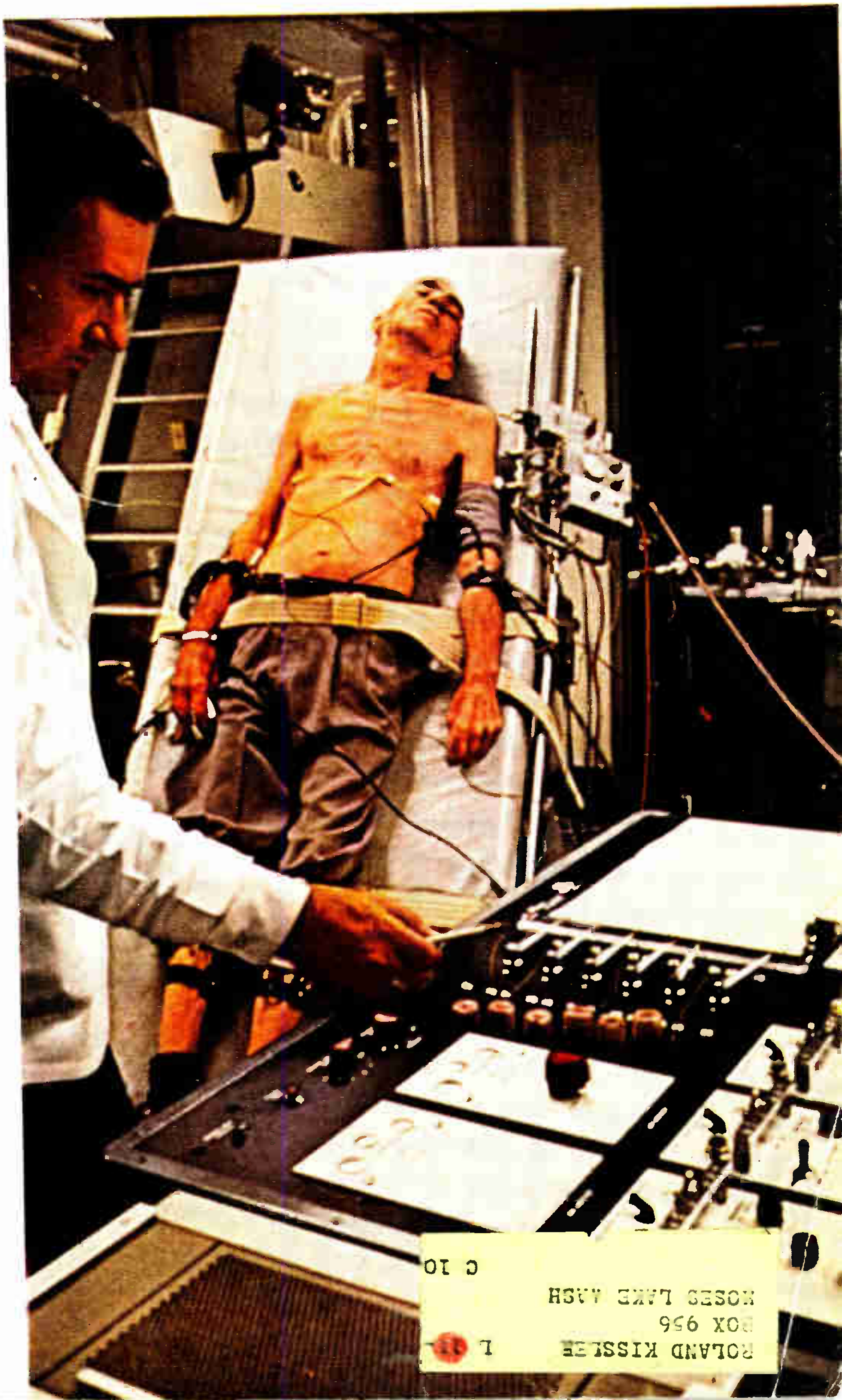
electronics

A McGRAW-HILL WEEKLY 75 CENTS OCTOBER 11, 1963

Human Salvage

Computer and instruments aid rehabilitation

(photo, right)



SOLID-STATE MICROWAVES

Design procedure for using varactors

MUSCLE VOLTAGE MOVES HAND

Needs four-stage transistor amplifier

PULSE-WIDTH MODULATOR

Achieving precision without high cost

HERMETICALLY SEALED
NOW to MIL-T-27B
VARIABLE INDUCTORS
HIGH-Q plus HIGHEST STABILITY

PIONEERS IN MINIATURIZATION

IMMEDIATE DELIVERY FROM STOCK

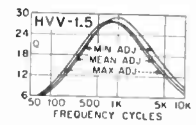
For almost a third of a century UTC has pioneered in the development of transformers, electric wave filters, high Q coils, magamps and similar iron core components. Highest engineering talent plus the most complete facilities for research and testing has made UTC the leading supplier in the industry for both stock and custom built components. UTC Variductors (stock variable inductors) have served as a simple solution to tuned circuit for almost 20 years . . . for oscillators, equalizers, filters, tuned radio circuits, etc.

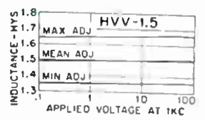
NEW!-VERNIER

HVV VARIDUCTOR™

HERMETICALLY SEALED

NARROW RANGE





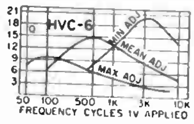
The HVV Variductors have been designed to emphasize extremely high stability with temperature, level, shock and vibration commensurate with the highest obtainable Q. They are ideal for precise matching to other components such as capacitors with standard 10% tolerance. Units are provided with a vernier adjustment variation of ±10% through 900° rotation of adjustment screw on top of case. Setting is positive. There are 12 units in the stock line with mean inductances ranging from .006 Hy to 150 Hys. Specific mean inductances other than stock items are available on special order. Manufactured and guaranteed to MIL-T-27B, MIL type TF4RX20YY. Drawn metal case: 1⅛" long, 25/32" wide, 1-7/32" high (including adjustment screw); weight: 2 ounces. Effective Q over a wide frequency range and variation of inductance with applied AC voltage are illustrated for a typical unit. Patent pending.

HVC VARIDUCTOR™

HERMETICALLY SEALED

WIDE RANGE

HVC units are usable over a wide frequency range and have high stability with temperature and voltage change. Nominal inductance values of 12 stock units in series range from .006 Hy to 150 Hys. The variable inductance range of each unit is +200%, −70% of nominal value through 900° rotation of adjusting screw on top of case. Setting is positive. Case size and weight is the same as HVV. U.S. Patent No. 2,879,489.



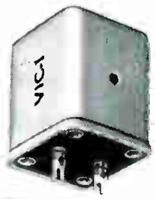
TVC VARIDUCTOR™

TVC Variductors are identical to the HVC units, but provide taps at 30% and 50% of total turns. Different taps are available on special order. U.S. Patent No. 2,879,489.

VIC VARIDUCTOR™

COMMERCIAL GRADE

WIDE RANGE



Nominal inductance values of 22 stock items in this series range from .0085 Hy to 130 Hys. Mean inductance may be varied +85%, −45% through 600° rotation of adjustment screw in side of case. Rugged die cast case: 1-11/13" long, 1¼" wide, 1-7/16" high; weight 5½ ounces.

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OCTOBER 11, 1963

electronics

A McGRAW-HILL WEEKLY 75 CENTS

Contents continued

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Extends High-Efficiency ECDC® Transistor Performance to VHF POWER RANGE

- High Voltage—40 Volts
- High f_T—800 mc (typ.)
- Isolated Mounting Stud offers Design Freedom

actual size

TYPE	V_{CES}	P_G @ 160 mc	P_O @ 160 mc
2N2962	40 V	6 db	.5 W
2N2963	40 V	5 db	.5 W
2N2964	30 V	6 db	.5 W
2N2965	30 V	5 db	.5 W

For application engineering assistance, write to Transistor Division, Sprague Electric Co., Concord, N. H. For technical data, write for Engineering Bulletins 30,452 and 30,454 to Technical Literature Service, Sprague Electric Co., 35 Marshall St., North Adams, Mass.

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287A-C	5.8-8.2 GC	1.1	1600
287A-XB	7-10 GC	1.1	1550
287A-X	8.2-12.4 GC	1.1	1500

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A Huge Amorphous Mass

INFORMATION RETRIEVAL has already generated considerable activity within the electronics industry and it is likely to generate even more. We are in favor of any worthwhile activity that will stimulate development, production and sale of electronic equipment. But sometimes it is necessary to speak out against a proposal that could do the industry more harm than good.

Such a proposal, if we understand it correctly, is H.R. 1946, introduced in Congress by Representative Roman C. Pucinski (D.-Ill). The bill would amend title IX of the National Defense Education Act of 1958 to provide for an all-inclusive Science Information Data Processing Center to be located at one place, in Chicago.

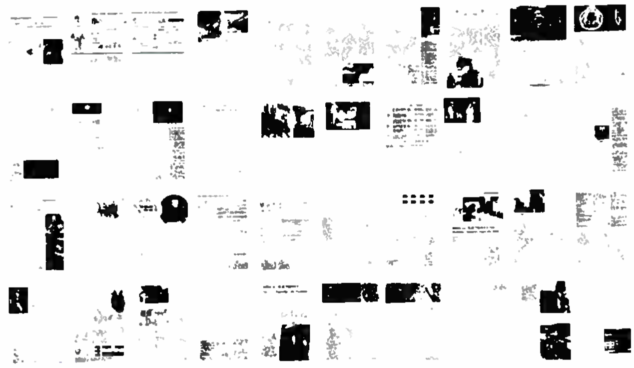
We believe Mr. Pucinski's proposal is a good one in principle but a bad one in practice, and that if it were implemented its almost inevitable failure could set the whole IR business back a decade or more.

There is abundant evidence that the performance of an IR system diminishes with increasing size and, especially, with breadth of coverage. A single, centralized national system probably could not deliver acceptable performance. Also, the effectiveness of such a system rises in proportion to the specialized subject knowledge of the operators. It seems unlikely that the Federal government could attract to any one place, and hold, the number and quality of experts in many diverse fields necessary to operate the system successfully.

Most civilian effort in IR has been supported by the Office of Scientific Information Services of the National Science Foundation, but this support has so far been for research, not implementation. We urge, like Pucinski, that substantial Federal support of implementation be made a matter of public policy, and that the National Defense Education Act of 1958 be so amended. But right there is where we appear to part company.

The Office of Science Information Services might well be given overall responsibility. However, we believe that the role of OSIS should be limited to setting policy and providing secretariat services for a national effort. The actual IR function should be organized on a field-of-interest basis, with the responsibility for maintaining each field-of-interest system assigned to the professional society, university, research institute or other civilian agency most capable of undertaking the work. In this way, public money will advance the public interest, not only by subsidizing a national IR system but also by helping to support worthy institutions.

Each individual IR center should be located near a principal academic community for that discipline. The centers should be linked by the most modern



digital communications network. Thus a requestor would have at his fingertips the keys to several efficient centers, each serving a discipline that impinges on his query rather than having to address his inquiry to a huge amorphous mass whose accuracy might be questionable and whose effectiveness could be dubious.

Let's beef up existing developmental IR systems in special fields of interest and fill in the gaps. Then integrate them with a modern communications system. The communications center could, indeed, be in a city such as Chicago.

Coming In Our October 18 Issue

ULTRASONICS. A leading authority on ultrasonics, W. P. Mason, of Bell Telephone Labs, will report next week on the state of the ultrasonic art.

This is no ordinary review of the applications for ultrasonics in detection, communications, manufacturing and research. Mason orients his report toward the latest and most significant advances—present and promising—in materials, components and techniques.

These developments are not only improving transducers for equipment such as sonar and ultrasonic cleaners. They are also influencing the design of radar and other equipments requiring such components as filters, delay lines and oscillators. For example, the problem of attenuation in delay lines may soon be eliminated by piezoelectric semiconductor amplifiers.

Among other interesting and useful articles next week will be:

- A self-modulation technique for klystrons. A simple tuned circuit can replace an external modulator and power supply
- Ways to combine tunnel diodes and charge-storage diodes into nanosecond logic circuits with improved characteristics
- Cook-book design methods for determining resistance values in transistor switches. With the equations, worst-case d-c design can be calculated
- Radar that uses a color-tv picture tube to show the ppi map and moving targets in contrasting colors.

COMMENT

HEAT FLOW PATTERNS

Today I saw the . . . August 23 ELECTRONICS. I am quite pleased both with the outcome of the cover and with the *Components and Materials* rewrite inside, Phosphors Trace Heat Flow Patterns (p 40). . . .

Apparently you . . . judged accurately that interest would be high. The first paper. first session. was presented to a nearly full hall of very interested people at WESCON. For nearly two hours after the presentation, I was talking to interested persons outside the hall. . . .

Again, thank you for an efficient reporting job. It is certainly a pleasure to deal with a situation and people where everything works without errors, like well-oiled machinery.

HENRY D. FRAZIER

Rolling Hills Estates, California

THERMAL RESISTANCE

I am especially interested in some of Harold Bauman's comments with regard to MIL-SPECS (p 4, June 14). There appear to be about 130 current MIL-SPECS on transistors, of which 42 are JAN types (reference: June 1963 D.A.T.A. Transistor Tabulation). Our own file indicates 84 types, as in Canada we do not get any of the single-service specifications unless we specifically request them. Anyway, of these 84, only one (2N539) included a test for thermal *time constant*, although a great many, nearly half, included a test for thermal *resistance*. . . .

I agree roughly with his statement that I_{cbo} for a germanium transistor doubles for each increase of 10 deg, close enough. To be more specific, we find that $I_T = kT^{1.7}\epsilon^{-8350/T}$, where T is in deg K. This assumes that only the bulk diffusion current is significant, which is probably quite true for a clean surface at any normally encountered temperature. In the case of silicon, the diffusion current is negligible up to about 175 deg C, and again assuming a clean surface across the junction, we find that the measured reverse current is principally the charge generation current, given by $I_T = kT^{1.5}\epsilon^{-7020/T}$, where T is in deg K as before.

An accurate plot of these two curves shows that actually, at room temperature, the current increases *faster* than double for every 10 deg C in both germanium and silicon. The calculated increase between 20 and 30 deg C may be of interest: germanium, 2.72; silicon, 2.32. . . . Experimental measurements on a number of transistors, both germanium and silicon, tend to show slightly lower values than those quoted above, probably due to surface effects.

It may be of interest to know that this multiplication figure decreases as the temperature increases, and is exactly 2 at about 90 deg C for germanium and 55 deg C for silicon. . . .

In his article, Mr. Bauman draws typical calibration curves assuming that the variation is linear over the range 25-60 deg C. These extremes give currents in the approximate ratio of 1:23 for germanium. Assuming a linear relationship, this gives an increase of 22 units for a 35-deg C change in temperature. The calculated current at 40 deg C would then be $1 + 15/35 \times 22 = 10.4$. It is actually 4.2!

Conversely, if the measured current were 10.4, his linear approximation would say that $T_j = 40$ deg C, whereas it would actually be almost exactly 52 deg C. For a case temperature of 37 deg C, and say 9.8 watts dissipation (as in his example), we have: thermal resistance (linear approximation) $= (40-37)/9.8 = 0.31$ deg C/w; thermal resistance (more accurate calculation) $= (52-37)/9.8 = 1.53$ deg C/w. Quite a difference! . . .

Even though I do not agree with all that Mr. Bauman says, I must admit that it has been very interesting analyzing his article (Practical Way to Measure Transistor Thermal Resistance, p 66, Feb. 15), and by going into the subject as thoroughly as I have, I have certainly learned a few things that I might not otherwise have.

SIDNEY V. SOANES

Research Department
Ferranti-Packard Electric Ltd.
Toronto, Ontario, Canada

TELEMETRY GROUND STATION

May I compliment you on your *New Products* treatment of the Bendix Pacific Correlated Data Systems DDS-1000 PCM ground station (p 65, Sept. 13).

However, the address indicated is no longer used by The Bendix Corporation. Instead, all reader inquiries should be directed to Bendix-Pacific Division, The Bendix Corporation, 11600 Sherman Way, North Hollywood.

W. S. LEITCH

Bendix-Pacific Division
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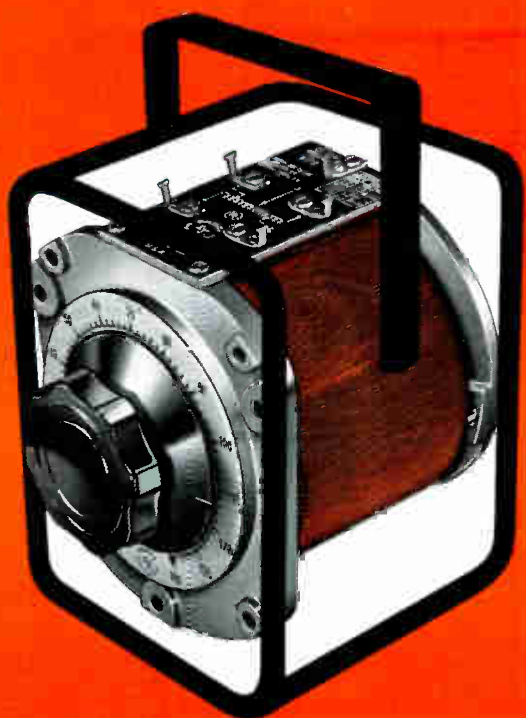

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120	2.8	0-140	Fixed Mtg.	VT4E
120	3.5	0-140	Portable	VT4F
120	3.5	0-140	VT4F w/gnd. in. & out.	VT4FC
120	3.8	0-120	Fixed Mtg.	VT4NE
120	4.75	0-120	Portable	VT4NF
120	4.75	0-120	VT4NF w/gnd. in. & out.	VT4NFC
120	6.0	0-140	Fixed Mtg.	VT8E
120	7.5	0-140	Portable	VT8F
120	7.5	0-140	VT8F w/gnd. in. & out.	VT8FC
120	6.0	0-120/140	Deluxe Portable	VT8G
120	6.0	0-120/140	VT8G w/gnd. in. & out.	VT8GC
120	8.0	0-120	Fixed Mtg.	VT8NE
120	10.0	0-120	Portable	VT8NF
120	10.0	0-120	VT8NF w/gnd. in. & out.	VT8NFC
120	20.0	0-120/140	Basic Case	VT20B
120	25.0	0-120	Basic Case	VT20NB
120	16.0	0-120/140	Fixed Mtg.	VT20E
120	20.0	0-140	Portable	VT20FC
120	16.0	0-120/140	Portable	VT20GC
120	20.0	0-120	Fixed Mtg.	VT20NE
120	25.0	0-120	Portable	VT20NFC

Input Volts	Maximum Output Amps.	Maximum Output Volts	Feature or Connection	Stock No.
			WITH METERS	
120	6.0	0-120/140	w/voltmeter, gnd. conn.	VT8GCV
120	6.0	0-120/140	w/volt. & ammtr., gnd. conn.	VT8GCVA
120	6.0	0-120/140	w/volt. & wattmtr., gnd. conn.	VT8GCVW
120	10.0	0-120	w/voltmeter, gnd. conn.	VT8NFCV
120	10.0	0-120	w/volt. & ammtr., gnd. conn.	VT8NFCVA
120	10.0	0-120	w/volt. & wattmtr., gnd. conn.	VT8NFCVW
120	16.0	0-120/140	w/voltmeter, gnd. conn.	VT20GCV
120	16.0	0-120/140	w/volt. & ammtr., gnd. conn.	VT20GCVA
120	16.0	0-120/140	w/volt. & wattmtr., gnd. conn.	VT20GCVW
120	25.0	0-120	w/voltmeter, gnd. conn.	VT20NFCV
120	25.0	0-120	w/volt. & ammtr., gnd. conn.	VT20NFCVA
120	25.0	0-120	w/volt. & wattmtr., gnd. conn.	VT20NFCVW
			TWO-IN-TANDEM ASSEMBLIES	
240	20.0	0-240/280	Series Conn.	VT20-2B
240	25.0	0-240	Series Conn.	VT20N-2B
120	20.0	0-120/140	Open Delta Conn., 3-Phase	VT20-2B
120	25.0	0-120	Open Delta Conn., 3-Phase	VT20N-2B
			THREE-IN-TANDEM ASSEMBLIES	
240	6.0	0-240/280	"Y" Conn. 3-Phase	VT8-3E
240	20.0	0-240/280	"Y" Conn. 3-Phase	VT20-3B
240	25.0	0-240	"Y" Conn., 3-Phase	VT20N-3B

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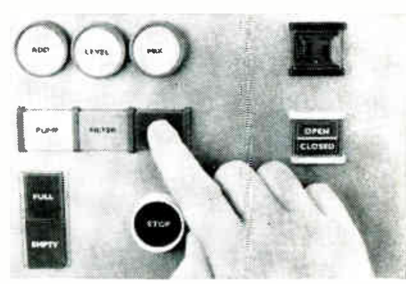

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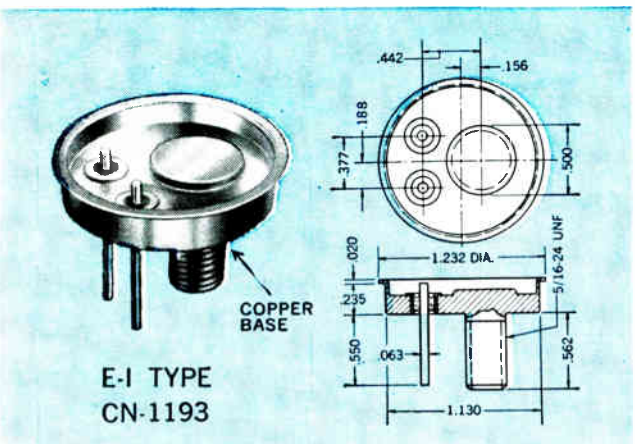

