, antenna splitters and converters.

Jensen Manufacturing division of the Muter Company introduced a private earphone stereo system featuring right-to-left and left-to-right electrical cross feed with frequency and phase adjusted to simulate presence of conventional stereo. RCA introductions included a stereo, high-fidelity, multiplex receiver amplifier with a Nuvistor f-m tuner and a 90-mw citizens band transceiver.

An electronic oven, using a 2,450-Mc German magnetron, was introduced for the industrial market by Seco Electronics. The unit is priced at $2,650. Franklin Company produced its own magnetrons for consumer units priced just above $1,000.



ACTUAL SIZE

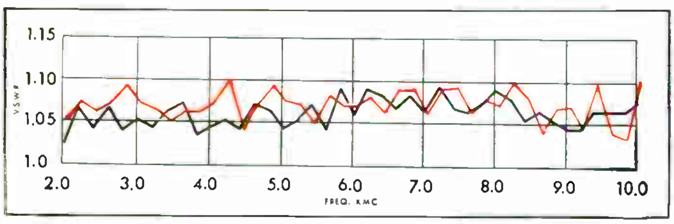
We have two new r-f connectors. They are wee ones.

They are designed to replace N series connectors in the 1 to 10 KMC frequency range where size, weight, and low VSWR ratings are critical factors.

The larger small one is the BRM. It terminates .140 semi-rigid cable either by threading or by threading and soldering. The smaller small one is the BRMM. It is for a .085 semi-rigid cable.

Talk about low VSWR ratings. Look at these curves. The black one is for the BRM; the red one is for the BRMM. The maximum VSWR is less than 1.1:1 over the frequency range of 1 to 10 KMC.

Now, about size and weight. The BRM connector is 1/28 the size of its N series counterpart. And it weighs 1/38 as much. The BRMM unit is 1/48 as large as the N series connector, 1/70 as heavy. You might call them miniatures. They are.



These precision r-f environmental resistant electrical connectors are machined from brass and heavily gold plated over silver underplate. The center dielectrics are electrical grade Teflon. They show high performance and excellent durability.

Developed at the Research Laboratories Division of Bendix, this new series of r-f connectors has been thoroughly production designed by Scintilla Division for maximum user satisfaction. Possibly you have an application in which the use of our new r-f connectors would be advantageous. Tell us about it. Or, write us in Sidney, New York, for technical data.

Scintilla Division

THE Bendix CORPORATION

CIRCLE 31 ON READER SERVICE CARD

MEETINGS AHEAD

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

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

AEROSPACE TRANSPORTATION RECEIVERS CONFERENCE, IRE; O'Hare Inn, Chicago, Ill., **June 18-19.**

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

PRINTED CIRCUIT SYMPOSIUM, Stanford U., California Circuits Assoc.; at the University, Palo Alto, Calif., **June 20-22.**

MILITARY ELECTRONICS 6TH NATIONAL CONVENTION IRE-PGMIL, Shoreham Hotel, Washington, D. C., **June 25-27.**

ELECTROMAGNETIC THEORY & ANTENNAS SYMPOSIUM, Tech. Univ. of Denmark, et al; Copenhagen, **June 25-30.**

COMPUTER AND DATA PROCESSING SYMPOSIUM, Denver Research Institute; Elkhorn Lodge, Estes Park, Colo., **June 27-28.**

AUTOMATIC CONTROL JOINT CONFERENCE, IRE-PGAC, AIEE, ISA, ASME, AICHE; N. Y. Univ., New York City, **June 27-29.**

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

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

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

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

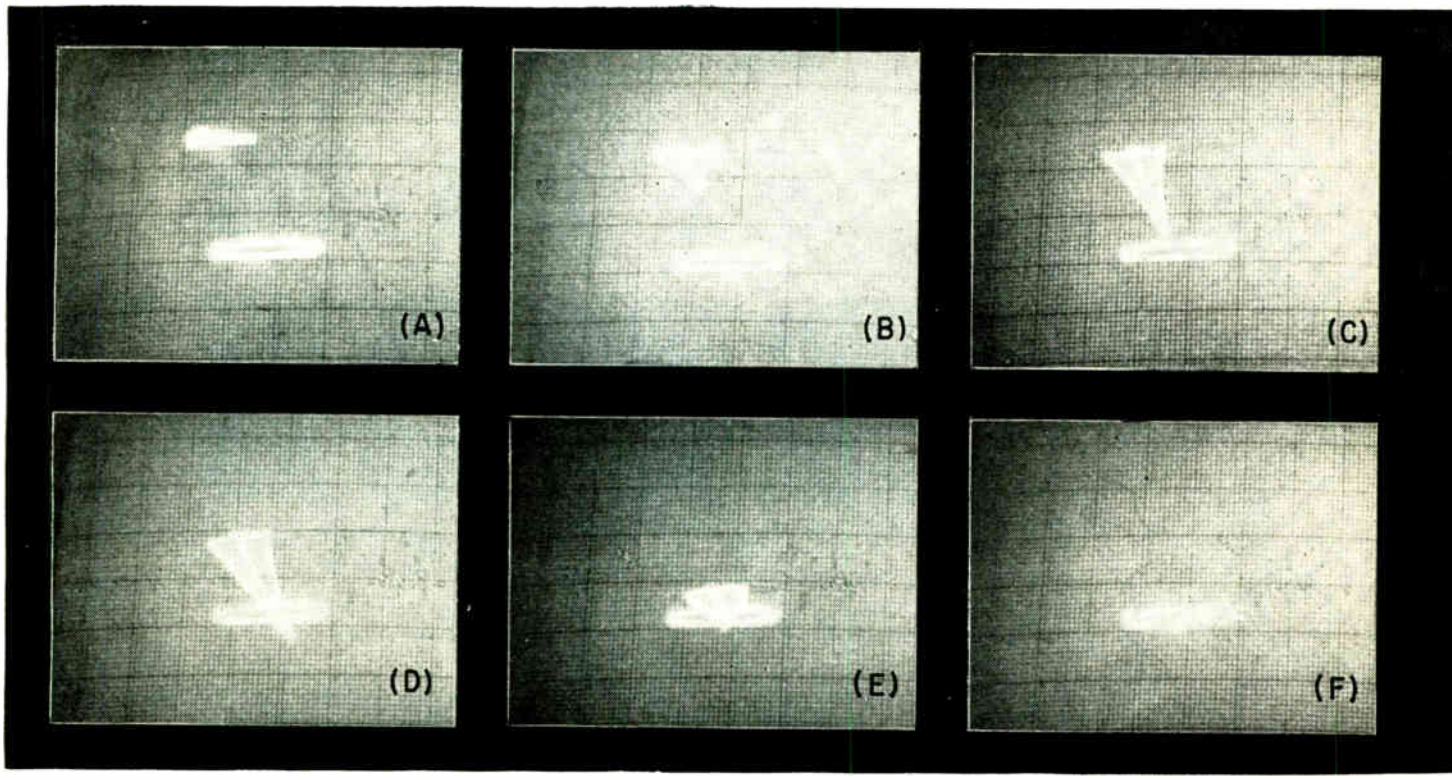
ENERGY CONVERSION PACIFIC CONFERENCE, AIEE; Fairmount Hotel, San Francisco, Calif., **Aug. 13-16.**

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

ADVANCE REPORT

AEROSPACE & NAVIGATIONAL ELECTRONICS EAST COAST CONFERENCE, IRE; *Baltimore, Md., Oct. 22-24. June 15 is the deadline for submitting 5 copies of 500-word abstract together with brief professional biography to: William C. Verga, Chairman Technical Program Committee, Adv. Res. Dept., Bendix Radio Corp., Towson 4, Md. Areas include: communications, computers, air traffic control, ground support equipment, guidance and control, spectrum utilization, propagation, microwaves, antennas, radar, optical masers.*

ULTRASONICS SYMPOSIUM, IRE-PGUE: *Columbia University, NYC, Nov. 28-30. Aug. 13 is the deadline for submitting 3 copies of a 280-word abstract to: R. N. Thuston, Technical Program Chairman, Bell Telephone Laboratories, Murray Hill, N. J. Particular emphasis will be given to microwave ultrasonics.*



Control of a vehicle using a predictor instrument. Ellipse defines desired position; predictor symbol defines predicted position of vehicle for next five seconds, assuming control is returned to center. This vehicle is so unstable that it is uncontrollable with normal instrumentation. Photos show: level flight above and to the left of desired position (A); begin dive (B); dive and turn in progress (C and D); leveling off (E); straight and level "on target" (F)

Piloting Nuclear Submarines

WITH CONTROLS THAT LOOK INTO THE FUTURE

Predictor gives an operator information about the future of the variable he controls by extrapolating present conditions into the future. Applications are in planes, ships, submarines or any dynamic system with a measurable response that can be simulated

By A. GEORGE BERBERT
Senior Engineer

CHARLES R. KELLEY
Laboratory Director

Dunlap and Associates, Inc.
Stamford, Connecticut

AS AN EXAMPLE of the problems of manual control, when a submarine commander orders a quick dive to a certain depth, the usual method is to move the controls to the maximum dive angle, pull out before the desired depth and try to level off as soon as possible. The result is usually an oscillation type of submarine motion, above and below the desired depth.

A new predictor instrument allows the operators of a submarine, or any other vehicle or system requiring such control, to predict their future motion, and to see when to start leveling off, thereby minimizing overshoot and oscillation.

Semiautomatic control systems

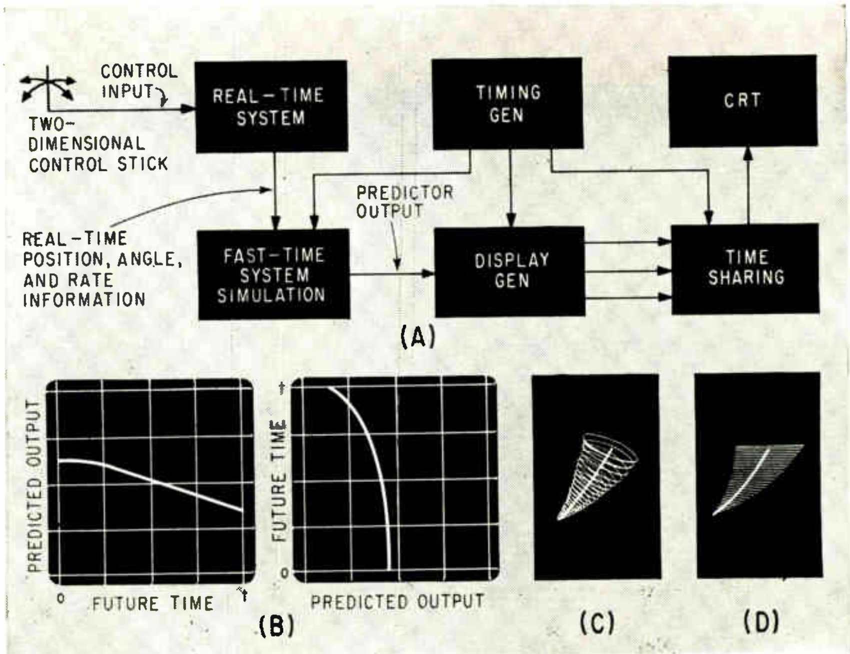


FIG. 1—Predictor instrument and associated equipment (A); display 1 (B); spiral predictor display (C); road-type predictor display (D)

can program a submarine to perform a dive along a projected trajectory, but at a sacrifice of flexibility. Using the predictor, an operator is not held to the trajectory, and can change it at will.

The predictor instrument is a display for manual control of a vehicle or other high-order system. It is an application to manual control of a concept developed originally for automatic systems.[1] The predictor provides the operator with an extrapolated future value of the variable under control, which is generated by a high-speed electronic model of the system. Operating repetitively, the model is set to correspond to conditions in the real-time system at the start of each cycle of its operation. As the model then predicts, a programmer generates an assumed control action by the operator during the prediction period; for example, that he returns his control to zero. The prediction signal therefore consists of real conditions extrapolated into the future by a fast-time model as constrained by the program. This prediction signal is displayed to the operator on a cathode-ray tube or other presentation.

The operator controlling by a predictor instrument interprets his prediction as follows: "This display shows what is going to happen if I move my control according to the program, such as returning it to zero." The operator using a predictor instrument moves his control to modify continuously what is predicted into what is desired of the system.

An article has appeared detailing the predictor instrument concept and describing the improvements in control and the reductions in training time that result from its use.[2] This article describes circuits used in laboratory versions of the instrument. The circuits are the result of combining equipment on hand, mainly analog computer components, with constructed electronic accessories. The results were satisfactory, although the techniques were not elegant. Such things as the time-sharing and reset circuits and their pulse generators could well have been used as special-purpose equipment. However, the circuits used work well.

The equipment generates a number of displays that predict the future motion of an observer-controlled real-time vehicle. The discussion concerns the method of obtaining these displays for this two-dimensional predictor instrument. All displays for the predictor instrument are generated with the same vehicle circuits and are controlled for display by the same time-sharing devices. Differences between the displays are in the method of modulating the vehicle information (Fig. 1A).

A number of displays of the future motion of the vehicle are used at different times during the testing period. Display 1 (Fig. 1B) is a two-line display that graphically predicts vehicle position using separate plots of the vertical and horizontal courses. A 17-inch cathode ray tube face is divided into two areas, the left area presenting the vertical information and the right area presenting the horizontal information. The vertical information is a line indicating present position vertically at its left extremity and future position along a horizontal time axis with time increasing toward the right. The horizontal information indicates present position horizontally across the bottom and future position along a vertical

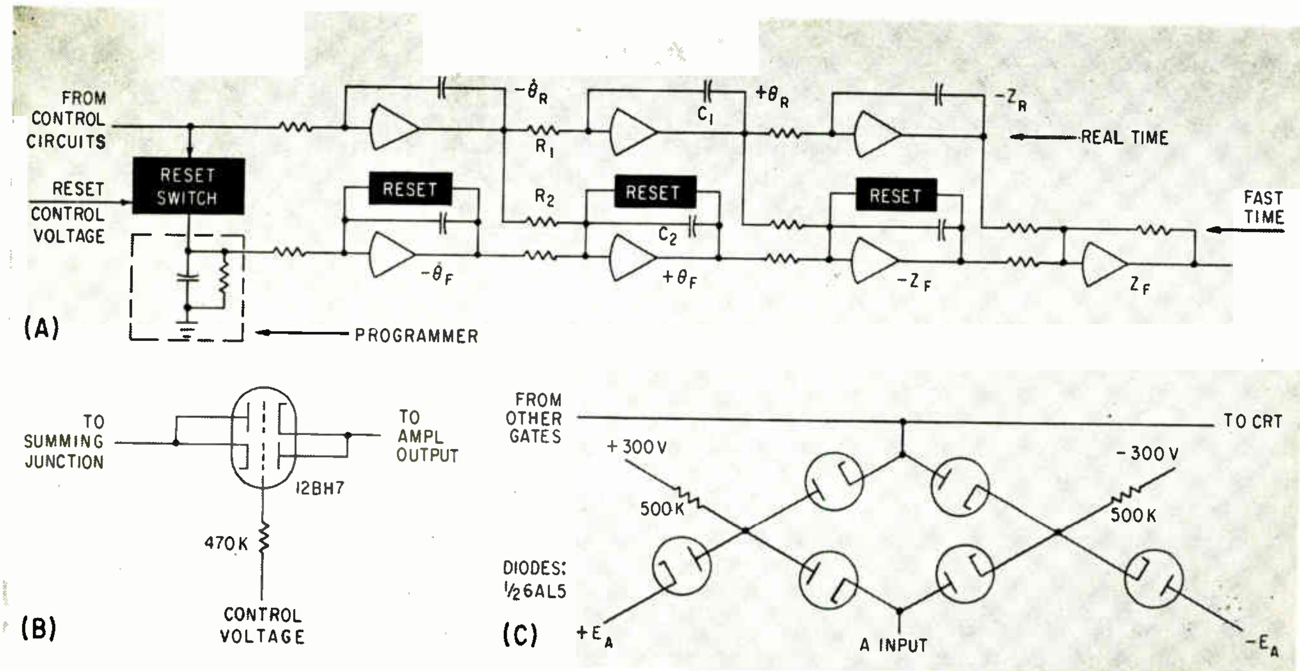


FIG. 2—Simplified single dimension of predictor vehicle (A), in which R_1C_1 is nominally 200 times R_2C_2. The reset switch is a diode gate as shown in Fig. 2C. Reset device (B) for resetting fast-time integrators; display switching circuits (C), single dimension shown

time axis, with time increasing toward the top.

Display 2 (Fig. 1C) presents the same information in a combined fashion with a different pictorial scheme. Vertical and horizontal positions are indicated by distances vertically and horizontally on the cathode ray tube face. A spiral-cone symbol indicates present position at its large end and future position along its length to the limit of prediction at its pointed end. In addition, a line is presented that indicates the exact predicted course extended along the locus of the centers of the circles generating the cone shape. This line is accentuated at its present-position end by a bright dot.

Display 3 (Fig. 1D) is identical to display 2 except for the omission of the vertical axis of the superposed spiral. Thus, a flat road is presented with present position at its large end. Again, the exact predicted course is shown as a single line extending along the center-line. The road has the advantage of permitting a third dimension, such as roll, to be coded into the display. Both the spiral and the road are compatible with aircraft and submarine contact-analog displays, which show the operator a picture of a simulated environment analogous to what he might see through a port or a wind screen in contact flight.

One of two dimensions of the circuit employed to simulate the vehicle and its fast-time model is shown in Fig. 2A. Such things as sign changers, damping and other feedback terms, and the geometric operators required to convert from body axes to fixed coordinates are omitted to illustrate the principle. The real-time vehicle is a combination of the usual integrator simulator circuits with voltages available to represent angular rate, $\dot{\theta}_R$, angle, θ_R, and present position, Z_R. The fast-time model is constructed analogously using faster time constants. Time accelerations of 100, 200, 400 and 800 are used at various times.

The resistors and capacitor at the input to the first fast-time amplifier of Fig. 2A form the programmer for many predictor instrument studies. The capacitor is charged to equal the control voltage at the start of each cycle, at which time the reset switch closes momentarily. This capacitor discharges exponentially through the resistor during the operating cycle. The program thus generated assumes that the operator's control is returned to zero through a lag determined by the values of R and C chosen. In some cases the circuit, including the integrator it feeds into, is omitted entirely, and the program assumes zero control action or the instantaneous return of the control signal to zero. For many applications this provides a fully adequate predictor signal.

For predictor purposes, the fast-time model requires that the integrators representing the various angular and position parameters shall start each prediction cycle at the initial voltage representing the real-time parameters. Since an initial voltage on an integrator is a starting point for an integration whose change of output would be the same regardless of the initial voltage, simplifications can be made. If initial voltages are added to the output of an integrator initially reset to zero, the net output voltage is the same as where the integrator is started at the initial voltage. This was done to allow integrators to be reset to zero.

An example of this is the fast-time angle term, θ_F, illustrated in Fig. 2A. Nominally, disregarding sign changes

$$\theta_F = \int_0^t (K_1\dot{\theta}_R + K_2\dot{\theta}_F)\,dt + \theta_R$$

where θ_R would be the initial condition of the θ_F integrator. This sum would be presented as an input to the next integration stage. The same results are obtained eliminating the θ_R initial condition and resetting the θ_F integrator to zero when the θ_R term is an input to the next integrator, as shown in Fig. 2A.

Each integrator is started at an initial zero voltage, and both the integrator output and the real-time initial voltage are inputs to the succeeding stage. At the start of each cycle of the fast-time model, all fast-time integrators are reset to zero. Due to the speed of this repetition, no switching is needed on the real-time inputs, since these are effectively constants over the computing period. (In Fig. 2A, the three upper amplifiers are Philbrick type USA-3; the four lower amplifiers are Philbrick type K2W.)

Fast-time integrators are reset to zero using a reset device (Fig. 2B) composed of two triodes in parallel, with the plates tied to the cathodes. One end of this combination is connected to the summing junction, and the other end to the output terminal of the amplifier. Both grids are tied together and to a control voltage. The control voltage is made negative during the computing cycle (tubes cut off) and positive during the reset cycle (either tube conducting). A resistor protects the grids from excessive grid current. Thus this circuit acts as an electronic relay presenting an open circuit during the computing period and a low resistance during the reset period. One of the triodes will conduct during reset, depending upon the polarity of the output voltage. The plate resistance of the triode is low enough, compared to the input resistors, to reduce the output voltage to essentially zero.

Displays 1, 2 and 3 (Fig. 1B to 1D) consist of two symbols presented in rapid alteration. In display 1 the symbols are the vertical and horizontal prediction lines. In displays 2 and 3 the symbols are the cone and the cone center-line. Since one-gun cathode-ray tubes are used, a time-sharing circuit is necessary. The display is switched by alternate acting gates, each composed of six diodes (Fig. 2C). These gates have a gain approaching unity, and are satisfactory.

The control voltages for the time-sharing gates and the fast-time vehicle reset circuits are generated as shown in Fig. 3A. A sinusoid of frequency f (Fig. 3B) is input to a saturating amplifier, yielding square waves (Fig. 3C). These are differentiated (Fig. 3D), and the negative pulses (Fig. 3E) are applied as inputs to both stages of an operational amplifier flip-flop, thus producing voltage E_3 (Fig. 3F) at frequency $f/2$.

These voltages are added with d-c biases in saturating operational amplifiers (Fig. 3G) to produce control voltages that are positive during a quarter of the whole cycle, and which control the time-sharing gates. Voltage E_2 resets the fast-time integrators, and this occurs twice each cycle for a quarter-cycle each.

Figure 3H is a time chart for display control, showing the result. Note that two time periods are available for displaying prediction information, as well as two time periods for present position information. These latter display times are used in displays 2 and 3 to enhance the present-position point, the start of the prediction line.

Display 1 is generated by using the vehicle (fast-time) output for one dimension and a ramp voltage (sweep) for the other dimension (Fig. 4A). The vertical and horizontal predictions are displayed at alternating periods (D and B) by switching in the proper vehicle dimension and alternating the sweep input direction. Bias voltages are added to these voltages to place the displays at the proper position on the screen. The display shown in Fig. 1B resulted.

Display 2 is generated by multiplying a high-frequency sinusoid by a ramp function which starts large and decreases during each cycle, thus modulating the amplitude of the high frequency sinusoid into a decreasing triangular shape. This is then phase-shifted to yield two decreasing sinusoids 90 degrees out of phase, thus producing a spiral when the voltages are connected to the horizontal and vertical deflection plates of a cathode ray tube. These separate sinusoids are then added to the proper outputs of the fast-time model of the vehicle, and the resultants displayed, forming the curving conical spiral shape (see Fig. 1C and 4B). This is displayed during the D time period.

The second portion of this display, the locus of the center of the conical shape, is displayed during time period B by using the predicted vehicle path without modulation.

Time period C displays present position, thus enhancing the initial (present) position of the above line by creating a bright dot.

Time period A presents a dot (not shown) at the center of the display to indicate the true electrical center of the system.

Display 3 (Fig. 4C) uses the same inputs as display 2 with the omission of the vertical conical modulation. The result is a road display (Fig. 1D).

These circuits yield a stable, clear display. Negligible flicker resulted with basic switching frequencies of 60 to 120 cps, using a 17-inch crt with a P7 phosphor.

One final refinement consists of brightness modulation by an input to the cathode circuit of the crt. Brightness modulation was employed for three purposes: blanking the scope during unused portions of the display cycle, and eliminating display clutter during switching; reducing the brightness of the prediction symbols in proportion to future time; and controlling the length of the prediction span of the display. The first of these is accomplished using the control voltages of Fig. 3G during unused portions of a display cycle, as when only two or three of four possible displays are shown. A 5-percent blanking period during the transition between displays is added for displays 2 and 3 to eliminate some visible switching noise or clutter.

A sawtooth synchronized with the predict cycles of Fig. 3G is employed for brightness modulation on the spiral and road displays (Fig. 1C and 1D), reducing brightness toward the small end of these symbols. Unless this is done, the symbols are brighter at their smaller end, because the trace has a lower velocity there, describing shorter distances in equal times. By adjusting the sawtooth modulation, this effect is reversed. It is desirable that these symbols decrease in brightness as they decrease in size, because the smaller size represents the part of the prediction more distant in time, and the decreasing brightness combines with the decrease in size to provide an effective perspective coding to the symbols.

The third brightness modulation, that controlling the prediction span displayed, is accomplished by the same sawtooth that modulates brightness. The length of the prediction cycle times the time acceleration determines the maximum length of prediction that could be displayed, but the sawtooth brightness modulation adjustment permitted as much of the symbol as desired to be erased from the scope. Thus, any length prediction under the maximum could be selected.

The development of the predictor instrument, after its invention, has been supported by the Engineering Psychology Branch of the Office of Naval Research under Contract Nonr 2822(00).