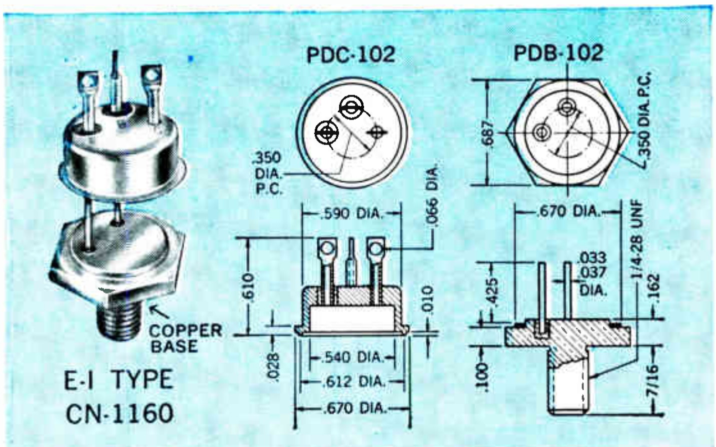

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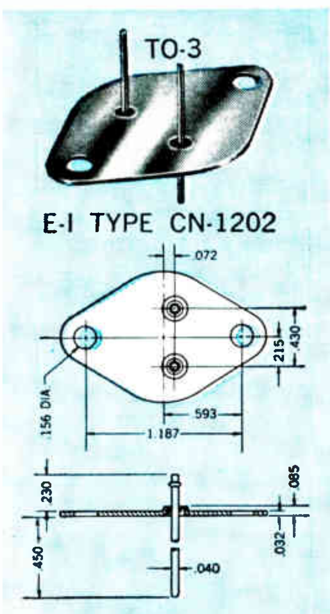

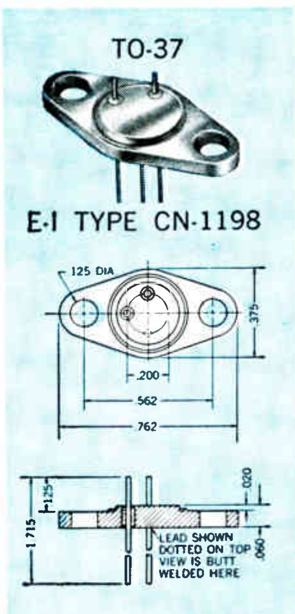

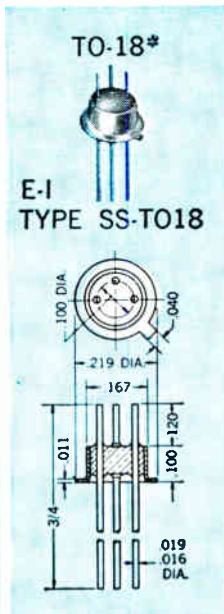

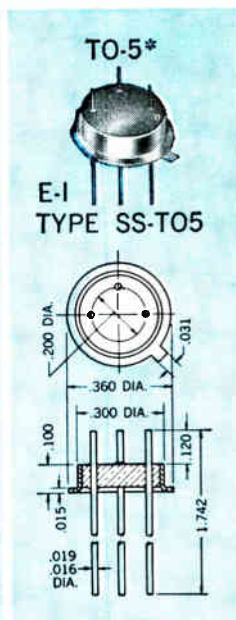

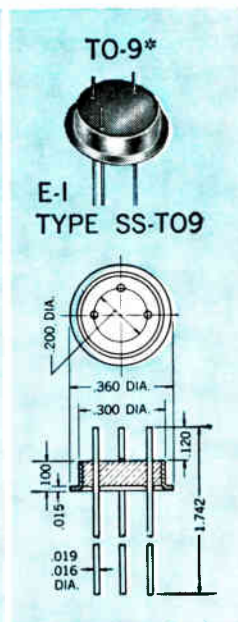

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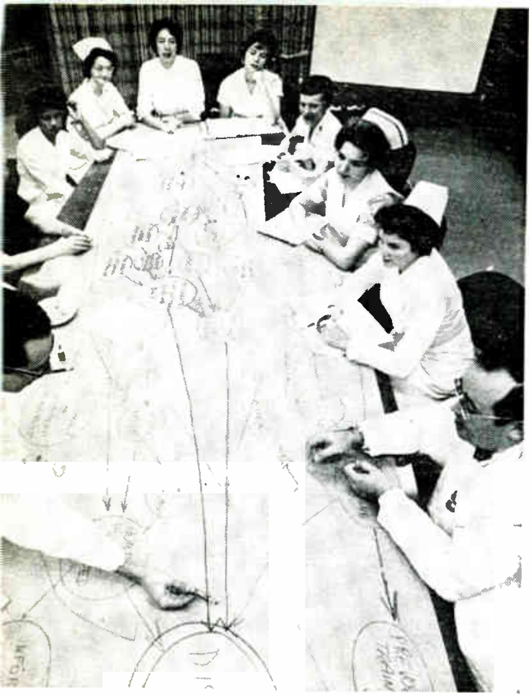

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Computers Pace Progress

Advanced diagnostic methods help salvage disease-wasted lives

By **HAROLD C. HOOD**
Regional Editor, Los Angeles

HOUSTON—Visitors to the Texas Institute for Rehabilitation and Research here are getting a preview of the "hospital of tomorrow." They seldom leave without feeling that TIRR's staff of 260, using digital computers and other electronic tools, are making giant strides toward overcoming the disabling effects of long-term illness and catastrophic injury.

Most of the 600 in-patients and 400 out-patients treated yearly at the Institute have been stricken with such serious illnesses as polio, cystic fibrosis, strokes, muscular dystrophy, and congenital defects, or have suffered spinal injuries causing partial or complete paralysis. Others have lost limbs from automobile accidents and other mishaps.

All cases are treated with the same basic approach—"medical humanetics." This phrase, coined at TIRR, refers to the integration of medical, psychological, and social factors for the optimum treatment and rehabilitation of the patient.

Hospital Computers—Use of computers in hospitals and clinics throughout the country is not new. Mayo Clinic analyzes electroencephalograms and the blood chemistry of mentally disturbed patients with computers. At Yale, scientific computers are helping researchers unravel mysteries associated with certain diseases of the eye, such as glaucoma. Installations of computers in city hospitals for diagnostic purposes are being reported in increasing numbers.

But TIRR is probably unique in the number of functions which have been relegated to its IBM 1401 and ancillary equipment. Areas into which computer usage has been extended include patient diagnosis, monitoring of illness, scheduling of services, medical record keeping, and fiscal control.

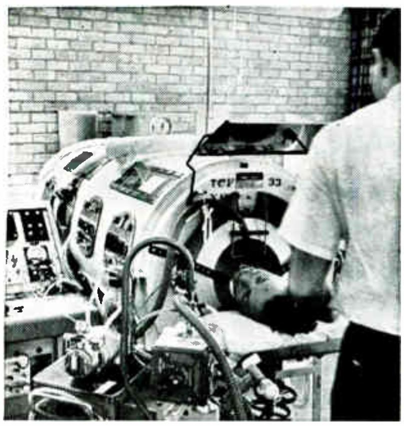
Information on patients, which is digitized and recorded on punched cards, falls into four general categories:

- Routine descriptive data such as date of admission, age, weight, height, marital status, educational level, occupation, etc.
- Data descriptive of the course of each patient's illness, such as results of laboratory tests, treatment rendered, running records of physiological parameters including temperature, respiration rate, blood pressure and heart sounds
- Case history data gleaned from interrogation into the patient's past illnesses, accidents, etc.
- Information resulting from special biomathematical and biostatistical procedures, such as multiple correlations and time-series analysis.

Combined with highly sensitive, modern instrumentation, this painstaking tabulation of data makes possible fast and frequent checks on patients and produces a new kind of quickly retrievable health record.

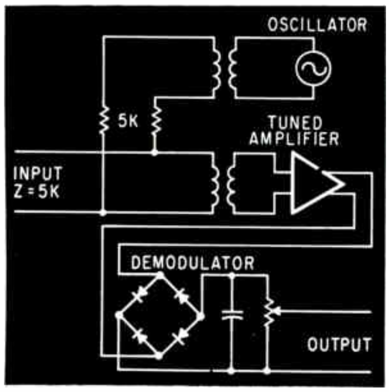
Knowing the Patient—Hard-driving, 41-year-old Dr. William A. Spencer, director of TIRR and named as one of "America's ten outstanding young men" by the U. S. Junior Chamber of Commerce in 1954 for his work in polio rehabilitation, points out that TIRR's instruments and records enable its staff physicians to review accurately what happens to a patient and to generalize from one patient or group of patients to help the next individual.

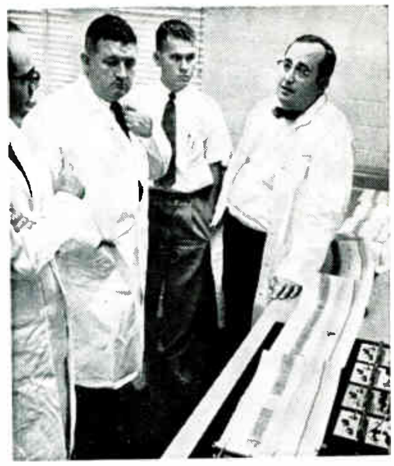
"This could be done by the country doctor with his little black bag when medical skills were rudimentary and the data few."



FOUR-CHANNEL RECORDER monitors temperature, pulse rate, respiration and blood pressure of patient in iron lung. He was completely disabled by cerebral aneurism

INSTITUTE'S DIRECTOR, Dr. William Spencer (right) and colleagues study real-time data transmitted from bedside of patient. Direct-line physiograph handles wide variety of diagnostic equipment inputs





IMPEDANCE PNEUMOGRAPH for measuring respiration rate. Electrodes on either side of patient's chest pick up variations in impedance caused by breathing

in Medical Humanetics

"The country doctor had the advantage of knowing his patients personally and observing them within the context of their families. But with the advent of our many new drugs, new tools for medical practice, and better understanding of the causes of physical disorders, help was needed to interrelate the vastly increased amount of data. Computer analysis techniques are providing this help."

High Cost, High Reward — Dr. Spencer admits that this type of intensive-care, research-oriented operation is expensive. Operating costs for the $1.3 million facility are running at $2.2 million per year, whereas the average hospital holds its annual costs to about one-third capital investment.

"But if our work here means that illnesses can be treated more effectively, and will enable us to make critical judgments about the care of the aged and the chronically ill, the use of our hospitals, and the training of young physicians and other health personnel, then the cost is certainly not exorbitant," he says.

An example of this optimization of medical treatment by means of computer-generated information at TIRR was the discovery that, in the treatment of spinal fusion, patients should be immobilized for exactly 12 weeks. The analyses of physiological data from several patients indicated that this period provided the best conditions for recovery and did not introduce any of the problems of overtreatment or prolonged immobilization.

In another computer-supported study, the centers of gravity of various parts of amputees' bodies are being determined from measurements of length, width and weight in an effort to design prosthetic devices which do not alter the individual's equilibrium.

Studies for NASA—Similarities in the physiologics of bed-fast patients and of future space travelers, destined to be confined in cramped quarters over long periods of time, was a factor in the recent award of a $66,950 study contract to TIRR by NASA. Included in the study will be the development and testing of instrumentation systems for applications to space exploration.

Because of its proximity to NASA's Manned Spacecraft Center, its familiarity with advanced computer analysis techniques, its well-equipped biochemical laboratories and special dietary capabilities, TIRR appears to be a good choice. Sophisticated new sensor and electrode techniques are being evaluated, signal conditioning devices applicable to space travel will be tested, and principles of transduction of physiological or medical events will be investigated.

The Institute is expected to provide NASA with an applied research facility and consulting capability and to integrate the basic findings of other research centers into needs of the manned space program. NASA data collecting and processing equipment has already been installed at TIRR in connection with an "immobilization" or bed-rest phase of the study expected to provide controlled experimental conditions. One part of the study will deal with the analysis of results of the introduction of a variable, such as exercise, after the immobilization period.

Associated with the Baylor University College of Medicine, TIRR is providing medical students with invaluable educational tools. Real-time physiological data is transmitted by direct wire from multiple-channel bedside recorders at the Institute to medical school laboratories half a mile away. Here the data is reproduced on recording physiographs, and students can view the patient by closed circuit tv.

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Peak One Cycle Surge Current (i_{surge})	18	15	15 amperes
Storage Temperature	← −65°C to +150°C →		
Operating Temperature	−65°C to +125°C	−65°C to +100°C	−65°C to +150°C

GENERAL ELECTRIC

KEYBOARD of computer that simulates actions of 100 pilots is used in British atc experiments

ALPHANUMERIC indicator driven by Elliott 502 computer updates airport controller's information

Multicomputers to Rule English Sky

British will hitch new radars to the computers for air traffic control

By **DEREK BARLOW**
McGraw-Hill World News

LONDON—An integrated military and civil air-traffic-control (atc) system is to be operational in Britain by 1968. It will use linked multi-computer systems installed at two atc centers in Northern and Southern England to provide information coverage of the U. K. and its approaches. The two computers, each with 20 to 30 million components, will process all flight information and radar data, and will provide special displays to both radar controllers and air traffic controllers.

The system is still experimental, but already civil radars suitable for data extraction are being installed and new military radars linked in. Under construction are broadband microwave links to feed radar surveillance data to the atc centers. The centers are to be operational before 1967 and the data processing system by 1968.

Even more exciting are future systems under consideration. At an R&D symposium at the Royal Radar Establishment, Malvern, computer control of radar-beam scanning was proposed by a government engineer and by W. Hersch, of E. M. I. Electronics.

Instantaneous position of the beam would be controlled from pulse to pulse and radar prf varied by the computer. The radar would spend most of the time tracking aircraft, not searching empty airspace. Beam-positioning flexibility allows four operating modes: surveillance, tracking, tracking command and interrogation.

In surveillance, the radar systematically searches the entire airspace and stores in the computer memory positional coordinates and velocity vectors of each aircraft detected. In tracking, the computer decides how frequently speed of each aircraft must be updated. Updating the rate controls the beam position so each aircraft is updated according to its importance in the traffic pattern. Thus data rate is no longer fixed by scanner rotation rate but is adjusted by the computer.

In tracking command, pulse-position-modulated signals go over the radar beam to the aircraft tracked Command signals could be fed directly to the aircraft's autopilot.

Britain's ATC System—In the atc system under development, digital techniques will be used to automatically accept, store and update aircraft flight data. Another section of the system will track automatically all aircraft in the area from primary and secondary radar information. The system's third task is to display data from remote radars, provide for intertrace marking and digitally labeled situation-plan presentations, and to provide crt tabular data displays.

In the labeled-plan display alphanumerics can be written at 20 μsec/character to annotate over 256 tracks. Category selection allows the viewer to choose aircraft type and heights.

The crt tabular display will present processed flight-plan information and radar data on a time sharing basis with facilities for strobing each display line and providing intermarking between the tabular plan-position displays.

Experiments Underway—While system guidelines are already laid down, experiments are underway to fill in details. A rundown follows.

System Reliability—To provide in the multicomputer concept the redundancy needed for flexibility and reliability, the system developers, Automatic Telephone and Electric Co., propose a central pool of storage and computer equipment. Each computer has a fast-access, medium-size instruction and working store and can transfer data to stores and other parts of the system. The computers operate "highway" system for high-speed long-distance signaling between subsystems. Transfer demands from the computers control random highway usage. Particular time slots are allocated to particular transfers.

Routining computers detect faults. Upon detection, a special program from a magnetic drum goes into the routining computers. The special programs, in a central store, can go into various computers as required so that effects of multiple faults only reduce the system operating rate and do not destroy system facilities.

Radar—Circular polarization and pulse compression are being actively investigated. The aim is to improve resolution and make 10-cm radar's all-weather performance as good as longer-wavelength systems operating at longer lengths.

A pulse-compression system being developed by Marconi Ltd. raises pulse powers without increasing transmitter peak power. Applied to the receiver, it improves discrimination. Transmitter frequency is swept within the 10-μsec long-period transmitter pulse. A dispersive delay line then selectively delays the frequencies within the swept pulse. Delaying the leading edge of the pulse until the back edge is received shortens the output pulse to 0.1 μsec and raises effective peak power. Gain is improved 17 db on rain signals and aircraft echoes are not reduced.

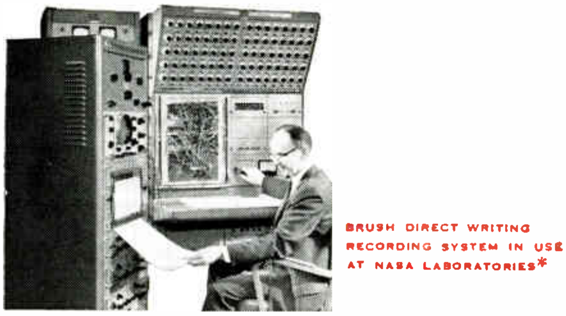
Displays—Tabular displays developed by Marconi's and Associated Electrical Industries Ltd. use high-speed electronic beam writing on a crt from a digital store.

Three-dimensional systems are under development. E.M.I. Electronics would picture on a crt a faint perspective view of a transparent cube representing the airspace. Aircraft positions, obtained from a computer store, appear as spots within the cube. Airways and other geographical features are also traced by the crt beam.

An experimental Standard Telephone and Cable system at Shannon airport is electromechanical. Projection indicators for each aircraft show height, air-lane position and flight attitude of aircraft.

Flight-Plan Processing—Due for experimental installation next fall is a system based on an Elliott 502 computer driving some 9,000 miniature alphanumeric indicators. Teleprinted flight plans, stored in the memory, are displayed at the airport atc console. If a conflict appears, the controller can try out solutions on the computer, which updates the display when a solution is found.

In another flight-plan presentation system, by General Precision Systems Ltd., a matric of styli energized by an encoder prints flight plans on paper strips and delivers them to the controller.



Brush uses Allen-Bradley Hot Molded Resistors because their reliability is established by years of experience

To insure consistently accurate readout of their recorder, Brush insists upon the ultimate in component reliability. For this reason, Allen-Bradley hot molded resistors are their standard for their direct writing recording system.

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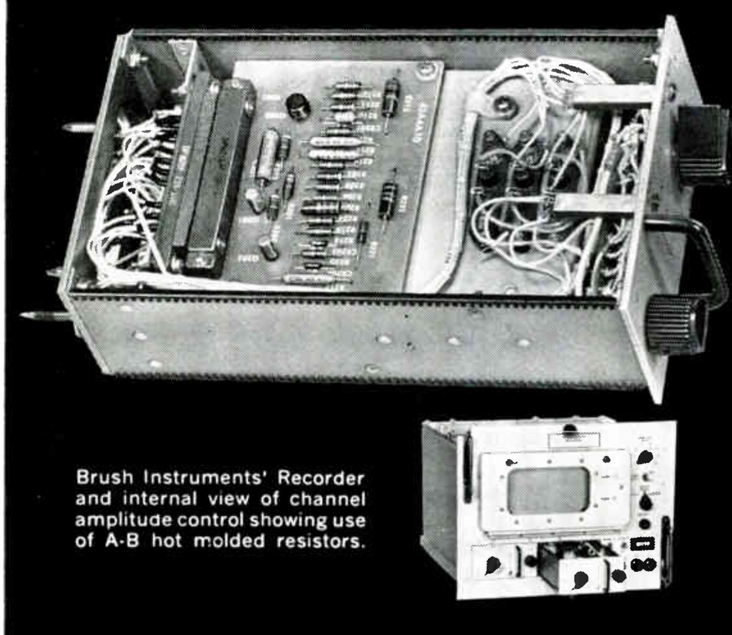
*At NASA, a Brush Recorder was used to design a control system which would bypass the pilot and project the plane into prolonged zero gravity flight.



Brush Instruments' Recorder and internal view of channel amplitude control showing use of A-B hot molded resistors.

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DOD Weighs a Sweetener

DOD MAY TAKE some of the sting out of cutbacks in defense procurement by sweetening its rules on civilian market research. Present regulations allow contractors to charge for long-range studies of military to civilian conversion, but not for studies aimed at determining the civilian market potential of a device or technique developed as a byproduct of defense R&D.

An amendment to section 15 of the Armed Services Procurement Regulations now under consideration would change this, a Pentagon spokesman told ELECTRONICS early this week.

At a recent gathering in Boston, where reports of the liberalization first circulated, defense marketing executives were told it could provide companies with the incentive to remain in the defense business.

"Too good to be true," said an industry official in the Boston area, where defense cutbacks and stretchouts are hitting hard.

Contractors should settle for this help from DOD, one speaker said, instead of pushing for such things as higher profits and return on equity, less reporting and scrutinizing.

Apollo Price Tag Too High?

BOSTON—D. Brainerd Holmes, until recently director of NASA's Manned Space Flight Program, last week disputed the $40-billion price tag put on the man-to-the-moon program. His own estimate would be $20 billion, although "this could be doubled to $40 billion if the management is not good." Holmes, now senior vice president of Raytheon, spoke here at a meeting of the Government Contracts Management Association.

He also denied that Apollo is a crash program, saying it has been fund-limited from the start and would cost more if it were either slowed down or speeded up.

House Committee Trims NASA's Space R&D Funds

WASHINGTON—The House Appropriations Committee has chopped the $5.7-billion budget NASA requested for this year to $5.1-billion. This is $250.8-million lower than Congress has authorized for the space program. The bulk of the cuts were made in space R&D. The committee voted $3.9 billion for this, $425.7 million lower than requested and $193.6 million below what had been authorized.

Expressing concern over the rise in government-financed R&D, the committee also eliminated all money for new programs presented by the National Science Foundation. It approved a $323.2-million budget for NSF, some $265.8-million lower than requested. The committee also cut $245,000 from a $1,025,000 request of the Office of Science and Technology, trimmed $700,000 from the FCC's $16.5-million request, and lopped $64.5-million from the Federal Aviation Agency's $815.1-million request.

New Laser System Tracks Target Angles

BALTIMORE—Optical equivalent of a bistatic tracking radar is being evaluated at Westinghouse's Air Arm division. The system consists of a pulsed-laser transmitter and an optical receiver. At present, it can measure line-of-sight angles in azimuth and elevation to a target with a single pulse; prf is 40 pps. In the experimental system, transmitter and receiver are separate units; each is aimed at the target by an operator. The transmitter illuminates the target and the receiver determines target angle from the reflection. Operation can be made automatic by coupling the two units by a tracking servo, Westinghouse said. With modifications, the system could also be used for ranging. Range is more than 1 mile.