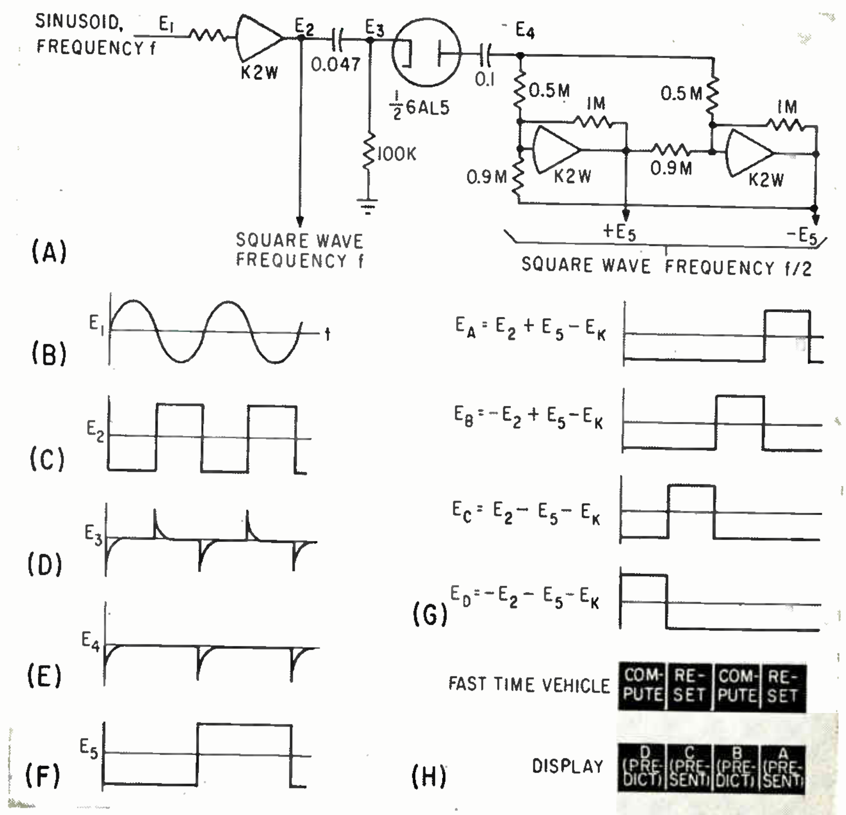


FIG. 3—Generation of control voltages (A); control voltages (B to F); gate control voltages (G), where E_K is bias voltage; time chart (H)

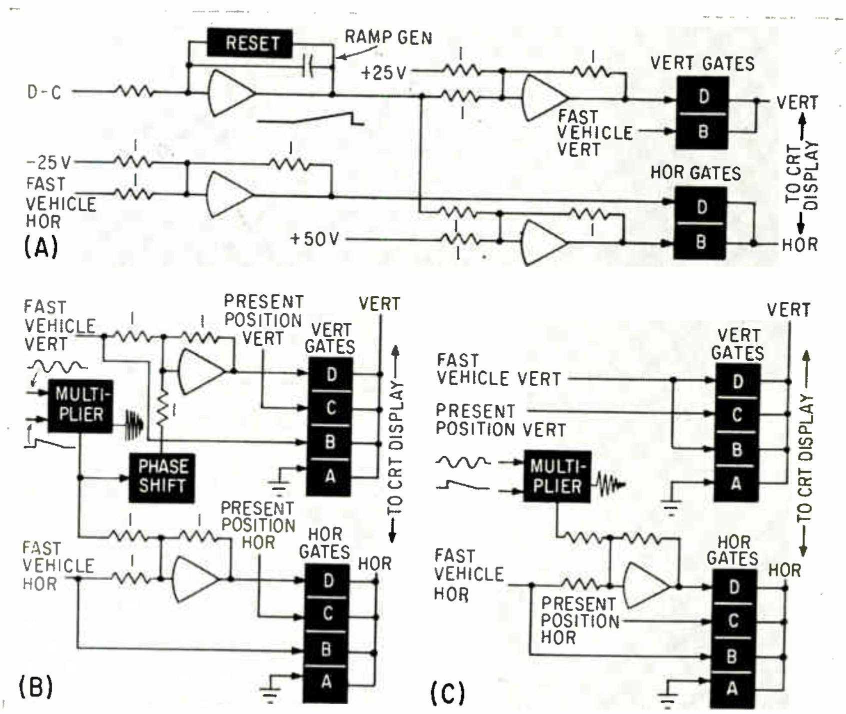


FIG. 4—Circuit for display 1 (A), in which the bias voltages shown are merely representative; circuits for display 2 (B) and display 3 (C)

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Lock-in Amplifiers for

Phase sensitive detector followed by low pass filter is heart of lock-in amplifier. Signals 40 db below the input noise level of a microwave receiver can be recovered with lock-in technique; oscillators can be checked to high precision quickly

SIGNAL INTENSITY measurements can be made where noise would otherwise rule them out by using a lock-in amplifier. Applications to date include radio astronomy, nuclear magnetic resonance and solid state investigations.

A lock-in amplifier is essentially a narrow band detection system in which a signal is beat with a reference signal of the same frequency, giving a d-c output. The heart of the lock-in amplifier is a phase sensitive or synchronous detector, essentially a balanced mixer. The upper side band derived from the mixer is of no interest and is stopped by a low pass filter. The lower side band (d-c) is passed by the low pass filter, the band width of which determines the band width of the amplifier. Sometimes the lock-in amplifier is operated with the reference frequency differing from the signal frequency by as little as 0.1 cps with difference frequency output recorded directly on a strip chart recorder.

While the detector elements that function as the mixer in a synchronous detector are basically nonlinear, the mixer itself functions as a linear device; for purposes of transient response or noise rejection the narrow bandpass achieved in the low-pass filter is completely equivalent to a corresponding bandwidth before mixing. Thus noise rejection with this technique is excellent.

Assume a balanced mixer is followed by a filter with a pass band from 0 to 10 cps, and that the reference frequency is 1,000 cps. I. the signal frequency is between

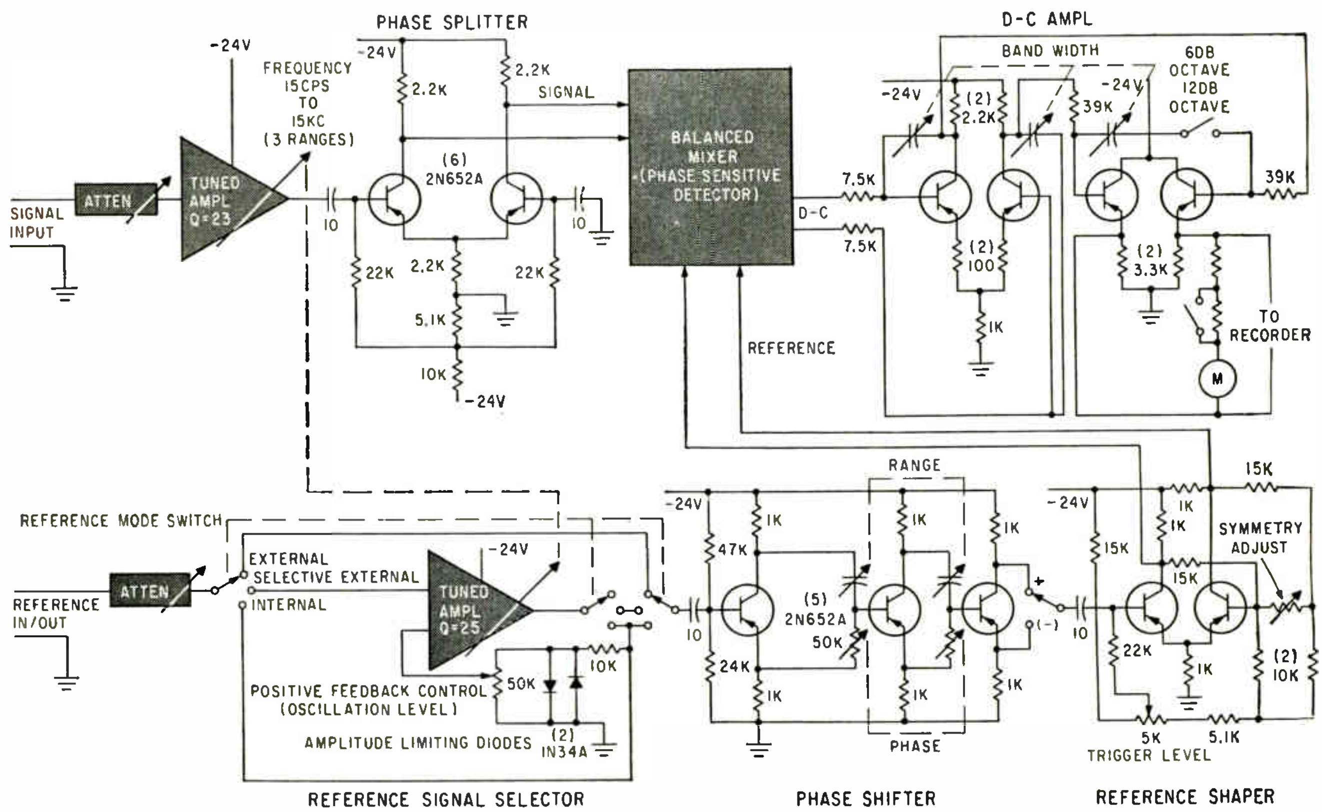

FIG. 1—Heart of lock-in amplifier is phase-sensitive detector or balanced mixer. The reference signal channel can accept an external reference or be used as a local oscillator to provide both reference and signal frequencies

Signals Buried in Noise

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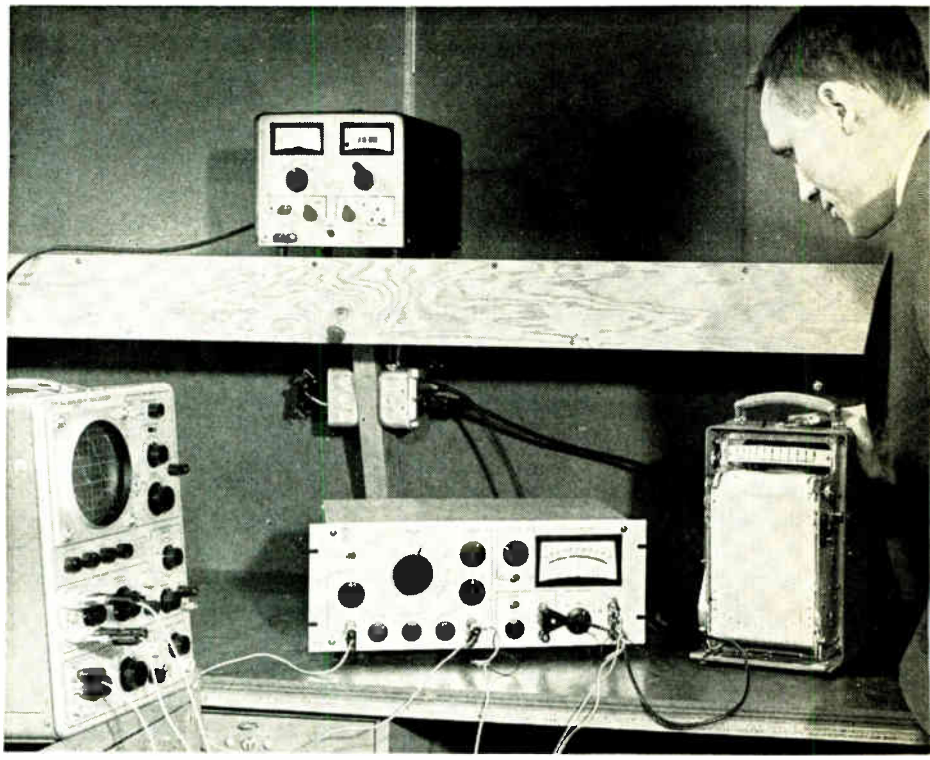

Lock-in amplifier is being used to check oscillator to high precision in short measuring interval

990 and 1010 cps, an output signal is obtained; signals outside this band are attenuated by the low pass filter. Regardless of how the center frequency is shifted (in this example it is set at 1 Kc), the output is always the narrow band of frequencies passed by the low pass filter.

The circuit has several advantages over a conventional tuned amplifier followed by a single square law detector. First, it is easily tunable since the reference signal determines the center frequency of the pass band. Second, no matter how narrow the bandwidth of the detection system, the center of the pass band is always locked to the signal frequency if the signal is available for use as the reference. It is this characteristic that gives the lock-in amplifier its name. Since the problem of recovering a signal from noise is essentially the problem of detecting the signal with a narrow bandwidth device, the narrow band lock-in amplifier is a powerful and highly versatile tool for this purpose.

Balanced mixers are essentially nonlinear devices. Consequently, even if the reference signal $R(t)$ is sinusoidal, the function $R'(t)$ (at the same frequency but different phase) with which the signal is multiplied by the mixer in general will be nonsinusoidal. However, $R'(t)$ can be written as a Fourier series in harmonics of $R(t)$

$$R'(t) = A_0 + \sum_{1}^{\infty} A_n \cos n\omega t + \sum_{1}^{\infty} B_n \sin n\omega t \quad (1)$$

where ω is the angular frequency associated with $R(t)$. The phase of the reference signal can be chosen so that the coefficient of the $\cos\omega t$ term (A_1) in the expansion is zero, giving

$$R'(t) = A_0 + \sum_{2}^{\infty} A_n \cos n\omega t + \sum_{1}^{\infty} B_n \sin n\omega t \quad (2)$$

Assume the signal input is

$$S(t) = C \sin(\omega t + \delta) \quad (3)$$

After passing through an idealized low-pass filter with $(\sin f)/f$ frequency response and a cut off frequency much lower that ω, the output E_o will be

$$E_0 = \frac{1}{T}\int_{\tau}^{T+\tau} R'(u) \sin(\omega u + \delta)\, du \quad (4)$$

where T is the integrating time of the filter. When intergrated

$$E_0 = \frac{C A_1 \cos\delta}{2} \quad (5)$$

If δ is 0 (the signal is in phase with the reference) the output is maximum and has positive polarity. If phase angle δ is 180 degrees, the output is again a maximum but of opposite polarity. If δ is 90 degrees there is no d-c output. For any phase angle the output is a function of both the amplitude and phase of the signal and the amplitude of the fundamental component of $R'(t)$. Therefore the circuit is often called a phase sensitive detector.

A phase sensitive detector is sensitive not only to a particular frequency, but also to a particular phase component of this frequency. In lock-in amplifier applications both or either property may be exploited.

The general problem is to recover a weak signal obscured by noise. Noise arises from such statistical fluctuation phenomena as Johnson noise in resistors and shot noise in vacuum tubes and semiconductors; these both produce a white noise spectrum, in which the noise power per unit bandwidth is the same at all frequencies. Another source is the so-called gain modulation or flicker effect noise associated with both vacuum tube and transistor amplifying circuits. This noise frequency spectrum varies as $1/f$; a large contribution to the total noise occurs near d-c. Interference phenomena, which are not really noise but produce the same effect in obscuring the signal one desires to detect, include power line pick up and r-f interference.

With respect to white noise, little can be gained by moving the signal frequency to a different value. However, the contribution of the white noise to the output voltage of the detection system is inversely proportional to the square root of the bandwidth, and can be reduced to an arbitrary small value by reducing bandwidth. For $1/f$ noise and interference, an operating frequency different from d-c and from interfering frequencies can be selected.

Figure 1 shows a general purpose lock-in amplifier with a tuning range from 15 to 15,000 cps and a variable bandwidth down to 0.12 cps. The front panel of the instrument is shown in the photograph. The input signal, including its associated noise, is passed through a narrow-band tuned amplifier; this initial stage, though of relatively wide bandwidth, reduces noise signals that could overdrive the phase-sensitive detector, thus allowing a larger output before non-linearity is encountered.

Furthermore, the waveform with which the signal is mixed usually contains harmonics of the reference frequency. The tuned amplifier is useful in preventing these harmonics from reaching the detector.

If the signal is only a small percent of the input to the detector, and if its peak value (signal plus noise) is within the linear range of the detector, detector output is small but can be amplified; this is accomplished by the d-c amplifier shown in Fig. 1.

In the reference channel (also Fig. 1) a variable phase shifter controls the phase between reference and signal. The phase sensitive detector used in Fig. 1 is essentially a dpdt switch requiring a square wave drive obtained by applying the reference signal to a Schmitt trigger. The waveform applied to the input of the phase shifter must be nearly sinusoidal and thus a tuned amplifier is also provided in the reference channel; The tuned amplifier can be switched out of the reference channel when a nearly sinusoidal reference signal is available. Also, the reference channel tuned amplifier can be used with a positive feedback loop as an oscillator, simultaneously driving the phase detector and providing a sinusoidal output. Thus, the phase detector can be synchronized to an external frequency or the reference frequency can be generated internally. The amplifiers are gang-tuned over the full operating range, which is 15 cps to 15 Kc in three ranges.

The lock-in amplifier has many uses. In radio astronomy it enables stellar noise signals as much as 40 db below the input noise level of the receiver to be detected and measured. It has been used to compare the frequencies of oscillators within one part in 10^{11}, in only a few minutes measuring time. It is able to detect the small change in the absorbed losses of an r-f coil used in nuclear magnetic resonance experiments. It can be used as a narrow-band spectrum analyzer to detect and measure a particular Fourier component in a signal spectrum.

The weak noise signal picked up by the antenna of a radio telescope is similar to the noise generated in the radio receiver and is indistinguishable from it. Moreover, the level of the stellar noise is much lower than the effective input noise of a typical microwave receiver. A microwave radiometer, shown in Fig. 2A, designed to apply the lock-in amplifier technique to this problem was described by R. H. Dicke in 1947[1].

The input of the receiver is alternately switched between the signal from the antenna and a laboratory noise source (a warm resistor generating thermal noise). The microwave switching device is driven by a small synchronous motor and the driving frequency applied to the synchronous motor

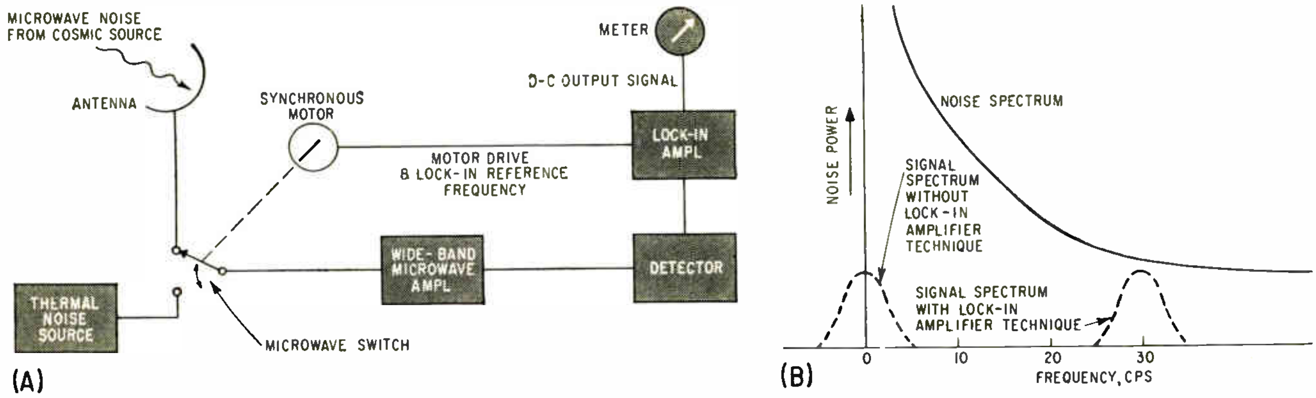

FIG. 2—Lock-in amplifier is used in radio telescope (A) to detect cosmic noise signals 40 db below the level of the wideband microwave receiver used to amplify the signals. Effect of the lock-in technique (B) is to shift the signals of interest to a less noisy part of the spectrum

is also applied to the lock-in amplifier as reference. If the level of noise from the antenna is different from the laboratory noise source, the switching produces a noise signal whose amplitude varies at the frequency used to drive the synchronous motor. This modulated noise signal is then applied to the input of the microwave receiver, which consists of a wideband amplifier followed by a detector. The output of this amplifier consists of two components: one is the modulated noise signal produced by the switch; the other, usually much larger, is the noise generated at the input of the microwave amplifier itself. This combination is applied to the detector.

Consider the output of the detector in a small interval about the frequency at which the microwave switch is driven. All the frequency components of the modulated noise signal carry sidebands corresponding to the frequency at which the switch is driven; thus all these frequency components contribute to the output of the detector. The contribution of the noise produced at the amplifier input to the output of the detector at this frequency is almost entirely due to intermodulation between the various frequency components of this noise signal. The result is, while essentially all the modulated noise signal contributes to the detector output in this frequency interval, only a small fraction of the internally generated receiver noise contributes to it. The output of the detector is then fed into the input of the lock-in amplifier.

The lock-in amplifier selects that part of the detector output lying in the frequency interval provided by the synchronous motor-driven microwave switch and converts it to an equivalent bandwidth at d-c As has been shown, the bandwidth is determined by the low-pass filter at its output. The output of the lock-in amplifier consists of the d-c voltage due to the modulated cosmic noise signal plus fluctuations due to receiver noise. The d-c level is entirely due to, and gives a measure of, the strength of the cosmic noise source. The parameters of the system are such that

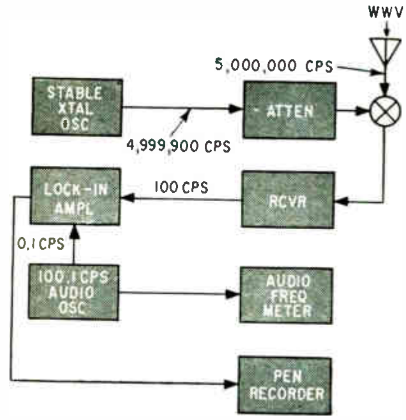

FIG. 3—Oscillators can be checked to one part in 10^{10} in five minutes using lock-in technique

cosmic noise sources that produce a level 40 db below the effective input noise level of the microwave receiver may be detected.

Another application is in the study of a particular phase component of a signal in the presence of a quadrature component. This situation occurs in making a measurement that depends on the balance of an a-c bridge. By setting the phase of the reference signal equal to the phase component of interest, the instrument will reject the quadrature component completely. In the case of balancing an a-c bridge, if one desires to deal with both the in-phase and the quadrature component, the lock-in amplifier can be used to pick up the in-phase and the quadrature components separately and allows each to be balanced separately. This usually allows the bridge to be balanced systematically and avoids the typical successive approximations approach.

An example of an application where the reference frequency is different from the signal frequency is the WWV comparison system shown in Fig. 3. The frequency of the precision crystal oscillator is offset 100 cps from WWV, to 4,999,900.0 cps if the 5-Mc carrier is used.

A small amount of the oscillator output is applied to the antenna terminals of the receiver, which is tuned to the 5-Mc signal from WWV. The result is that the 100-cps beat frequency between the oscillator and WWV appears at the audio output terminals of the receiver; this signal is applied to the input of the lock-in amplifier. The reference frequency for the lock-in amplifier is set to 100.1 cps and the output is thus 0.1 cps, which may be recorded.

In this example the frequency of the oscillator is given by the standard WWV frequency minus the audio frequency, plus the frequency exhibited on the recorder. If a comparison is desired to one part in 10^7 (to 0.5 cps), the audio frequency need only be known to 0.5 percent and the 0.1 cps being recorded may be completely neglected provided it stays reasonably close to this value throughout the entire time of the measurement interval.

Since this technique involves measurement intervals of about twenty minutes, even inexpensive commercial audio oscillators are adequate for the check. For a high precision measurement, such as a local comparison between two stable crystal oscillators, or between a crystal oscillator and an atomic clock with an accuracy of better than one part in 10, the beat frequency should be recorded for about twenty minutes and a cycle counter and interval timer should be used to measure the time interval for about 10^5 audio frequency oscillations.

Standard commercial interval timers have a precision adequate for this application. Since the recorder allows a phase measurement at the beginning and end of the measurement interval, the accuracy of the measurement can be substantially greater than the total number of cycles in the measurement interval. If, the recorded output phase can be read to better than 0.1 radian, a comparison accurate to one part in 10^{10} can be made in an interval containing 3×10^8 cycles of crystal frequency. At one megacycle this is 300 seconds or five minutes, a short time for a measurement of such high precision.

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GLASS DISK GENERATES ANY

Waveform printed on rotating disk is scanned by light beam and reflected onto a phototransistor. The frequency is continuously variable from 0.005 cps to 50 cps

FIG. 1—Function generator disk can be rotated in both directions, as indicated by the cps scale

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MANY control functions can be reduced to electrical waveforms, but often the complexity of those waveforms make them both difficult and costly to generate. In designing a low frequency function generator (Fig. 1), the generation of unusual waveforms was much in mind. While the generator will produce the waveforms such as sawtooth, square, sine and so on, it can produce many other wave patterns. The only limiting factor is that the wave shape to be generated must be single-valued and repetitive.

Several systems for the generation of complex functions were considered. Multiphase oscillators were suitable for only sinusoidal generation, and diode-shaping devices had limitations in discrimination, as well as being elaborate and costly. The answer appeared to be in a mechanical optical system that would allow for rapid changes of function for a small capital outlay.

The conventional oscillator circuit is replaced by a rotating transparent disk scanned by a narrow light beam. The waveform or function to be generated is printed on the disk by silk screen or similar process, the area confined by the periphery of the waveform being opaque. The light beam is concentrated on the disk providing a radial sweep as the disk rotates (Fig. 2). The light source is a bulb fed from a stabilized d-c supply (which also supplied the heaters of the d-c amplifier), thus insuring constant light intensity free from ripple. This light source is condensed into a collimated beam and focused onto the function disk as a narrow slit. Light passing through the transparent areas of the disk is reflected by a concave mirror on a phototransistor. As the disk rotates, the amount of light falling on the phototransistor will vary directly in accordance with the opaque area of the waveform on the disc. The phototransistor converts the light into an electric signal whose amplitude is about one volt peak to peak. As the instrument operates down to virtual d-c, the following amplifier is d-c coupled throughout. The linearity of the system is such that with a sinewave output the total harmonic content is typically one percent.

Changes in output signal caused by fluctuations in the transistor collector current due to temperature variations are minimized by a compensating thermistor in the base circuits. The amplified voltage of the phototransistor is fed to the out-

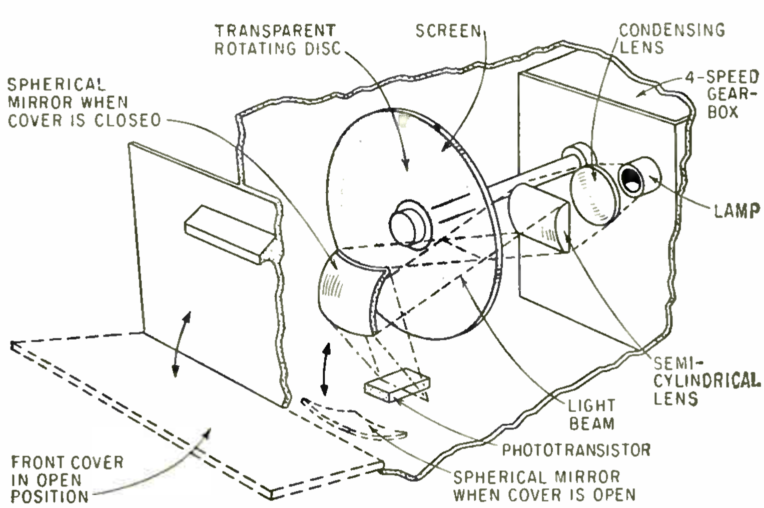

FIG. 2—Mechanical-optical scanning system of the generator

LOW-FREQUENCY WAVEFORM

put terminals through a decade attenuator.

It is essential that the motive power for the disk be accurately controlled to achieve a stable output frequency. This has been achieved by driving the disk through a four-speed gear box coupled to a servo-controlled split-field motor (Fig. 3). Both the motor and the associated tachogenerator are controlled by a velocity feedback system. The rpm., which is in fact the output frequency, is set by a precision potentiometer fed from a stabilized voltage supply, and the direction of disk rotation can be changed to reverse the time sequence of the output waveform, thus altering the sign of the differential coefficient. The disc acceleration on the two lower frequency ranges is sufficient to permit an almost instantaneous start from any predetermined point of the waveform, thus allowing effective single-stroke operation. To help in this operation, the periphery of the disk is calibrated in degrees. The frequency is continuously variable from 0.005 cps up to a maximum of 50 cps but by increasing the number of complete patterns on a disk, the upper frequency limit can be raised to several times its nominal value. The two highest ranges, 0.5 cps to 50 cps, may be swept automatically from the lowest to the highest frequency by driving the frequency control from the gearbox, permitting rapid assessment of the response of any equipment under test. This is particularly useful in the study of the causes and effects of vibration in machinery. The sweep time for a 10:1 range of frequency is approximately two minutes, but as the gear box drives the frequency control that governs the rpm, the sweep rate is logarithmic accelerating at the high-frequency end of the scale. At the end of the sweep an automatic switch-off cuts out the motor.

Although the nominal frequency range is 0.005 to 50 cps, both lower and higher frequencies can be obtained but with decreased accuracies. The frequency dial is calibrated linearly 0 to 5 and 0 to 10 with a four-position decade multiplier ×10, ×1, ×0.1 and ×0.01. The frequency calibration accuracy is ±1 percent of full scale. Output voltage is 200 microvolts to 20 volts peak-to-peak with an output impedance of 3,000 ohms at maximum output, selected by a five-position decade multiplier and a continuously variable attenuator. The output amplitude variation is within one db over the entire frequency range.

Of the five waveform disks, three are standard sine, square and sawtooth waveforms (Fig. 4). The fourth disc generates noise with a bandwidth ratio of about 250:1, accommodated anywhere in the frequency range 0.005 cps to 3 Kc. The fifth disk is blank, for plotting any waveform that may be required.

The function is reproduced as a waveform on the disk by polar coordinates. The output waveform is plotted on a linear scale to derive the true values of the Y coordinates for each cardinal angular position on the polar function pattern. This applies particularly to the waveforms that do not conform to a known mathematical equation. The polar function pattern is then plotted on a polar chart. The polar graph is subdivided into a positive and negative decade to enable a polar function pattern to be plotted direct from an equation. This eliminates the need to draw the output waveform diagram. When a square or rectangular waveform disk is used, the instrument is designed to provide a rise time of less than 5 microseconds. There is also a built-in one-inch monitor tube for checking the waveform and the output voltage level at 40 cps.

The multiplication of the basic frequency can be achieved by increasing the number of waveform cycles on the disk and is limited only by the amount of distortion acceptable by the operator. Using the sine disk with the frequency sweep enables resonance points to be noted when checking vibration in machinery, the frequency at any instant being shown visually on the frequency dial.

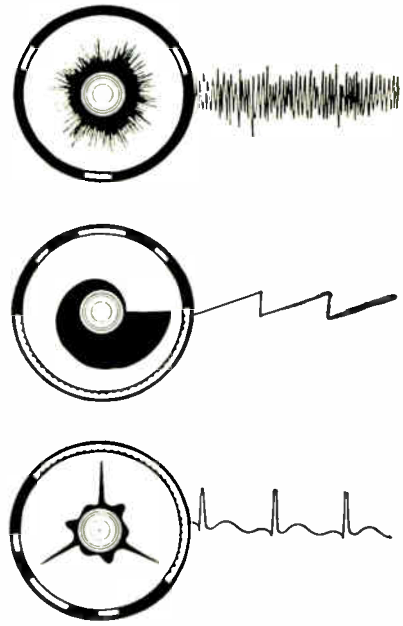

FIG. 4 — Examples of disks and waveforms: noise, sawtooth, heart beat

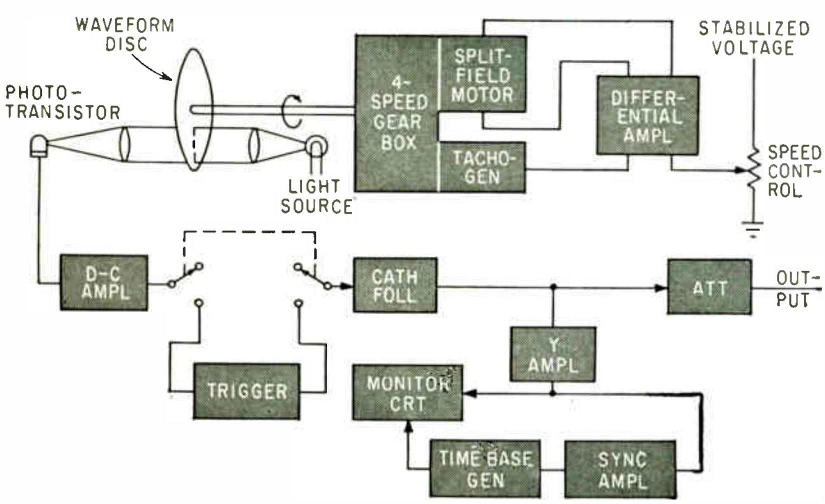

FIG. 3—Block diagram of function generator

Transient Generator Checks Missile

Transients are simulated and injected into missile system wiring to determine its

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INTERFERENCE TESTS on missile systems require a generator to simulate interference external to the missile and insert this simulated interference back into the missile wiring. Military specification MIL-I-006051B requires that the interference present in the system be no greater than half the amplitude required to cause a malfunction. This audio frequency generator produces interference at twice the measured amplitude and injects it back into the weapons system. It also functions as the operating power source for the system.

All areas of the system under test are completely infiltrated by the test transient, eliminating the necessity for analyzing the system for the most susceptible points and monitoring only these. The possibility of overlooking some critical point is eliminated and internal modification of the equipment under test is not necessary. Assembly of special monitoring equipment is obviated as normal operation is the only quality monitored.

The transient shape of the generator output is adjustable over a wide range and a transient power output of 400 watts is available. Assembling general-purpose test equipment to do this job would be difficult and time consuming.

Shapes of the required a-c and d-c transients have been determined by observation of the transients existing in various systems. All d-c transients observed were of one basic shape (Fig. 1A) or variations thereof. The most common deviation was a carrier, amplitude-modulated by the pulse of Fig. 1A as shown in Fig. 1B.

All the a-c transients were basically the quiescent a-c line voltage amplitude modulated by the transients of Fig. 1B (Fig. 1C). (Fig. 3).

All transients, first observed in experimentation and later in actual missile testing, were variations of the above three patterns. They varied in time duration but the shape was consistently proportional. These shapes are to be expected when consideration is given to missile circuitry. The pulse of Fig. 1A is comparable to the output of a low-pass circuit with a square-wave input. Missile wiring offers high-capacitance paths to ground for any high-frequency transient components; that is, it acts as a natural low-pass filter.

The pulse of Fig. 1B is essentially a ringing pulse caused by exciting an inductance-capacitance circuit with a step function. Both the inductance and capacitance are easily provided by the missile wiring and circuitry.

Since the basic transient shapes were consistent, the problem is to generate these families of shapes over an adjustable range of pulse length. The shaping process is started with the pulse of Fig. 1A and accomplished by integrating, clipping, and differentiating a rectangular wave. The rectangular wave is integrated (Fig. 2A). The pulse of Fig. 2A is then differentiated and the trailing edge clipped (Fig. 2B). The resultant pulse is the desired shape. The duration and

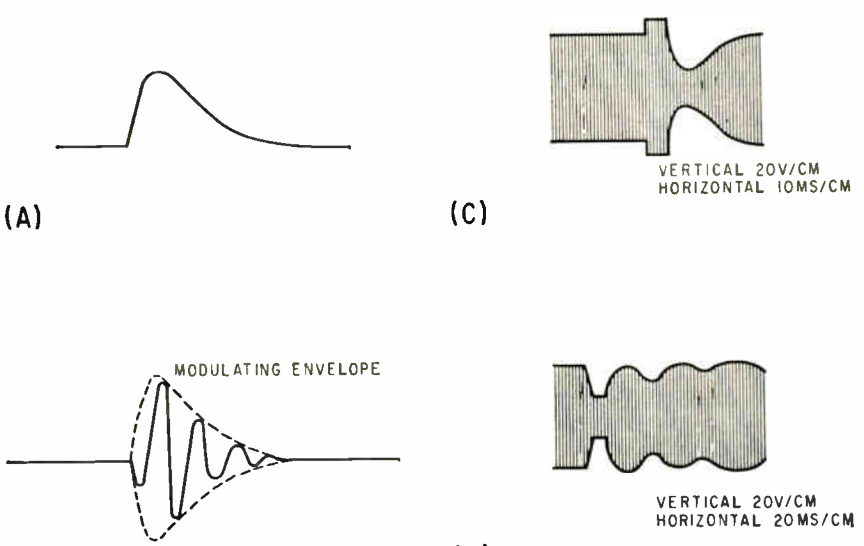


FIG. 1—Typical transient (A) and its modulating envelope (B). Generated a-c transients produced by modulating the a-c voltage with pulses (A) and (B) result in waveforms shown in (C) and (D)

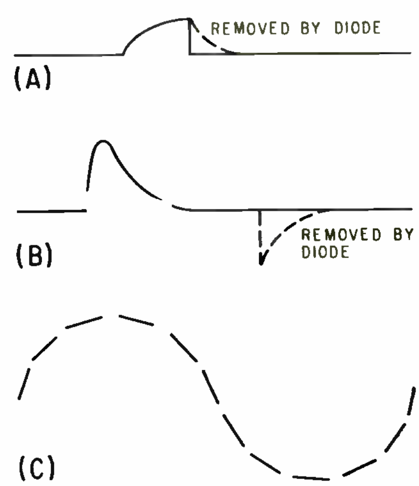


FIG. 2—Integrated square wave with trailing edge clipped (A), pulse of Fig. 2 differentiated and trailing edge clipped (B), and output of synthesizers showing conversion of triangular wave to approximate sine wave (C)

Systems

susceptibility to interference

proportion of this pulse are varied by changing the initial rectangular pulse length and by changing the time constants of the integrating and the differentiating circuits.

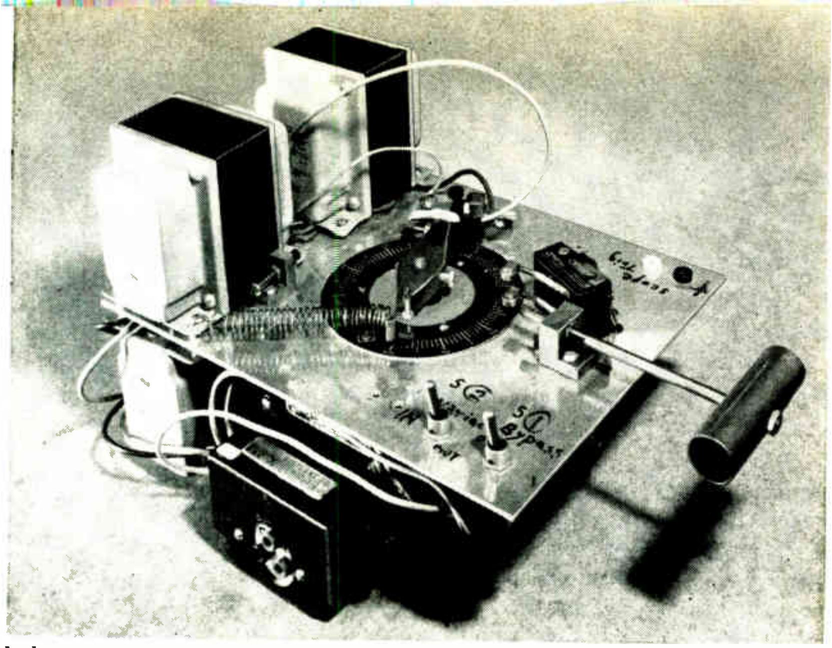
The shape of Fig. 1B can be obtained by amplitude-modulating a carrier with the pulse of Fig. 2B. The carrier is obtained from a gated, free-running multivibrator. Three carrier shapes are available; rectangular, triangular, and sinusoidal. The rectangular wave is the multivibrator output, and the triangular wave is obtained by integrating the multivibrator output, and the sine wave is approximated by putting the triangular wave through a sinewave synthesizer. The synthesizer is a resistor-diode network that converts the triangular wave to an approximate sine wave by changing the slope of various sections of the triangular wave. The synthesizer output is shown in Fig. 2C.

The final, desired transient shape is obtained by amplitude modulating the carrier with the pulse. The amplitude modulation is accomplished by phase splitting the carrier, modulating, and subtracting the undesired frequency components. Fig. 1B is a typical transient. If desired, the pulse alone may be used as the transient shape without any modulation, giving an output similar to Fig. 1A. Typical d-c transients are shown in Fig. 3.

Transients on a-c voltages (Fig. 1C and 1D) are produced by amplitude modulation of the a-c voltage with the pulses of Fig. 1A and 1B.

Another major problem in building the transient generator was putting large transients on missile a-c and d-c power lines without lowering normal operating voltages and without damaging the transient or missile power sources.

If the transient supply is simply connected across a missile power line (Fig. 4A) the transient supply is operating into the parallel com-



Laboratory model of the transient generator unit

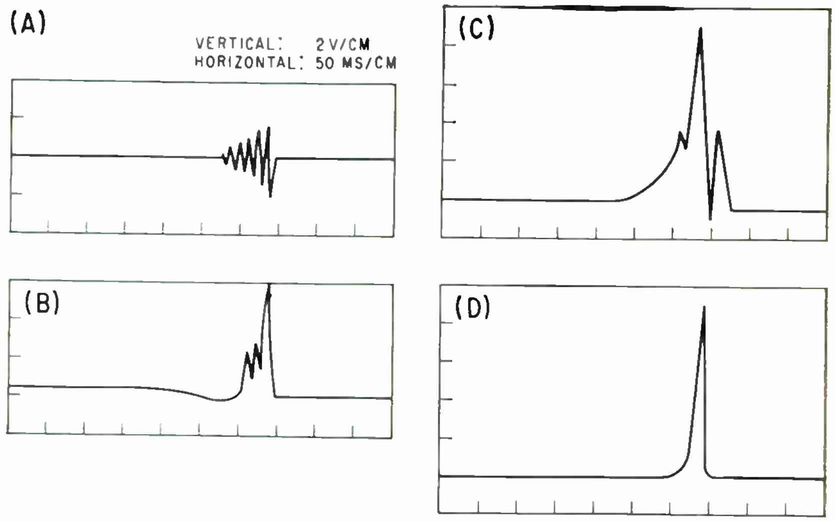


FIG. 3—Four typical generated d-c transients produced by the generator

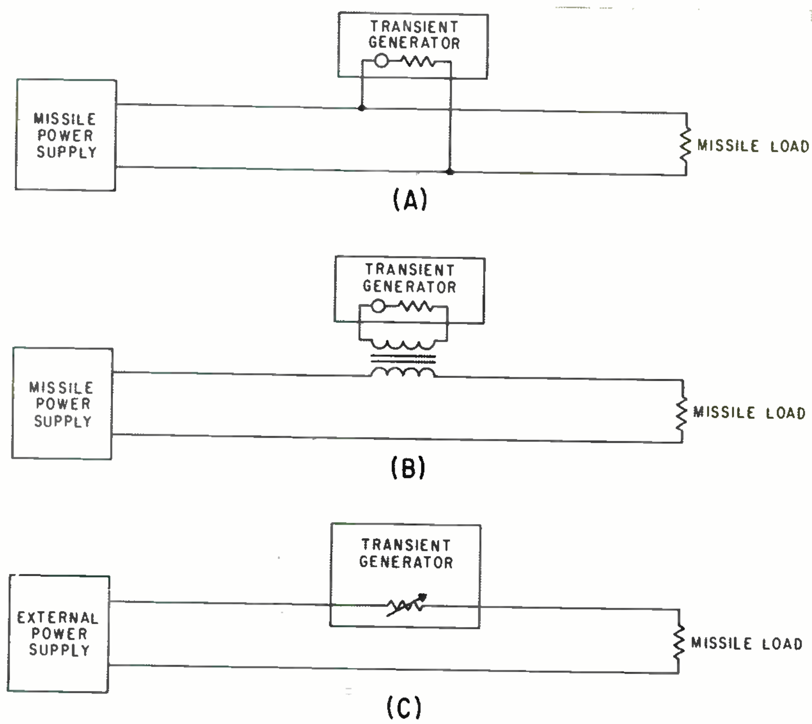


FIG. 4—Methods of putting the transients into the system showing parallel connection (A), in series with missile power supply (B) and with transient generator as passive device in series with missile load (C)

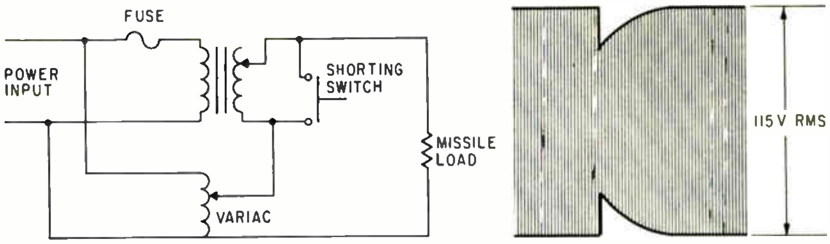


FIG. 5—A-c transient shown is generated by the circuit, left

The method for applying transients to a-c power lines differs from that used on d-c lines. In the a-c case, an a-c amplifier is used to operate the equipment under test, with an a-c modulator supplying the low-level a-c input to the amplifier. When transient shapes are put into the a-c modulator, transient modulation of the low-level a-c signal occurs. The transient-modulated signal then goes to the a-c amplifier where it is amplified and applied as primary a-c power to the item being tested.

Some loads draw more a-c power than can be supplied by readily available a-c amplifiers. A different method of generating a-c transients is used in these cases.

This method consists of operating the missile a-c load from two transformer secondaries connected in series. When a transient is desired, one of the secondaries is shorted, giving an instantaneous reduction in missile a-c voltage. The second transformer, actually a variable-power transformer, is then mechanically activated to return the missile voltage to the normal operating value. A fuse must be replaced and the device set through a reset cycle each time a transient is thus generated. The type of transient generated is shown in Fig. 5A. Figure 5B is a schematic of the system.

Figure 6 is a block diagram of the complete transient generator.

bination of the missile load and the output impedance of the missile power supply. The low output impedance of the missile power supply makes it difficult to vary the missile line voltage without causing large currents in the missile supply, with the attendant danger of burning out the missile supply.

If the transient source is placed in series with the missile supply (Fig. 4B), the output impedance of the transient source must be kept low to maintain normal operating voltage on the missile load and to prevent the transient source from absorbing power from the missile supply.

If the turns ratio of the coupling transformer is such as to keep the output impedance low, the transient output voltage will also be low, and the magnitude of the transient that can be applied will be limited accordingly.

The system of transient application used on d-c power lines (Fig. 4C), is in essence one of supplying power to the missile loads from an external power source through a controlled series resistance. Varying the series resistor according to the transient shape causes the voltage across the missile load to vary inversely. In terms of hardware, the series resistor is a series voltage regulator. The regulator supplies both normal operating voltage and transient voltages to the missile. In the quiescent state, the regulator supplies a constant regulated voltage. When a transient is desired, the transient shape is used to modulate the regulator reference voltage and the regulator output follows accordingly, apply the transient to the missile power line.

The series regulators are conventional circuits employing differential amplifiers operating over a wide dynamic range, allowing the regulator output voltage to follow changes in the reference voltage.

Output impedance of the regulators is less than 1 ohm. The d-c power to both regulators and their missile loads is furnished by conventional d-c power supplies.

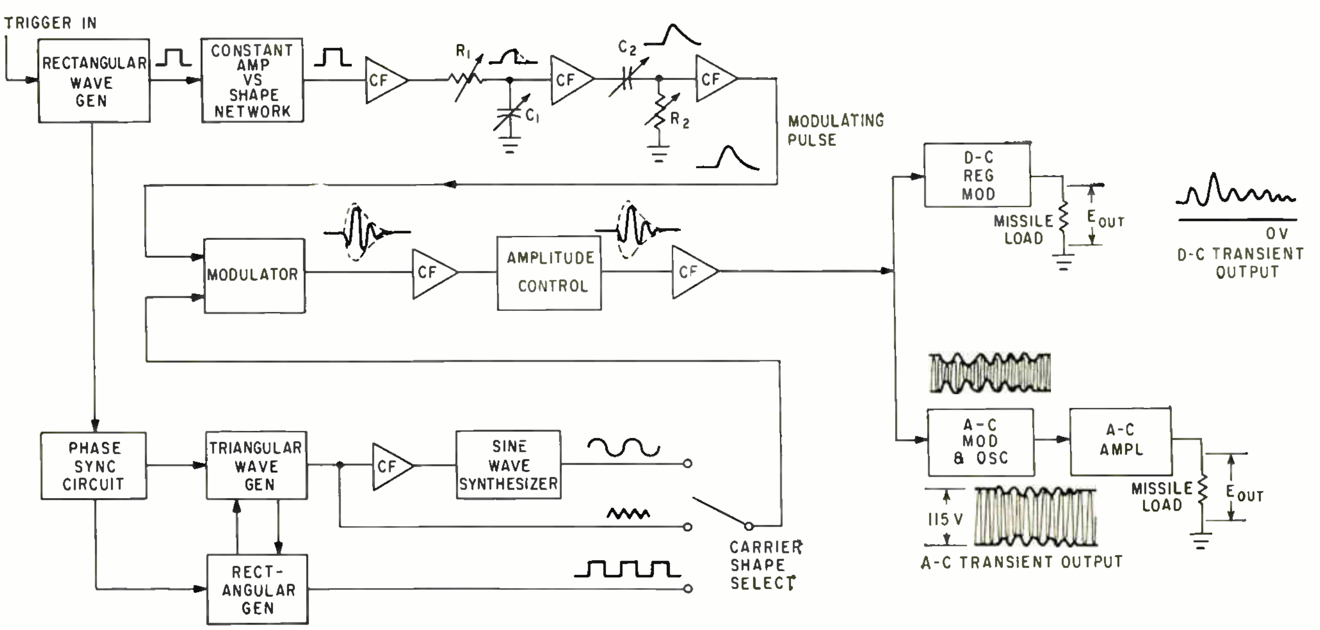


FIG. 6—Block diagram of complete audio transient generator

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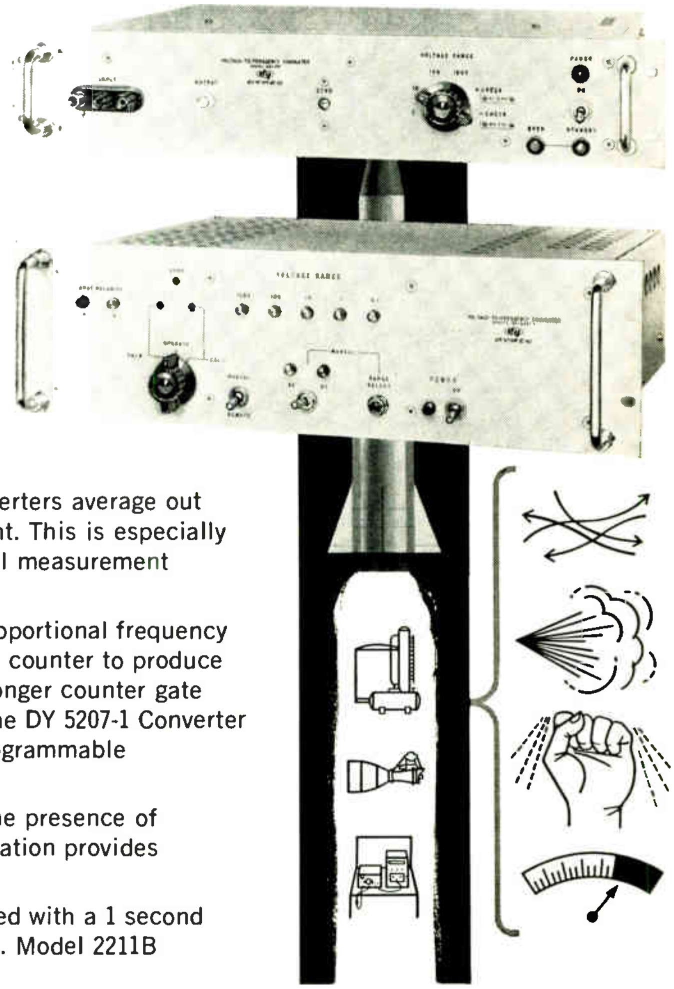

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Models 2210 and 2211A/B convert an input dc voltage to a proportional frequency of constant amplitude which is applied to a gated electronic counter to produce a direct digital reading of the input analog voltage. With a longer counter gate time you also can obtain the integral of the input voltage. The DY 5207-1 Converter permits similar measurement of ac input voltages and is programmable for both dc and ac voltage measurements.

In addition to flexible systems use, especially effective in the presence of ac input interference, the Dymec Converter/Counter combination provides an inexpensive digital voltmeter for lab or factory.

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Here are brief specifications of Dymec Voltage/Frequency Converters. Call your Dymec/Hewlett-Packard representative or contact Dymec direct for detailed data sheet and application information.