Nike-X Program Gets $213-Million Boost

WESTERN ELECTRIC has been awarded a $213,385,000 incentive-type contract for continued R&D on the Nike-X. The contract—covering development and testing of the three-stage Nike Zeus, the Sprint, and phased-array radar—is the largest single missile contract ever awarded by the Army, says the Pentagon. Subcontractors include Avco, Cornell Aeronautical Laboratories, Douglas Aircraft, GE, Martin, Sperry Rand, Raytheon, and Sylvania.

Laser-Operated Display Called Practical

NEW YORK—A practical laser-operated display unit will be developed within a few years, predicts A. D. Rugeri, of Rome Air Development Center. At the East Coast Symposium of the Society for Information

Display last week, he said a laser beam would be used in place of the cathode-ray beam in something like a huge crt, with a room-sized screen.

Two techniques are under considerations active-screen, where the laser indexes only, and passive-screen, where the laser provides scanning and illumination. Biggest problem is how to deflect the laser beam. So far, using electro-optical techniques, deflections are only a fraction of a degree.

Research Head Hits Reliability Program

PALO ALTO, CALIF.—John R. Pierce, director of research-communications, Bell Telephone Labs, deplored the "nonsense" in the field of reliability, at the AIAA meeting last week. Statistics, redundancy and special reliability programs, he said, won't take the place of good components. Uniform, well-controlled, realistic tests are essential before a component can be considered part of a reliable system. Avoid novelty, except where necessary, he advised. The trouble with our space effort, he claims, is that it is goal-oriented rather than fact-oriented. The lag in satellite communication is due to the uninspiring nature of the problems, he added.

Optical Scanner Speeds Credit-Card Accounting

IBM has developed an optical scanner designed to channel the rising flood of credit-card sales (more than $1 billion a year in the petroleum field alone) into a smooth-flowing accounting operation. Into the IBM 1282 optical reader card punch are fed card-stock copies of sales forms received from the field. The 1282 can read preprinted information, account numbers imprinted by credit cards, and dollar amounts entered on the sales slip as small horizontal pencil marks, and transfer this data to punched cards for high-speed data processing. The 1281, which can process either 80 or 51-column cards up to 200 a minute, sells for $72,000 and rents for $1,550 a month. Deliveries are scheduled for the first quarter of 1965.

Phonon Emission Hints Tunable Laser Possible

NEW PHENOMENON that might lead to continuously tunable optical masers has been observed at Bell Telephone Labs. L. F. Johnson, R. E. Dietz and H. J. Guggenheim report the simultaneous emission of phonons in optical maser oscillations from nickel-doped magnesium fluoride. This is believed unique since all known solid-state optical masers utilize purely electronic transitions in solids.

Because the phonon portion of the emission spectrum is a smoothly varying function of wavelength, such a maser theoretically should be continuously tunable over a frequency range that constitutes an appreciable part of the emission spectrum, Johnson told ELECTRONICS. There is no basis, however, for thinking the phonon emission is coherent he said. Details of the report appear in the current Physical Review Letters

MEETINGS AHEAD

SOCIETY OF MOTION PICTURE-TELEVISION ENGINEERS CONVENTION, SMPTE; Somerset Hotel, Boston, Mass., **Oct. 13-18.**

AUDIO ENGINEERING SOCIETY FALL CONVENTION—EXHIBIT, AES; Barbizon-Plaza Hotel, New York, **Oct. 14-18.**

NEW YORK CONFERENCE ON ELECTRONIC RELIABILITY, IEEE; United Engineering Center, N. Y., N. Y., **Oct. 18.**

EAST COAST CONFERENCE ON AEROSPACE-NAVIGATIONAL ELECTRONICS, IEEE-PTGANE; Emerson Hotel, Baltimore, Md., **Oct. 21-23.**

NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION ANNUAL MEETING, NEMA; Edgewater Beach Hotel, Chicago, Ill., **Oct. 21-24.**

NATIONAL ELECTRONICS CONFERENCE, IEEE, IIT, Northwestern University, University of Illinois; McCormick Place, Chicago, Ill., **Oct. 28-30.**

ELECTRON DEVICES MEETING, IEEE; Sheraton Park Hotel, Washington, D. C., **Oct. 31-Nov. 1.**

17TH NORTHEAST ELECTRONICS RESEARCH-ENGINEERING MEETING, New England Sections IEEE; Commonwealth Armory and Somerset Hotel, Boston, Mass., **Nov. 4-6.**

RADIO FALL MEETING, IEEE, EIA; Hotel Manger, Rochester, N. Y., **Nov. 11-13.**

FALL JOINT COMPUTER CONFERENCE, AFIPS, IEEE, ACM; Las Vegas Convention Center, Las Vegas, Nev., **Nov. 12-14.**

MAGNETISM-MAGNETIC MATERIALS ANNUAL CONFERENCE, AIP, IEEE-PTGMTT; Chalfonte-Haddon Hall, Atlantic City, N. J., **Nov. 12-15.**

NUMERICAL CONTROL PRESIDENTS' CONFERENCE, NCS; Hotel Plaza, N. Y., N. Y., **Nov. 14-15.**

TECHNICAL WRITING WORKSHOP, University of California Extension Center; San Francisco, Calif., **Nov. 18-19.**

ENGINEERING IN MEDICINE AND BIOLOGY ANNUAL CONFERENCE, IEEE, ISA; Lord Baltimore Hotel, Baltimore, Md., **Nov. 18-20.**

ADVANCE REPORT

SCINTILLATION AND SEMICONDUCTOR COUNTER SYMPOSIUM, IEEE, AEC, NBS; *Hotel Shoreham, Washington, D. C., Feb. 26-28, 1964; Dec. 1 is deadline for submitting abstracts to W. E. Higinbotham, Chairman, Program Committee, Brookhaven National Laboratory, Upton, Long Island, N. Y. Topics include photomultipliers and image tubes, scintillators and scintillator combinations, semiconductor and special detectors, circuitry and applications, multidimensional data acquisition, presentation track imaging complex detector and data processing systems, radiation detection in space.*

Mitre Steps Up Size of NMCS Staff

MITRE is planning to increase its staff over the next nine months in support of the Defense Communications Agency's National Military Command System (p 20, April 26). The 1964 contract is expected to be about $1 million. C. A. Zraket, formerly director of Mitre's system planning, research, and advanced planning, will head the new group in Washington, D. C.

Weathermen Nix Nimbus

WASHINGTON—In the wake of last week's cancellation of the operational Nimbus satellite system, gravity-gradient stabilization (p 16, Aug. 23) is now seen as a leading contender for attitude control of a new satellite that will replace Nimbus. Weather Bureau dropped Nimbus because of its $80-million annual cost and short, one-year life span. Construction of the Nimbus ground station at Nova Scotia was also suspended. Cancellation of the program came after more than $100 million had been pumped into it, $45.6 million by the Weather Bureau.

Atomic power and redundancy will probably be included in the new operational satellite, to be designed by NASA to operate at low cost for more than three years. The gravity stabilizer would have to be a three-axis system because of weather satellites' gridding requirements. As an interim system, however, the Weather Bureau will use the modified, wheel-configured Tiros (p 7, May 31), to be operational within two years. Two Nimbus R&D satellites are not affected by the decision.

Economist Calls R&D Key to Electronics Growth

BOSTON—Preliminary results of a study by the McGraw-Hill Economics department indicate electronic industry sales will grow by 40 percent in the next seven years, Douglas Greenwald, chief economist, reported to the Financial Executives Institute this week. He estimated 1963 sales at $16 billion.

Pointing out that two thirds of the industry's 1962 sales were in products developed since 1952, he urged that financial executives of electronics companies not judge R&D's values by concepts applicable to slower-moving industries.

In electronics, Greenwald said, they should familiarize themselves with research trends, form an alliance with research personnel and "go aloft with the scientist rather than holding him down"

Coding Doppler Return Avoids Enlarging System

PALO ALTO, CALIF.—Increases in spectrum bandwidth at orbital velocity of 25,000 feet sec and 600,000-foot altitude indicate that doppler navigators should have a complex frequency tracker or a larger antenna, it was brought out at last week's AIAA meeting here. Both are undesirable in spacecraft; antenna size becomes impractical, complexity raises weight. There is also loss of peak power amplitude.

R. G. McManus and J. C. Rand, of Raytheon, reported on an alternative that showed promise in flight tests of a breadboard system. They alter spectral bandwidth by modulating transmitter frequency, thus coding the ground return. Recommended modulation waveform is a linear sawtooth modified by superimposing a slight parabolic component. Signal band width was reduced about 40 to 50 times.

Pocket Transceiver Answers Telephone

NEW YORK—A remote-telephone extension that allows a telephone subscriber to use his phone even when he is a mile away was demonstrated last week by the Chromalloy Corp. When the phone rings, a stationary transceiver under the telephone buzzes a pocket-size transceiver carried by the user. By pressing a button, he can signal a mechanical arm to release the telephone's cradle buttons, putting the stationary transceiver in operation. Chromalloy would not comment on price except to say the device would be within the range of present telephone accessories.

IN BRIEF

UNITED AIRCRAFT is developing a computer-controlled processor for manufacturing microelectronic circuit devices, under a $630,000 Air Force contract. A laser beam and high-intensity electron beams will provide the prime energy sources.

ONR SATELLITE, scheduled for launch early next year by NASA, will seek evidence to confirm the existence of a "horn" cutting across the Van Allan radiation belt and penetrating the earth's atmosphere near the North Pole.

TV CHANNEL 37 (608 to 614 Mc) has been reserved by FCC for exclusive use of radio astronomy until the beginning of 1974. Canada and Mexico will be asked to make similar reservations.

MARTIN received a $27,739,662 Army contract for additional engineering services for the Pershing weapons system.

FAIRCHILD crash-data recorders for Lockheed C-141 jet transport were ordered by the Air Force. The contract calls for 206 of the recorder systems at a total cost of $753,033.

PERKIN-ELMER has been awarded a $276,500 NASA contract for five Aerobee rocket camera and experimental instrument packages to study nightglow and nebular emission.

GENERAL PRECISION has received $1-6-million Navy contract for radar navigation systems for anti-submarine, attack and carrier-based early warning aircraft.

RAYTHEON has received contracts totaling $12.4 million for work on the Hawk missile system.

GT-1, the first Gemini-Titan launch vehicle, is completing factory check-out at the Martin Ga. plant in Baltimore and will be delivered to Cape Canaveral within 30 days. McDonnell delivered the first capsule last week to the Cape.

SYSTRON-DONNER has received a $1.8-million Army contract for guidance system components for the Lance missile. The Lance series is expected to total $20 to $23 million for Systron-Donner over the next nine years.

ITT is planning a $30-million expansion program in Europe.

Senate Report Wants Contracts Channeled Into Distress Areas

Shift in government buying to favor electronics contractors and R&D firms in less prosperous areas of the country will be coming in the next two years if Hubert H. Humphrey (D-Minn.), Senate majority whip, has his way. As chairman of a Senate Small Business Committee subcommittee, Humphrey has just issued a report recommending new procurement policies to "balance the pattern of defense spending."

Bluntly, this means keeping more electronic, missile and R&D contracts from going to the West Coast. He says the shift in that kind of procurement to the West Coast has cost Ohio, Indiana, Illinois, Michigan and Wisconsin $6.1 billion a year in defense contracts, resulting in "the loss of hundreds of thousands of jobs and the growth of new distressed areas."

Humphrey's recommendations include: set aside all of particular procurement contracts for a distressed region, not just a portion; send task forces to help midwestern and other universities get more R&D contracts; place more subcontracts in distressed areas by requiring prime contractors to report names and locations of their subcontractors; require special clearance before allowing new bases and government facilities outside distressed areas; allow government purchasing agents to buy at "point of origin" to give firms in distressed areas a break in competition with sources of supply nearer the point of delivery.

Early next year, defense officials are expected to testify on these proposals before Humphrey's subcommittee.

Satellites to Seek Breaches Of A-Test Ban

First two Vela Hotel weapons-detection satellites are being readied for launch aboard an Atlas Agena from Cape Canaveral. Ten of the satellites will be launched this fall and early next year, to provide a system for detecting possible violations in outer space of the nuclear test-ban treaty. Each 485-lb satellite will carry 17 solar-powered radiation detection instruments: 6 gamma, 10 x-ray and 1 neutron detector. They will go into 60,000-mile orbits and will be separated from each other by 140 degrees.

Air Force is now beginning to set up the space telemetry network. The first data-receiving station for the Vela Hotel satellites is being built on one of the Seychelle Islands in the Indian Ocean.

NASA Rakes Industry for Mercury Work

In a major review of Project Mercury at the Manned Spacecraft Center in Houston, industry was raked harshly by NASA for sloppy workmanship on space projects. NASA says industry delivered spare parts that were 50 percent defective, space capsules with more than 500 defects, improperly soldered electronic parts and so on. On the average, 10 components malfunctioned on each of the six Mercury capsules, NASA reported. NASA says that space reliability needs are higher than for any program ever undertaken, and that industry must improve workmanship. The Houston meeting came on the heels of a new incentive contracting policy (ELECTRONICS, p 20, Oct. 4) aimed at upgrading contractor performance.

SST Hearings Get Underway

Senate Aviation Subcommittee will explore, in hearings starting October 16, the technical problems and economic risks involved in development of a supersonic transport plane. Major issue is how much industry should pay of the $1-billion development cost. Several new automatic flight control systems are being considered for the SST (ELECTRONICS, p 7, June 14, 1963).

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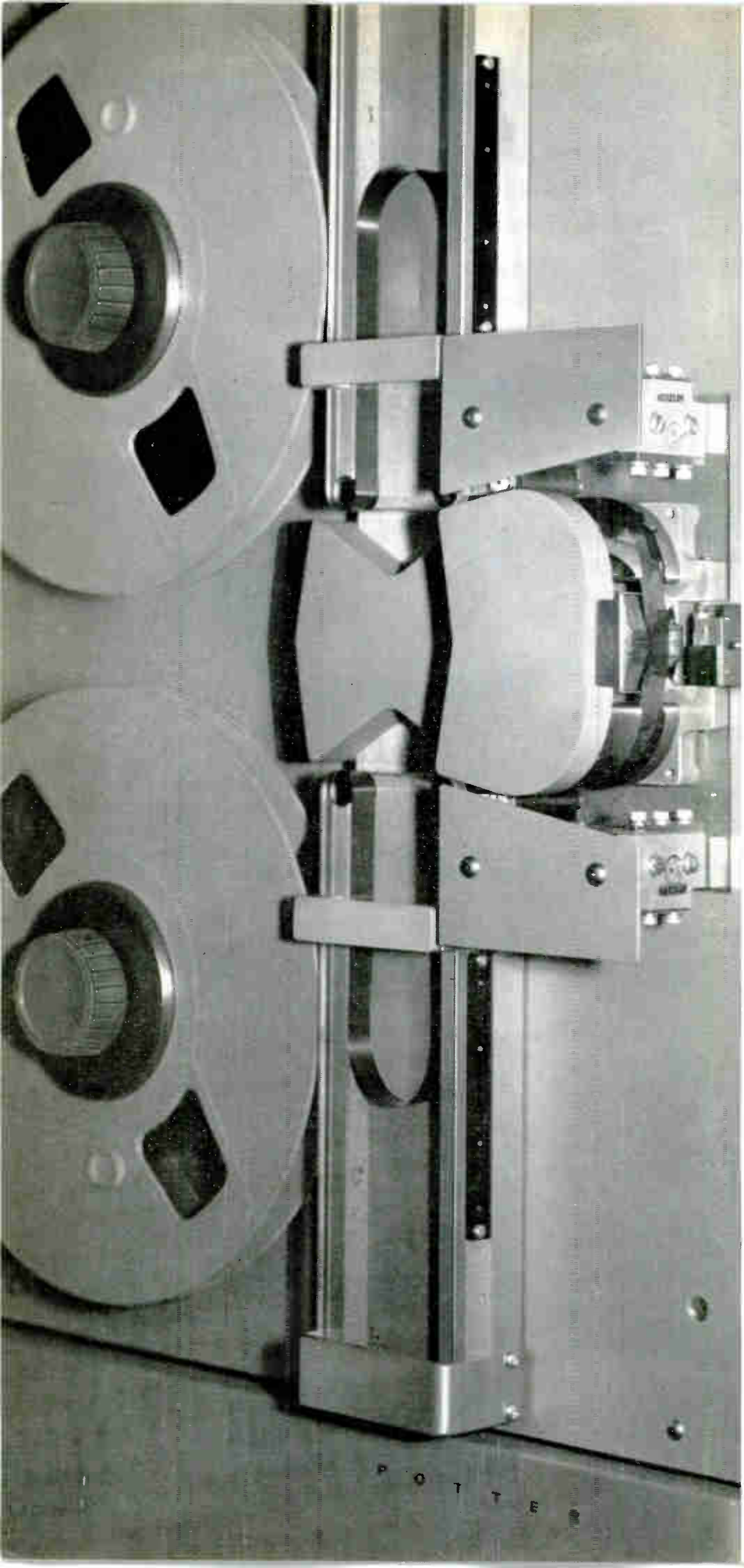
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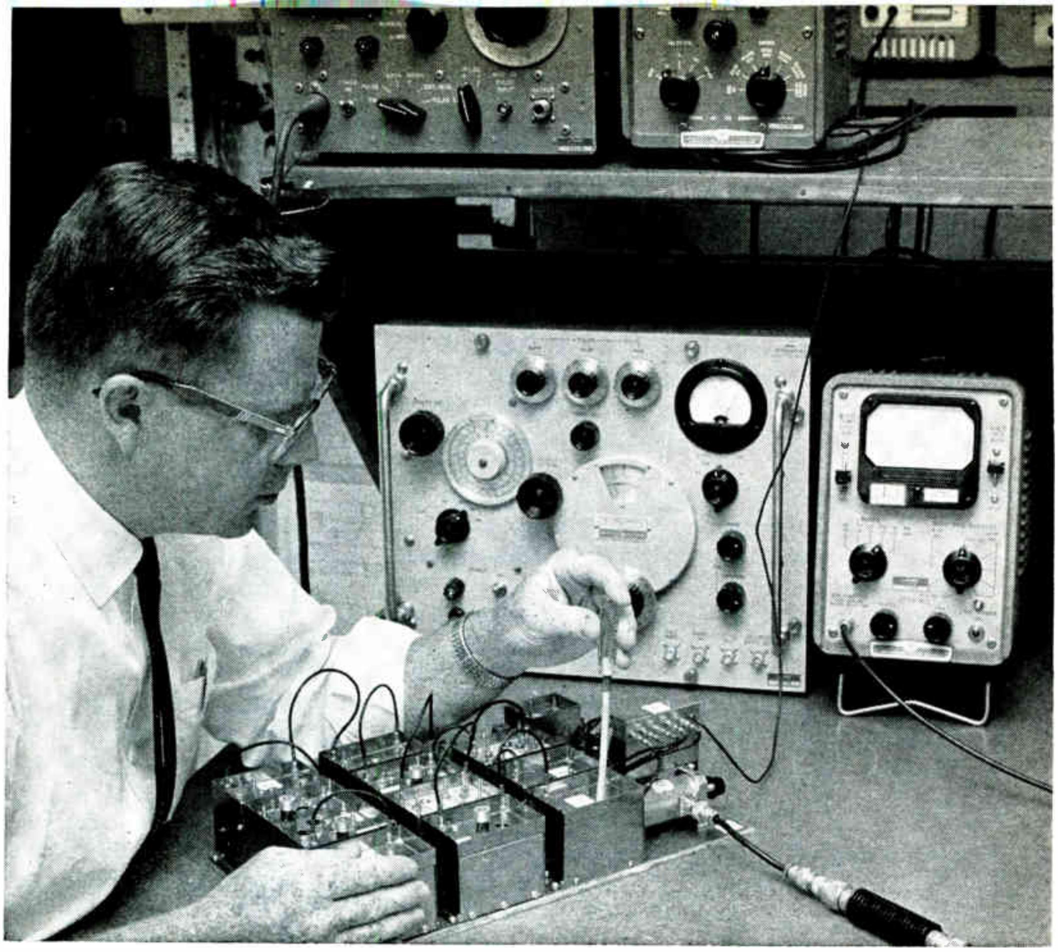

MULTIPLIER TUNING requires spectrum analyzer or selective receiver and each stage should be tuned separately before cascading

By **D. O. FAIRLEY,**
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HOW TO DESIGN

Solid-State Microwave Generators

New look in microwave generators is solid-state. Varactor diodes allow frequency multiplication to Gc bands without prohibitive power loss, may replace klystrons for some applications

A STRAIGHTFORWARD approach to high-power high-frequency generators is to start with high power and low frequency and multiply, using tuned circuits and keeping circuit losses as low as possible. The variable capacitance diode—or varactor—is particularly useful in such circuits, but its nonlinearity leads to special design problems.

Electrical circuits containing nonlinear reactances are analogous to mechanical problems of forced vibrations with a nonlinear restoring force. For a simple system consisting of a mass M, nonlinear spring, small damping factor, and applied periodic force, the differential equation is

$$M \frac{d^2x}{dt^2} + B \frac{dx}{dt} + F(x) = F_0 \cos \omega t$$

where x is displacement and $F(x)$ is restoring force.

A procedure for solution where $F(x) = Kx - \delta x^3$ is to approximate successively using an assumed function $x = a\cos \omega t$ for the first approximation.[1]

Results for a specific set of system constants and various driving forces are shown in Fig. 1. No generalization of the problem can be made since each set of system constants gives a new set of curves and—because of the nonlinearity—solutions to the differential equation are not additive.

The solution[2] using the even restoring function $F(x) = Kx - \delta x^2$ which would correspond to an abrupt junction varactor is similar to that shown in Fig. 1. The shapes of the curves have been experimentally verified.[3]

The notable aspect of the curves is that large driving forces produce a multivalued function. In general, any curve with more than one value is unstable; in this case the circuit has two possible amplitudes for a given frequency.

For a frequency multiplier using a nonlinear reactance, the problem is further complicated in that a single differential equation will not suffice to represent the circuit. A set of equations is required to deal with coupling between input, output and idler circuits (if present). Analysis of the varactor[4] without regard to any particular circuit, however, has led to asymptotic operational limits for abrupt junction varactors that can be used in circuit design.