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Ranges: (VDC, ±, full scale)	±1, ±10, ±100, ±1000; ±.1, ±1, ±10, ±100 M6	±1, ±10, ±100, ±1000 M6; ±.1, ±1, ±10, ±100 M10	DC ±.1, ±1, ±10, ±100, ±1000; 1, 10, 100, 750 AC volts rms, 20 to 100,000 cps
Output Frequency:	0-10 KC	2211A, 0-10 KC 2211B, 0-100 KC	0-10 KC
Accuracy:*	±0.06%	2211A, ±0.02% 2211B, ±0.03%	±0.06% dc ±0.5%, 50-10,000 cps ±0.75%, 20-100,000 cps
Stability:**	±0.03%	±0.02%	±0.03% dc
Price:	DY 2210, $660.00 (cabinet) DY 2210R, $650.00 (rack) M6, add $100.00	$1,250.00 (rack) M6, add $150.00; M10 add $350.00	$1,850.00 (rack)

*Accuracy includes stability, is given in per cent of full scale and is affected by frequency and accuracy of calibration, line voltage variations, temperature changes and accuracy of multi-range input attenuators. Figures given are those attained under normal operating conditions. ** Given as per cent of full scale per 24-hour day.

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Plate Dissipation Nomograph For Damper Diodes

Two nomographs give average plate current and average plate dissipation in terms of tube parameters and diode-current waveshape

By H. A. WHITTLINGER,
RCA Astro-Electronic Products Division, Princeton, N. J.
M. E. FOSS,
RCA Electron Tube Division Harrison, N. J.

DISSIPATION in television horizontal-deflection damper diodes may be determined by a method that also lends itself to other diode circuits having similarly shaped pulses. The simplicity, speed and accuracy of this method ensure a considerable saving in engineering time.

Because an idealized damper current waveform is triangular, integration-by-parts is used to determine dissipation and average diode current.

The equation for diode current is

$$i = ke^{3/2} \qquad (1)$$

where i is the diode current, k is a constant for the diode, and e is the voltage across the diode for any value of i.

This equation may be rewritten to define a new diode constant K.

$$e = Ki^{2/3} \qquad (2)$$

The instantaneous power p is then given by

$$p = ie = i(Ki^{2/3}) = Ki^{5/3} \qquad (3)$$

Average power P_{av} may then be expressed by

$$P_{av} = \frac{1}{T}\int_0^\tau Ki^{5/3}\,dt \qquad (4)$$

where T is one complete cycle and τ is the conduction time of the pulse.

At any time t for the triangular cathode-current pulse, inset in Fig. 1, diode current i may be defined in terms of peak current i_p by

$$i = i_p\left[1 - \frac{t}{\tau}\right] \quad \text{for} \quad 0 < t < \tau \qquad (5)$$

When Eq. 5 is substituted in Eq. 4, the average power is given by

$$P_{av} = \frac{1}{T}\int_0^\tau K(i_p)^{5/3}\left[1 - \frac{t}{\tau}\right]^{5/3} dt \qquad (6)$$

$$= -\frac{3K\tau}{8T}(i_p)^{5/3}\left[\left(1 - \frac{t}{\tau}\right)^{8/3}\right]_0^\tau \qquad (7)$$

$$P_{av} = \frac{3}{8}K\frac{\tau}{T}i_p^{5/3} \qquad (8)$$

where the τ/T is the ratio of conduction period τ to the total time of one cycle T.

The table in Fig. 1 lists values of K derived with Eq. 2 from registered tube-drop information for some of the more widely used damper diodes. Figure 1 shows Eq. 8 plotted for K of 51, which is between the values listed for the 6AU4-GTA and the 6W4-GT. The dashed line in Fig. 1 represents the bias current for the tube conducting continuously. Equation 3 determines this condition.

The graphs of Fig. 1 indicate that peak currents of less than 40 milliamperes may be neglected because dissipation is less than 0.1 watt. Similarly, peak currents of up to 700 milliamperes may be neglected when τ/T is less than 0.01.

In Fig. 2, Eq. 8 is presented as a nomograph for other values of K. Average power values are obtained from the nomograph by constructing a line from the conduction ratio on the τ/T scale,

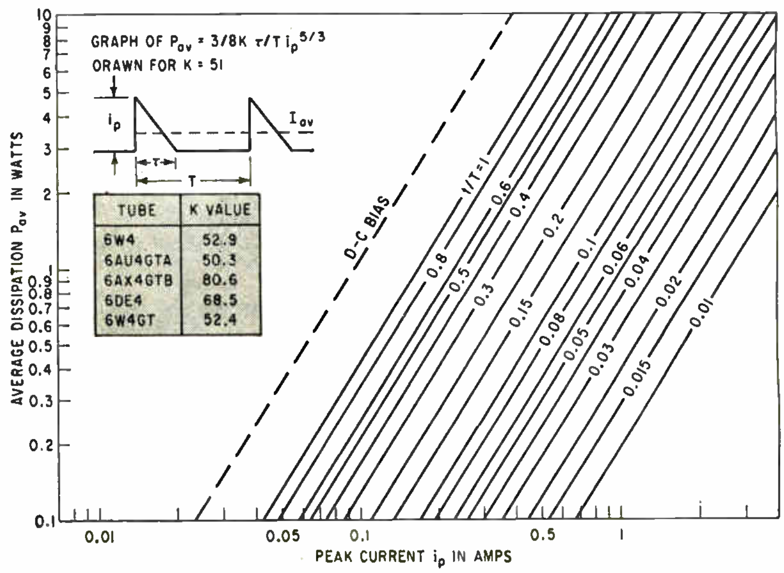
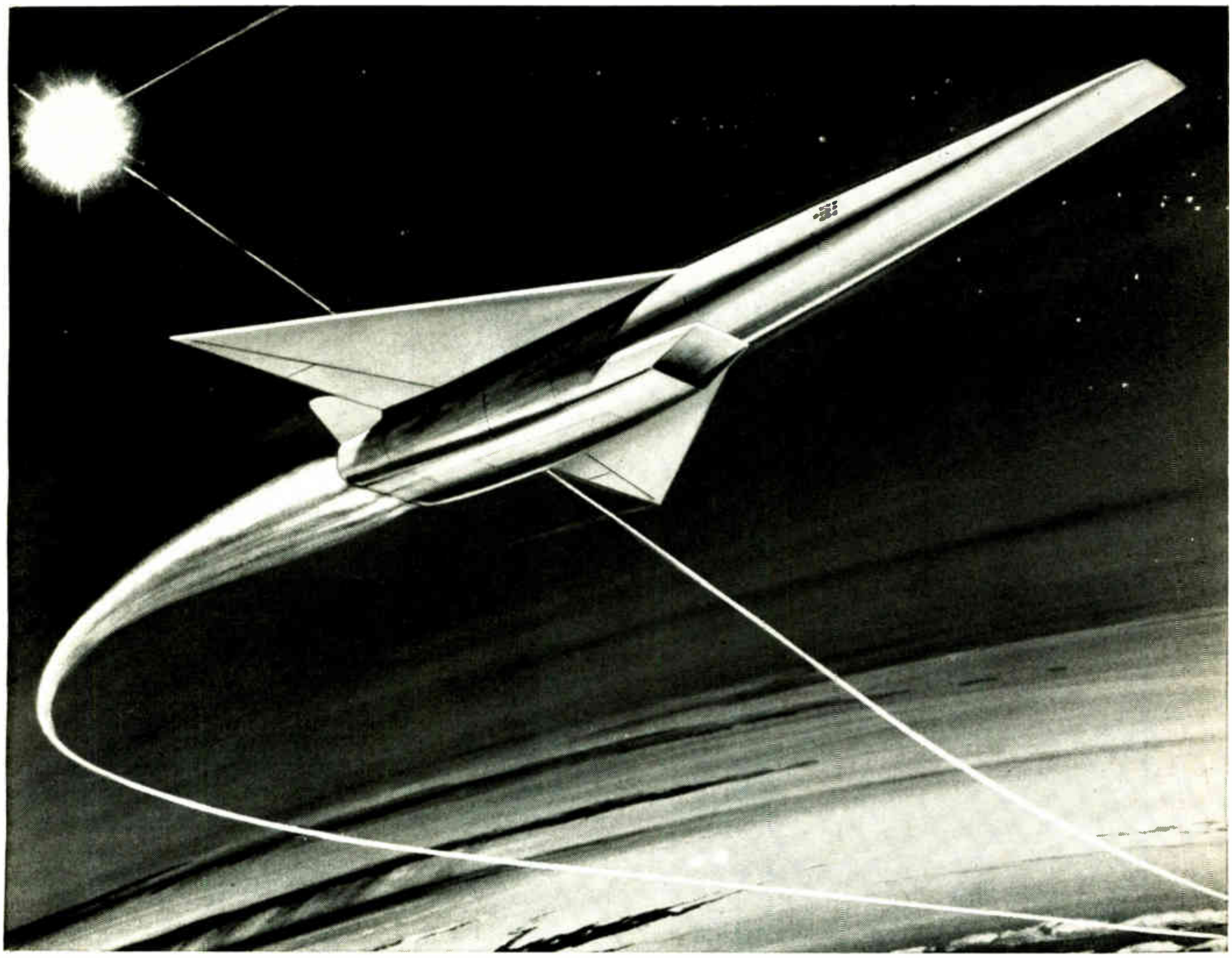


FIG. 1—Plate dissipation P_{av} is a linear function of the conduction ratio τ/T, but changes rapidly with variations in peak current i_p



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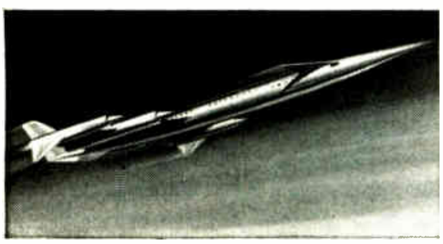

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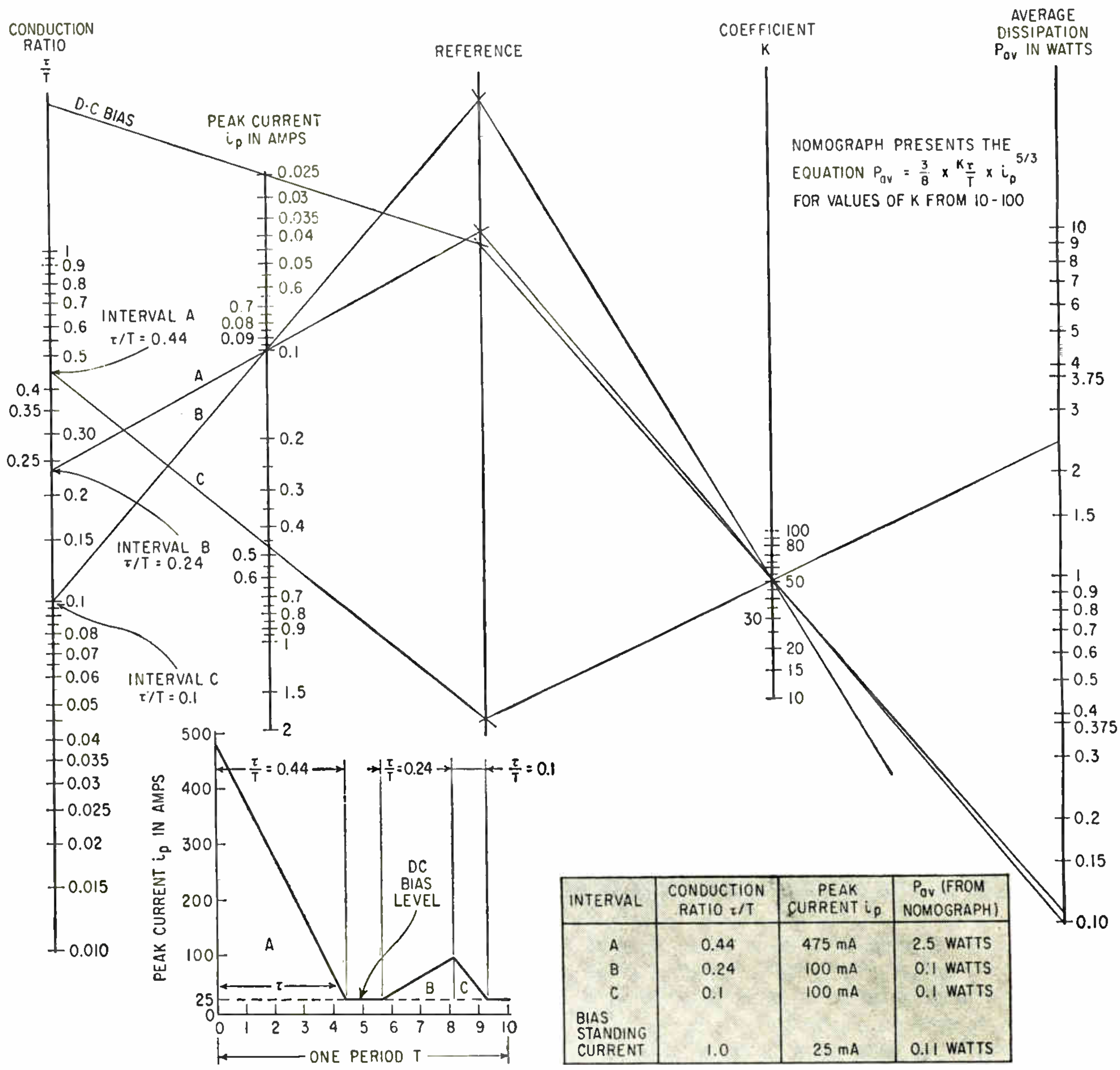


INTERVAL	CONDUCTION RATIO τ/T	PEAK CURRENT i_p	P_{av} (FROM NOMOGRAPH)
A	0.44	475 mA	2.5 WATTS
B	0.24	100 mA	0.1 WATTS
C	0.1	100 mA	0.1 WATTS
BIAS STANDING CURRENT	1.0	25 mA	0.11 WATTS

TOTAL PLATE DISSIPATION = 2.71 WATTS

FIG. 2—Nomograph relates average dissipation P_{av} to peak current i_p, permits dissipation to be found when K is available from tube tables and τ/T from the actual circuit. Graph, inset, and its accompanying table show how the nomograph is used

through the peak current value on the i_p scale, and extending to the reference point. From the reference point, the line is drawn through the listed *K* value for the diode and extended until it intersects the P_{av} scale at a point that indicates average power dissipation.

The graph inset in nomograph, Fig. 2, shows the complex damper-current waveform of a 1-ohm sampling resistor in series with a 6AU4-GTA damper diode. Part *A* of the waveform is typical of television applications; parts *B* and *C* result from a particular setting of the drive control. In this inset graph, the ordinate of the waveform is peak current i_p; the abscissa is in terms of relative time: that is, one complete cycle *T* is divided into ten arbitrary units. The conduction period τ of part *A* is 0.44 units long; parts *B* and *C* have conduction periods of 0.24 units and 0.1 units respectively. The table in Fig. 1 lists a *K*-value of 50.3 for the 6AU4-GTA. A d-c bias line is shown on the τ/*T* scale of the nomogram.

Average power dissipation P_{av} is then obtained from the table inset in Fig. 2 nomograph. Adding the four components of total dissipation: 2.5, 0.1, 0.1 and 0.11 watt, respectively, gives the tube dissipation as 2.71 watts total. Average values of plate current for sections *A*, *B* and *C* are derived from the three ordinate nomograph of Fig. 3. From Fig. 3 the bias current plus the three additional current components bring the total average current I_{d-c} to 146 milliamp.

This value can then be compared with the measured average plate current to provide a good evaluation of the measurement and construction techniques.

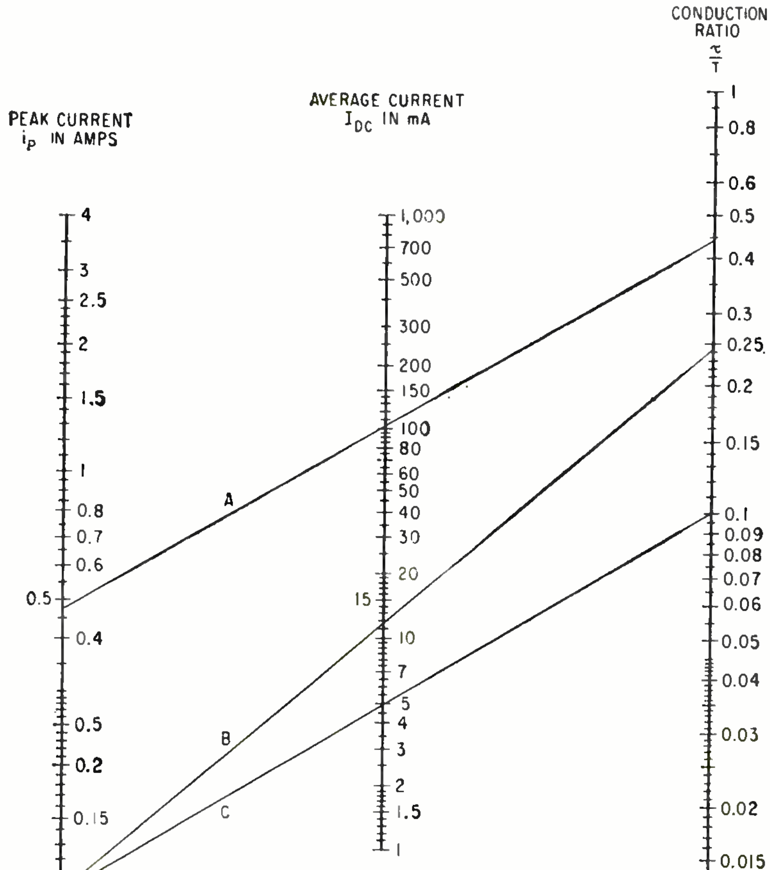
The plate current for a 6DE4 damper diode is shown in Fig. 4; one complete cycle T occupies 10 centimeters on the oscilloscope screen. The solution of the problem is simplified when the current is divided into two triangular parts A and B to smooth out the irregularly shaped pulses. Figure 4 shows the first line drawn from $t = 0$ and $i_p = 400$ ma to $t = 3.7$ and $i_p = 0$ ma. Another line then carries the waveform on to the point $t = 8.3$ and $i_p = 100$ ma. There is no bias current in this circuit so the waveform returns to zero at both $t = 3.7$ and $t = 8.3$.

Using the nomograph Fig. 3 to relate peak-to-average current in terms of the conduction ratio τ/T, the two components of average current are derived as 74 ma and 23 ma, respectively, giving a total average plate current, $I_{d-c} = 97$ ma.

The actual damper current measured 100 milliamp, showing the close correlation between measured and calculated values of current.

The plate dissipation is next calculated by using the dissipation nomograph, Fig. 2. The two components of average power are 2.06 and 0.25 watt respectively, giving a total dissipation P_{av} of 2.31 watts. This figure agrees reasonably closely with the value of 2.4 watts measured by thermocouple.

Although these nomographs were developed to assist tube design engineers in evaluating performance in television circuits, they may also be used in transistor applications to determine collector dissipation in dc-to-dc converters.



INTERVAL	PEAK CURRENT	CONDUCTION RATIO	AVERAGE CURRENT
A	475 mA	0.44	104 mA
B	100 mA	0.24	12 mA
C	100 mA	0.1	5 mA
BIAS CURRENT	25 mA	1	25 mA

TOTAL PLATE CURRENT = 146 mA

FIG. 3—Average plate current I_{d-c} is related by this nomograph to the peak current i_p when the conduction ratio τ/T is known from circuit information

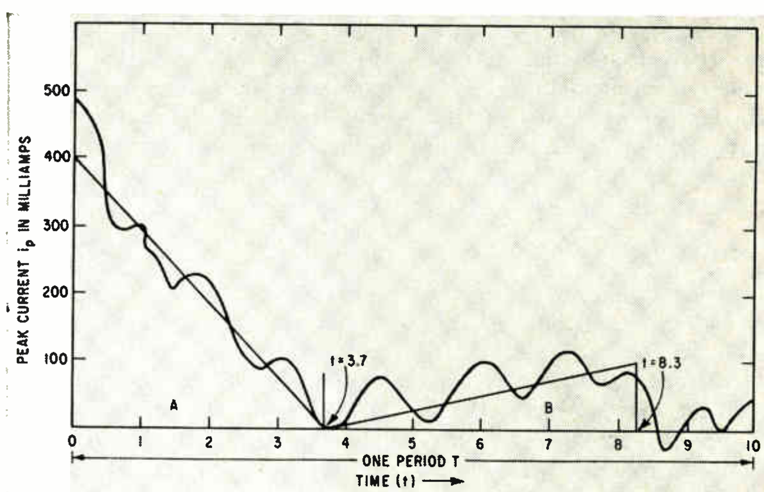
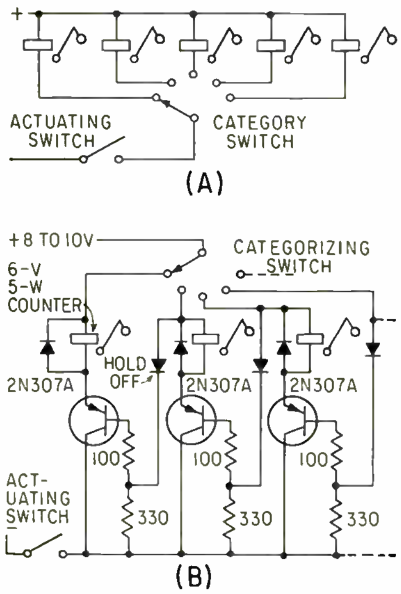


FIG. 4—Transients are ignored in this circuit-derived example; a pair of triangular pulses simulate the actual waveform with reasonable accuracy. There is no bias current in this example

Reducing Errors in Category Counters



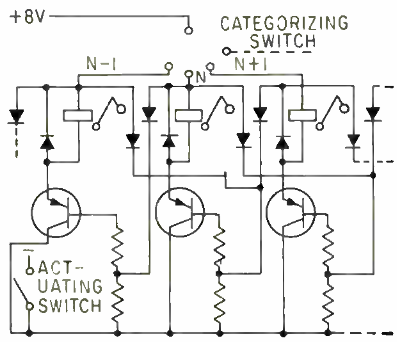


FIG. 2—Counters are disabled when adjacent contacts are bridged

FIG. 1 — Typical categorizing counter circuit (A) is improved by diodes (B) to absorb flyback and prevent sneak circuits

By RONALD L. IVES
Palo Alto, Calif.

MEDIUM-POWER audio transistors can prevent duplicate counts when categorized information is fed to banks of electromechanical counters. These readily available components reduce equipment costs, lower noise and virtually eliminate maintenance.

A typical categorizing circuit is shown in Fig. 1A. In an actual application, the category switch might be contact sectors of a wind vane and the actuating switch might be the contacts of an anemometer. Individual counters would store wind data in particular directions, and the basic information would be formed for plotting wind roses.

Source of Errors

If the input signal operating the category switch is continually varying, duplicate counts could be recorded if two adjacent contacting sectors of the category switch are bridged. This statistically undesirable duplication has been eliminated by banks of multiple-pole, cross-connected relays.[1] However, this expedient requires considerable space, power and maintenance. Noise from the relays can be annoying to personnel working near the equipment. Also, switching transients require extensive design work with flyback absorption to reduce contact maintenance and to lower radio interference to tolerable limits.

Circuits for eliminating duplicate counts can be considerably simplified using low-cost transistors like the 2N307A. The antiduplication circuit in Fig. 1B uses reverse diodes to absorb flyback from the counter coils and forward diodes to prevent sneak current through the system. In this circuit, if the category selector bridges two contacts, only the counter connected to the higher numbered contact is energized. Positive bias supplied through the diode from the higher numbered contact cuts off the transistor in series with the lower numbered counter.

The slight statistical error introduced by this system can be completely eliminated in circular arrays by indexing the switch arm. In linear arrays dealing with Gaussian functions, careful indexing can make the error statistically unimportant. Actuation of the lower numbered counter is possible with bridged contacts by mirror-like reversals of the hold-off circuit in which the higher numbered counter is held off.

In Fig. 2, the hold-off circuits are cross-connected with forward diodes between contact N and the bases of transistors $N-1$ and $N+1$. When any two contacts are bridged, this circuit will not count.

Interpolating Counter

In a circular array, one additional circuit for each category makes possible an interpolating counter system. It provides the total number of actuations during which each pair of contacts is bridged. With a suitably proportioned categorizing switch arm, an interpolating counter enables construction of a sixteen-point wind rose from data provided by an eight-point wind vane. Considerable outside wiring is eliminated, which is particularly important when the sensor (wind vane) is remote from the recording point. An overlap signal can be obtained from a cross-connected circuit using the arrangement in Fig. 3A.