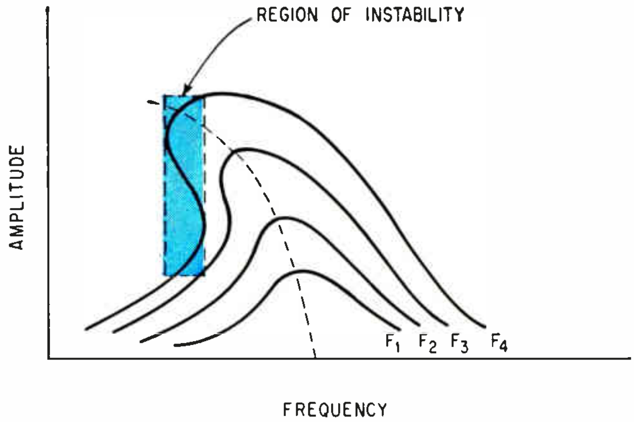
Idler Terminations—Conversion efficiency improvement with idler terminations in multipliers of order greater than two has been shown matematically and verified empirically.[7, 8, 9] Mathematically output power at the nth harmonic is proportional to some power of the (n-1)th, (n-2)th, etc., currents through the diode. Reactive terminations maximize these currents through resonance and limit power dissipation to the spreading resistance of the diode. Table I shows the necessary idler currents for high-order multiplier circuits.[9]

Diode Selection—The optimum operating point on a diode's capacitance-voltage characteristic is determined by its voltage breakdown (V_b), specified capacitance and spreading resistance.

For an abrupt junction diode operating to the limit of forward conduction, the optimum bias point[4, 8] is approximately $V_b/3$. Experiments have shown that $V_b/3$ is a reasonable bias for both abrupt and graded junction diodes.

High-frequency operation requires a diode with a high cutoff frequency, which dictates low spreading resistance and low capacitance. Multiplier efficiency falls off rapidly if the ratio of cutoff frequency (at the operating capacitance) to output frequency becomes less than ten.[10, 11]

The low capacitance required for high frequency is incompatible with high-power operation. Power-handling capability is proportional to diode capacitance and its breakdown voltage squared. A compromise is usually made that will allow a reasonably high cutoff frequency and a large enough breakdown voltage to handle the expected power. The circuit design value of the average capacitance then corresponds to $V_b/3$.



ELECTRICAL CIRCUITS containing a nonlinear reactance show a double-valued characteristic if the driving signal becomes too large—Fig. 1

Bias—Thus a specific operating point is desirable and can be obtained through either fixed or self-bias or a combination. Fixed bias is provided by a low-impedance voltage source through an r-f choke or bypass capacitor, self-bias by charge build-up across an RC circuit from rectified curent. One useful combination bias is a large resistance in series with the fixed bias source. Self-bias developed across this resistance is adjusted with the fixed-bias source. The series resistance prevents accidental high currents through the diode from the source. For high-power operation, fixed bias alone does not seem workable. No protection for the diode is provided without a series resistance.

Multiplier Circuits—In lumped circuits operating at high power in the lower uhf range, a shunt diode configuration is recommended. The circuit allows direct heat sink connection for maximum heat transfer.

A basic circuit for doublers, triplers, and quadruplers is shown in Fig. 2A. The circuit is doubly resonant for doublers and triply resonant for triplers and quadruplers.

For the doubler,[12] with the element values as shown in Table II, the average capacitance of the diode is chosen at $V_b/3$ to be C_o. Series inductance L_o resonates the diode's capacitance at the geometric mean frequency of input and output, which is $\omega\sqrt{2}$. An input trap prevents second harmonic power from reach-

Idler Terminations in High-Order Multipliers—TABLE I

Multiplier	Required idler order for high efficiency
3	2
4	2
5	2, 3 or 2, 4
6	2, 3 or 2, 4
7	2, 3
8	2, 4
10	2, 3, 5
16	2, 3, 4, 8
32	2, 4, 8, 16

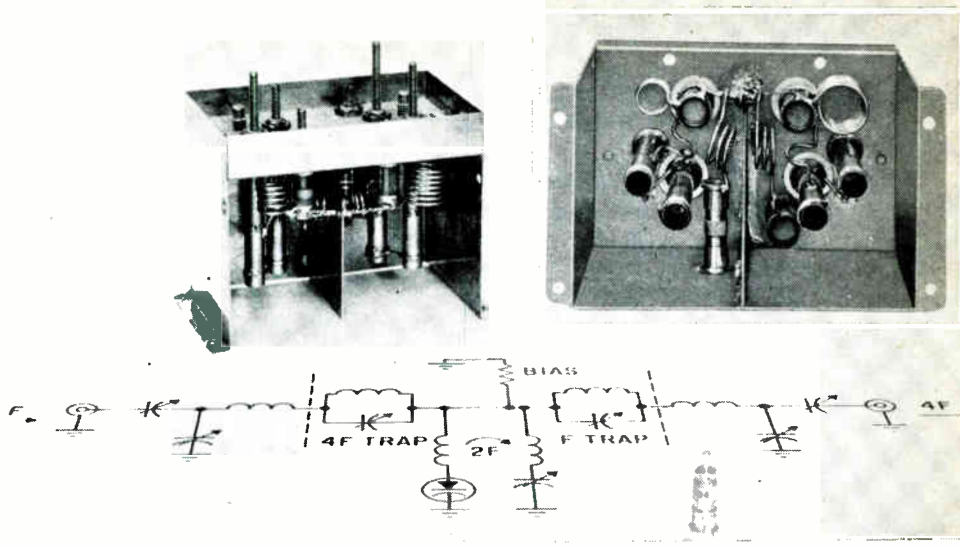
Element Values for Standard Lumped Multiplier—TABLE II

Element	Doubler	Tripler	Quadrupler
C_0	C_d	$2C_d$	$2C_d$
L_0	$1/2\omega^2C_o$	$1/4\omega^2C_o$	$1/4\omega^2C_o$
C_1	$4C_o/3$	$9C_o/10$	$16C_o/45$
L_1	$3L_o/2$	$40L_o/9$	$45L_o/4$
C_n	$2C_o/3$	$C_o/6$	$4C_o/45$
L_n	$3L_o/4$	$24L_o/9$	$45L_o/16$

A COMBINED OPERATION

The nature of the semiconductor beast is to be a low-power, low frequency, low-input-impedance device. Yet the advantages of solid-state devices are so attractive that device manufacturers and circuit designers have never stopped trying to push the limits upward.

Varactor diodes used in resonant multiplier circuits to produce all-solid-state microwave generators are a late example of the combined approach. Solid-state generators can now deliver 200 mw at 3.2 Gc or 15 watts at 100 Mc. There is still a long way to go but the numbers are already satisfactory for many microwave applications



FREQUENCY quadrupler and schematic

ing the generator; an output trap prevents the fundamental frequency power from reaching the load. The input circuit will be series resonant at ω and the output circuit will be series resonant at 2ω. The double resonance leaves only a pure resistance to be matched to the generator and load. In addition, the inductance in series with the diode presents a high impedance to other harmonics.

For tripler and quadrupler operation, the shunt arm of the circuit is modified as shown in Fig. 2B to be two arms, both of which are resonant at the second harmonic idler frequency. Since each arm is resonant, the series combination is also resonant and an idler path is provided around the loop. The series traps are again chosen such that the complete circuit is resonant at both input and output frequencies.

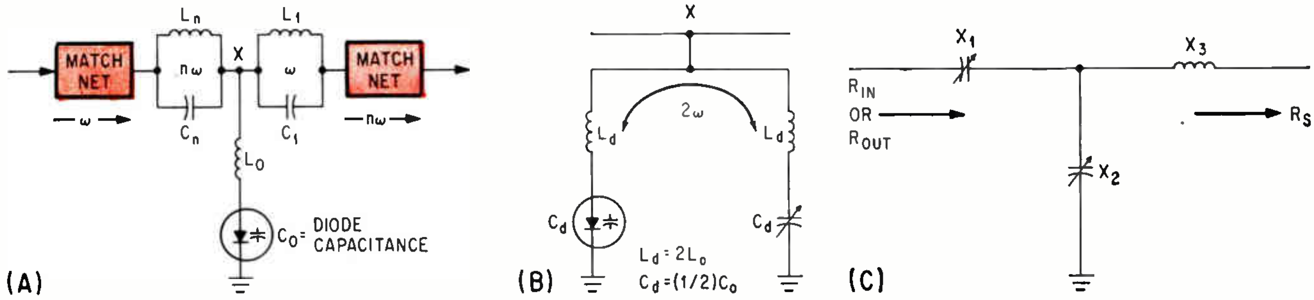
Two alternatives are available in the modified shunt arm of the circuit. Both arms are identical in value but one capacitor can be a diode and the other an idler tuning adjustment; for high-power operation both arms could have diodes. If both arms contain diodes, one of the coils should be tuned to provide an idler adjustment. If it is impractical to tune one of the coils, an additional trimmer capacitance should be included.

Tuning procedure for the lumped multiplier is.

(1) Temporarily impress the bias voltage upon the diode through a resistor or choke
(2) Using a low level signal generator at the input, tune the input and output traps for a null at their respective frequencies at the output
(3) Tune the idler circuit (if used) for a null at its frequency
(4) Restore the bias circuit to its intended configuration and impress full drive power on the input
(5) Tune the matching networks for maximum output power
(6) Retune the idler slightly for maximum power and stable response. Retuning the input and output traps should not be necessary.

Matching Networks—Because of the nonlinearity of the multiplier circuits, the exact value of the input and output resistance to be matched is unknown. From qualitative reasoning, however, a value greater than the spreading resistance is to be expected for the input, since a portion of the input power must be dissipated in the load. As the frequency increases and the diode Q is reduced, then the input resistance should approach the spreading resistance of the diode. (Also, the conversion efficiency should approach zero.) Input and output resistances for an abrupt junction varactor when driven between the limits of breakdown and forward conduction have been calculated.[4, 8]

As a starting point, the matching networks can be designed to match the spreading resistance of the diode—with adjustment capable of matching a larger



LUMPED DOUBLER circuit (A) uses resonant circuits to block $n\omega$ from input and ω from output. Doubler is converted to tripler or quadrupler by substituting circuit (B) for L_o and diode at point **X**. Matching network (C) fits a wide range of multiplier circuits—Fig. 2

value—and then adjusted for optimum power and efficiency. This technique has produced acceptably good results.

The matching network[13] shown in Fig. 2C has advantages in this situation. Because of its three-elements, the coil need not be precisely chosen; a wide range of real impedances can be matched and a d-c block is inherent in the circuit.

Coaxial Multipliers—Even-order multipliers in coaxial circuits are facilitated by the inverse relationships in resonant lines at even integer harmonic frequencies. The circuits described are a coaxial doubler and quadrupler using a series-diode configuration.

In the simple coaxial doubler of Fig. 3A, the input $\lambda/4$ short stub is an open to ω and a short to 2ω; the output $\lambda/4$ open stub is an open to 2ω and a short to ω. The matching networks simultaneously cancel the varactor susceptance and match the input and output resistances. Bias is provided by a large resistance attached to the center conductor and passing through the outer conductor of the coaxial line.

A coaxial quadrupler is shown in Fig. 3B, with current paths for the fundamental, second harmonic idler and fourth harmonic output frequency as shown. The $\lambda/4$ short-circuited stub (at the input frequency) provides an open circuit for the fundamental and a short circuit for the second and fourth harmonics; the $\lambda/4$ open stub provides a short circuit to the fundamental and an open circuit to the fourth harmonic; the $\lambda/8$ open stub provides a short circuit to the second harmonic and an open circuit to the fourth harmonic. Thus, input current is not allowed to flow through the load, output current cannot pass back to the source, and a shorting path is provided for the second harmonic idler curent on either side of the varactor. Matching networks cancel the susceptance and match diode resistance at the input and output frequencies.

In both the doubler and quadrupler circuits, the $\lambda/4$ short and open stubs can be set independently of the varactor used. The $\lambda/8$ stub in the quadrupler is then used for idler tuning. In most cases, the impedance of the input and output circuits is within the matching range of a double stub tuner. Tuning procedure for the coaxial multipliers is similar to that given for lumped circuits. Using the basic coaxial circuits described, stripline multipliers have also been built successfully.

Spurious Enhancement—If a carrier signal and a spurious signal separated by some frequency difference from the carrier are both impressed upon a nonlinear doubler, the output will contain twice the carrier frequency (which is desired) and a new spurious signal having the same spacing from this new carrier. This new spurious signal is the sum of the original carrier and original spurious signal. Also, the relative amplitude of the original carrier with respect to the spurious signal will have been degraded at the output of the doubler. This is known as spurious enhancement. Thus the doubler is actually a better mixer than a multiplier.

The generalized expression for spurious enhancement, which is approximately correct for all types of multipliers, is

$$\text{Spurious Enhancement} = 20 \log R \text{ (db)}$$

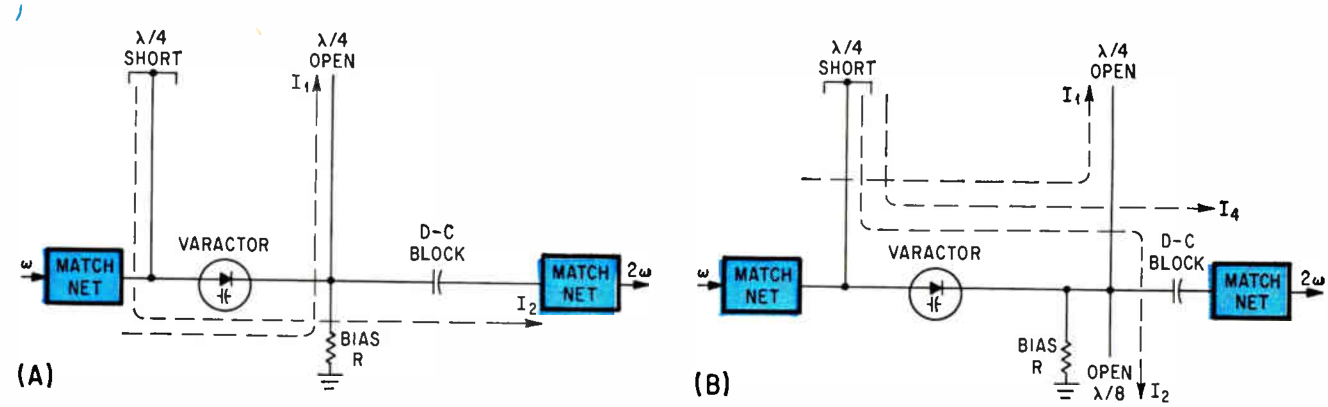
where R is the multiplication ratio.

There is no way of avoiding the production of spurious signals in a multiplier chain. The first multiplier in the chain will produce the spurious signal that will be closest to the carrier and this frequency spacing will be maintained to the output. If the desired spurious rejection at the output is X db, the filtering through the multiplier is Y db, and the spurious enhancement is Z db, then the suppression (or filtering) required out of the first multiplier is $(X - Y + Z)$ db.

Relaxation Modes—One of the difficulties in the development of solid-state generators has been the suppression of relaxation modes of oscillation in the high-power multipliers of a chain. The relaxation oscillation establishes itself in the varactor bias circuit under the large signal conditions and severely modulates the desired harmonic of the input voltage.

The oscillation is believed to be caused by a negative resistance in the diode I-V characteristic, which is induced by the r-f drive on the diode. The magnitude of the effect depends on the amplitude of the r-f drive voltage and the particular diode (or diodes) in the multiplier. Since the amplitude of the r-f driving signal itself depends on the circuit tuning, the difficulty is usually found during tuneup, making this a more difficult process.

Several theories about the negative resistance effect have been offered.[14, 15, 16, 17]



COAXIAL DOUBLER (A) and quadrupler (B) use open and shorted stubs as tuned circuits to provide input and output isolation—Fig. 3

The problem of spurious oscillation is increased by cascading. If the effect occurs in an early stage, spurious enhancement of the sidebands generated by the relaxation oscillations takes place in successive stages; a major portion of the developed harmonic power will then be contained in the output as noise, and will have a spectrum similar to white noise.

Careful tuning will eliminate the sidebands or will reduce them sufficiently. A combination of fixed and self-bias helps; changing the value of bias resistor may also help.

Hysteresis—Parametric multipliers show a hysteresis tuning effect. Optimum output is obtained when tuning from one direction but not from the other. The effect seems to be greater for high-power operation and can also be observed when adjusting the varactor bias circuit.

Spontaneous detuning is believed due to the change in average diode capacitance with respect to r-f drive. Since the diode forms part of a resonant circuit, any tuning change results in a voltage change across the diode, which changes its capacitance and produces further detuning. In the reverse direction, the same sequence cannot occur and therefore the tuning characteristic exhibits hysteresis.

A similar effect occurs with regard to the input power level for a given tuning condition. In addition to the hysteresis seen when power is increased and decreased, the perfomance of the multiplier goes through a definite peak and exhibits power sensitivity. Increasing the input any further degrades the output. On the other hand, unless sufficient input is present, the conversion efficiency will be poor.

A jump effect is sometimes noted simultaneously with hysteresis under high drive. This is a direct result of the nonlinearity of the diode.

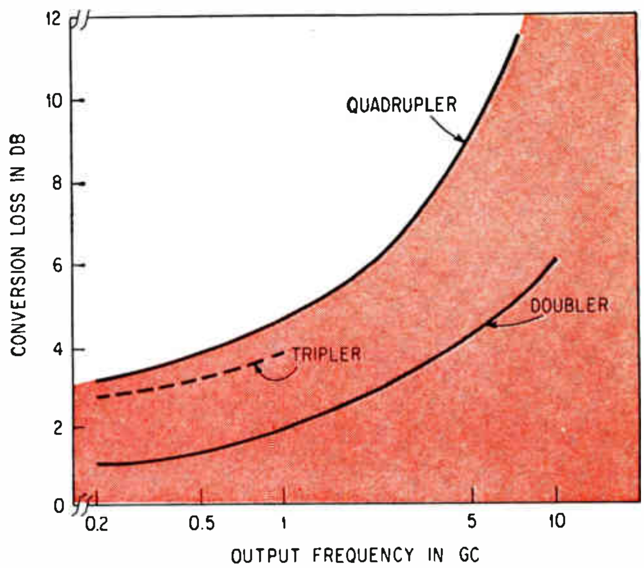
Bias Noise—Noise may sometimes be present due to pickup in the bias circuit. This can be eliminated by filtering or by shielding the bias leads.

Output Frequency—The output frequency fixes the cascaded multiplying ratio if the design is limited to doublers, triplers and quadruplers. Multiplying ratios are given in Table III.

For an output at 8 Gc and a 200 Mc limit on active amplification, the minimum multiplying ratio would be about 40 and the maximum about 80. From Table III the desirable multiplication ratios would be either 48 or 64: cascades of 3 × 4 × 4 or 4 × 4 × 4. The 48 multiplier would have a higher multiplying efficiency while the 64 would relax amplifier and oscillator requirements.

Output Power—Output power is a function of individual multiplier efficiencies and available power at the input frequency. Efficiency of each multiplier may be calculated or obtained from empirical data. Table IV presents a large number of solid-state results.

Using the circuits described, with presently available diodes, conversion losses for doublers range from 1 to 6 db from vhf to the shf band, 2 to 9 db for triplers, and 3 to 12 db for quadruplers. The curves of Fig. 4 show average results for these circuits. For



CONVERSION loss chart for varactor multipliers can be used as first approximation in cascade multiplier design —Fig. 4

Multiplying Ratios for Fewest Diodes in Doubler, Tripler, and Quadrupler Cascades—TABLE III

Output in Gc. (0.1 to 0.2 Gc Input)	Mult. Ratio	Fewest Mult. Factors
0.2 to 0.4	2	2
0.3 to 0.6	3	3
0.4 to 0.8	4	4
0.6 to 1.2	6	2 × 3
0.8 to 1.6	8	2 × 4
0.9 to 1.8	9	3 × 3
1.2 to 2.4	12	3 × 4
1.6 to 3.2	16	4 × 4
1.8 to 3.6	18	2 × 3 × 3
2.4 to 4.8	24	2 × 3 × 4
2.7 to 5.4	27	3 × 3 × 3
3.2 to 6.4	32	2 × 4 × 4
3.6 to 7.2	36	3 × 3 × 4
4.8 to 9.6	48	3 × 4 × 4
6.4 to 12.8	64	4 × 4 × 4

MULTIPLIER CASCADE DESIGN

(1) Select overall multiplication ratio and the individual multiplier ratios from Table III

(2) Use Fig. 4 to determine power requirements of the individual multipliers

(3) Provide an amplifier to supply required input power

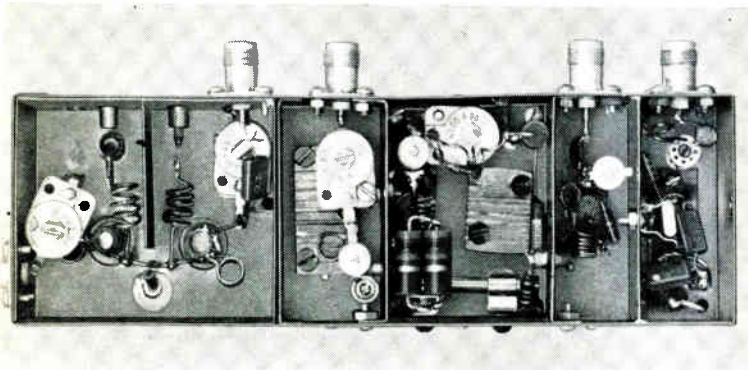
(4) Design the individual multipliers and tune independently for the necessary characteristics

(5) Cascade the circuits and tune to system specifications

the 3 $\times$ 4 $\times$ 4 multiplier with 8-Gc output, total expected conversion loss is about 22 db.

Bandwidth—Multiplier bandwidth is more a function of the circuit than the diode. A high-efficiency doubler has at least four separate tuned circuits corresponding to diode resonance and input and output matching. A tripler or quadrupler with idler has five. To broaden the bandwidth of a single multiplier, the Q of the tuned circuits must be lowered or the circuits stagger tuned. Reducing Q causes a loss in efficiency. Stagger tuning increases circuit complexity but may be the only way to fufill the design. In additon, cascading multipliers results in further bandwidth narrowing, as in synchronously tuned amplifiers.

Thus a parametric multiplier cascade is essentially a narrow-band device, unless great sacrifices in efficiency and input power are acceptable. For cascades including three or more multipliers and a driving amplifier, bandwidths of one percent are typical.



TYPICAL solid-state circuit consisting of crystal oscillator, amplifier and varactor-diode tripler to produce 700 mw at 400 Mc

Stability—Output frequency stability seems to be purely a function of the controlling oscillator. In general, if the oscillator frequency lies above 100 Mc, a fifth overtone crystal is normally used and a stability of one or two parts in 10^5 is obtainable over temperature ranges of 50 C without oven control. Bias and tank circuits must be carefully compensated to achieve this stability.

Cascading—To allow individual multipliers to be separately tuned and then cascaded, all units should be designed for input and output impedances of 50 ohms. This will minimize sensitivity to cable length and will simplify system tuning and repair. If system requirements are so severe that the additional circuit losses and space are intolerable, temporary matching networks can be used for tuning and then removed. With ingenuity, this can be done in both lumped and coaxial multipliers even in compact cascades.

An additional problem sometimes exists when harmonics generated in a preceding stage upset the resonant balance of a stage. Bandpass filters between units eliminate this interaction. A low-pass filter may also suffice unless the interfering signal is due to divider action on the part of the preceding multiplier.

The recommended procedure for tuning a multiplier cascade is.

(1) Tune each unit individually at the expected power input

(2) Add units from the lower frequency up and retune at each step

(3) If trouble is experienced, retune individual units

(4) Use a spectrum analyzer or selective receiver at each step to insure signal purity.

Solid-State Results: Parametric Multipliers—TABLE IV

Output in Mc	Mult. Ratio	Watts Out	Conversion Loss in db	Diode
Lumped Design				
100	2	15.0	1.9	PC 117–47 (2)
144	3	0.5	4.2	PC 117–47
200	2	8.0	2.7	PC 116–22 (2)
300	2	1.5	1.25	MA 4347 E
400	2	6.0	1.3	PC 116–22 (2)
400	4	7.0	4.3	PC 117–47 (2)
400	3	0.7	3.2	PC 115–10
553–1/3	4	0.21	5.8	D 4252 C
576	4	1.0	4.3	MA 4348 D
Coaxial Design				
800	2	3.2	1.9	MA 4348 F
1,600	2	0.5	3.4	MA 4348 C
1,600	4	2.0	4.8	MA 4348 F
1,600	4	0.21	5.3	MA 4348 E
2,300	4	0.2	5.5	MA 4358 C
3,200	2	0.96	3.6	MA 4348 B
3,200	4	0.2	10.0	MA 4348 C
6,400	4	0.18	9.8	D 4262 D
6,400	4	0.16	10.9	D 4260 C
6,400	4	0.015	11.2	D 4221 H

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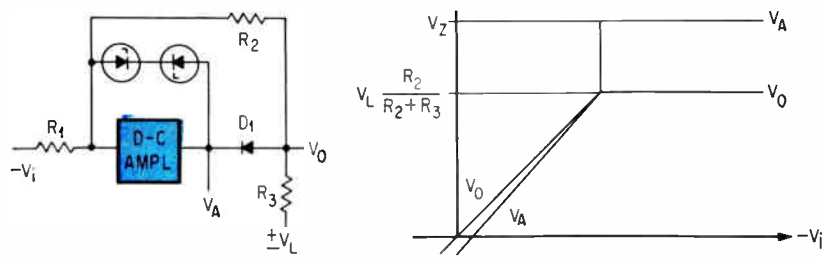

PRECISION LIMITER and voltage graph—Fig. 1

Pulse-Width Modulator

Offers Precision Performance

Transistor input switches, integrator, comparator and flip flop provide amplitude modulation of the controlled-width pulse, accurate to better than one part in 1,000 at a 1-kc repetition frequency

A NEW CIRCUIT for pulse-width modulation has been developed that offers precision performance without the need of precision resistors, precision capacitors or stable power supplies. Applicable to analog computers, analog-to-digital converters and telemetry, the circuit can operate with a relatively low-gain (G = 1,000) d-c amplifier, and performs to an accuracy of better than 1 part in 1,000 at a 1-kc repetition frequency over an input range of +10 v to −10 v.

A pulse-width modulator is a device that accepts a d-c voltage as input and provides as output a pulse whose duration is proportional to the input amplitude. Most conventional pulse-width modulators use a closed-loop circuit with a voltage or current switch and a low-pass filter in the feedback to obtain high accuracy.[1-5] These devices require highly sophisticated d-c operational amplifiers with high gain and low drift. The feedback loop of these circuits create stability problems and the low-pass filter severely limits the bandwidth.

Another class of pulse-width modulators developed for telemetering application[6,7] uses a method of linearly charging and discharging a capacitor. The main design objective in this application is to minimize the bandwidth of the transmitted data, which is done by operating with a variable repetition frequency (delta-sigma modulation). In pulse-time analog computers[8-10] and pulse-time hybrid computers, however, the repetition frequency must be constant and synchronized with some central reference; therefore, the capacitor-charging type of pulse-width modulator is not applicable.

The modulator described uses the method of linearly charging and discharging a capacitor, but in combination with a precision high-speed comparator and a two-mode ramp generator, which improves performance with relatively simple circuits.

HOW CAN IT BE USED?

This circuit requires neither precision resistors nor precision capacitors nor stabilized power supplies. This fact, plus high circuit performance and relative circuit simplicity, make the modulator an excellent building block for analog computers, analog-to-digital interface equipment and control circuits

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Considerations—The time required for a linear voltage ramp, starting at zero, to reach a certain value X is directly proportional to the magnitude of X. A pulse-width modulator can thus be built if a linear voltage ramp is compared with a d-c voltage representing the input variable X. The precision of this modulation process is a function of the linearity of the ramp, and of the accuracy and speed of the comparator.

One of the most accurate comparators is the precision limiter (Fig. 1). When the magnitude of the input voltage V_i approaches the magnitude of the limiting or comparison voltage V_L, the current i_1 through diode D_1 approaches zero, increasing the diode impedance.

With more impedance in the feedback path, the closed-loop gain of the d-c amplifier increases; the amplifier output voltage V_A becomes larger, and cuts off the diode still more. This in turn causes an even higher feedback impedance, and so on. A regenerative process continues until V_A reaches the Zener breakdown voltage V_Z of the diodes across the amplifier. The output voltage V_o of this limiting circuit is determined by the current i_2 through the feedback resistor R_2. With current i_1 equal to zero, i_2 must equal current i_3, and if V_L is constant, V_o is also constant. With no additional load, the output voltage of the limiter

$$V_o = V_L \frac{R_2}{R_2 + R_3}$$

When the gain of the d-c amplifier is large, the precision with which V_o is determined usually depends only on the tolerance of the resistors R_2 and R_3; a magnitude of error in the order of ± 0.01 percent is feasible. However, the precision limiter is not fast. The amplifier output voltage V_A (Fig. 1), needs as much as 100 microseconds to rise from the value V_o to V_Z. In a 10-volt computing system, and with a one-kilocycle voltage ramp, this would constitute an error of 10 percent of full scale. To overcome this speed limitation, diode D_1 in the precision limiter is replaced by a transistor amplifier.

The pulse-width modulator in Fig. 2A[12] generates a linear ramp V_S which is compared with the input voltage V_X. When V_S equals V_X the comparator provides an output pulse, resetting the flip-flop that was set with the negative-going edge of the RESET pulse.

This pulse-width modulator offers excellent performance under room-temperature conditions. However, it is difficult to maintain the high accuracy when the temperature changes from -55 deg C to $+125$ deg C, as experienced in military environment. It is particularly difficult to maintain the slope of the ramp constant unless the integrating capacitor and resistor are highly stable or put into an oven. The linear ramp is reset by shorting a transistor across the integrating capacitor. This causes transient settling problems in the operation, which require careful circuit layout and close control of the RESET pulse. Also, transients and ripple on V_X are transmitted through the modulator with unity gain. Finally, summing into the modulator creates bias and impedance problems.

Circuit Description—Most of these problems are overcome with the pulse-width modulator shown in Fig. 2B. It consists of input switches, integrator, comparator and a conventional set-reset flip-flop.

The input switches are conventional transistor voltage switches,[13] either shunt or series-shunt type. For operating temperatures below 60 deg C, germanium alloy-junction transistors are preferred; for higher temperatures, silicon transistors are required.

The integrator is a conventional transistor d-c operational amplifier with the appropriate input resistor and feedback capacitor. The effective drift current I_D of the amplifier, with respect to time and temperature, must be smaller than 0.1 percent of the maximum input current I_i. With a 10,000-ohm input resistor, $I_{i\ max}$ is 1 ma; thus, I_D must be less than 1 μa over the desired temperature range. For a $+20$ to $+60$ deg C range, this is within the capability of a differential d-c amplifier, such as the Philbrick P65. However, due to the two-mode operation of the modulator, the amplifier needs only a gain of about 1,000. Therefore, a relatively simple d-c amplifier can be used.

The comparator is basically a one-stage current amplifier and a one-stage voltage amplifier. The two transistors are connected into the feedback path of the integrator in such a way that the integrator sees only a diode. When comparator input current I_c becomes zero, the comparator provides a fast change of its output signal.

Circuit Operation—The operation of this modulator is divided into two discrete modes, each lasting for a period T. The T_1/T_2 control signal (Fig. 3A) connects the modulator alternately into the two modes by energizing switch S_1.

With S_1 in position *a*, the output voltage of the integrator V_A increases with a slope proportional to the input voltage V_X (Fig. 3B). At the end of period T_1, the voltage V_A is $V_A = kV_X$.

With S_1 in position *b*, the output voltage of the integrator decreases with a slope proportional to the reference voltage V_R. When V_A becomes equal to the bias voltage V_B, the comparator provides an output signal that opens switch S_2 and resets the flip-flop. Switch S_2 disconnects V_R from the integrator and maintains V_A at V_B. The output of the flip-flop, which was set when the T_1/T_2 control signal changed from plus to zero, is the output of the modulator. The time required for the process of decreasing V_A from kV_X to V_B is $t = kV_X/V_R$.

The output signal of the modulator (Fig. 3C) has a pulse ON time of t and a repetition period of $2T$. The maximum modulation of the output signal is thus limited to 50 percent of the repetition period.

Mathematics—The following analysis proves that the performance of the modulator is independent of the variation of the integrating time constant RC.

During period T_1, the output voltage of the d-c amplifier is

$$V_{A1}(t) = \frac{1}{RC}\int_0^{T_1} V_X dt = \frac{V_X}{RC} t$$

and at the end of T_1

$$V_A(T_1) = \frac{V_X}{RC} T_1$$

During period T_2, the output voltage of the d-c amplifier is

$$V_{A2}(t) = \frac{V_X}{RC} T_1 - \frac{1}{RC}\int_0^{\tau} V_R dt$$

$$= \frac{V_X}{RC} T_1 - \frac{V_R}{RC} t$$

and at the end of the period

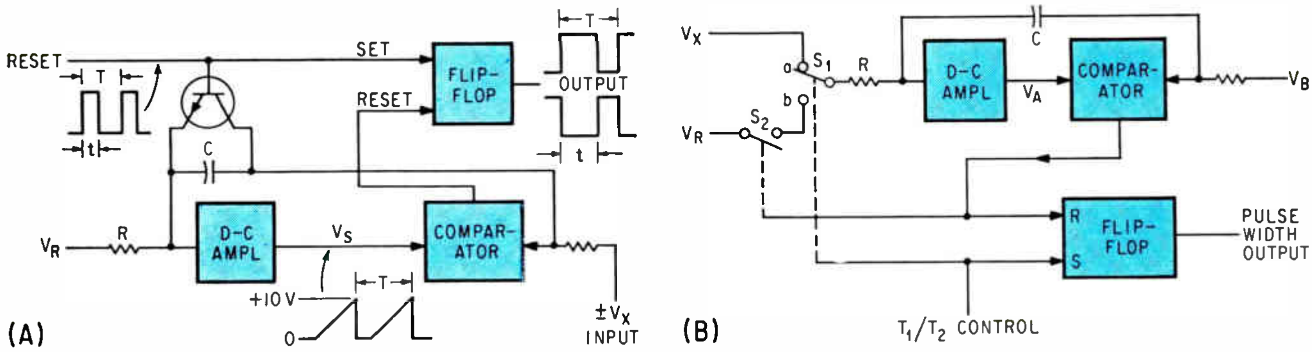
$$V_A(\tau) = \frac{V_X}{RC} T_1 - \frac{V_R}{RC} \tau$$

When V_{A2} equals zero, the equation above can be solved for the pulse time

$$\tau = \frac{V_X}{V_R} T_1$$

This equation does not contain the value RC; thus, the operation of the modulator is independent of variations in RC.

Performance—The performance of any pulse-width modulator is, at best, a compromise between static and dynamic performance. Within limits, static accuracy can always be traded for speed of operation, or



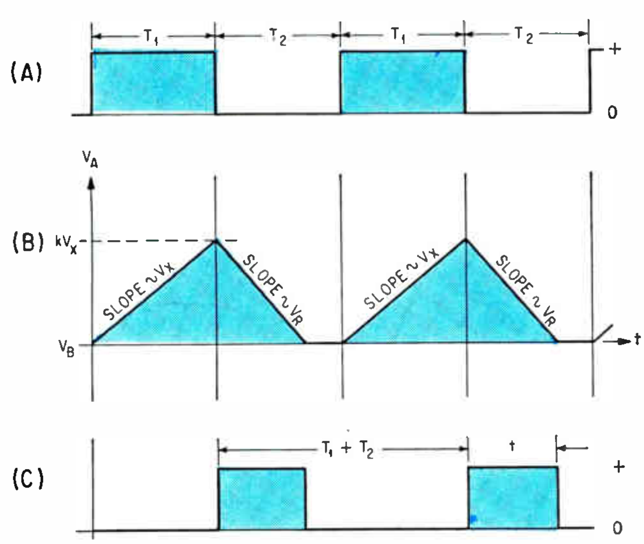
CONVENTIONAL pulse-width modulator, consisting of a ramp generator and a comparator (A); improved pulse-width modulator (B)—Fig. 2

conversely, by changing the frequency of the control signal T_1/T_2.

Static accuracy is a measure of how well the circuit produces the desired output with an input that does not vary with time. Factors affecting static accuracy are

- Offset voltage of the input switches. This can be made less than 1 mv out of 10 volts, or 0.01 percent.
- Comparator error about 0.02 percent; this is largely a timing error due to variations in component characteristics with temperature.
- Drift in the d-c amplifier is the largest error component. Better performance is always possible with an amplifier having smaller drift.
- Switching-time errors at the input and in the flip-flop. Individual switching times can be made less than 0.1 μsec. The cumulative effect of all switching is about 0.02 percent.
- Combined effect of all other errors, including noise and jitter, is about 0.02 percent.

This error analysis assumes perfect inputs. The total error, verified by laboratory tests, is less than 0.1 percent of full scale at a repetition rate of 1 kc. Static accuracy is a function of carrier frequency. Greater accuracy up to a maximum of $\pm$ 0.01 percent could be obtained with a lower frequency of operation. The dynamic range of this modulator; that is, the ratio between the maximum output voltage and the minimum output voltage, is 10,000:1, 1,000:1 and 100:1 at carrier frequencies of 1, 10, and 100 kc, respectively.



MODULATOR WAVEFORMS: T_1/T_2 control signal (A); output of d-c amplifier (B); modulator output (C)—Fig. 3

When the input voltage V_x changes as a function of time, the pulse width output signal from the modular must also change as a function of time. The pulse-width modulator is a device whose operation is based on the sampling theorem. In such a circuit, there is a linear phase-shift but no noticeable amplitude variations as the input signal frequency changes from zero to one-tenth of the repetition frequency. If the frequency is raised still further, the output pulse train becomes unstable and finally breaks down altogether. The bandwidth of the pulse-width modulator is, therefore, limited to approximately one-tenth of the repetition frequency.

The proposed pulse width modulator has operated with repetition frequencies up to 100 kc, where it maintained an accuracy of $\pm$ 1 percent of full scale.

There is, however, one limiting factor. The modulator, in its present form with the Philbrick P65 differential amplifier, will not maintain its accuracy over the full military temperature range. The accuracy deteriorates from 0.1 percent between + 20 and 60 deg C to 0.25 deg between − 20 and + 100 deg C and to 1 percent between + 55 and + 125 deg C. To overcome this limitation, it is suggested a simpler d-c amplifier with a gain of 1,000 be designed. Such an amplifier should be considerably smaller and can thus be oven-controlled to minimize drift.

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Capacitance Chargers For Space Employ Controlled Rectifiers

Development of reliable high-power silicon controlled rectifiers makes possible light, highly efficient charging circuits that are particularly advantageous where the ratio of charging period to supply frequency period is high

By FELIX ELLERN, Power Conversion Systems Division, Republic Aviation Corp., Farmingdale, N. Y.

RECENTLY, a conventional charger for a 30-kw plasma pinch engine, fed from a 1,000-cps supply into a 360-μf capacitor whose discharging rate was 80 cps, required a 70-pound inductor and a 40-pound transformer. Its losses were estimated at 2,500 watts. The circuit of Fig. 1 reduces the size of this inductor to 7 pounds by shaping the input voltage in a special manner and making use of a silicon controlled rectifier (SCR).

The input voltage waveshape is modified so that the current waveshape will consist of a series of rectified sine curves at a frequency of f_2, Fig. 2A. Current waveform (1) will provide the same power-transfer efficiency as that of (2). However, the relative increase in frequency allows the use of lower inductance. Maximum transfer efficiency occurs when inductive reactance equals capacitive reactance. If the supply frequency is f_2 and it takes n half cycles to charge the capacitor, the ratio of the resonating frequency to the discharge frequency is

$$\frac{f_2}{f_1} = \frac{\frac{1}{t_2}}{\frac{1}{T}} = \frac{\frac{1}{t_2}}{\frac{1}{n\,t_2}} = n$$

where t_2 is half the supply voltage period and T is the charging period. This ratio will also determine the inductance required in the SCR circuit L_2 compared to that of a conventional circuit L_1

$$n = \frac{\frac{1}{\sqrt{L_2 C}}}{\frac{1}{\sqrt{L_1 C}}} = \sqrt{\frac{L_1}{L_2}}$$

However, $L = KN^2$ where N is the number of turns and K is a proportionality factor of the inductor, hence

$$\frac{N_1}{N_2} = n$$

If it is assumed that the number of turns is proportional to weight W then

$$\frac{W_1}{W_2} = \sqrt{\frac{L_1}{L_2}} = n$$

where W_2 is the weight for the SCR inductor and W_1 the weight of the original inductor. Assuming equal diameters of conductors for the two cores, the weight is reduced by a factor of n. Thus, if the weight were the only consideration, the larger the charging period for a given input frequency the more advantageous the SCR charger becomes. When larger diameter conductors with lower resistances are used in the larger inductor the weight advantage increases in favor of the SCR method. For equal size conductors, the resistance of the inductor is directly proportional to the number of turns used so that the effective resistance decreases for the SCR charger. Also, the overall efficiency is increasing by a considerable amount since at slow discharge rates the inductor contributes the major part of the losses.

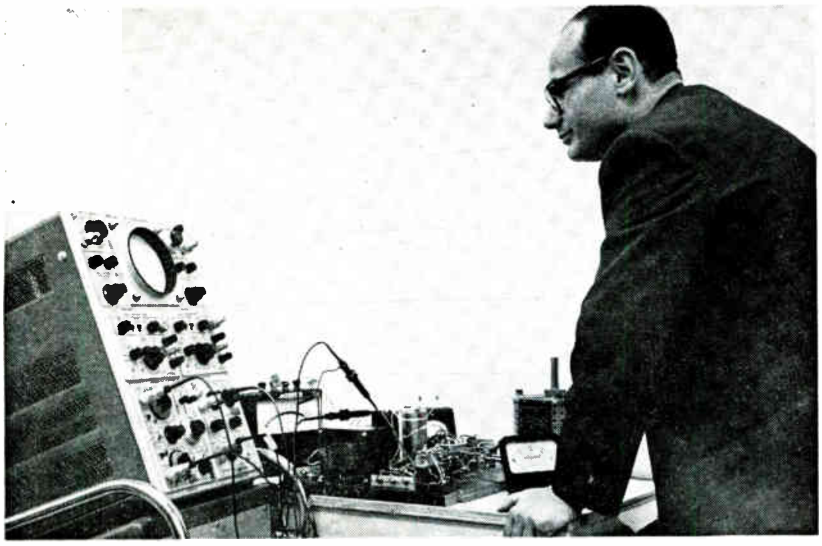
SCR Charger—The new constant-current charging circuit uses active control elements such as silicon controlled rectifiers with their high efficiency-controlling capabilities. Basically they are switches operating similarly to mercury switching tubes. Little power is required to switch large loads. Like the mercury switch, the SCR is switched off when the current through it decreases to zero.

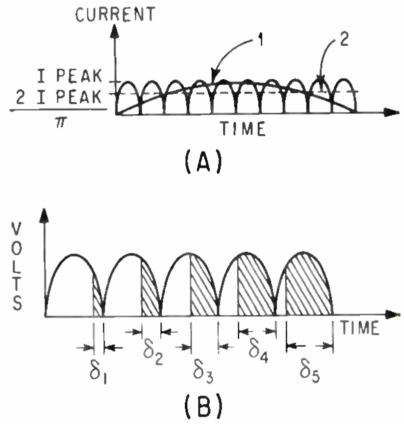
In this application, regulation is achieved by a shift in the firing angle of the supply voltage (Fig. 2B). At first this firing angle approaches 180 deg. After each supply cycle the angle is decreased so that the input current surge remains at a constant amplitude. The circuit used, Fig. 1, is identical to that of a conventional full-wave rectifier bridge with two rectifiers of the bridge replaced by SCR's and an appropriate firing circuit. The magnitude of the firing angle is determined from the voltage on the capacitor delivered by a feedback loop to the firing circuits.