All resistors R are equal and their value greatly exceeds counter resistance. The diodes serve as isolators, preventing a system-wide network of sneak circuits. When one counter is operating, the voltage at point A is about half the transistor drop or slightly less than

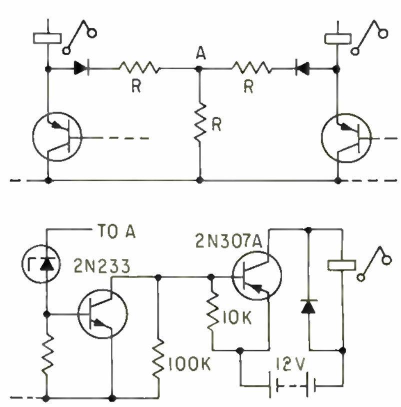


FIG. 3—Overlap circuit (A) makes possible an interpolating counter, and tap-off circuit (B) is one of many possible arrangements resulting from the wide voltage swing

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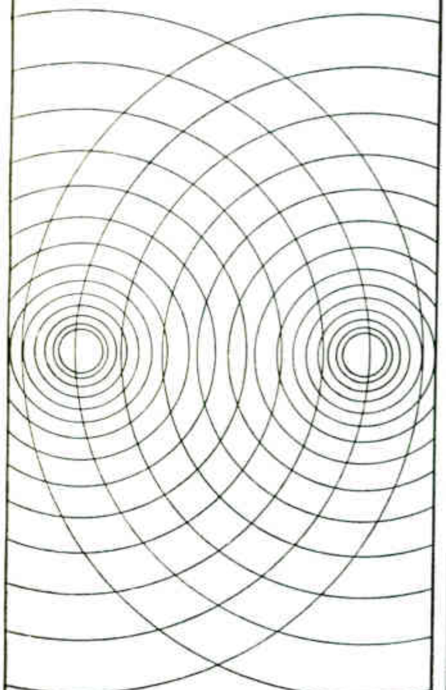

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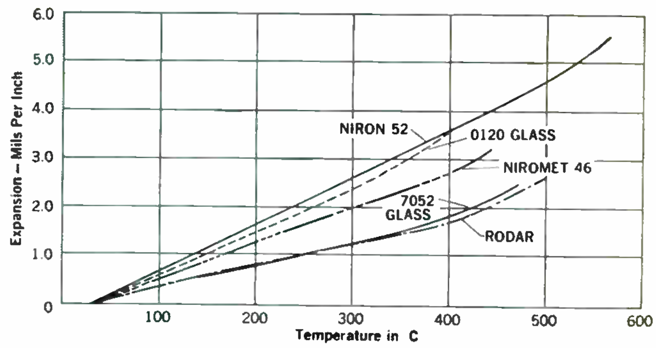

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one volt using the values in Fig. 1B. With the actuating switch closed and two contacts bridged in the cross-connected circuit in Fig. 2, voltage at A is about $\frac{2}{3}$ supply voltage or slightly less than 6 volts using the values shown in the circuit in Fig. 1B.

With a voltage swing at point A of nearly 5 volts, a variety of tap-off circuits can be used to indicate contact bridging or actuate an intermediate category counter, such as the tested tap-off circuit in Fig. 3B. Because of the wide tolerances in this circuit, stock components can be used.

Limited experience with transistorized antiduplication circuits indicates that they can provide superior performance with reduced cost, power consumption, maintenance and noise. Even greater savings appear possible by transistorizing relay-type interpolating circuits.

REFERENCE

(1) R. L. Ives, Anti-Duplication Contactors for Wind Direction Recorders, Trans Amer Geophys Union, **27**, p 556, 1946.

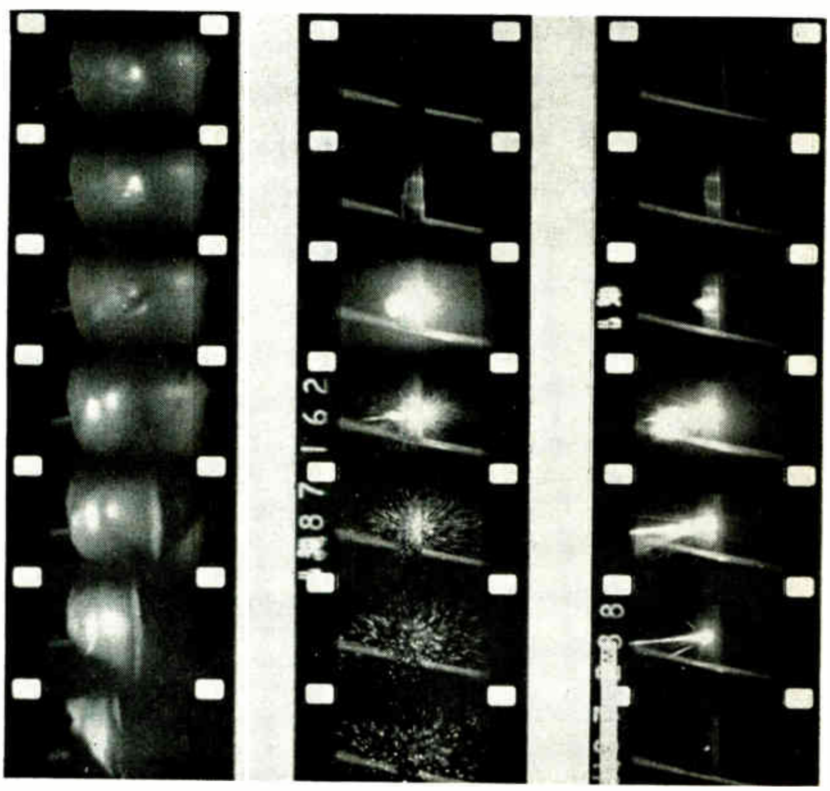
Meteorology of Mars and Venus Is Studied

THEORETICAL MODELS of the atmospheres of Mars and Venus are being made. They will describe temperature variations, seasonal variations and atmospheric circulations of the two planets. The models are expected to be ready by the end of the year.

The National Aeronautics and Space Administration has awarded a contract to Geophysics Corporation of America to conduct the coordinated study of the meteorology of the two planets. It is being carried out by a team of meteorologists, astronomers and astrophysicists.

The group is reviewing more than one hundred completed studies of Venus and more than two hundred similar studies of Mars. The purpose of this review of information previously gathered is to evaluate the data in terms of its meteorological significance.

Camera Photographs Laser Beam



Three motion-picture strips were made by high-speed camera in laser study at U. S. Army Signal Research and Development Laboratory. At left, laser beam bursts a balloon, at center it burns hole in steel razor blade and at right it decomposes graphite sample

Device Designers Eye Tellurium

By ALLEN NUSSBAUM
Division Head, Solid State Division,
American Electronic Laboratories,
Colmar, Penn.

AN EXAMINATION of the interesting and potentially useful characteristics of tellurium should prove stimulating in connection with the search for new effects possible in the performance of circuit functions. (See ELECTRONICS, May 11, p 52)

As an elemental semiconductor, tellurium has both useful and annoying properties. Tellurium is chemically similar to sulphur, the semiconductor selenium, and the metal polonium. Similarity to sulphur has led to the use of tellurium

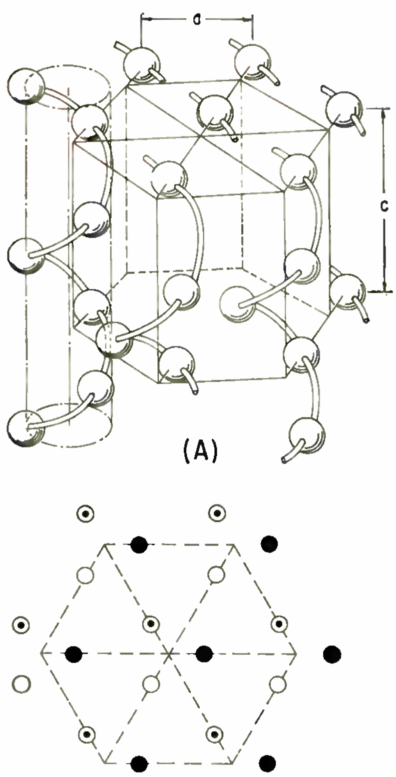


FIG. 1—Spiral-chain crystal structure of tellurium, showing a side view (A), and an end view (B)

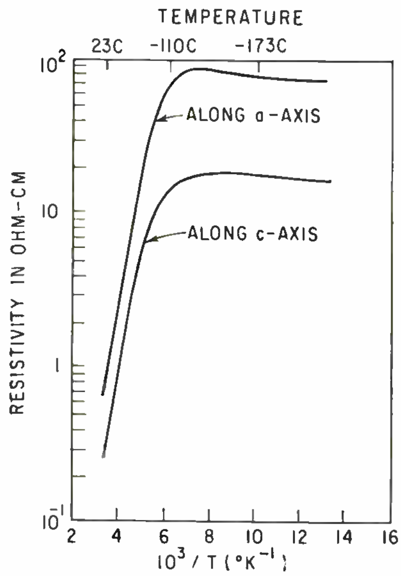


FIG. 2—Dependence of the resistivity of tellurium on temperature and direction of current

in rubber compounds, and addition of about 2 per cent will improve resiliency and abrasion resistance.

Electrical properties of tellurium are a consequence of its unusual crystal structure. Atoms are arranged in spiral chains, each spiral having three atoms per turn, Fig. 1A. The top view of Fig. 1B indicates that the fourth atom in each spiral lies directly over the first atom, the fifth one over the second, and so on. Spiral chains are arranged in a hexagonal pattern. Spirals can exist in either a right handed or left-handed form. Polarized light is rotated in one direction by a right-handed crystal and the same amount in the opposite direction by a left-handed one.[1]

Tellurium crystals have been grown by the Czochralski method.[2] These crystals are small in diameter, a few millimeters at the most, but recently a group at the Ecole Normale Superieure in Paris, under Pierre Aigrain, have succeeded in producing large crystals.

Tellurium is brittle and cleaves nicely in directions parallel to the hexagonal faces by merely tapping lightly with a razor blade, yielding bright, mirror like surfaces. It is also soft, simply carrying it nested in cotton wool will scratch the surface. Highly sensitive to mechanical action, imperfections are easily introduced by merely picking up samples with tweezers and the best method of carrying tellurium is to slide it onto a sheet of paper.

Unlike silicon and germanium, tellurium is anisotropic—that is, its electrical properties in the direction parallel to the axes of the chains are different from those measured in a direction perpendicular to these axes *c*-axis and *a*-axis of Fig. 1A. Resistivity, shown as a function of temperature, indicates that the values along the two directions are different, although shapes of the curves are almost the same, Fig. 2.

Another important property of tellurium is the Hall coefficient. Figure 3 shows peculiar properties of the Hall coefficient of tellurium measured with the current along the c-axis.[3] At low temperatures (below about −20 C), tellurium is *p*-type. When warmed up to room temperature and above, it goes to *n*-type. This is normal in a semiconductor, since heat produces electron-hole pairs, and the higher-mobility electrons determine the conduction type. No one has yet reported producing *n*-type tellurium, and although iodine is the most logical choice as an *n*-type dope—in analogy with phosphorus in silicon—the addition of this impurity has simply made tellurium more *p*-type. Hence, it is not possible at this time to make tellurium pn-junctions.

Figure 3, taken from Nussbaum and Hager[3], shows also that at temperatures above about 230 C, tellurium reverts back to *p*-type. Low-temperature reversal depends on the amount of impurities present, since the more holes that are contributed by the impurities, the higher the temperature will be needed to cancel electrons.

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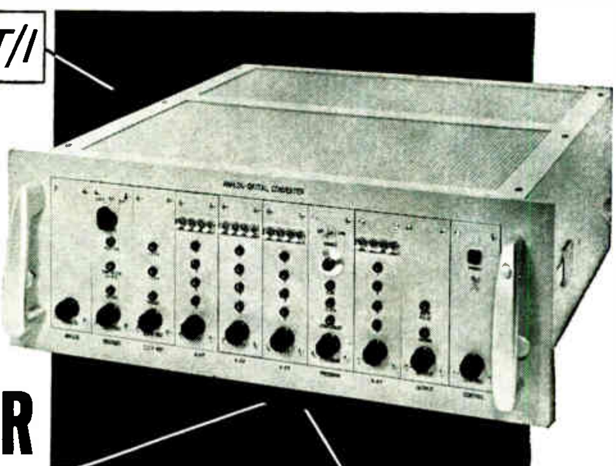

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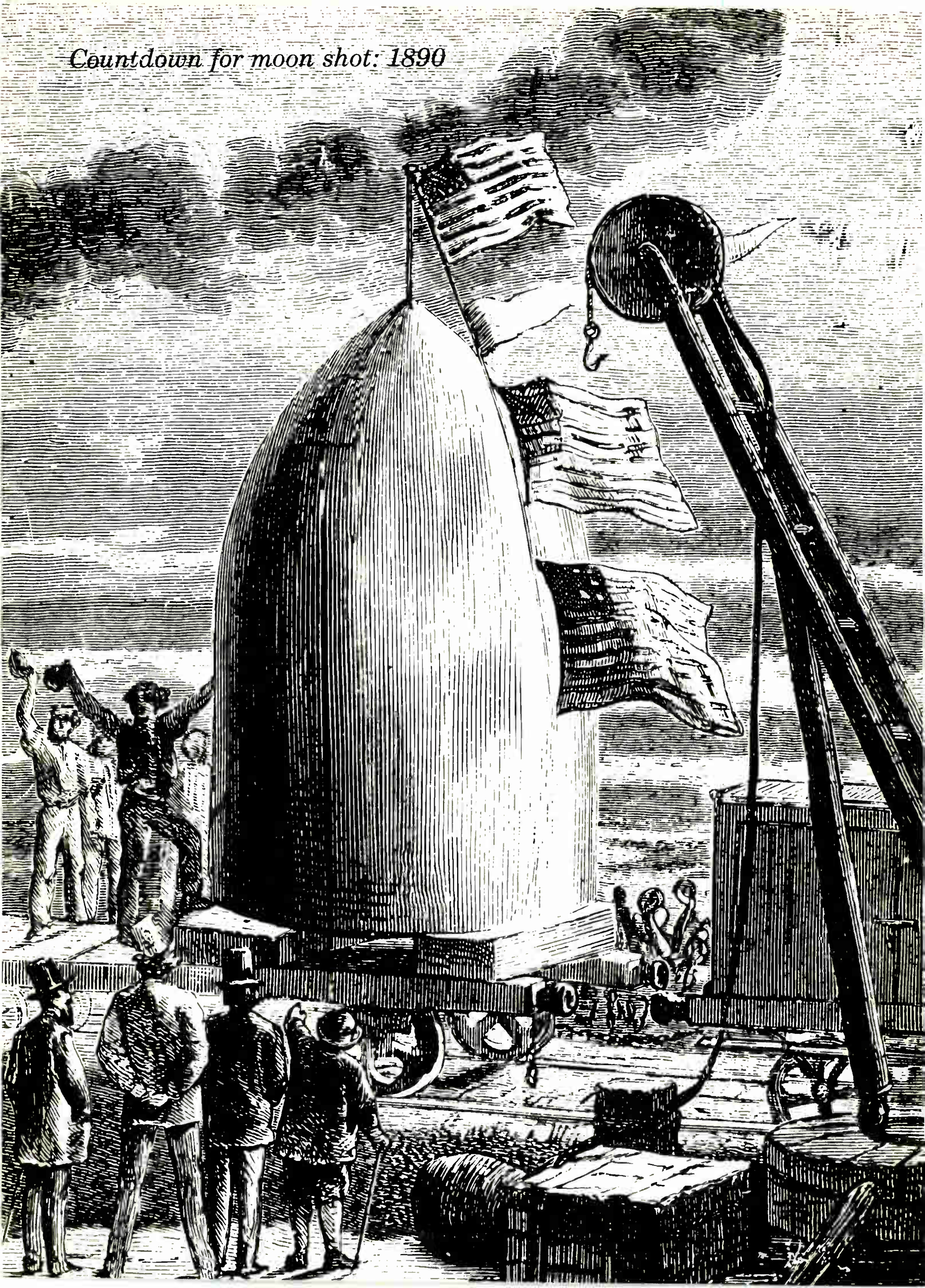

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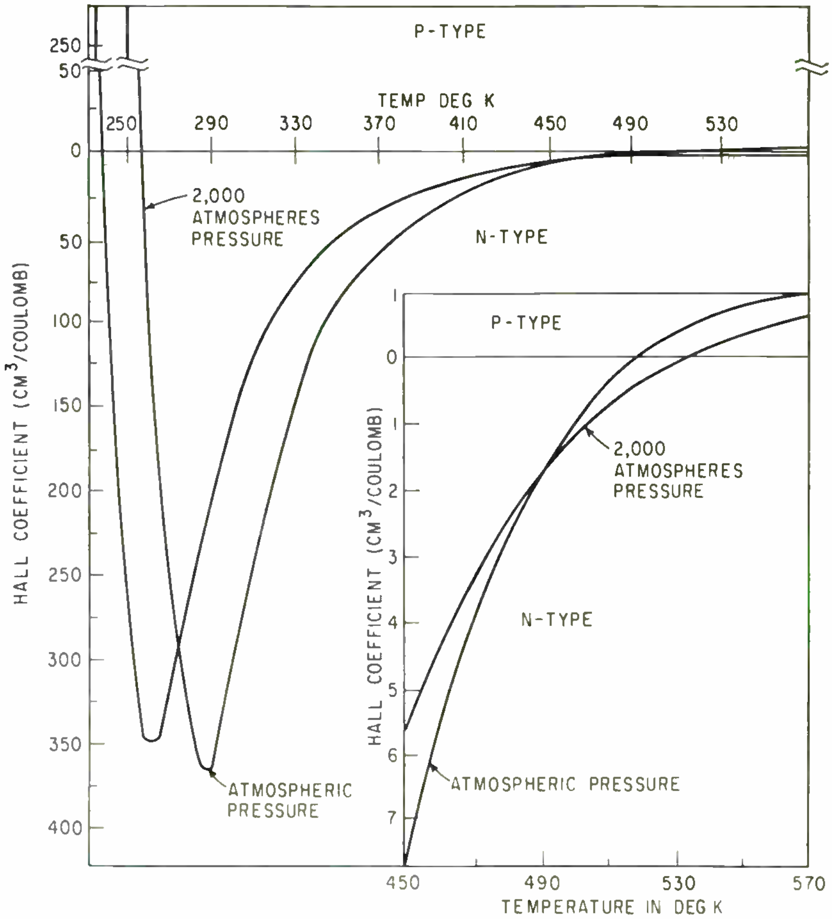

FIG. 3—Dependence of the Hall coefficient on temperature and pressure. Note double reversal from p-type to n-type and back to p-type, which is unique to tellurium

reversal, which has not been found in any other semiconductor, is that tellurium contains two kinds of holes. Normal, or slow holes are involved in conduction at ordinary temperatures, whereas fast holes, requiring a high temperature to be activated, can overwhelm the electrons at the anomalous reversal point. The graph also shows that the Hall coefficient is pressure-dependent, and the reversal temperatures are shifted away from each other under high hydrostatic pressure.

The resistivity of tellurium has also been found to be pressure-dependent[4], and this leads to the well-known piezoresistance effect. Change in resistivity with pressure is quite large, especially near the fracture point of 4×10^9 dynes/cm^2. These whiskers are generally obtained by accident during the growing process, when the tellurium vapor condenses on cool spots in the apparatus. With careful handling, they can be mounted and used as sensitive strain gages, but are quite heat sensitive, as Fig. 2 shows.

Optical properties of tellurium are of the most practical importance. These also are dependent on the relative orientation of the crystal.

Comparative data for a number of common infra-red cells shows that tellurium, when cooled to liquid air temperature, falls into a "window" in the atmospheric absorption bands, and hence possesses a definite advantage over lead sulphide.

Cells made with the detector crystal mounted on a second, inactive element, have resulted in units which are quite sensitive at room temperature, and which are among the best available in the near-infrared region when cooled.[5]

REFERENCES

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(4) G. Syrbe, Ann. der Physik 7, 132 (1959)
(5) C. D. Butter and L. D. McGlauchlin, Proc IRIS 5, 103 (1960)

Ultrasonic Welding in Electronic Production

By J. M. PETERSON
Sonobond Corp., West Chester, Pa.

H. L. McKAIG
C. F. DePRISCO
Aeroprojects Inc., West Chester, Pa.

ULTRASONIC WELDING appears to have a number of significant advantages in electronic production. The bond created by ultrasonic welding is a true solid state metallurgical bond and does not require melting of the base metals. Heat as such is not applied in the process; the mechanical motion imparted by the ultrasonic transducer creates the necessary conditions for the weld.

It has been known for a number of years that when two pieces of metal with surfaces sufficiently smooth and clean are brought into intimate contact, the unsatisfied bonds of atoms of the surfaces link to form a metallurgical bond. This phenomenon is the mechanism involved in ultrasonic welding.

Under normal environmental conditions, however, even a superfinished surface has peak to valley irregularities of about 5×10^{-6} cm, which is equivalent to about 200 atomic layers. In addition, metal surfaces are not clean when viewed on an atomic scale. An apparently clean, bright steel surface, for example, will typically be covered by a layer of iron oxide about 200 molecules thick. The oxide layer itself has unsatisfied bonds that attract moisture, forming another layer that depends somewhat on the relative humidity but is always 2 or 3 molecules thick. These two layers, shown in the sketch, are sufficient to prevent metallurgical bonding under normal environmental conditions.

The vibratory energy transmitted to the weld zone by the transducer (Fig. 1) produces complex tension, compression and shear stresses. When these stresses exceed the elastic limit of the materials being joined, plastic deformation occurs at the interface, dispersing adhered moisture, organic films, and surface oxides. When the

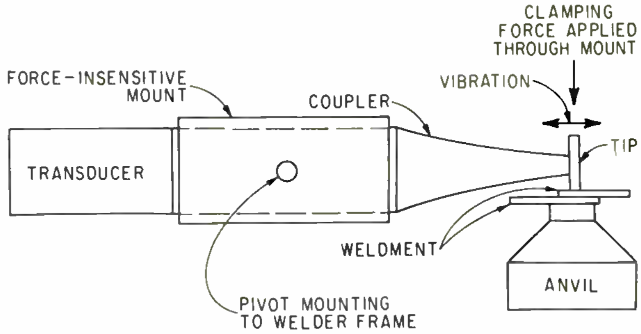

FIG. 1—Clamping force to hold weldment in place plus vibratory motion imparted by the welding tip are the essential elements in ultrasonic welding

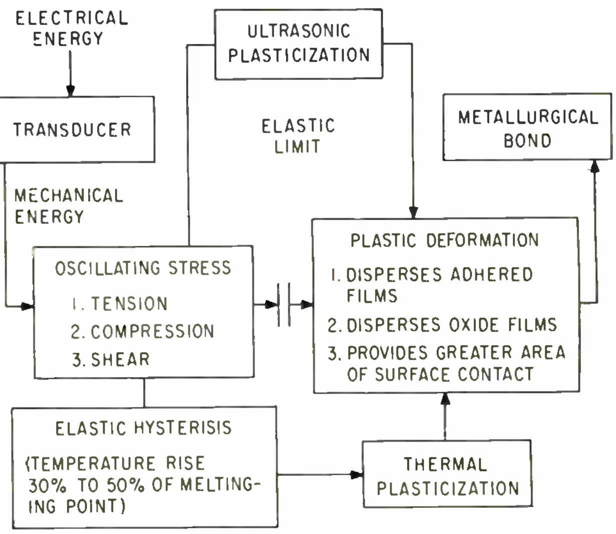

FIG. 2—Model of ultrasonic welding process indicates how energy operates on materials being welded to produce a true metallurgical bond. Many combinations of materials can be welded

	AL	BE	CU	GE	AU	FE	MG	MO	NI	NB	PD	PT	SI	AG	TA	SN	TI	W	U	ZR
AL & ALLOYS	●	●	●	●	●	●	●	●	●		●	●	●	●	●	●	●		●	●
BE & ALLOYS		●	●			●											●			
CU & BRASS			●		●	●		●	●			●		●			●			●
GERMANIUM					●							●								
GOLD					●	●			●			●	●							
IRON & STEEL						●		●	●			●		●			●	●	●	●
MG & ALLOYS							●							●						
MO & ALLOYS								●	●						●		●	●		●
NI & ALLOYS									●	●		●					●			
NB & ALLOYS										●					●					
PD & ALLOYS											●			●						
PT & ALLOYS													●							
SILICON															●					
AG & ALLOYS														●	●					●
TA & ALLOYS															●		●			
TIN																●				
TI & ALLOYS																	●			
W & ALLOYS																		●		
URANIUM																				●
ZR & ALLOYS																				●

FIG. 3—Material combinations that have been joined by ultrasonic welding. Many of the blanks are not necessarily impossible but either have not been tried, required higher power than was available, or presented a transducer problem

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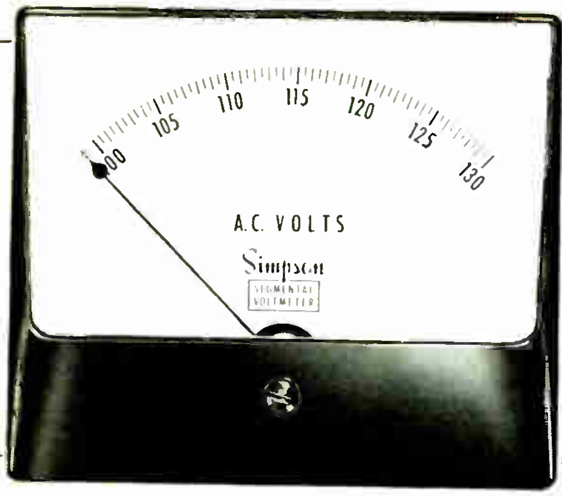

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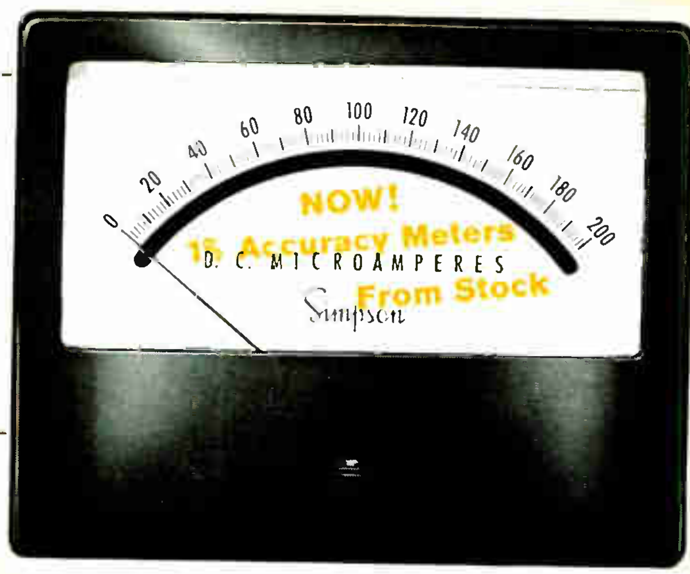

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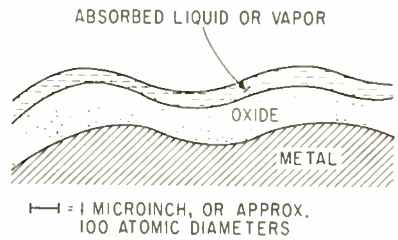
work-piece surfaces are thus brought into intimate contact over an adequate area, a metallurgical bond is created.