For a conventional charger, the actual current waveshape obtained is shown in Fig. 3A. The current

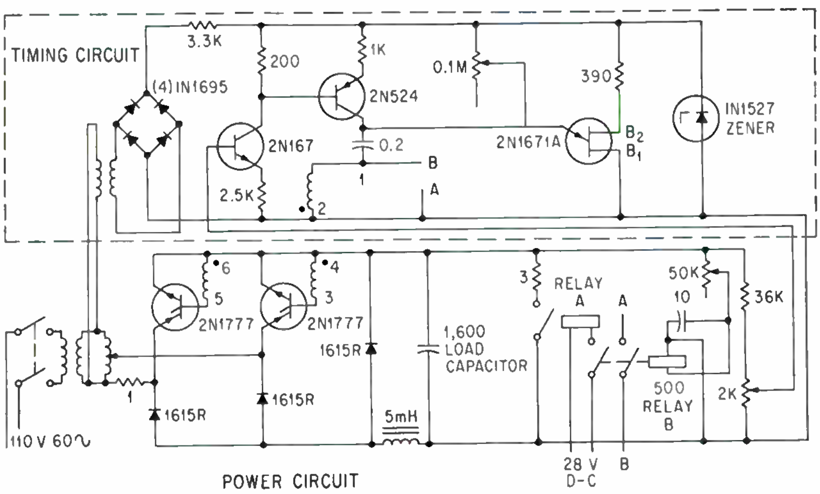
USES IN SPACE

Many actual and proposed systems for use aboard space craft involve charging a capacitor bank periodically. These systems include plasma engines, pulsed lasers and some thermonuclear devices. Here is a way to do it efficiently while conserving both weight and power

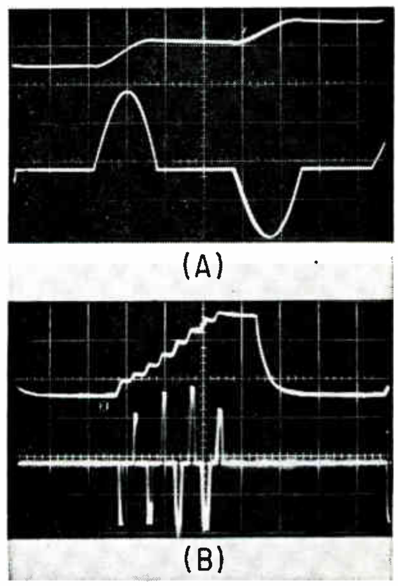

BREAD-BOARD LAYOUT of 100 watt SCR charger



HALF-SINE waveform (A1) has an average value that approaches the ideal (A2). Shaded area is voltage applied to charging capacitors, SCR firing angle varies in proportion to this voltage (B)—Fig. 2



CONTROLLED RECTIFIERS replace diodes of full-wave rectifier bridge circuit, provide a-c charging of load capacitor. Voltage on the capacitor determines magnitude of SCR firing angle through a feedback loop, thus providing a constant-current source—Fig. 1



CONVENTIONAL charger waveforms, voltage, top, and current, bottom, (A); SCR charger waveforms (voltage, top, and current, bottom) provide increased efficiency due to reduced duty cycle—Fig. 3

spikes have a long duty cycle that reduces efficiency. This duty cycle will be considerably improved with a three-phase supply but its actual efficiency proportional to its duty cycle ratio, may be calculated to be 0.38 that of the SCR charger. The relative losses, however, are 2.6 times as great if the equivalent resistance were the same in both chargers. However, the total resistance of conventional resonant charging circuit is more than twice that of the SCR circuit due to the much larger inductor so that the efficiency in the SCR circuit will be the same or greater.

Results—Using the full-wave SCR single-phase charger of Fig. 1 produced the typical voltage and current waveforms of Fig. 3B. The period is 0.09 second, the voltage before discharge is 120 volts and the output is 103.5 watts. The voltage, increasing in linear steps, indicates that the current pulses are identical and equal to an average peak of about 8.6 amperes.

The resistance of the source including transformer and Variac is 2.3 ohms. The resistance of the coil is 0.03 ohm. The rectifiers contribute 0.4 ohm, the capacitors 0.3 ohm. An additional 1-ohm resistance is used to measure the current by voltmeter, so that the total equivalent source resistance is 3.3 ohms and the total equivalent load resistance is 0.73 ohm.

The size of the inductor needed without SCR's can be calculated to be 0.62 henry. With SCR's it shrinks to 5 mh. The weight is reduced by approximately 90 percent.

The actual losses in the circuit are only due to rectifiers, capacitor and resistance of the inductor which is 0.73 ohm. The effective value of the current is 3.8 amperes and the losses are 10.5 watts. Excluding the losses in the capacitor itself (common to both chargers), the losses are only 4.5 watts.

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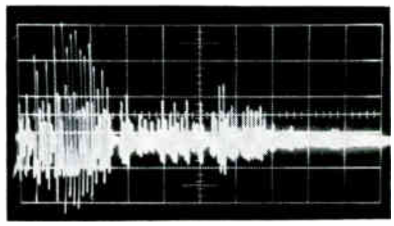
MUSCLE VOLTAGE MOVES

Artificial Hand

MYOELECTRIC control of prostheses offers advantages over conventional mechanical or transducer control of artificial limbs. Muscular effort generates the electromyographic (emg) signal without the exercise of physical force. Only mental concentration is required. In the type of device to be described, the amputee needs only to think of closing his missing hand, whereupon the artificial hand closes electromechanically. Physical movement of the stump, relative to the prosthetic device, can be used to modify or refine the movement.

Muscle potentials, termed emg signals, can be detected at the surface of the body using small plane electrodes pressed against the skin covering the desired muscle. The nature of the emg signal is a carrier that is amplitude modulated by the integrated activity of the whole muscle. A typical emg signal, recorded during a sequence of strong and light muscle effort and relaxation, is shown in Fig. 1.



FILTERED typical emg signal corresponding to strong grasp, light grasp and relaxation of muscle—Fig. 1

Detected Signal—The total electrical activity at a given time is randomly distributed along the muscle mass and only a sample is detected by surface electrodes. For this reason, the detected signal is only roughly proportional to the contraction effort. Similarly, the emg signal fluctuates, even at constant muscular tension, around a mean value. There is crosstalk between the emg of a muscle and that of its antagonist, the magnitude varying among patients and with the siting of the pickup electrodes. The crosstalk is generally 10 to 15 db below the desired signal from the active muscle.

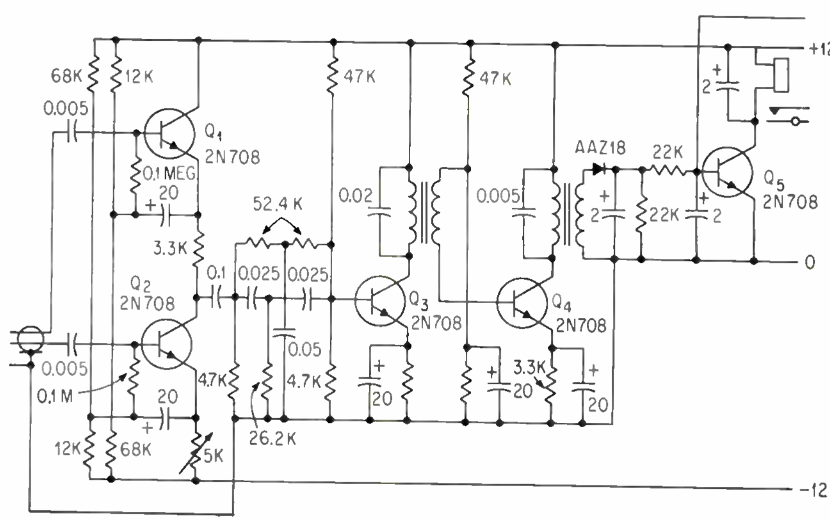
Myoelectric signals are always present in a stump muscle even when the amputation is many years old. A muscle affected by polio or other paralyzing disease produces emg signals, even when the muscle is so weak that it cannot operate against gravity. Since the amplitude is often larger in polio patients than in normal subjects, emg-controlled orthotic aids may be particularly applicable to the relief of paralyzed patients.

Characteristics—Myoelectric signals are complex pulse potentials of 10 to 1,000 microvolts with durations between 1 and 10 milliseconds when recorded from the body surface. Individual muscular fiber discharge is about 1 millisecond in duration. However, the pulses overlap in the muscle bundle to produce lower frequency components.

Interference arises from stray electromagnetic fields, especially power lines, and myoelectric tissue noise (some 10 μv in amplitude), involuntary contractions and electrode-skin contact instability.

ELECTROMEDICAL CHALLENGE

Despite some unfamiliar terminology, most of the words that are uniquely descriptive have been retained in this article by the editors. The prefix myo is a combining form meaning muscle and the electromyographic (emg) signal is a muscle-initiated electrical impulse that makes possible the actuation of the prosthesis, or prosthetic device, which in this case is an artificial hand. An orthotic (from the Greek straight) aid in medical terminology concerns correction of a deformity. The availability of a usable electric signal from even a polio damaged muscle may come as a revelation to most electronics engineers—and should set them thinking



MYOELECTRIC amplifier accepts muscle signal through differential amplifier. Processed, integrated signal operates a relay—Fig. 2

Electromyographic signal produced by muscle movement controls grasp of prosthetic fingers

By **G. W. HORN,** Consulting Engineer
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The input amplifier should have a front-end impedance in excess of 1,000 ohms and should preferably match skin resistance that varies between 50,000 to 100,000 ohms when dry to less than 5,000 to 10,000 ohms when lightly sandpapered and coated with an electrode jelly.

Limiting overall bandwidth increases signal-noise ratio. Preliminary tests showed that beyond 1 kc useful myoelectric signals were insignificant whereas noise was added. Limitation of the lower cutoff frequency to 100 cycles results in information loss but this condition may be tolerable under conditions of severe power-line noise. The more significant harmonic content of the emg signal falls between 100 and 1,000 cycles.

Equipment Design — By designing the input of the amplifier as a differential stage spurious signals can be reduced. An extraneous potential picked up by the two skin electrodes is in phase and if the amplifier is perfectly symmetrical, no output results. The desired out-of-phase signal is passed to the following amplifier. Transistor amplifiers are less subject to spurious-signal pickup.

Even after filtering and amplification, the emg signal is raw and irregular, requiring further electronic transformations. A 100-ms iterative integration improves discrimination between different signal levels, achieved by summing over a discrete time interval. However, the concomitant time lag affects tracking performance. A smoothing transformation of the rectified emg signal provides a steady, slowly varying input to the control system, but by itself introduces signal attenuation and degrades system capability to discriminate between different activity levels.

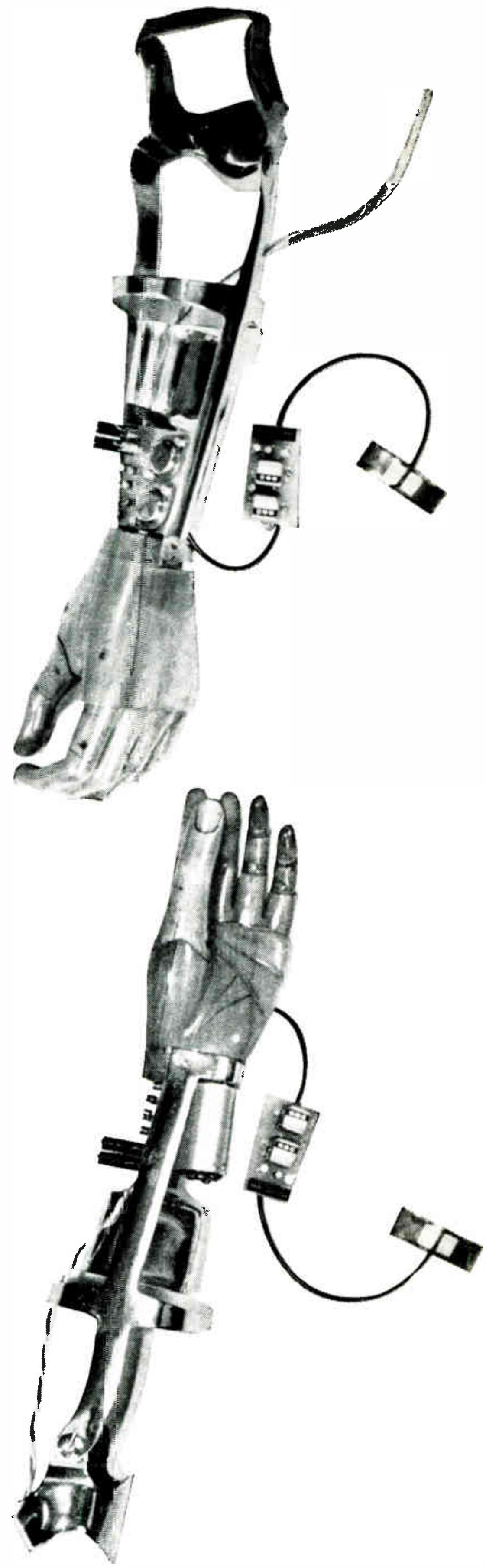
Fluctuations in emg signal after filtering and rectification are a source of trouble. With a long time constant, response is sluggish. When the time constant is too short, the actuator vibrates with signal fluctuations. Backlash between the control signal and actuator response has solved this difficulty.

Amplifier—The diagram of a suitable transistor amplifier is shown in Fig. 2. Transistors Q_1 and Q_2 act as a differential input amplifier. Feedback from emitters to bases raises input impedance between the electrodes to about a megohm. Using matched transistors, a common mode rejection of 5,000 is possible. A band-pass amplifier (Q_3 and Q_4) employs stagger-tuned interstage transformers to obtain a 100-1,000 cycle bandwidth. Attenuation at 50 cycles is almost 45 db down and the amplifier response falls 18 db at 2 kc. An optional T-pad can be used to reject the second harmonic of power-line interference.

After amplification, the emg signal is integrated in the detector stage. If a predetermined level is attained, the output relay closes. This device gives a proportional output as well as a binary response corresponding to the state of contraction of the muscle.

Practically, the binary output is more useful, because the emg signal, as a sample of total muscle electrical activity, is itself more binary in nature. Obtaining a proportional servo motion is possible but probably only with central logic blocks responsive to several emg signals from different muscles.

Working Model—To test the control system, a conventional hand prosthesis (illustrated) was used, only the thumb and first two fingers being driven by a 1/60-hp motor

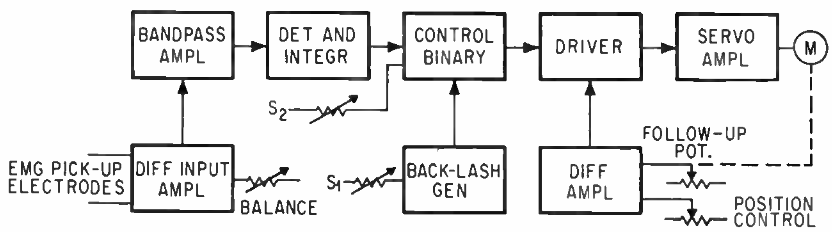


EXPOSED views of prosthetic hand with cosmetic glove and socket removed to show servoamplifier, positioning potentiometer rotative control, and motor assembly; emg pickup electrodes are attached to adhesive strap through a reduction gear and set of levers. The other two fingers are passively positionable in an infinite number of arbitrary positions. The motor and mechanical system are placed close to the wrist and the emg pickup electrodes are arranged on a small leather strap to be tightened on the patient's forearm stump or, alternatively, attached by adhesive strapping to the skin over the muscle.

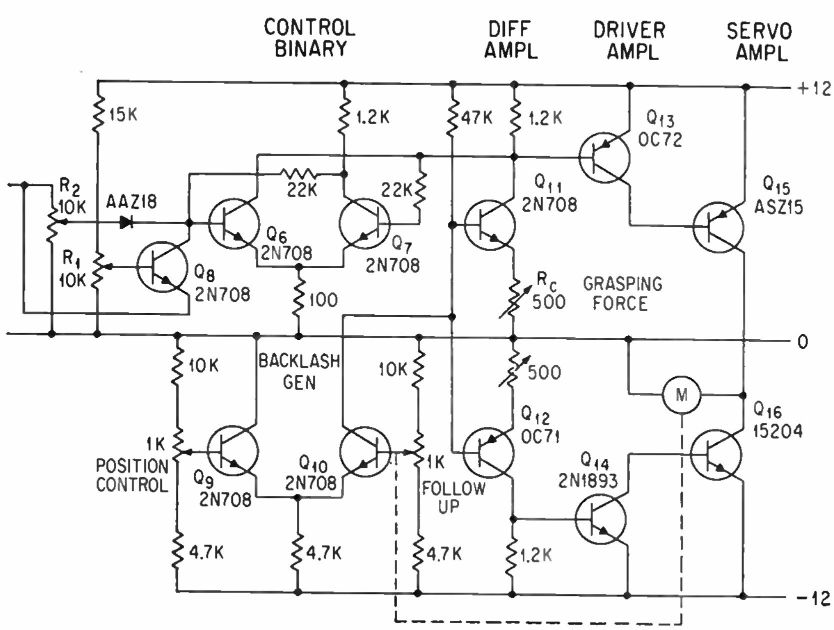
Electrical functions of the prosthesis are shown in block form in Fig. 3. The output circuit for control-motor excitation is designed to use minimum power with the system at rest. The patient can control the grasping force of his artificial hand through R_c, (Fig. 4), a pressure-sensitive variable resistor. This transducer is actuated by the patient's contracting and pressing the stump against it. The schematic diagram in Fig. 4 shows additional detail. In the absence of emg signal, a voluntary positioning of the prosthesis active fingers is possible through a potentiometer controlled by axial rotation of the stump in the socket. The servo action is determined by mutual position of the control and follow-up potentiometers.

The position servo and emg control cannot operate at the same time. As the patient contracts the muscle that closes the prosthesis, emg takes control, disconnecting the position servo. As he relaxes the muscle to open the prosthesis and release the grasped object, the position servo again takes control allowing the patient to reposition his fingers.

Practical use of the prosthesis is improved by introducing some backlash into the control system such that a considerable effort must be made to initiate the grasp, which is then maintained by a lesser effort.



ELECTRICAL functions of the prosthetic device are summarized in block form —Fig. 3



CONTROL amplifier drives servomotor that operates fingers of artificial hand —Fig. 4

Control binary (Q_6 and Q_7) is triggered on through a diode and reset by Q_8 for which the conduction threshold is determined by the setting of R_1. Amplitude of the emg signal must override the threshold S_2 causing the binary to shift state and close the prosthesis. Once triggered, the control binary cannot flip back, even if signal amplitude falls back under R_2, so long as it remains higher than R_1. Transistor Q_8 conducts only when the signal falls under R_1, resetting the binary and causing the prosthesis to open. The adjustable settings for thresholds R_2 and R_1 determine the effort necessary to close the hand and to maintain the grip.

Motor current is supplied by a couple of complementary transistors, Q_{15} and Q_{16}, driven by Q_{13} and Q_{14}. The stage is driven by differential amplifier Q_{11} and Q_{12}. Transistors Q_9 and Q_{10} are biased so that zero voltage appears at Q_{11} and Q_{12} bases when the system is at balance. Transistors Q_9 and Q_{10} inputs are supplied by the control and follow-up potentiometers. When the control binary, driven by an emg level above R_2 triggers on, transistor Q_{11} bias is shifted so Q_{15} conducts heavily and the motor rotates. With muscle relaxed, the signal disappears, the control binary resets and the system switches back to position servo.

Battery drain is negligible at rest, but increases to 0.6 amp at maximum grasp. Miniature alkaline silver-zinc cells provide current.

The author is indebted to A. Variolo, president of the Italian Orthotics and Prosthetics Association, for stimulating and helpful discussions.

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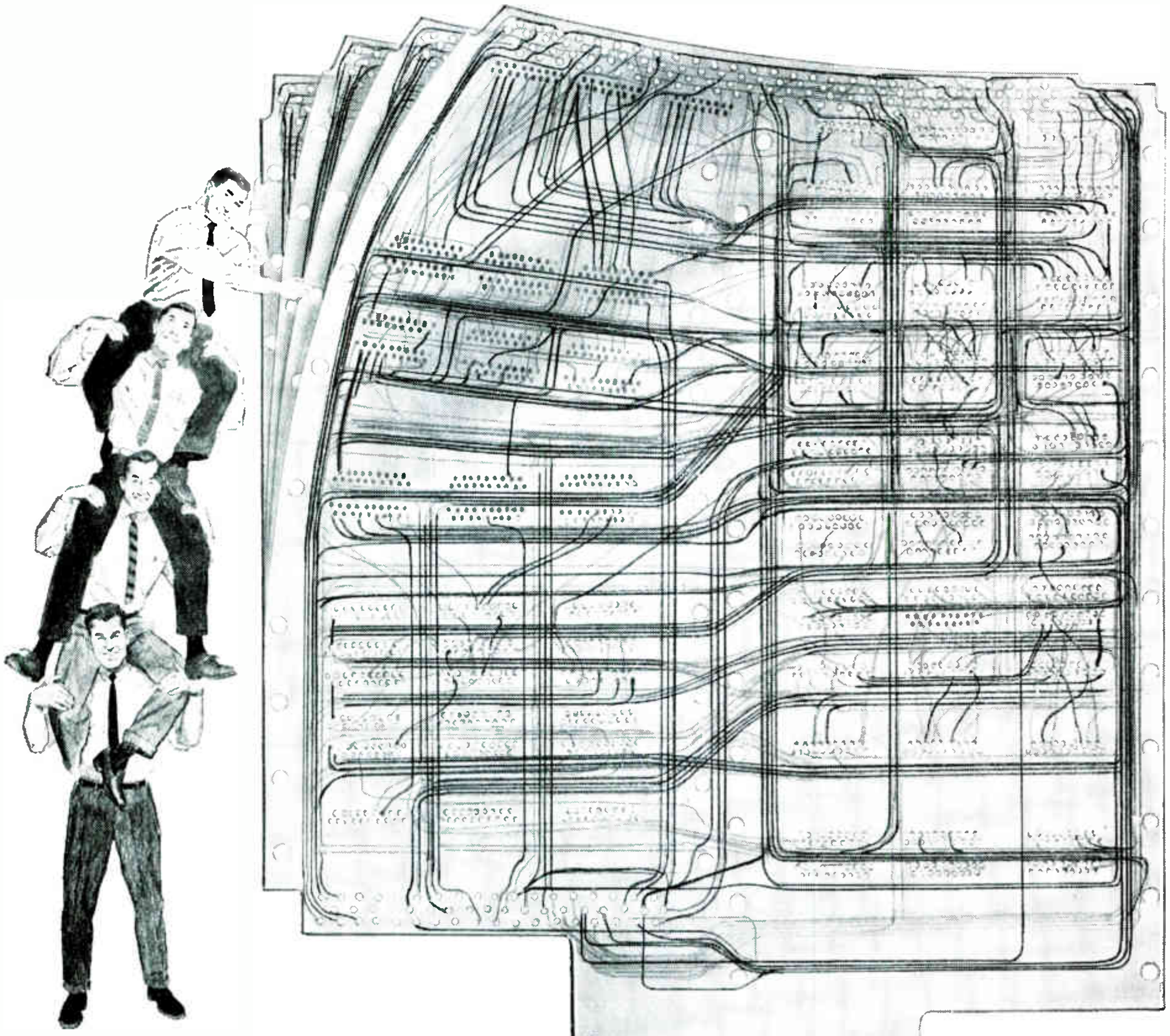
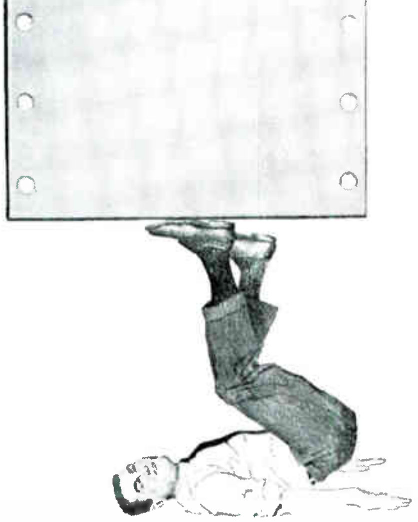


ENCAPSULAYER CIRCUITS SOLVE HIGH-DENSITY DESIGN PROBLEMS



"Encapsulayer" is Photocircuits' multilayer printed circuit —an advanced new technique embodying great technical advantages. Thin printed circuit layers are stacked over each other—laminated together in registry to make one integral board. Plated-through holes provide interconnections between layers, interlinking all layers' circuitry with each other and board surface. Some advantages?