A small transient temperature rise—30 to 50 percent of the melting point for like metals—results from elastic hysteresis and deformation. The plasticity of the metals is increased both by this temperature rise and by the ultrasonic vibrations themselves, as the process model shown in Fig. 2 indicates.

The creation of true metallurgical bonds without the melting of parent metals is responsible for many of the characteristics of the process. For one thing, there appears to be no lower limit to the thickness of material that can be welded. Wires as small as 0.003 inch in diameter and foils 0.00017 inch thick have been routinely welded without damage. Materials



Surface of a smooth, clean metal has peaks and vallies, an oxide layer and a film of water. The surface coatings are displaced and the peaks and vallies are plasticized in ultrasonic welding

as thin as these can be welded without burning through because heat as such is not applied and thus does not present a control problem.

Thin materials can be welded to thick materials because there is no great heat sink problem as there is in thermal welding, where the amount of heat required to melt the thick section is often enough to damage the thin section.

A wide variety of similar and dissimilar materials can be joined, as indicated in Fig. 3. Many of the blank spaces in the chart are combinations for which welding has not been attempted, or which appeared to require higher power than was available at the time, or in which the tip problem had not been solved. Aluminum, however, can be welded to glass and copper can be welded to steel.

Materials that have relatively

large coefficients of electrical or thermal conductivity require relatively large amounts of electrical energy in resistance welding, and good control is necessary to prevent burn-through and yet assure adequate melting. This limitation does not apply in ultrasonic welding. Some materials are too sensitive to heat to be welded with a thermal process; oxidation, grain growth, recrystallization and other metallurgical and mechanical effects are undesirable by-products of some thermal welding operations.

The local heat rise in an ultrasonic weld results from the combined effects of elastic hysteresis, highly localized slip, plastic deformation, etc. Although melting does not occur, at least in monometallic welds, the transient heat rise sometimes causes phase transformation, recrystallization, diffusion and other effects, depending on the materials being welded.

Bonds are Clean

An important factor is lack of contamination of the weld area. Fluxes, electrode shielding coatings and adhesives are not required in the process and thus there is no residue.

Surface cleaning is not critical prior to welding since the vibratory energy breaks down many common oxide films and disperses other surface films. Many of the more easily welded materials can be welded in the mill-finish condition, provided only that the surface lubricant is removed. It is possible to produce ultrasonic welds even through surface deposits and coatings, but the power requirements go up. Welds have been made in aluminum through 0.0001 inch anodized coatings.

Void free junctions are the rule and there is relatively little inclusion of foreign material. Thus low noise, low ohmic connections are typical, especially in joints of dissimilar metals, where the low temperature of the operation eliminates or greatly reduces the formation of brittle, high resistance intermetallic compounds.

The low temperature of the process also allows it to be used close to temperature sensitive and even volatile material. Preheating is not required so there is no danger to assemblies from thermal distortion.

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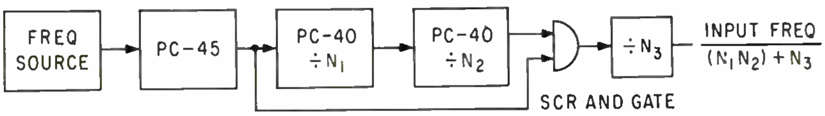
DESIGN AND APPLICATION



Solid State-Magnetic Counting Element

LOW IDLE POWER REQUIRED

MANUFACTURED by Waugh Eng. Div., Foxboro Co., 7740 Lemona Ave., Van Nuys, California is the PC-40 magnetic frequency divider based on the principle of incremental saturation of a magnetic core. The flux state of the core is changed from a minus flux density saturation level to plus flux density saturation in a prescribed number of steps by close control of input energy per step. A transistor switch is used to detect core saturation by comparing pulse impedance of an input winding with a fixed resistance in the transistor base circuit. When the winding impedance is very low, denoting saturation in the direction of the input pulse polarity compared to the fixed resistance, the transistor switches on and is held in conduction until the core is saturated in the opposite direction. This operation resets the accumulator core. The reset pulse is used as the output. Division factor range is 3 to 11 with 25 turn adjustment, frequency range is d-c to 7 Kc random periodic, division factor stability is constant at selected integral value over all environmental conditions, temperature is −65 to +160 F, shock is at least 100 g for 10 ms, vibration is 20 g from 10 to 2,000 cps and the unit is 1 × 1 × 0.6 in. The sketch shows a typical use in division by prime numbers.

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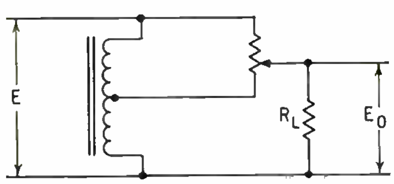

Log Voltmeter

70 DB ON ONE SCALE

ANNOUNCED by Houston Instrument Corp., P. O. B. 22234, Houston 27, Texas, is the model HLVC-150 log voltmeter-converter providing continuous ranges between 0.001 to 3.16 v, 0.01 to 31.6 v and 0.1 to 316 v. Lower linear db scale is moveable over a range of ±75 db to permit readings relative to any selected reference level. Output for log recording is 1 mv per db with 0.2 db absolute accuracy over a 70 db range. Operation is with either a-c or d-c inputs between 10 cps and 50 Kc, with input impedance of 10 megohms. The principle of logarithmic conversion is shown in the sketch. A selected load resistor loads a potentiometer wiper to provide a close approximation to logarithmic interpolation with an error decreasing extremely rapidly with the ratio of voltage across the ends of the potentiometer. The unit uses a 3-turn linear potentiometer with 11 equally-spaced taps. Each tap point is clamped by a special tapped toroid in a manner to maintain the voltage at each tap twice that of the lower tap, to provide 6.02 db tap spacing. The load resistor provides loading between successive taps accurate to ±0.05 db. The process is repeated as the wiper is driven by a servo to maintain constant wiper output voltage. The latter is detected and compared with a double-regulated, temperature-compensated zener reference. The servo drives the scale pointer and output potentiometer to provide output of 1 mv per db.

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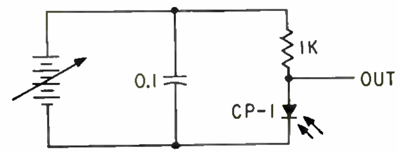

Laser Detector

ULTRAFAST DIODE

MANUFACTURED by CBS Laboratories, High Ridge Road, Stamford, Conn., the CP-1 solid-state laser detector is a silicon diffused, planar, surface-passivated light sensor designed for ultra low leakage current at high reverse bias and with ultrafast response time. The *n*-type base is connected to the collector lead of the header while the emitter makes the top contact. For single diodes, the base lead is left open. Forward voltage is 1 v at 5 ma, dark reverse current is −10 na at −10 v, while photo reverse current is −20 na at −10 v measured using a tungsten lamp at ≈ 2790 K at an illumination level of 100 ft candles (light-sensitive area is about 1 × 10^{-5} sq. in.). Breakdown voltage is −50 v at −10 μa, reverse recover time to 1 ma is 4 nsec at forward current of 10 ma and reverse voltage of −6 v, and the capacitance is 3 pf at zero reverse voltage. The sketch shows a typical application of the diode to detect output from a ruby laser.

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Microwave Tube

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SYLVANIA ELECTRIC PRODUCTS INC., Mountain View, Calif., announces a microwave tube capable of mega-

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watt-level peak power outputs across an 18 percent bandwidth in X-band. The tube, which is designed to produce up to 15 Kw average power, utilizes a slow-wave structure that is capable both of propagating a wide range of frequencies and dissipating large amounts of heat.

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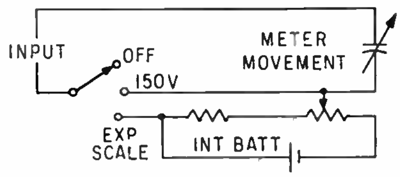

Electrostatic Voltmeter

EXPANDED SCALE

RECENTLY announced by Sensitive Research Instrument Corp., 310 Main St., New Rochelle, N. Y., is the model ESX expanded scale electrostatic voltmeter enabling practical readings down to 2 v with an input resistance of 1 × 10^{14} ohms minimum. The range goes to 300 v with ±1.5-percent full-scale accuracy, capacitance is 220 pF and frequency response is d-c and 25 cps to 0.75 Mc. The instrument is an a-c/d-c 0 to 150 v full scale true rms responding electrostatic voltmeter with an adjustable built-in battery power supply. Instrument is switched for operation with either electrostatic movement directly or battery circuit added in series (see sketch). Once standardized, any d-c voltage applied from external source is in opposition to internal battery and deflection is from normal full scale back to normal zero. The instrument measures the difference between internal power and external applied signal. As a result, scale characteristics are reversed and greatly expanded in the area between 0 and 75 v, a portion normally unusable because of insufficient resolution.

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Scalers and Timers

BAIRD-ATOMIC, INC., 33 University Road, Cambridge 38, Mass. Employing computer-type solid-state logic circuits for all counting functions, the Cambridge series of scalers and timers provide the accurate, reliable response required for a wide variety of counting applications. Transistorized circuitry is utilized throughout, and each decade, input, and logic circuit is packaged on a separate plug-in circuit card.

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Data Display

COMPACT UNIT

METRIC SYSTEMS CORP., 736 North Beal St., Fort Walton Beach, Fla. Series 4001 is a line of converter-display units, designed to accept one of several binary code formats, and translate to a six digit decimal presentation. Unit is completely self-contained, including power supplies and removable indicator section. Several remote indicator banks may be driven by a single converter.

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Diode Clip

SPEEDS TESTING

TERADYNE, INC., 87 Summer St., Boston, Mass. The Daymarc diode clip automatically locates the test component in the contacts when it is dropped from the hand. Four contacts reliably permit error-free measurements. Ease of loading permits extremely high testing rates. Diodes and components with magnetic leads including glass resistors, capacitors, etc., are rapidly handled even with bent leads. Price is $65.

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Image Rejection Mixer

MICROWAVE DEVELOPMENT LABORATORIES, INC., 15 Strathmore Rd., Natick Industrial Center, Natick, Mass., has developed an image rejection mixer, model 90MR16-1, operating from 8.5-9.6 Gc in WR90 waveguide. The mixer, by phasing out the image, provides 20 db image rejection without the use of filters.

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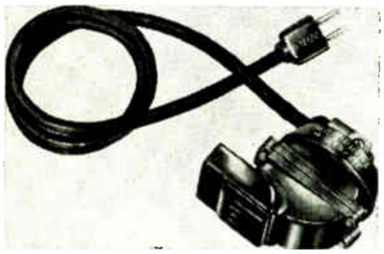
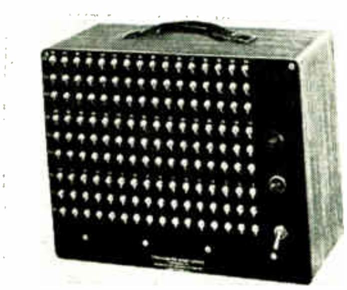


Microphone

OXYGEN-MASK

ROANWELL CORP., 180 Varick St., New York 14, N. Y. Model ROM-32(29) is a dynamic (moving coil) type microphone with application in both pressure breathing and demand oxygen masks. Microphone is tested to USAF specification MIL-M-9434B. Unit's noise cancellation feature permits intelligible speech transmission in a 120 db ambient noise field. The microphone has a sensitivity of −64 db ref 1 mw/Newton/m² (10 dynes/cm²) taken across a 5 ohm load; frequency range of 200 cps to 5,000 cps.

CIRCLE 310 ON READER SERVICE CARD



Thermocouple

REFERENCE JUNCTION

CONSOLIDATED OHMIC DEVICES, New Hyde Park, N. Y., has developed a series of 48 multichannel thermocouple reference junctions available with negative or cold reference temperatures far below ambient. The 4800 series junctions were designed to fill the need for absolute accuracy in laboratory instrumentation. The junctions are designed around a cavity whose temperature is stable to within ±0.05 F. The stabilizing devices for the cavity

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are of proportional control solid state construction, eliminating problems due to noise.

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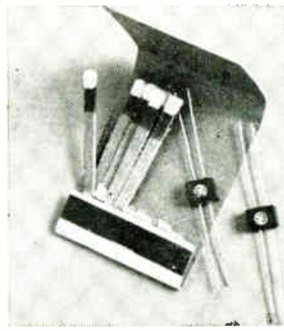

Tunnel Diode Pairs

A-C AND D-C MATCHED

GENERAL ELECTRIC CO., Syracuse, N. Y., offers germanium tunnel diode pairs a-c and d-c matched over a 40-deg temperature range. They are characterized for use as high speed voltage and current comparators, as sense amplifiers and in pulse modulation and sampling systems. Models are available with peak point currents of 1 ma, 2.2 ma, and 4.7 ma. A 1-ma pair will sense a 10-μa current change in about 10 nsec.

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Tiny Connector

AMP INC., Harrisburg, Pa., is marketing a subminiature connector for coaxial cable and shielded wire. The A-MP Coaxicon will handle RG/U cable sizes as small as 0.075 in.

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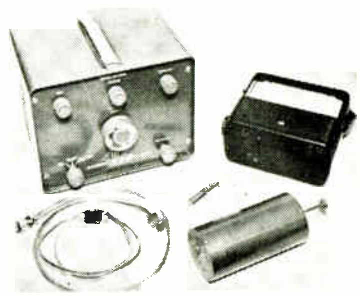

Slotted Lines

FOR 26 TO 110 GC

TRG, INC., 400 Border St., East Boston, Mass., announces slotted lines for use at 26 to 110 Gc. The probe has a variable depth adjustment and a built-in slide screw tuner for optimizing the r-f coupling to the waveguide. Precision linear bearings and a smooth friction wheel drive assure accurate control, and long life of the probe travel, and the travel measurement is indicated on a dial with 0.01 mm divisions.

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Magnetic Reed Switch

NO-BOUNCE

HAMLIN, INC., Lake Mills, Wisc., announces the HRC-1 mercury wetted magnetic reed switch. It combines the advantages of no-bounce and unchanging contact resistance of a mercury wetted switch with the size, speed and cost of a standard 50-w dry reed switch. In relays, where coil dimensions have been designed for a standard dry reed switch, the HRC-1 fits right in place—the same as the dry reed switch—without coil changes or expensive circuit modifications.

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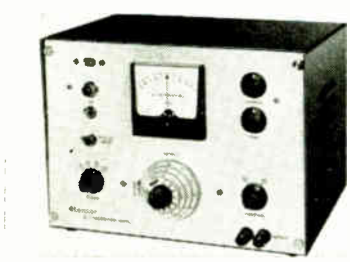


Calibration Supply

HIGH-IMPEDANCE

TENSOR ELECTRIC DEVELOPMENT CO., INC., 1873 Eastern Parkway, Brooklyn 33, N. Y. This supply, which can be used as a source of precise a-c or d-c voltage, has an output impedance of 3,000 ohm max; 0.1 ohm at 100 v. Output is continuously variable from 0 to 100 v (a-c or d-c) in four ranges. Input is 115 v (±10 percent) 60 cps, 65 w and frequency is a built-in 60 cps and d-c. Accuracy is 0.15 percent of reading plus 0.01 percent of full scale d-c and 0.2 percent of reading plus 0.01 percent of full scale a-c.

CIRCLE 316 ON READER SERVICE CARD

PRODUCT BRIEFS

COLOR TV CAMERA minimum of operational control. Marconi's Wireless Telegraph Co. Ltd., Chelmsford, Essex, England. (317)

MICROWAVE PHASE & TIME DETECTOR infinitesimal resolution. Ad-Yu Electronics Lab., Inc., 299 Terhune Ave., Passaic, N. J. (318)

OSCILLOSCOPE split beam, general purpose. Cossor Instruments Ltd., Cossor House, Highbury Grove, London, N.5, England. (319)

SECONDARY PRESSURE STANDARD fused-quartz. Texas Instruments Inc., 3609 Buffalo Speedway, Houston, Texas. (320)

POWER SUPPLY constant voltage/current. Lasers and Masers Corp. of America, Hudson St., Mineola, N. Y. (321)

ZENER VOLTAGE REGULATORS temperature compensated. International Rectifier Corp., 233 Kansas St., El Segundo, Calif. (322)

SILICON RECTIFIERS in ratings to 40,000 v piv and 2.5 amp. Columbus Electronics Corp., 1000 Saw Mill River Road, Yonkers, N. Y. (323)

MINIATURE ACCELEROMETER high natural frequency. Giannini Controls Corp., 1600 S. Mountain Ave., Duarte, Calif. (324)

50 MA POWER SUPPLIES four models. Trans Electronics Div., Burton Mfg. Co., 8910 Winnetka Ave., Northridge, Calif. (325)

TINY SOLENOID weighs 10 grams. Rocker Solenoid Co., 140 N. Marine Ave., Wilmington, Calif. (326)

UPSIDE DOWN ELECTROLYTICS capacities from 35 μf at 450 v to 80,000 μf at 5 v. West-Cap Electrolytic division, 10124 Edes Ave., Oakland 3, Calif. (327)

STORAGE REGISTER 10 line input. ARA, Inc., 4130 Howard Ave., Kensington, Md. (328)

P-C CARD RACK for high density assembly. Garde Mfg. Co., Cumberland, R. I. (329)

PULSE GENERATOR variable rise and fall time. Rutherford Electronics

Co., P. O. Box 472, Culver City, Calif. (330)

COAXIAL ISOLATOR 4.0 to 11.0 Gc. E&M Laboratories, 15145 Califa St., Van Nuys, Calif. (331)

VERTICAL MOUNTS for microwave antennas. Mark Products, Skokie, Ill. (332)

TRANSIENT STORAGE OSCILLOSCOPE high speed. Calvert Electronics, Inc., 220 E. 23rd St., New York 10, N. Y. (333)

SUBMINIATURE JACK fully molded housing. Carter Parts Co., 3401 Madison St., Skokie, Ill. (334)

METALIZED MYLAR CAPACITORS microminiature. J. M. Frankel & Co., 245, Av. Georges-Clemenceau, Nanterre (Seine), France. (335)

SCREW TERMINATION CONNECTOR flag design means space savings. Berg Mfg. Corp., New Cumberland, Pa. (336)

TRANSIENT VOLTAGE ARRESTORS and signal input connectors. Electro-Neutronics, Inc., 1401 Middle Harbor Rd., Oakland 20, Calif. (337)

ULTRASONIC GENERATORS output 250 w-2,500 w at 20 Kc. Acoustica Associates, Inc., 10400 Aviation Blvd., Los Angeles 45, Calif. (338)

CONSTANT TEMPERATURE ANEMOMETER mfr'd by DISA Elektronik of Herlev, Denmark. Zitzewitz Engineering Associates, 700 N. Michigan Ave., Chicago 11, Ill. (339)

FLOW-TO-DIGITAL TRANSDUCER turbine type. Diginamics Corp., 2525 E. Franklin Ave., Minneapolis 6, Minn. (340)

TRANSDUCERS for altitude chamber control. H. E. Sostman & Co., P.O. Box 60, Cranford, N. J. (341)

HIGH-GAIN ANTENNAS improve uhf reception. Technical Appliance Corp., Sherburne, N. Y. (342)

MASS SPECTROMETER for research and industrial uses. The Bendix Corp., 3130 Wasson Road, Cincinnati 8, O. (343)

SHAFT POSITION ENCODER for rugged use. Datex Corp., 1307 S. Myrtle Ave., Monrovia, Calif. (344)

Literature of the Week

SILICON LOGIC MODULES Packard Bell Computer Corp., 1905 Armacost Ave., Los Angeles 25, Calif. Brochure describes a line of silicon logic modules. (345)

PARTICULATE-SPECTRUM INSTRUMENTS Royco Instruments, Inc., 440 Olive St., Palo Alto, Calif. Folder describes 4 basic instruments for recording and analysis of the particulate spectrum. (346)

MINIATURE WHITE ROOM Ultrasonic Industries Inc., Ames Court, Engineers Hill, Plainview, N. Y. Bulletin contains specifications, features and uses for the White-Roomette. (347)

SILICON RUBBER Dow Corning Corp., Midland, Mich. Brochure 09-011 on silicone rubber is edited to assist the engineer to meet specific design problems. (348)

ANTENNA TEST SITE Technical Appliance Corp., Sherburne, N. Y. Four-page Form 2090Y describes the company's antenna evaluation facilities and capabilities. (349)

PANEL METERS Assembly Products, Inc., Chesterland, O. Bulletin 30 contains information on ultrasensitive panel meters. (350)

CROSSBAR SCANNERS James Cunningham, Son & Co., Inc., P.O. Box 516, Rochester, N. Y. Engineering bulletin covers SQ transistor driven crossbar scanners. (351)

HIGH SPEED PRINTERS Anelex Corp., 150 Causeway St., Boston 14, Mass. A 12-page booklet contains an overall cross-section of the company's high speed printers and printer systems. (352)

IMPULSE COUNTERS Landis & Gyr, Inc., 45 W. 45th St., New York 36, N. Y. A 4-page bulletin covers a line of Sodeco electromagnetic impulse counting devices. (353)

WAVEGUIDE SWITCHES Waveguide, Inc., 851 W. 18th St., Costa Mesa, Calif. Bulletin describes a line of 3- and 4-sided solenoid-driven, spdt waveguide switches. (354)

MULTIPLE CAPACITOR Gulton Industries, Inc., 212 Durham Ave., Metuchen, N. J. Technical bulletin

describes and illustrates the Faradyne Mylar multiple capacitor series. (355)

SKEW REDUCTION Mincom Division, Minnesota Mining and Mfg. Co., 2049 S. Barrington Ave., Los Angeles 25, Calif., has published a brochure entitled "Reduction of Tape Skew in Magnetic Instrumentation Recorders." (356)

VARIABLE SPEED DRIVE PACKAGE Fidelity Instrument Corp., 1000 E. Boundary Ave., York, Pa. Bulletin describes a v-s drive package with a-c induction motor. (357)

TANTALUM CAPACITORS Electra Mfg. Co., 800 N. 21st St., Independence, Kansas. Catalog describes a wide range of solid electrolyte tantalum capacitors. (358)

TRANSISTOR TESTER RD Instruments division, Hickok Electrical Instrument Co., 10514 Dupont Ave., Cleveland 8, O. A technical brochure describes the model 1880 dynamic beta transistor tester. (359)

SCOPE PREAMP Marbach Electronics, P. O. Box 2731, Cleveland 11, O., has issued a bulletin on a high gain, low noise, solid state a-c amplifier for scope preamp use. (360)

INSTRUMENTS Beckman Instruments, Inc., Berkeley Div., 2200 Wright Ave., Richmond, Calif. Vol. 1 No. 1 of *Criteria* describes a solid-state printer and a high resolution digital voltmeter. (361)

INSTRUMENTS Acton Laboratories, Inc., 533 Main St., Acton, Mass. A 4-page brochure illustrates and describes a wide variety of precision electronic instruments. (362)

ALUMINUM ELECTROLYTICS General Electric Co., Schenectady 5, N. Y. GEA 6819C, 4 pages, covers computer-grade Alumalytic capacitors which feature up to 165,000 μf in a single case size. (363)

CURRENT MEASUREMENT Elcor, Inc., 1225 W. Broad St., Falls Church, Va. A current indicator and integrator—two electronic instruments in one—is described in CAT 4-362. (364)

CURRENT REGULATOR CircuitDyne Corp., 480 Mermaid St., Laguna Beach, Calif. An 8-page brochure shows circuit diagrams for new Currector current regulator applications. (365)

EIA Elects Officers for 1962-63

ELECTRONIC INDUSTRIES ASSOCIATION brought to a close its annual convention in Chicago late last month with the election of a new president and the installation of a new board of directors.

Charles F. Horne, of General Dynamics, was named new president, succeeding L. Berkley Davis, of General Electric.

Charles F. Horne

Horne, senior vice president of General Dynamics, New York, is president of G-D's Pomona and Electronics divisions. He is a retired rear admiral, having served as a communications and radar officer. He joined G-D's former Convair division in 1953 as manager of its Pomona operating division. In 1957 he became a Convair vice president.

New directors of EIA are:

Joe Friedman, Trav-ler Radio Corp., from Consumer Products division.

M. H. Benedek, General Instrument Corp., and R. J. Grigsby, Grigsby Co., from Parts division.

Robert C. Coon, Sperry Rand Corp.; J. J. Graham, ITT; Robert W. Galvin, Motorola; and W. E. Andries, Jr., IBM, from Industrial Electronics division.

M. W. Kremer, Sylvania Electric Products; and J. L. Hanigan, Corning Glass Works, from Tube and Semiconductor division.

New division chairmen and vice chairmen are:

Morris Sobin, The Siegler Corp., chairman for Consumer Products division. He succeeds Edward R. Taylor, Motorola.

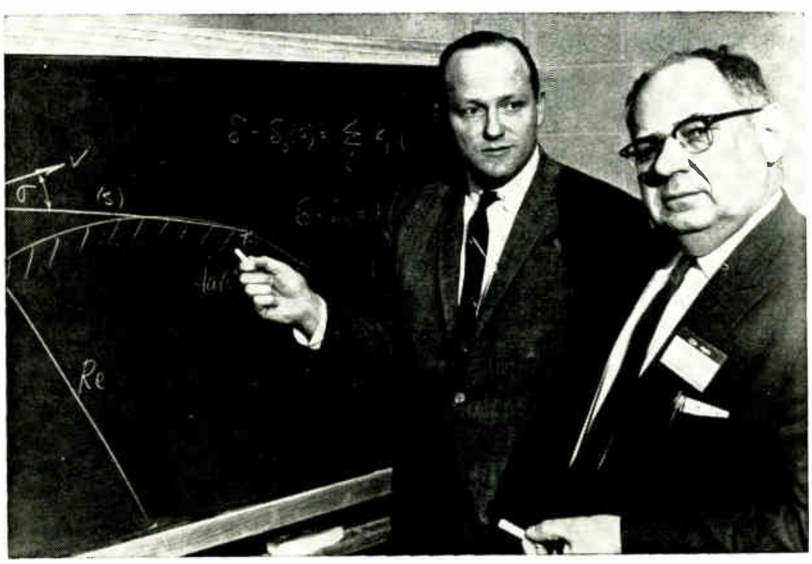
Ashley A. Farrar, Raytheon Co., chairman for Military Products division. He succeeds L. L. Waite. North American Aviation Co., who was made a new EIA vice president. Two new vice chairman are W. Preston Coderman, Litton Industries, and Richard B. Long, Quantatron, Inc.