- Problems of conductor cross-over, spacing, and routing are sharply minimized—space required for component or module interconnection circuitry is reduced.
- Expanded printed circuit design freedom—much more than possible with conventional circuits. Encapsulayer circuits are dip-solderable and are able to meet severe environmental requirements.
- Hole spacing on .050″ centers is possible; shielding or ground layers can be put directly into board; and the number of layers is virtually unlimited.

Simplifying wiring of complex sub-assemblies at reasonable cost – Encapsulayer provides maximum reliability in the smallest space—*another Photocircuits value engineering first.*

Photocircuits
CORPORATION
Glen Cove, New York • Anaheim, California

CIRCLE 37 ON READER SERVICE CARD

CIRCLE 38 ON READER SERVICE CARD→

Geometry. Performance. Price.

There are dozens of rack-and-panel connectors that give you either geometry, performance, *or* price—maybe even two out of three. Only Amphenol Blue Ribbons, though, give you all three. That explains their popularity.

THE THREE BASICS

These are the three fundamental considerations behind every rack-and-panel connector application:

Geometry. The connector must fit the package. It must be small enough to serve unobtrusively in miniaturized equipment; large and rugged enough to handle the heavy duty jobs; and at the same time, accommodate the necessary number of interconnections.

Performance. Not only must a rack-and-panel connector mate perfectly. It also has to carry current with a minimum of resistance. And it must perform again and again in a wide range of environments.

Price. A truly great rack-and-panel connector should be a bargain. That is, the connector should deliver top value per purchase dollar.

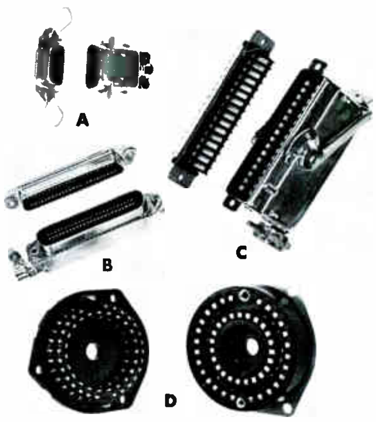
LET'S TALK GEOMETRY

Blue Ribbons come in two series . . . small (26 series) and smaller (57 series . . . called Micro-Ribbons). Series 26 units pack 32 contacts into a 3¼" x ¾" body with 8, 16, and 24 contact units available in proportionately smaller bodies. Micro-Ribbons come with 14, 24, 36, and 50 contacts and are, contact for contact, one-third the size of the 26 series. All are rated 5 amps.

Unlike pins and sockets, Blue Ribbon contacts join with a wedge-like mating action. Once united, resilient spring action binds male and female together.

The advantages are fourfold:

1. Extremely low insertion and withdrawal forces combined with high contact pressure when mated;
2. Remarkably low contact resistance because of large contact surfaces;
3. Self-wiping action of contacts assures a clean mating surface after every insertion; and
4. No pin bending or socket jamming.



Four Blue Ribbon connector types:
(A) Micro-Ribbon 14-contact pair in cable-to-chassis housing; (B) Micro-Ribbon 50-contact pair with cable-to-chassis housing; (C) Blue Ribbon 36-contact pair in latch-type housing with end cable outlet; (D) Circular Blue Ribbon pair.

14 MILLIVOLTS DROP

Performance? Blue Ribbons behave like champs after thousands of mating cycles in salt spray. Electrical and mechanical changes are barely measurable.

Contact resistance, for example, is normally in the order of 14-millivolts drop at 5 amps.

Reliability? Over 5 billion contacts have been used by the maintenance-conscious telephone industry—without a single reported failure! (Confidentially, we think there must have been a failure someplace, but nobody told us about it.)

ACCEPTANCE

Competition, oversupply, and panic have forced many electronic component prices down, often to profitless levels.

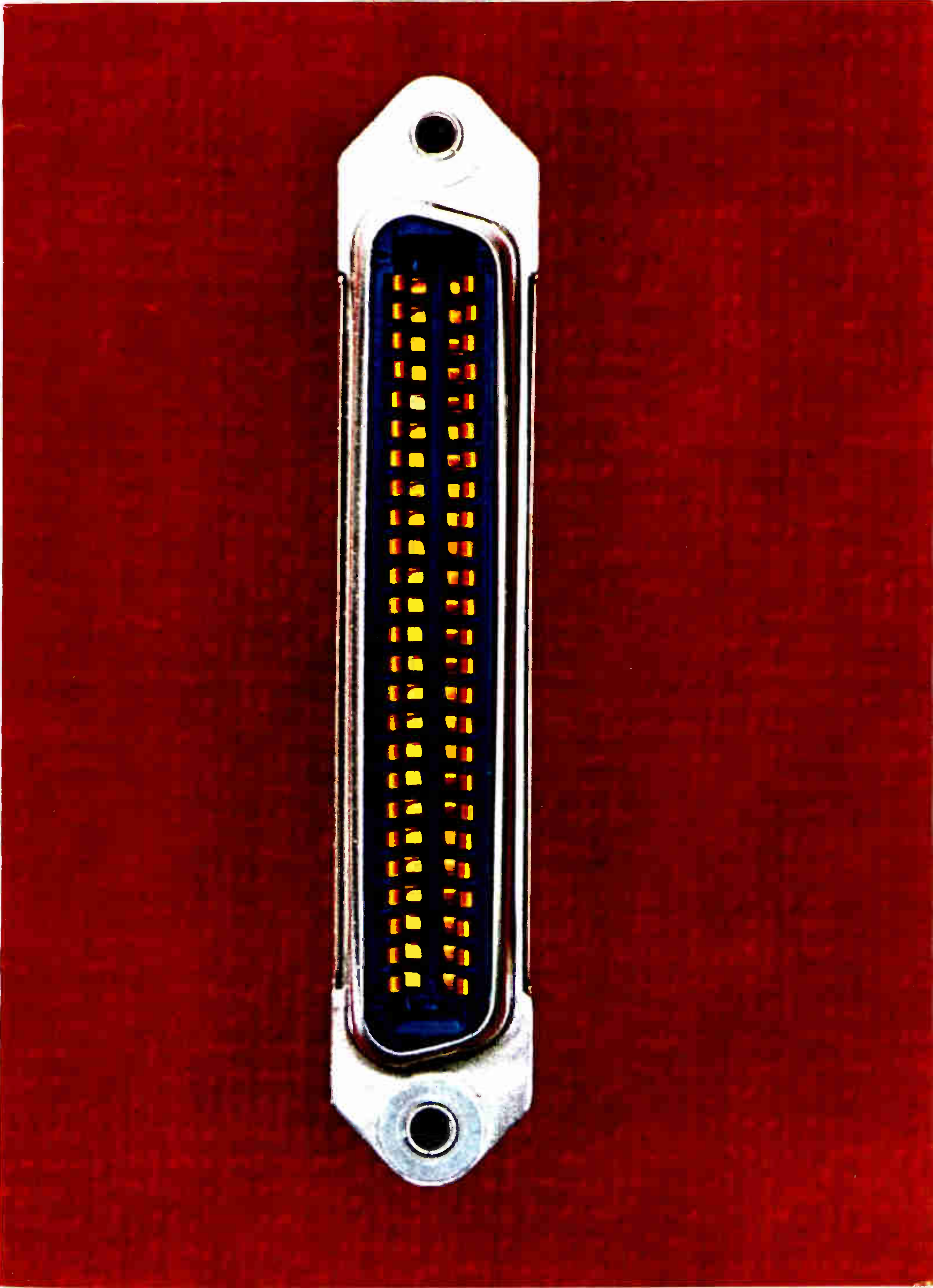
Blue Ribbon prices are down, too. But for a different reason. Blue Ribbon prices have resulted directly from the acceptance that this unique connector has built up since its introduction nearly fifteen years ago.

EASY TO BUY

You can get Blue Ribbon (or Micro-Ribbon) connectors as fast as one of our sales offices or stocking distributors can arrange shipment.

If you'd like to know more about Blue Ribbon connectors, just write to: Dick Hall, Vice President, Marketing, Amphenol Connector Division, 1830 S. 54th Avenue, Chicago 50, Illinois.

AMPHENOL **Amphenol Division** / Amphenol-Borg Electronics Corporation



A Foreword by
Dr. Walter East
President, Electro Instruments, Inc.

It has been largely out of a need for precise results that the aircraft, missile and spacecraft industries have taken the lead in the use of electronic measurement and control systems.

Industries which have lagged behind in their employment probably have felt the added precision wasn't worth the system's price tag.

Many businesses, I fear, have overlooked the fact *speed* alone is often a good dollar-and-cents reason for modernizing measurement and control systems. One of our more interesting "case histories," I think, is the experience of the glass manufacturer whose story is told below.

I am continually cautioning our own people not to use the word "system" too glibly. It sounds like something complex—and expensive. Actually, of course, a "system" for measuring can be quite simple. Witness the clock, the automobile speedometer, your furnace thermostat.

Our Aim—Save You Money!

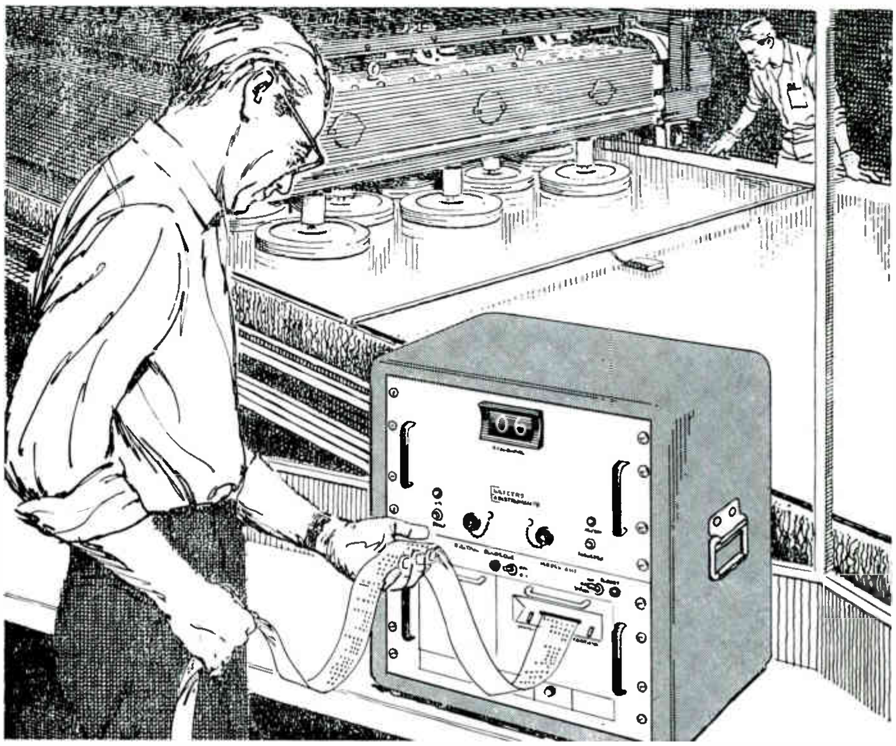
We manufacture and sell instruments and equipment for measuring everything under the sun. We make simple, inexpensive systems; we make complicated, expensive ones.

But you'll find our Sales Engineers are real "down to earth" people. They don't go around recommending systems with costs out of all proportion to the savings they make possible.

I mentioned last month that we like to offer the challenge: "You name it, we'll find a way to measure it." Maybe I should have added "on the budget you have in mind"!

Classic Jobs of Measurement

Performed by Electro Instruments



"Heart" of new glass scanning system was Electro Instruments' Digital Recorder.

Electronic Scanning Slashes Time, Labor of Grading Glass

. . . and manufacturer discovers output can be worth more money.

Glass, like steel, is poured and rolled to thickness while molten. After cooling, it is polished. Degree of polish will determine its quality, and will establish its market worth.

One manufacturer actually counted pits and blemishes, then determined grade by means of a tedious system of mathematical hand plotting.

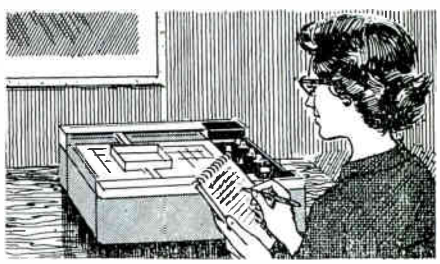
A consultation with Electro Instruments led to the development of an automatic system, based around a light source and a photosensitive instrument. These could be connected to an EI instrument to count pits electronically, simultaneously compute grade of glass, and visually display results. An additional output allowed information to be automatically graphed by an Electro Instruments' X-Y recorder.

More Accurate Grading, Too!

The whole process of grading glass thus could be drastically speeded up at this manufacturer's plant. A secondary benefit was greater accuracy in grading. Oddly enough, older measurement methods had resulted in substantial output being downgraded, and the glass priced below its true worth!

Unique Use of X-Y Recorder Saves Company over $20,000

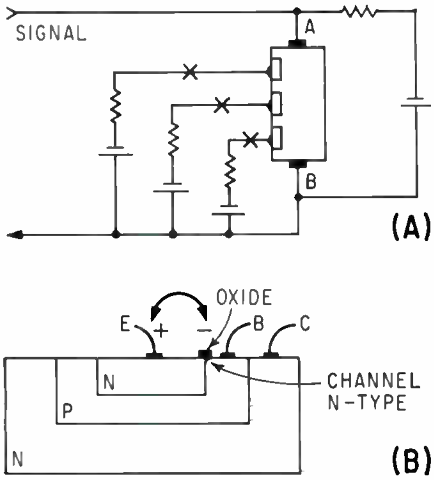
An odd one—involving measuring equipment but no measuring job! Operator at a major plant once had to hand-space ceramic wafers on a processing tray. Bid for automating job was $24,000. An EI X-Y recorder, with tray mounted to recorder in place of plotting pen, was found to be all that was needed for the job. The enterprising EI Sales Engineer saved the company involved more than $20,000!



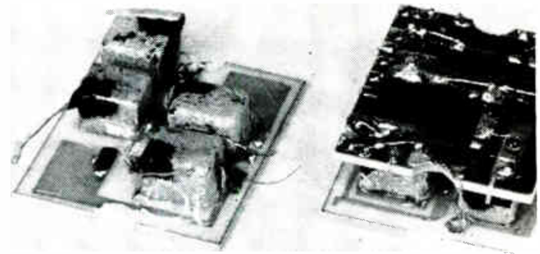
Electro Instruments offers the world's most carefully designed X-Y Recorders.

Electro Instruments, Inc.
8611 Balboa Avenue, San Diego 12, California

ELECTRO INTERNATIONAL, INC., ANNAPOLIS, MARYLAND • TRANSFORMER ENGINEERS, SAN GABRIEL, CALIFORNIA



MULTILAYER DIODE can be used as analog-to-digital converter (A), reports Westinghouse's Vasil Uzunoglu. Oxide between transistor emitter and base controls gain (B)



SERVO AMPLIFIER built with hybrid circuits

Active Thin-Film Device Problems Fade

ECCANE also to hear how oxide layer can control transistors

ACTIVE THIN-FILM devices can now be fabricated to meet most low-power circuit requirements at speeds up to 10 Mc, according to Charles Feldman, of Melpar, Inc. In fact, operational thin-film circuits using both active and passive elements are now just three to five years away, he estimates.

Feldman will be one of several speakers at the East Coast Conference on Aerospace and Navigational Electronics who see thin film circuits as the answer to space radiation and temperature problems. ECCANE will be held in Baltimore Oct. 21-23.

Among devices Melpar is developing is a new thin-film varistor. The device is a metal-boron-metal sandwich. Melpar uses aluminum as the metal, but other metals can be used.

Field-effect devices used as variable resistors and variable capacitors can be fabricated from cadmium selenide, silicon oxide, neodymium oxide and a wide variety of other materials. Melpar's field-effect devices are majority carrier, polycrystalline, nonjunction, large-energy-gap devices — a combination that makes for high temperature (500 C), radiation-resistant molecular circuits.

Radiation Resistance — Melpar's thin-film flip-flops have been tested in gamma fields up to 10^8 roentgens per second without changing state. Feldman claims semiconductor flip-flops would be damaged in radiation fields 1,000 times lower. Preliminary checks of some capacitors are now being made under neutron bombardment. The work is being done for the Bureau of Naval Weapons.

Martin Karp, of Alpha Microelectronics, will cite some of the chief advantages thin-films have over semiconductors including radiation resistance, higher temperature tolerances, lack of feedback and high power handling capacity with speeds of up to 50 Mc in passive devices. A custom digital computer made with 5,000 resistors in 300 circuits on 1.8 × 1.8-in. substrates will be used as an example.

Servo Amplifier—A 5-w hybrid microelectronic servo amplifier built at General Precision Aerospace (ELECTRONICS, p 48, Feb. 15) will be described by P. Smith, N. Mahoney, H. M. Pollack and M. Genser. The group now says units delivering 15 watts can be built in the same size and weight (0.3 cu. in., 0.5 oz.), and that the present unit, mounted in a suitable heat sink, has successfully driven two 5-w motors in parallel.

Transistor Memory—Placing oxide layers between the emitter and base of a transistor to control gain will be described by Vasil Uzunoglu, of Westinghouse Electric. Such devices (see figure) may provide memory elements with long storage times.

The oxide can be considered as a capacitor shunted by a resistor over 10^{12} ohms. Thus, it has a very long storage time, and a pulse applied to the transistor operating in its linear region will change the gain, depending upon pulse amplitude. This new state will last as long as the charge stored on the oxide remains. Typical storage times are as high as 25 minutes.

Diodes with oxide-coated junctions can be used as biasing elements on the transistors. Applying different voltages on the oxide and one of the layers can change the reverse current flow of the junction and thus adjust the transistor input impedance. Typical units, used in transistors, changed the impedance level over 500 percent within 6 volts of bias variation.

A multilayer diode (ELECTRONICS, p 38, March 8) used as an analog-to-digital converter will also be described by Uzunoglu. Each junction has a negative-resistance region. Depending on incoming signal strength, any one of the diodes or a certain number of them, will be actuated. Indicators can be used in series with the diodes to convert analog data to digital. Suitable pulses applied at terminals A-B of the multilayer diode (see illustration) reset the devices.

Telepathy Maybe

For now, lunar-mission planners figure on hardware, not software

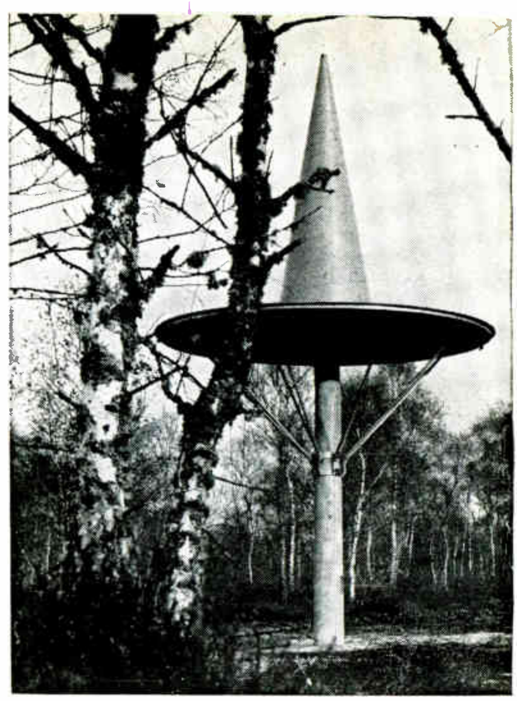
PARIS—While the revelation that Russians might achieve telepathic communications on the moon (ELECTRONICS, p 17, Oct. 4) stirred up the International Astronautical Conference last week, other reports showed that hardware development to do the job electronically was quite well in hand.

Translunar communications, said one speaker, is a "relatively simple problem." Near earth, reported M. G. Chatelain, of North American Aviation, voice would be transmitted at vhf with omnidirectional antennas like discones, biconical horns or scimitar arrays. At 4,000 n. mi out, frequency would shift to S band (1 to 3 Gc) using high-gain antennas like parabolic reflectors or end-fire arrays.