Grafton P. Tanquary, Litton Industries, chairman for Industrial Electronics division. He succeeds Russell Cox, Andrew Corp. New vice chairman is Ralph E. Van Hoorn, ITT.

Allen K. Shenk, Erie Resistor Corp., chairman for Parts division. He succeeds W. Myron Owen, Aerovox Corp. Owen is a vice president dent. Two new vice chairmen are J. A. Milling, Howard W. Sams & Co., Inc., and G. B. Mallory, P. R. Mallory & Co., Inc.

George W. Keown, Tung-Sol Electric Co., continues as chairman for Tube & Semiconductor division for another year. He is an EIA vice president as well.

GPI Forms Scientific Advisory Group



General Precision, Inc., has formed a scientic advisory group consisting of outstanding scientists and engineers from universities, research institutes and the company. Purpose of the group is to guide basic and applied research of General Precision and its divisions in advanced fields of science and engineering, and to encourage the development of new programs and products to meet the needs of modern technology. Chairman of the group is Coleman duP. Donaldson (shown at left), president of Aeronautical Research Associates of Princeton, Inc., and vice chairman is Raymond L. Garman (at right), vice president and chief scientist at GPI

Doles Moves Up At Eberline

ALBERT E. DOLES has been elected a vice president and member of the board of directors of Eberline Instrument Corp., Santa Fe, N. M.

He was formerly technical director.

Radar Range Lab Nears Completion

UNDER construction for the past month, Cornell Aeronautical Laboratory's radar cross-section range laboratory is now near completion. It is situated at the rear of present

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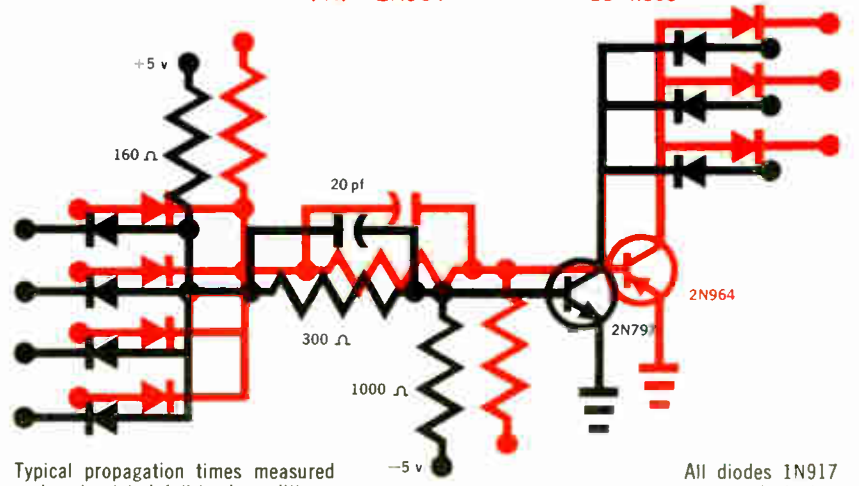
Your Ideal Circuit Complements for Ultra-High-Speed Switching

TI 2N964 GERMANIUM PNP EPITAXIALS

TI 2N797 GERMANIUM NPN MESAS

NAND CIRCUIT Typical Performance (7 Stages):	CIRCUIT	PROPAGATION TIME PER STAGE
	NPN - 2N797	22 nsec
	PNP - 2N964	19 nsec



Typical propagation times measured under simulated full-load conditions.

All diodes 1N917 or equivalent.

Increase your switching circuit design flexibility with TI's 2N964 and 2N797 **complementary** transistors. The 2N964 PNP germanium epitaxial series satisfies all your ultra-high-speed switching requirements in the 3 ma to 100 ma range. Provides high power dissipation and rugged mesa construction combined with the epitaxial features of high-gain bandwidth, short storage time and low saturation voltage. ■ Form the ideal circuit complement to the 2N964 series with TI's new NPN 2N797 germanium mesa transistor. The 2N797 also features ultra-high switching speed, low saturation voltage and high-gain bandwidth. This transistor is well suited for complementary use with all high-speed PNP epitaxials. ■ Call today for immediate delivery. The 2N964 series (including 2N960, 1,2,4,5,6) and the 2N797 transistors are available in quantity from your nearest TI Sales Office or Authorized TI Distributor.

TO-18

Check These Specifications Against Your Present and Future Circuit Requirements

PARAMETER	TRANSISTOR	TEST CONDITIONS	RATING
$V_{CE(sat)}$	2N797 2N964	I_B = 0.5 ma, I_C = 10 ma I_B = −1 ma, I_C = −10 ma	0.14 v max 0.18 v max
$\lvert h_{fe} \rvert$	2N797 2N964	V_{CE} = 5 v, I_C = 30 ma, f = 100 mc V_{CB} = −1.0 v, I_E = −20 ma, f = 100 mc	6.0 min 3.0 min
C_{ob}	2N797 2N964	V_{CB} = 5 v, I_E = 0, f = 1 mc V_{CB} = −10 v, I_E = 0, f = 1 mc	4.0 pf max 4.0 pf max
t_{on}	2N797 2N964	I_{B1} = 1 ma, I_{B2} = −0.25 ma, I_C = 10 ma I_{B1} = −1 ma, I_{B2} = 0.25 ma, I_C = −10 ma	40 nsec max 30 nsec max
t_{off}	2N797 2N964	I_{B1} = 1 ma, I_{B2} = −0.25 ma, I_C = 10 ma I_{B1} = −1 ma, I_{B2} = 0.25 ma, I_C = −10 ma	80 nsec max 60 nsec max
V_{BE}	2N797 2N964	I_B = 0.5 ma, I_C = 10 ma I_B = −1 ma, I_C = −10 ma	0.30 v min 0.44 v max 0.30 v min 0.50 v max
h_{FE}	2N797 2N964	V_{CE} = 0.25 v, I_C = 10 ma V_{CE} = −0.3 v, I_C = −10 ma	40 min 40 min
BV_{CBO}	2N797 2N964	I_C = 100 μa, I_E = 0 I_C = −100 μa, I_E = 0	20 v min 15 v min

TRANSISTOR PRODUCTS DIVISION

TEXAS INSTRUMENTS
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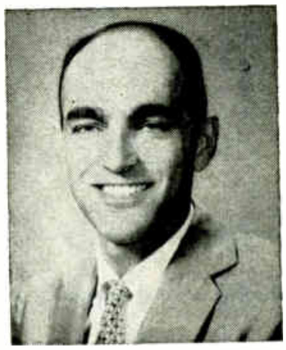
18931

laboratory buildings in Buffalo, N. Y.

Estimated to cost $186,000, the structure is the first stage of a $500,000 expansion program announced last December by Ira G. Ross, CAL president. Four radar range test areas will be housed in the 400 ft by 50 ft building which will feature a center core area with two floors of laboratory and office space.



Endres Organizes New Company

RICHARD O. ENDRES, who recently resigned as president of Rese Engineering, has formed a new company. The new organization, Computer Instrumentation Corp., has purchased the magnetics test equipment product line from Rese Engineering, and will continue design, manufacturing and sales operations of the line without interruption.

Initial operations of the new company will be in space leased from Rese Engineering in the Rese building in Philadelphia.

General Instrument Sets Up Division

GENERAL INSTRUMENT CORP., has announced formation of a separate International division based in

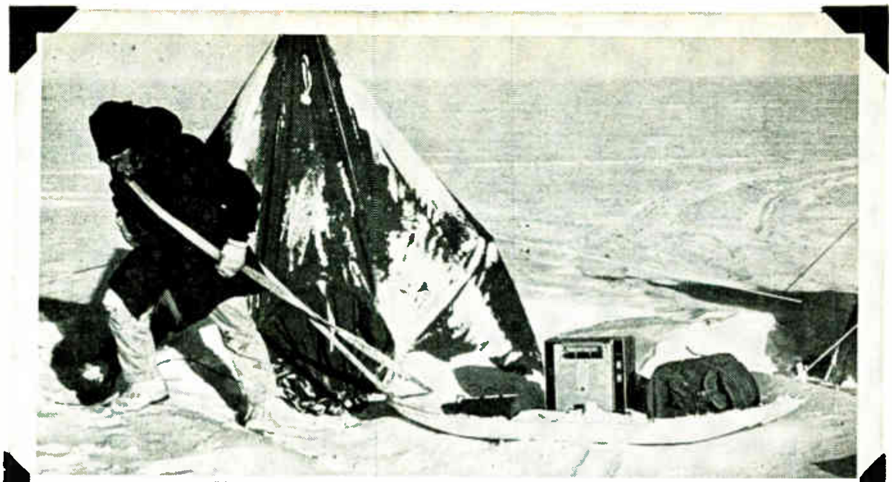
New York. It will be responsible for: 1) all the corporation's existing operations in Europe, the Far East and Latin America, previously handled on a divisional or product line basis, and, 2) expansion into new electronic markets (including Africa) and new product lines overseas.

Heading the new group will be Kenneth C. Moritz (picture on p 78) as vice president, International division. He was formerly vice president-marketing of the Semiconductor division.

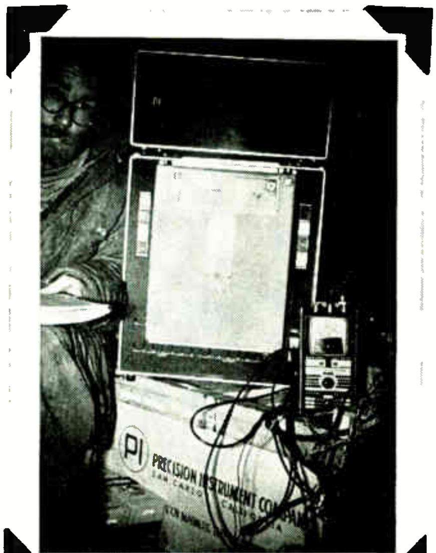
PEOPLE IN BRIEF

Abraham I. Dranetz, formerly v-p of Gulton Industries, Inc., has set up an independent consulting service in Scotch Plains, N. J. **Gerald M. Monroe** leaves National Data Processing to join Martin Co.'s Space Systems div. as program director, lunar systems. **Zoltan P. Szepesi**, of Westinghouse electronic tube div., appointed fellow engineer. **James B. Huffman**, ex-Hoffman Electronics, now mgr. of quality control for Electronic Communications, Inc. **Ernest H. Pallme**, previously with Palomar Scientific, named v-p engineering, by Chicago Aerial Industries. Sylvania Electric Products Inc. promotes **Gordon L. Fullerton** to v-p and g-m of the receiving tube operations of the Electronic Tube div., and **Eugene E. Broker** to g-m of the Parts div. Three members of Anaconda Wire and Cable Co. management elected v-p's by the board of directors: **Frank B. Dickey**, **Robert E. McIlvane**, and **R. Bruce Van Wagner**. **Joseph W. Auer** advances to applications engineer at Vitramon, Inc. Giannini Controls Corp. hires **Charles H. Odom**, ex-Television Utilities Corp., as senior project engineer of the Conrac div. **Phillip H. Mounts**, from Litton Industries, to Amphenol-Western Connector div. as manufacturing mgr. **Ralph S. White, Jr.**, leaves management consulting to take post of president and director of Pacific Electro Magnetics Co., Inc. Formerly attached to Clevite Corp., **Eugene Hoffman** is named mgr. of materials engineering of U. S. Sonics Corp.

CIRCLE 79 ON READER SERVICE CARD→



This is the PI in front of the "Recording lab"



Inside a little cramped, but cozy!

"up the pole" at the magnetic pole

PI Recorder captures Antarctic Whistlers

If you know how to listen, you can hear a thunderstorm halfway around the world. The "Whistler" that you hear as a momentary descending tone in your headphones is a fascinating phenomenon of electro-magnetic radiation that originates with a bolt of lightning and propagates outward along the earth's magnetic lines of force through an ever-changing system of ionized ducts. Traveling at only about one tenth the speed of light, the Whistler sweeps out as far as 25,000 miles into space before returning to earth laden with scientific information.

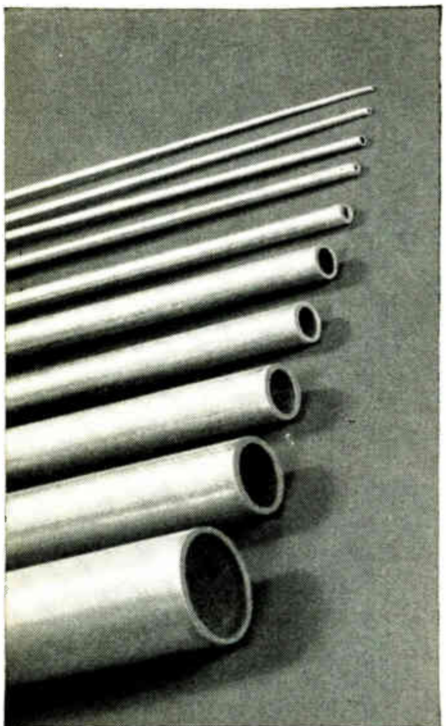
During the most recent Antarctic expedition* performed by Stanford University's Radioscience Laboratory, Whistlers were captured by a PI tape recorder fed directly by a simple audio amplifier and antenna system. Because Whistlers and related phenomena range widely in frequency, from 10 cps to 20,000 cps, incoming signals were recorded on both FM and direct record tracks, thus catching this entire range at the slow, tape-saving speed of 7½ ips. Analysis of the tape discloses a surprising wealth of information on the regions visited by the Whistlers. For example, the recorded time lag between the originating lightning bolt and the returning Whistler reveals the density of the electrons in the rarefied gas along its distant path.

In the Antarctic, "survival of the fittest" applies to both man and machine. The PI recorder was given the tough assignment of recording 50 miles of tape, 24 hours a day, 3 times an hour on schedule, regardless of adverse operating conditions, and was expected to survive and function despite frequent moves by helicopter, ice-breaker, and snow-cat. For this and other demanding applications, PI recorders offer a unique, space-saving stacked reel design, rugged and reliable all-solid-state electronics, and the performance you'd expect from a laboratory machine several times the size. Would you like to know more? Write for Bulletin 64.

* Supported by National Science Foundation

PI PRECISION INSTRUMENT
SAN CARLOS, CALIFORNIA / LY 1-4441

P.I. Invites inquiries from senior engineers seeking a challenging future.



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Sizes from 0.010″ to 0.625″ O.D.

Wall Thicknesses from 0.065″ to as thin as 0.0005″ in smaller sizes.

Tolerances from ±0.0005″ to ±0.00005″ when required.

Beryllium-Copper Alloy No. 25 has excellent spring characteristics as well as high strength, superior electrical conductivity and good forming properties.

Starting with precision-drawn tubing instead of bar stock when making Beryllium-Copper parts saves fabrication time, tooling maintenance and production costs. Whether you make the parts in your plant or entrust the job to Uniform's craftsmen, it is wise and economical to start with fine seamless tubing drawn to close tolerances by Uniform Tubes. Write for Bulletin 61 for complete details.

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LOW-LEVEL DC PREAMPLIFIERS

IMPROVE RELIABILITY

A new series of low-level ACROSTAT DC Preamplifiers, epoxy potted, self-contained, operate from 115 V ± 10% AC, 2 watts. Model 104 amplifies signals of 1 micro-microwatt with a power gain of 330,000 in a single stage from thermocouples, strain gages, Hall devices, and other low-level DC sources. Input, output and AC supply are isolated and floating. Null stability is better than 10 microvolts over moderate environments, and 50 microvolts over severe environments.

Price only $139.00 each, 1 - 5 units; quantity discounts; immediate delivery. Request Technical Bulletin No. 10.

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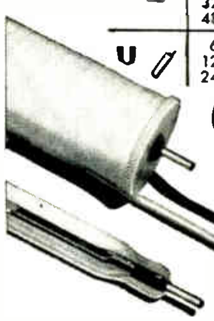
Coto-Coils
For Contact Capsules

TYPE	DC-V	Ohms	Nom. Watts	Nom. Amp/Turns
S	6 12 24	100 360 1400	.40	250
M	6 12 24	50 175 820	.70	250
T	6 12 24 32 48	100 400 1600 2800 4600	.35	125
U	6 12 24	150 600 2500	.24	125



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Providence 5, R. I.

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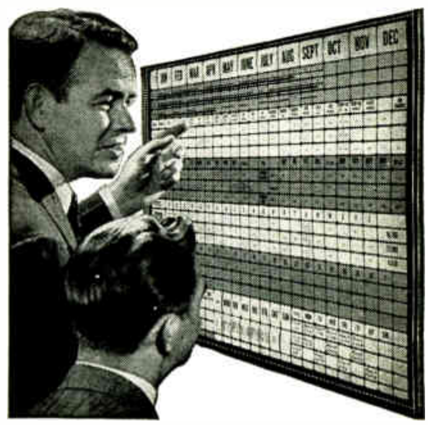

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4. Circle the corresponding key number below the Qualification Form.
5. Fill out the form completely. *Please print clearly.*
6. Mail to: D. Hawksby, Classified Advertising Div., ELECTRONICS, Box 12, New York 36, N. Y. (No charge, of course).

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BOEING CO., THE Seattle, Washington	22	3
BRISTOL COMPANY Waterbury, Conn.	82	4
COLLINS RADIO COMPANY Dallas, Texas	91*	5
DOUGLAS AIRCRAFT CO. Missile and Space Systems Div. Santa Monica, Calif.	85*	6
E. I. DuPONT DE NEMOURS & CO., INC. Wilmington, Delaware	116*	7
EITEL-McCULLOUGH INC. San Carlos, California	83*	8
GENERAL ELECTRIC CO. Defense Systems Dept. Syracuse, N. Y.	83	9
INTERNATIONAL BUSINESS MACHINES CORP. New York, N. Y.	115*	10
INTERNATIONAL BUSINESS MACHINES CORP. Space Guidance Center Owego, New York	82	11
LOCKHEED CALIFORNIA CO. Div., of Lockheed Aircraft Corp., Burbank, California	51	12
MARTIN COMPANY Orlando Division Orlando, Florida	116*	13
MILPAR, INC. Sub. of Westinghouse Air Brake Co. Falls Church, Virginia	82	14
MICROWAVE SERVICES INTERNATIONAL, INC Denville, New Jersey	118*	15
MOTOROLA, INC. Chicago, Ill.	84	16

CONTINUED ON PAGE 84

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

(please print or type)

Personal Background

NAME ....

HOME ADDRESS ....

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

HOME TELEPHONE ....

Education

PROFESSIONAL DEGREE(S) ....

MAJOR(S) ....

UNIVERSITY ....

DATE(S) ....

FIELDS OF EXPERIENCE (Please Check) 61162

- ☐ Aerospace
- ☐ Antennas
- ☐ ASW
- ☐ Circuits
- ☐ Communications
- ☐ Components
- ☐ Computers
- ☐ ECM
- ☐ Electron Tubes
- ☐ Engineering Writing
- ☐ Fire Control
- ☐ Human Factors
- ☐ Infrared
- ☐ Instrumentation
- ☐ Medicine
- ☐ Microwave
- ☐ Navigation
- ☐ Operations Research
- ☐ Optics
- ☐ Packaging
- ☐ Radar
- ☐ Radio—TV
- ☐ Simulators
- ☐ Solid State
- ☐ Telemetry
- ☐ Transformers
- ☐ Other ....
- ☐ ....
- ☐ ....
- ☐ ....

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

Space Guidance Systems

- Solid State Physicists (Radiation Effects Studies)
- Reliability Statisticians
- Logic Designers
- Circuit Designers
- Programmers
- Quality Engineers
- Control Systems Engineers
- Mechanical Engineers (Heat Transfer/Stress Analyst)
- Contract Negotiators

IBM SPACE GUIDANCE CENTER

At its Space Guidance Center in Owego, New York, IBM is responsible for vehicle guidance and control systems for manned aircraft, satellites, space craft, submarines, and other vehicles. Accomplishments include: successful test flights of the rugged IBM computer used in the all-inertial AChiever guidance system that directs the TITAN intercontinental ballistic missile to its target; an advanced memory system for the NASA Orbiting Astronomical Observatory; guidance computers for flight testing with the SATURN space vehicles.

The IBM Space Guidance Center is situated in pleasant surroundings with ample housing, good schools, and fine recreational facilities. The company-paid benefit program features broad educational opportunities. Relocation expenses are paid. IBM is an Equal Opportunity Employer.

For full details on career opportunities, please write, outlining your interests and background, to:

Fred Guth, Dept. 554S2
Space Guidance Center
IBM Corporation
Owego, New York

IBM®

INTERNATIONAL BUSINESS MACHINES CORPORATION

EMPLOYMENT OPPORTUNITIES

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

Positions Vacant	Civil Service Opportunities
Positions Wanted	Selling Opportunities Wanted
Part Time Work	Selling Opportunities Offered

Employment Agencies
Employment Services
Labor Bureaus

— RATES —

DISPLAYED: The advertising rate is $40.17 per inch for all advertising appearing on other than a contract basis. Contract rates quoted on request.

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

Subject to Agency Commission.

UNDISPLAYED: $2.70 per line, minimum 3 lines. To figure advance payment count 5 average words as a line.

Box numbers—count as 1 line.

Discount of 10% if full payment is made in advance for 4 consecutive insertions.

Not subject to Agency Commission.

FIELD SERVICE ENGINEER

Europe

International Division of major U. S. Corporation has immediate opening for a Field Engineer to coordinate maintenance of airborne electronic equipment at Customers' Depots in Europe. Degree not required. Prefer Doppler or microwave experience. Permanent position NOT associated with U. S. Government contracts. Range $7,400 to $8,100 plus overseas allowance. Please write complete background details. An equal opportunity employer.

P-9063, Electronics
Class. Adv. Div., P.O. Box 12, N. Y. 36, N. Y.

ELECTRONICS ENGINEER

The Research Division of a major producer of synthetic fibers and dielectric materials has an attractive opening for a B.S. or M.S. in electrical engineering or physics with 2-6 years experience to work in electronic instrument design and development related to physical measurements in the field of polymer and fiber physics. Experience with strain gauges, thermocouples, and other transducers desirable. Must have knowledge of transistors as well as conventional vacuum tube circuitry.

Pleasant working and living location near Asheville, N. C. Excellent benefit program; 5 day work week; moving expenses. Send complete resume, including salary requirements to Employment Manager, Enka, N. C.

AMERICAN ENKA CORPORATION

POSITION VACANT

Communications Engineer — To supervise technical assistance to schools participating in the Midwest Program on Airborne Television Instruction. Desire graduate Electronic or Electrical Engineer with experience in UHF TV reception or UHF air-ground communications. Send resume and salary requirements to DeW. Schatzel, Director of Engineering, MPATI, Memorial Center, Purdue University, Lafayette, Indiana.

PHYSICISTS

Melpar's more than 17 years of outstanding achievements, exceptional opportunities continue to be created at

MELPAR

Excellent assignments in our expanding RESEARCH DIVISION for—

MICROWAVE PHYSICIST

Engage in research in millimeter wave propagation through solids, higher order mode transmission, and problems involving general electromagnetic theory.

Ph.D or MS and 3 years experience required.

ADVANCED CIRCUIT PHYSICIST

Advanced circuit physicist for creative research in function synthesis and quantum mechanics, including material in solid, liquid and gaseous state.
Ph.D. required.

Write in confidence to—

J. HAVERFIELD
Employment Manager

MELPAR, INC.

A Subsidiary of Westinghouse Air Brake Co.
3322 Arlington Blvd.
Falls Church, Va.

An equal opportunity employer

Engineering or Science Graduates to be trained as

INSTRUMENT SALES ENGINEERS

with

The Bristol Company

Leading manufacturer of automation equipment and control systems requires men, preferably 25 to 35 years old, to sell high quality, nationally accepted products to wide variety of industrial markets.

Openings in various areas of the country. Successful applicants take comprehensive three-months course at headquarters. Salary and expenses

All replies confidential; every inquiry answered.

Write: **Charles F. Johnson, Mgr. of Sales Training**

The Bristol Company
Waterbury 20, Conn.

E. E.'s

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

A national employment agency for the Nuclear & Scientific Fields.

ATOMIC PERSONNEL, INC.
Suite 1207L, 1518 Walnut St., Phila. 2, Pa.

MANUFACTURERS' REPRESENTATIVES

IN THE ELECTRONIC INDUSTRY

SAMUEL K. MACDONALD, INC.

manufacturers representatives over 25 years

1531 SPRUCE STREET, PHILA. 2, PA.

Territory:
Pennsylvania • New Jersey
Delaware • Maryland
Virginia • West Virginia
District of Columbia

Other Offices:
Pittsburgh
Baltimore
Washington, D.C.

Some very successful companies are "sales oriented"—others, equally successful, receive their primary impetus from accounting, legal or business-management directions. Probably because of the highly technical nature of its product, Motorola has always been a company wherein engineering has been the moving force. At any management conference at Motorola, you'll find men think like engineers, and talk like engineers, because so many in the management echelon *are* engineers.

At Motorola the engineer achieves full professional status—because he is working in an environment where the state of the art has progressed to the point where only an "engineering oriented" management can direct the flow of achievement.

In this dynamic atmosphere, of course, the challenges are great—but equally rewarding for truly qualified engineers. Would you like to talk to us?

- Radar transmitters and receivers
- Radar circuit design
- Electronic countermeasure systems
- Military communications equipment design
- Pulse circuit design
- IF strip design
- Device using kylstrom, traveling wave tube and backward wave oscillator
- Display and storage devices

2-WAY RADIO COMMUNICATIONS
- VHF & UHF receiver
- Transmitter design and development
- Power supply
- Systems engineering
- Antenna design
- Selective signaling

- Transistor applications
- Crystal engineering
- Sales engineering

- Design of VHF & UHF FM communications in portable or subminiature development
- Microwave field engineers
- Transistor switching circuit design
- Logic circuit design
- T.V. circuit design engineering
- Home radio design
- New product design
- Auto radio design
- Mechanical engineering
- Semi-conductor device development
- Semi-conductor application work

Excellent opportunities also available in Phoenix, Ariz.; Riverside & Culver City, Calif., & Minneapolis, Minn.

MR. W. H. HAUSMANN
Engineering Personnel Mgr. Dept. D
4545 Augusta Blvd., Chicago 51, Ill.

AN EQUAL OPPORTUNITY EMPLOYER

MOTOROLA inc.

electronics

WEEKLY QUALIFICATIONS FORM FOR POSITIONS AVAILABLE

(Continued from page 81)

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION Washington, D. C.	117*	17
NATIONAL CASH REGISTER CO. Dayton, Ohio	116, 118*	18
NORTHROP CORP. Norair Div. Hawthorne, California	73	19
NORTHROP CORP. Space Laboratories Hawthorne, California	75	20
PAN AMERICAN WORLD AIRWAYS INC. Guided Missiles Range Division Patrick AFB, Florida	93*	21
PHILCO WESTERN DEVELOPMENT LABS. Palo Alto, California	85	22
SCOPE PROFESSIONAL PLACEMENT CENTER Waltham, Massachusetts	118*	23
P 9005	118*	24
P 9063	82	25

* These advertisements appeared in the 6/1/62 issue.

"Put Yourself in the Other Fellow's Place"

TO EMPLOYERS

TO EMPLOYEES

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

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

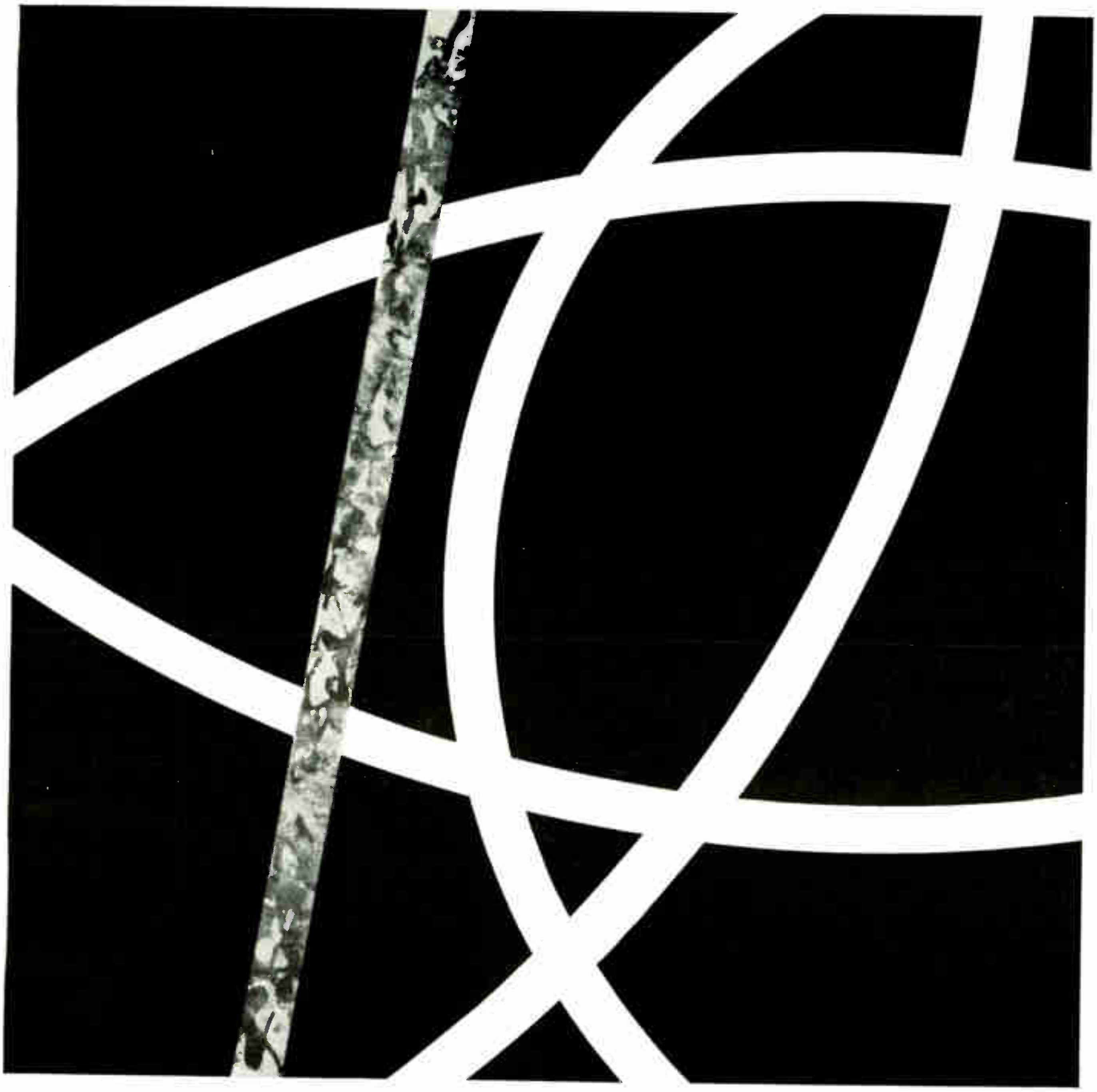
MR. EMPLOYEE you, too, can help by acknowledging applications and job offers. This would encourage more companies to answer position wanted ads in this section.

We make this suggestion in a spirit of helpful cooperation between employers and employees.

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

Classified Advertising Division

McGRAW-HILL PUBLISHING CO., INC.
330 West 42nd St., New York 36, N. Y.



SEARCHLIGHT SECTION

(Classified Advertising)

BUSINESS OPPORTUNITIES — EQUIPMENT - USED or RESALE

——RATES——

DISPLAYED

The advertising is $27.25 per inch for all advertising other than on a contract basis. AN ADVERTISING INCH is measured 7/8" vert. on a column, 3 cols.—30 inches—to a page. EQUIPMENT WANTED or FOR SALE ADVERTISEMENTS acceptable only in Displayed Style.

UNDISPLAYED

$2.70 a line, minimum 3 lines. To figure advance payment count 5 average words as a line.

BOX NUMBERS count as one line additional.

DISCOUNT of 10% if full payment is made in advance for four consecutive insertions.

Send NEW ADVERTISEMENTS or Inquiries to Classified Adv. Div. of Electronics, P. O. Box 12, N. Y. 36, N. Y.

Your Inquiries to Advertisers Will Have Special Value . . .

—for you—the advertiser—and the publisher, if you mention this publication. Advertisers value highly this evidence of the publication you read. Satisfied advertisers enable the publishers to secure more advertisers and—more advertisers mean more information on more products or better service—more value—to YOU.

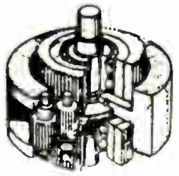
ELECTRONIC

WAR TERMINATION INVENTORIES

WRITE OR WIRE FOR INFORMATION ON OUR COMPLETE LINE OF SURPLUS ELECTRONIC COMPONENTS. ALL PRICES NET F.O.B. PASADENA, CALIFORNIA

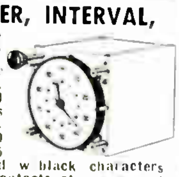
C&H SALES CO.
2176-E East Colorado St.
Pasadena 8, California
MUrray 1-7393

SIMPLE DIFFERENTIAL WITH BALL-BEARING SUN GEARS



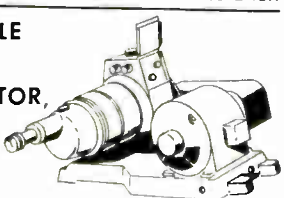
The 1:1 reverse ratio spur gears are 48-tooth, 32 pitch brass with 3/16" available face. On one side, the shaft is 23.64" dia. for 11/16" and has a pin hole, then increases in dia. to .377" for the remaining 3/16" of length On the other side, the shaft is .377 dia. ¼" lg. 2-13/16" dia. is required to clear the body. Stock no. A6-115 ....each $15.00

1/100 SECOND TIMER, INTERVAL, 115 VAC, 60 CYCLE



mfgd. by Standard Electric Time Co. accuracy ± .005 sec. w DC clutch first hand speed —1 RPS—totalizes 60 seconds short hand smallest gradua. tions .01 sec. 115 VAC, 60 ohms. brake solenoid 27.5 VDC dial—white background w black characters clock motor to close set of contacts at one second intervals contact rating 1 amp. 28 VDC. non-inductive. Manual reset. outside dim. 3³⁄₄ sq. in.
PRICE ....$25.00 EACH

400-CYCLE MOTOR GENERATOR, PU-20



The generator assembly consists of a 1400-watt, 120-volt, 400-cycle inductor-alternator and a 400-watt, 27-volt D.C. generator. The alternator rotor and the D.C. generator armature are mounted on a common shaft, which is dual-belt-driven by a 3-H.P., 1750-R.P.M., 115/230-volt, single-phase 60-cycle electric motor. Weatherproof output box is mounted on top of the stator shell. It contains a rheostat, adjustable resistor, two pin jacks for plugging in an A.C. voltmeter. Size: 28" W., 33" L., 18" H. Weight, approx. 250 lbs.
Price $175.00

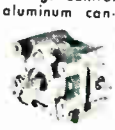
8-DAY ELAPSED-TIME SURPLUS AIRCRAFT CLOCK

Here's on accurate time control center that'll help you win your next rallye. It not only tells you the date and time of day right to the second, it's a stop watch that gives you elapsed time in seconds, minutes, and hours! The 24-hour clock simplifies adding and subtracting elapsed time for your navigator. Manufactured by Elgin Watch Co. to exacting military specifications, it will remain accurate in spite of road bumps and vibrations. Uses no electrical connections. Does the job of high-cost equipment. Jeweled/Sweep Second Hand/Luminous Hands and Numerals/25-Hour Dial/Block Face and Plastic Case/3⅛" Mounting.
Cost the Government $185.00
Only **$39.95** Postpaid

SPERRY VERTICAL GYRO

Part #673073. Motor 115 volts, 3 phase, 400 cycle, 8 watts, 20,000 RPM. 3-minute runup, synchro pickoffs, roll 360°, pitch 85°. Synchro excitation 26 volts, 400 cycle, 150 m.a. Vertical accuracy ±½° Weight 3½ lbs. Approx. dim. 5¼" L., 4½" W., 4½" H.
Price $35.00

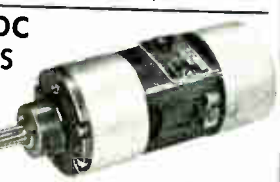
VARIABLE SPEED BALL DISC INTEGRATORS (All Shafts Ball Bearing Supported)



No. 145 Forward & Reverse 2¼"-0-2¼. Input shaft spline gear 12 teeth 9/32" dia. ⅜" long. Output shaft 15/64" dia. x 15/32" long. Control shaft 11/32" x ⅜" long. Cast aluminum construction. Approx. size 3" x 3" x 2¾" $17.50

No. 146 Forward & Reverse 4-0-4. Input shaft 5/16" dia. x ¾" long: Output shaft 15/64" dia x 9/16" long. Control shaf 11/64" dia. x 11/16" long. Cast aluminum construction. Approx. size 4½" x 4½" x 4". **$18.50 ea.**

SMALL DC MOTORS



(approx. size over 3¾" x 1¼" dia.:

5067043 Delco 12 VDC PM 1" x 1" x 2", 10,000 rpm. $7.50
5067126 Delco PM, 27 VDC, 125 RPM, Governor Controlled 15.00 ea.
5069600 Delco PM 27.5 VDC 250 rpm 12.50
#5069625 120 rpm, mfr. Delco, 27 VDC governor controlled $15.00
5069230 Delco PM 27.5 VDC 145 rpm 15.00
5068750 Delco 27.5 VDC 160 rpm w. brake 6.50
5068571 Delco PM 27.5 VDC 10,000 rpm (1x1x2") 5.00
5069790 Delco PM, 27 VDC, 100 RPM, Governor Controlled 15.00 ea
#5069800 575 rpm, mfr. Delco, 27 VDC, PM reversible governor controlled, equipped with 27 VDC clutch $17.50
5072735 Delco 27 VDC 200 rpm governor controlled. 15.00
5BA10A118 GE 24 VDC 110 rpm 10.00
5BA10AJ37 GE 27 VDC 250 rpm reversible 10.00
5BA10AJ52 27 VDC 145 rpm reversible 12.50
5BA10AJ50, G.E., 12 VDC, 140 rpm 15.00
5BA10FJ401B, G.E. 28 VDC, 215 rpm, 10 oz. in., 7 amp. contains brake 15.00
5BA10FJ421, G.E. 24 VDC, 4 rpm, reversible, 6 oz in. .65 amp 15.00

400 CYCLE PM GENERATOR

115/200 volts A.C. 1- or 3 phase, 200 watts 4,000 r.p.m. Approx. dimensions: 4¾" dia.; 3" long; ½" shaft, AN connector. $75.00

DIRECTIONAL INDICATOR, TYPE C5C

Mfgr. Summers Gyroscope Company. 115 volt A.C., 400 cycle, 3 phase. Contains direct reading gyro with caging mechanism and power failure indicator. Hermetically sealed case. 5" dial, 0 to 360°
PRICE $22.50

MINNEAPOLIS-HONEYWELL RATE GYRO (Control Flight)

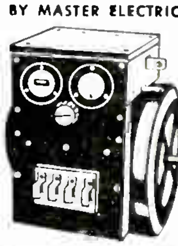
Part no. JG7005A. 115 volts A.C., 400 cycle, single phase potentiometer take off resistance 530 ohms. Speed 21,000 r.p.m. Angular momentum 2½ million, CM²/sec. Weight 2 lbs. Dimensions 4-7/32 x 3-29/32 x 3-31/64.
Price $22.50

SELSYNS-SYNCHROS

1CT cont. Trans 90/55V 60 cy	$27.50
1DG Diff. Gen. 90/90V 60 cy	34.50
1F Syn. Mtr. 115/90V 60 cy	34.50
1G Gen. 115V 60 cy	34.50
1HDG	37.50
1HCT	37.50
1SF Syn. Mtr. 115/90V 400 cy	12.50
23TR4 torque receiver	34.50
23TR6 torque receiver	37.50
23CT6 control transformer	37.50
23CX6 control transmitter	37.50
23TX6 torque transmitter	37.50
7DG differential generator	37.50
2J1F1 Gen. 115/57.5V 400 cy	7.50
2J1F3 Gen. 115/57.5V 400 cy	10.00
2J1FA1 Gen. 115/57.5V 400 cy	7.50
2J1G1 57.5/57.5V 400 cy	5.00
2J1H1 Diff. Gen. 57.5V 400 cy	7.50
2J5D1 Cont. Trans. 105/55V 60 cy	17.50
2J5F1 Cont. Trans. 105/55V 60 cy	17.50
2J5H1 Gen. 115/105V 60 cy	17.50
2J15M1 Gen. 115/57.5V 400 cy	17.50
5CT Cont. Trans. 90/55V 60 cy	34.50
5D Diff. Mtr. 90/90V 60 cy	34.50
5DG Diff. Gen. 90/90V 60 cy	34.50
5F Syn. Mtr. 115/90 VAC 60 cy	34.50
5G Syn. Gen. 115/90VAC 60 cy	34.50
5HCT Cont. Trans. 90/55V 60 cy	37.50
5SDG Diff. Gen. 90/90V 400 cy	12.50
6DG Diff. Gen. 90/90V 60 cy	25.00
6G Syn. Gen. 115/90VAC 60 cy	34.50
7G Syn. Gen. 115/90VAC 60 cy	42.50
C56701 Type 11-4 Rep. 115V 60 cy	20.00
C69405-2 Type 1-1 Transm. 115V 60 cy	20.00
C69406 Syn. Transm. 115V 60 cy	20.00
C69406-1 Type 11-2 Rep. 115V 60 cy	20.00
C78248 Syn. Transm. 115V 60 cy	12.50
C78410 Repeater 115V 60 cy	20.00
FPE 49-7 Diehl servo motor, 115 volts, 60 cycle, 10 watts	30.00

400 CYCLE, 3 PHASE GENERATOR

BY MASTER ELECTRIC



Type AG, frame 364Y, 7.5 kw, 3428 rpm, pf .95 Stor connected 120/208 3 phase, 22 amps. Delta connected 120 volt single phase 6 amps. Self excited. Complete with control box, voltage regulator, AC voltmeter and frequency meter. Shaft 1" dia., 2" long; overall dim. of unit: 21"x6x18"x 20".
Price $395.00 each

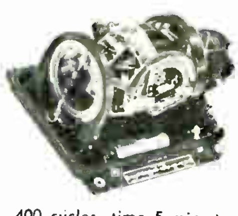
SENSITIVE INTEGRATING GYROS

This is the famous HIG Gyro which is being used in missile guidance systems, radar stabilization and fine control systems Government cost approximately $1500.
PRICE $50.00

400 CYCLE PM GENERATOR

Mfgd. by T K M Electric Corp.
Model #A-12
120/208 volts, 400 cycle, 1 or 3 phase, 1 kva, pf 0.8, rpm 8,000. Approx. dim. 6" x 5½". Internal spline drive.
Price $100.00

HONEYWELL VERTICAL GYRO MODEL AG7044A17



115 volts, 400 cycles, single phase, 35 watts. Pitch and roll potentiometer pickoffs 890 ohms, 40 volts max. AC or DC. Speed 20,000 rpm, ang. momentum 12,500,000 gm-cm 2/sec. Erection system 27 VAC, 400 cycles, time 5 min. to ½°; caging mechanism operates on 24 VDC.
$49.50

DIRECTIONAL GYRO

Mfg. Sperry Part #656519
115 VAC 400 N 3 phase
$35.00 ea.

CIRCLE 469 ON READER SERVICE CARD

SPECIAL PURPOSE TUBES

OA2	.80
OA2WA	2.00
OA3	.85
OB2	.60
OB2WA	2.00
OB3	.70
OC3	.50
OD3	.30
C1A	8.50
1AD4	1.50
1B24	7.50
1B24A	12.50
1B35A	3.00
1B63A	10.00
1C/3B22	5.00
C1K	7.50
1P21	32.50
1P22	8.00
1P25	10.00
1P28	15.00
1Z2	1.50
2-01C	12.50
2AP1A	8.50
2B23	20.00
2BP1	10.00
2C36	22.50
2C39A	9.75
2C39B	15.00
2C40	7.50
2C42	3.00
2C43	7.50
2C46	5.00
2C50	4.00
2C51	1.50
2C52	1.50
2C53	7.50
2D21	.50
2D21W	1.00
2E24	2.25
2E26	2.50
2E30	3.50
2J42	75.00
2J51	50.00
2J55	90.00
2K22	25.00
2K25	8.50
2K26	35.00
2K28	25.00
2K29	25.00
2K30	50.00
2K33A	200.00
2K34	75.00
2K35	200.00
2K39	150.00
2K41	50.00
2K42	125.00
2K43	200.00
2K44	125.00
2K45	20.00
2K47	150.00
2K48	50.00
2K50	175.00
2K54	10.00
2K55	15.00
2K56	50.00
2P21	40.00
2X2A	1.25
3A5	.75
3AP1	3.50
3B4	2.50
3B24W	3.00
3B24WA	5.00
3B25	2.50
3B26	2.25
3B28	3.00
3B29	5.00
3BP1A	7.50
3C22	15.00
3C23	4.00
3C24/24G	7.50
3C33	7.50
3C45	3.50
3CX100A5	15.00
3D21A	5.00
3D22	8.00
3DP1A	5.00
3E29	7.50
3GP1	2.50
C3J	7.50
C3J/A	9.50
3J21	35.00
3J31	100.00
3JP1	5.00
3K21	125.00
3K22	125.00
3K27	150.00
3K30	100.00
3KP1	9.75
3RP1	7.50
3WP1	12.50
4-65A	10.00
4-125A	20.00
4-250A	32.50
4-400A	30.00
4-1000A	80.00
4AP10	10.00
4B31	12.50
4C35	15.00
4CX250B	30.00
4CX1000A	125.00
4D32	15.00
4E27A	27.50
4J32	100.00
4J34	100.00
4J50	100.00
4J52A	100.00
4PR60A	50.00
4X150A	13.50
4X150D	15.00
4X150G	25.00
4X250B	20.00
4X250F	30.00
5BP1A	9.50
5C22	17.50
5CP1A	9.50
5CP7A	9.50
5D21	7.50
5J26	50.00
5JP1	7.50
5LP1	7.50
5R4GY	1.25
5R4WGA	4.00
5R4WGB	6.00
5R4WGY	2.00
5RP1A	9.50
5Y3WGT	1.25
5Y3WGTB	2.50
6AC7W	.50
6AC7WA	2.00
6AG5WA	1.50
6AG7Y	1.00
6AK5W	1.25
6AK5 (WE)	.75
6AL5W	.60
6AN5	1.75
6AN5WA	3.50
6AQ5W	1.00
6AR6	.75
6AS6W	1.00
6AS7G	2.50
6AU6WA	1.25
6B4G	3.35
6BA6W	.75
6BE6W	1.50
6BF7W	2.00
6BH6W	2.75
6BL6	20.00
6BM6	25.00
6BM6A	30.00
6C4W	2.50
6C4WA	1.00
6C21	17.50
6D4	1.50
6F4	3.50
C6J	10.00
C6J/A	15.00
C6J/K	20.00
6J4	1.75
6J4WA	2.50
6J6W	.60
6J6WA	1.00
6K4	2.00
6L6GAY	.75
6L6WGA	1.50
6L6WGB	2.00
6Q5G	2.50
6SJ7WGT	1.25
6SK7W	.75
6SK7WA	2.00
6SL7WGT	1.00
6SN7W	.50
6SN7WGT	1.00
6SN7WGTA	2.50
6SU7GTY	.85
6V6GTY	1.00
6X4W	.75
6X4WA	1.50
6X5WGT	1.00
SRL7H	100.00
7AK7	2.50
7MP7	22.50
10KP7	15.00
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HF-300	35.00
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304TL	35.00
307A	.50
310A	3.50
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313C	1.50
323A	6.00
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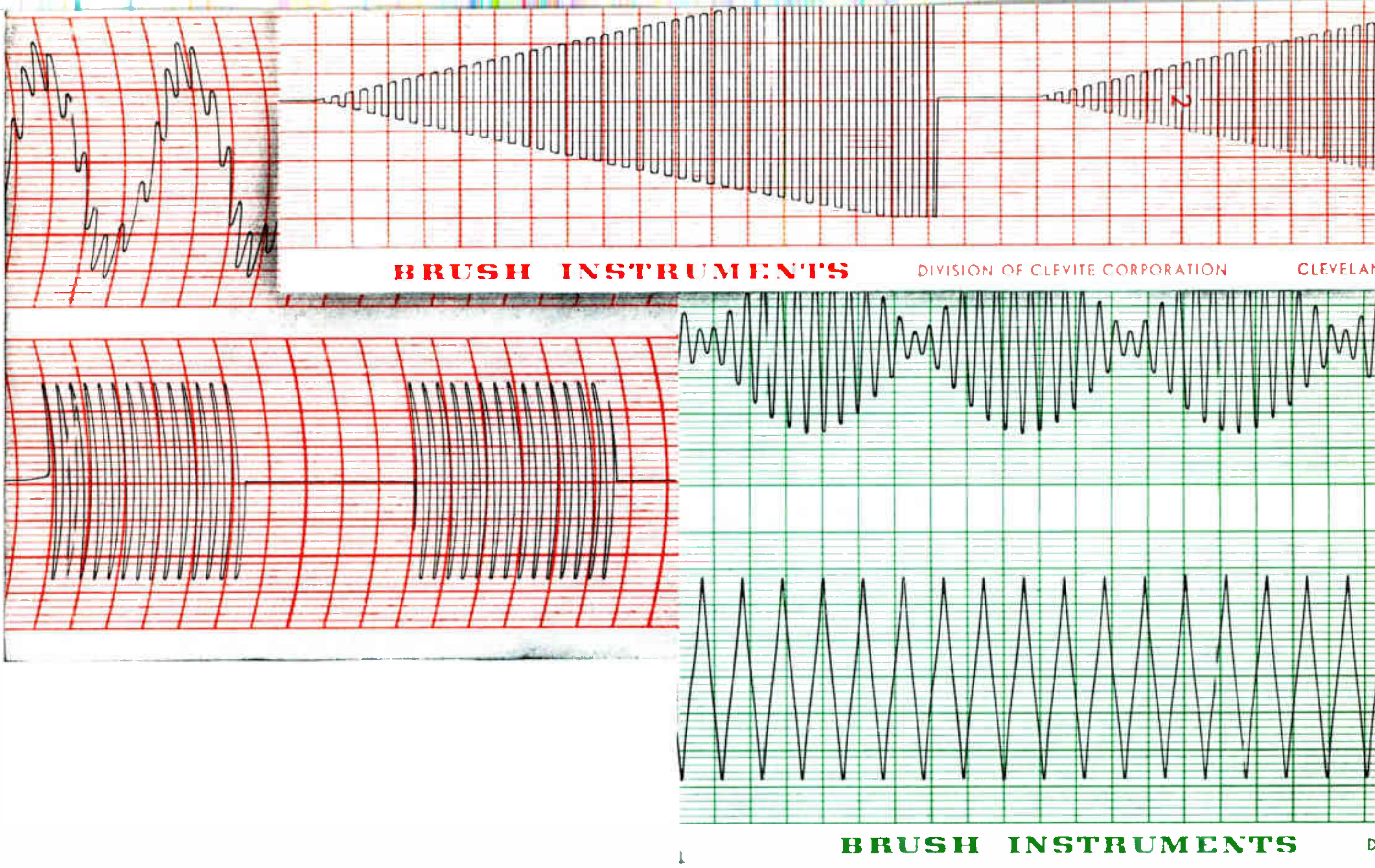

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