To talk to each other on the moon, astronauts would use vhf again. However, the moon's small diameter cuts line-of-sight range, its surface dielectric constant seems less favorable for wave propagation and ionization at the surface may bar over-the-horizon transmission. To solve these problems, Chatelain suggested inflatable passive-reflector lunar satellites or a belt of reflecting dipoles in orbit around the moon.

On earth reentry, he said, blackout might be solved by using a frequency scanner and tracker to find an optimum frequency window in the plasma sheath. Transmitter and receiver would automatically switch to the window frequency.

Antennas—H. R. Warren, of DeHavilland Aircraft, described an unusual communications-satellite antenna that has a frontal area less than 16 sq ft, but gives a gain of about 36 db at 2 to 3 Mc. It is a stacked end-fire parasitic array made of storable, tubular, extendible "stems." The construction, like a steel tape measure, also can be used for vlf dipoles as long as 2,000 ft.



HELICAL ANTENNAS for experimental CSF width, give accuracy of 100 microradians

Helical antennas used in CSF's experimental interferometer at Nancay cover a two-octave bandwidth. With no base change, said M. M. Bellenger, the interferometer functions at 136-137 Mc and at 400-401 Mc. Expected accuracy at 136 Mc is 100 microradians, the limit imposed by ionospheric refraction. Precision would be higher at 400 Mc.

Satellites—Eugene Burns, of Space Technology Laboratories, proposed a satellite that would provide data

Power Lag Postpones

Besides the lack of suitable power plants, there's no money

PALO ALTO, CALIF.—Although studies show flights around Mars and Venus are possible in the 1970's, manned interplanetary space flight is

interferometer cover two-octave band-

for a mineralogical map of the moon by recording the infrared emission at 8 to 25 microns. It would carry a modified Perkin-Elmer SG-4 spectrometer, using a liquid-helium-cooled, doped-germanium, photoconductive detector.

In guidance and control sessions, J. D. Welch's description of General Electric's self-contained spacecraft navigation system was rated a standout. It combines inertial navigation for the accelerating phase of a space mission and electro-optical tracking for nonaccelerating flight. The multimode image-tube tracker uses coaxial dual-field-of-view optics working with a tv picture tube. The electrostatic gyros for inertial guidance are strapped to the tracker and used by it for angle readout and angle memory when taking fixes on stars and planets.

Mars Flight

still at least 20 years away, said scientists last week at the American Institute of Aeronautics and Astronautics.

The biggest problem, aside from the fact that the money required for such a flight has not been programmed, is the lag in development of suitable nuclear engines and nuclear-electric systems. Nor do the launch power plants exist.

Requirements for flyby trips, 613 631 days long, to Mars or Venus in 1970-72, were studied by Philco's Aeronutronic division. In his report on the study, called Empire, Frank P. Dixon said booster development should have started in early 1963. The 1970 date will most probably be missed, which means a wait until the mid-1980's for favorable planetary positions.

It was also pointed out that at the time Empire would need heavy funding, the Apollo program would be in full swing, creating a funding problem.

Empire Electronics—On the trip, the navigator would get updated ephemeris from a network of ground tracking stations. He would establish vehicle attitudes and determine trajectory with a self-contained stellar tracker. Principal guidance sensor for planetary approach would be optical.

Earth-vehicle communications antennas would be stabilized by sun and earth trackers. Redundant S-band antennas with 40-db gain and 4-kc bandwidth are recommended. The communications system planned, a minimum system for voice and digital data, needs about 200 watts of power.

Power Supplies—A Mars or Venus spacecraft requires about 40 kw, in flight, including 5 to 8 kw per man for life support, 6 to 9 kw for telemetry and radio, 2½ to 5 kw for scientific experiments.

Eugene Zwick, of NAA's Rocketdyne division, surveyed power plants and saw none in existence that would satisfy the requirements. Photovoltaic systems weigh 500 lb/kw, too heavy; solar thermoelectric systems weigh 50 lb/kw and are large and inefficient; the amount of radioisotope material needed for a 40-kw thermoelectric system isn't available; the goal of 20 lb/kw in the Snap 70 reactor-thermoelectric system is, for now at least, foiled by high-temperature materials problems; solar dynamic systems require large mirrors to focus the sun's rays, don't produce enough power (3 to 15 kw in various models) and face mechanical problems; reactor temperatures of 2,000 C needed for efficient thermionic systems are not yet available.

Reliability of Mallory XT Tantalum Capacitors proved by 10,260,000 piece-hours of testing

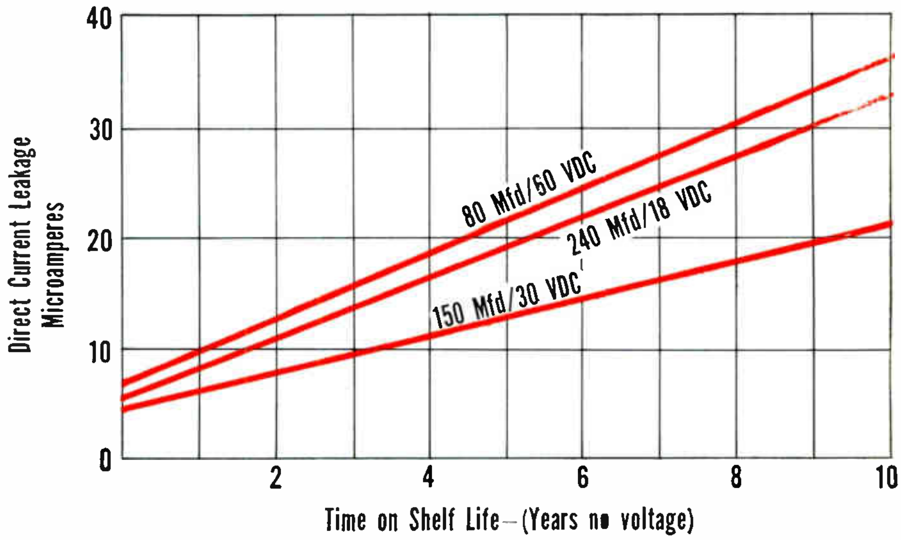
The original high temperature wet slug tantalum capacitor, the Mallory XT series has compiled a unique record of reliability in tests made in our own laboratories, by independent laboratories and by military equipment manufacturers. Here are typical results:

In 10,260,000 piece-hours of testing* **standard production capacitors,** the mean time between failure is presently 960,000 hours.

Independent tests over a two year period show that Mallory XT capacitors have *twice* the anticipated mean time to failure of other tantalum capacitors.

Ten-year shelf life tests prove that even after extremely long storage, Mallory XT capacitors meet original specification limits of d-c leakage.

Seal tests by independent laboratories indicate that the leak rate of the glass-to-metal hermetic seal used in Mallory XT capacitors is 1 x 10^{-11} standard cc. These capacitors are being used in airborne military equipment where stringent specifications for seal reliability must be met.

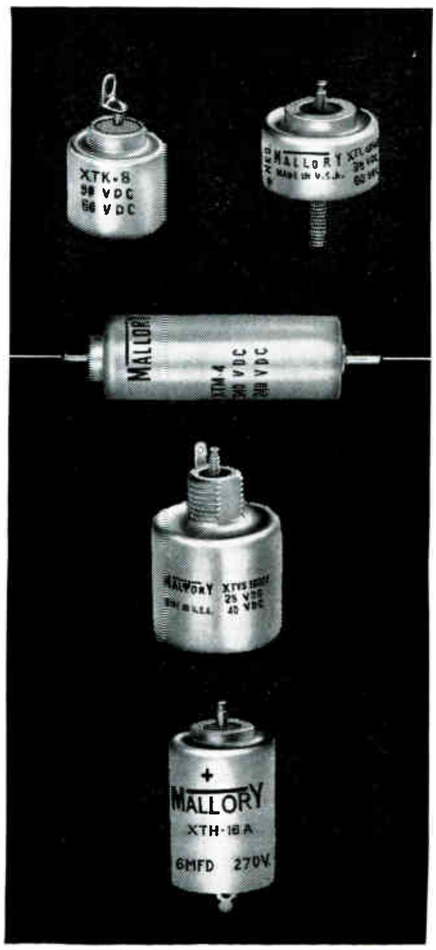


10-year shelf life test

The XT line has been in continuous production by Mallory for nearly 15 years . . . for the past five years operating under the Signal Corps RIQAP plan. For each production lot, individual records of quality control test data are kept for a five-year period.

The XT series includes 175°C and 200°C ratings in many configurations, including a broad range of MIL types and new radiation-resistant models. For complete data and a consultation, write to Mallory Capacitor Company, Indianapolis 6, Indiana—a division of P. R. Mallory & Co. Inc.

*Test conditions at rated voltage at 85°C and 175°C



Type	Temp. Range	Capacity Range	WVDC (85°C)
XTM	—55 to +175°C	4 — 14 mfd	340— 8V
XTK	—55 to +175°C	2 — 70 mfd	340— 8V
XTH	—55 to +200°C	7 — 240 mfd	630—18V
XTL	—55 to +200°C	3.5— 120 mfd	630—18V
XTV	—55 to +200°C	12 —2200 mfd	630—12V

WET SLUG, FOIL AND SOLID TANTALUM CAPACITORS

P. R. MALLORY & CO. Inc.
MALLORY

Vocal Analog Synthesizes Speech

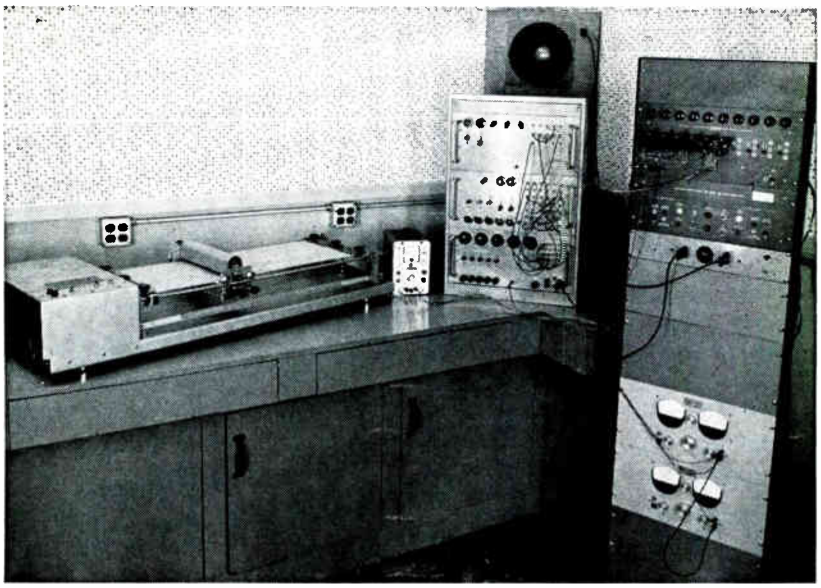
System produces intelligible sounds from hand-drawn curves

SPEECH SYNTHESIS instrument that can reconstruct artificial speech from hand-drawn patterns has been built by the Electronics Research Laboratory of Melpar's Research Division. Called EVA for Electronic Vocal Analog, the research-oriented tool consists of a programmable function generator and a controllable formant type speech synthesizer. It was designed for the basic study of speech production, for evaluating various speech recognition concepts, and also studying various configurations of the compression system.

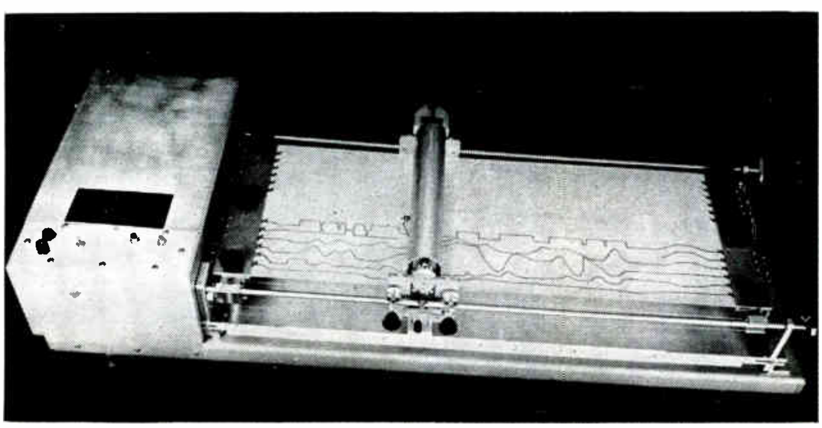
Adapted from a similar machine developed at Sweden's Royal Institute of Technology by Gunnar Fant, the EVA system uses a grid on which up to 12 parameters of speech can be plotted with conductive ink. The carriage electrifies the traces with voltages that vary according to the position of the traces on the grid. The twelve analog voltages are then fed to a speech synthesizer and there combined to produce intelligible sounds.

The hand-drawn parameter curves can be erased and altered between passes, thus allowing study of the effects of a change in any one parameter. Among the basic parameters are pitch, or frequency of larynx vibrations, also the formant frequencies or natural resonances of the vocal tract, amplitude of nasology, amplitude of fricative sounds, amplitude of source excitations, and frequency of nasal poles.

Purpose of the research involving EVA is to establish the invariant rules regarding production of speech, paving the way to the development of a phonetic typewriter, or "speakwrite", which would type out any vocal messages dictated to it.



ELECTRONIC VOICE ANALOG system includes programmable function generator, left, controllable formant synthesizer, center, and associated circuits, right



FUNCTION GENERATOR has Mylar plate on which patterns representing speech parameters are hand-drawn in conducting ink. Voltage-fed resistive rollers, center, pass over traces and generate analog signals

Function Generator — The programmable function generator, shown in the photographs, consists of a carriage-like mechanism, moving along a Mylar sheet. On the Mylar sheet are drawn the speech parameters to be reproduced, using a special ink that has high conductivity and is easily removed.

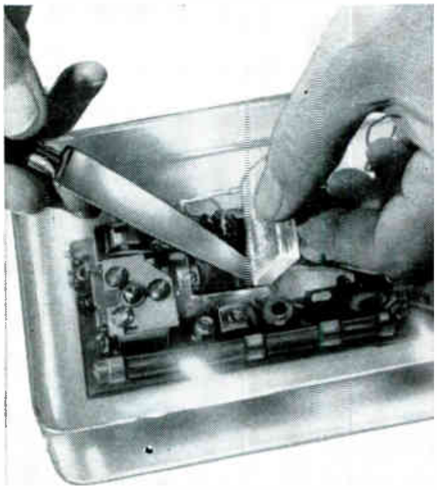
The moveable carriage consists of a resistive roller element, kept in contact with the conductive parametric traces. With a potential applied to the resistive element, each conductive trace assumes the potential at its point of contact with the roller. The playback unit thus converts the hand-drawn curves into

SILICONE

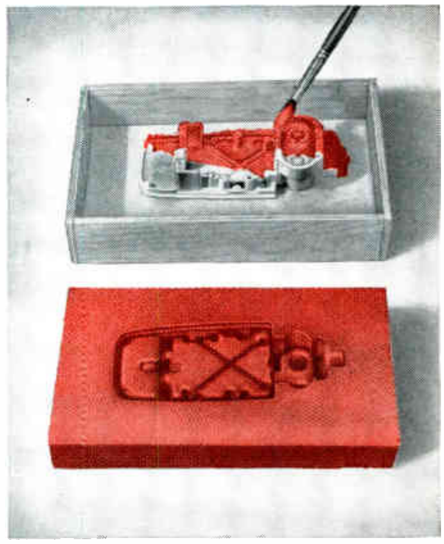
What you can do with General Electric's RTV silicone compounds

to insulate, seal and mold from –150°F to 500°F

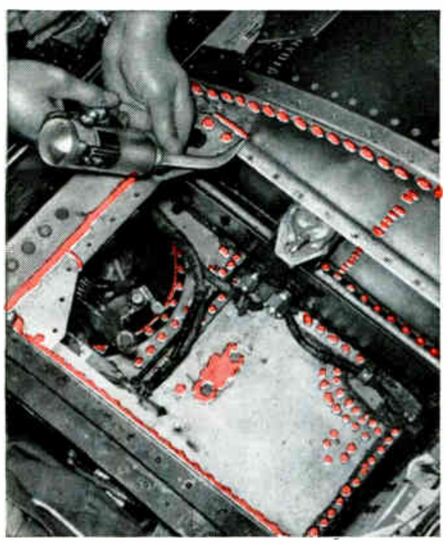
Encapsulate it. Fluid RTV silicone rubber penetrates deep into transformer coils. RTV has excellent dielectric strength and practically no shrinkage. Cure time at room temperature can be varied from minutes to hours.



Pot it. Transparent or opaque, G-E silicones provide a resilient protection against moisture, ozone, thermal and mechanical shock. Flows freely around complicated parts, can be cut away to replace internal components.



Duplicate it. Flexible RTV is often used to make molds for prototypes and short run production. This part requires deep undercutting, but duplicate parts flex free easily. RTV's tensile strength is as high as 850 psi.



Seal it. Bondable RTV (when surface is properly primed) seals against moisture and vibration, ozone and chemicals. Can be used for sheet metal fabrication, shock mounts, gasketing. Viscosities range from pourable to paste.

Insulate it. Adhesive/sealant RTV-102 requires no mixing of catalyst, can be used to insulate open wiring, for on-the-spot caulking, gluing and soldering. RTVs are virtually ageless, will not stress-crack or weather.

Manufacture it. RTV adhesive/sealants are fast working assembly tools, eliminate prefabricated parts or more costly, time consuming techniques. Here an RTV adhesive laminates flexible mica strips to form cylindrical ducts.

If you would like a free sample of one of the nine General Electric RTV silicones for evaluation, write on your letterhead, describing your application. For additional information, check reader service card SectionN1095 Silicone Products Dept., General Electric Company, Waterford, New York.

GENERAL ELECTRIC

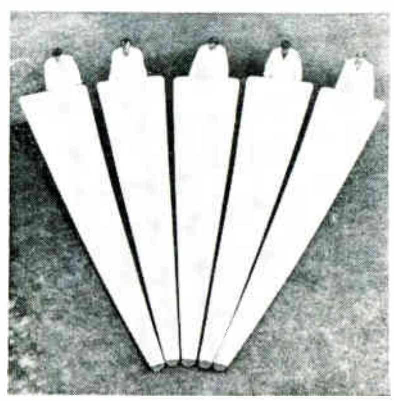
equivalent electronic signals controlling a speech synthesizer; the carriage movement corresponds to time, and the distance along the resistance roller is a function of frequency or of amplitude.

The moving carriage can be slowed down considerably, allowing the study of the microstructure of speech. In addition, any parameter can be easily erased and changed to study its effect on intelligibility.

Formant Synthesizer—The controllable formant synthesizer is basically an electrical analog of the human vocal mechanism. Action of the vocal chords is simulated by a glottal pulse generator, shaped to conform to the energy content typical of that produced by a human. The energy is then transmitted through circuits that simulate the poles of the transfer function of the vocal tract. Repetition rate of the glottal pulses, as well as the frequencies of the poles (or formants) are typical of the functions under control of the function generator when speech is being produced.

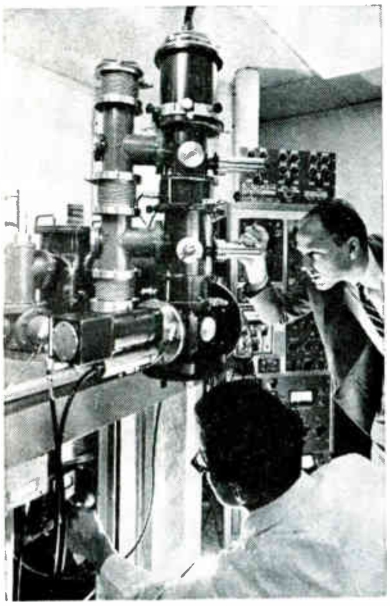
The formant synthesizer allows control of 16 possible variables, including the frequencies of pitch and the formants. An additional feature is the ability to control the spectral shape of the glottal excitation pulse in order to vary the personality of the speech.

Space Reflector Unfolds



ELECTROFORMED petals for a 45-ft, 2,000-sq ft unfurlable reflector that will provide from 50 to 250 kilowatts of solar power to a space power conversion system, have been made in a feasibility study by Electro-Optical Systems, Pasadena, Calif. The parabolic reflector will weigh less than one pound per square foot of reflecting area

Scanning Electronic Eye

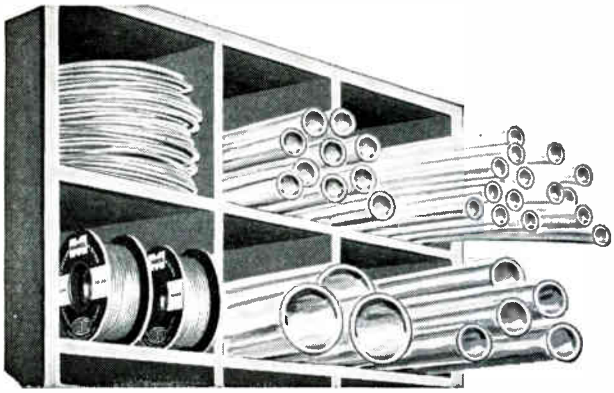


CLAIMED to be the first successful scanning electron microscope in the U. S., this new instrument at Westinghouse Research Laboratories, Pittsburgh, develops an electron-microscope image by sweeping the object with a 0.1-micron electron beam. Area viewed can be as small as 15 millionths of a square inch; image is obtained by generating secondary electrons at the scanned surface and converting these into light by a scintillating crystal, then back to electric pulses and then to display crt. Resolution is from 250 to 1,000 lines per frame

New Digitizers Track Flying Particles

TWO NEW devices for studying the traces of collisions between nuclear particles are nearing completion at Brookhaven National Laboratory. Called flying-spot digitizers, the machines will help analyze pictures of particle tracks left in bubble chambers. They are being built to help handle the large number of track photographs that will be produced by the Laboratory's new 80-inch bubble chamber; present methods are too slow.

The digitizer uses a 15-micron beam of light, split into two, with one half scanning the bubble-chamber film, and the other half scanning a grating to act as a position reference. Photocells behind both the film and the grating convert the light intensity into voltage, and the resulting signals are passed on to a computer for analysis.



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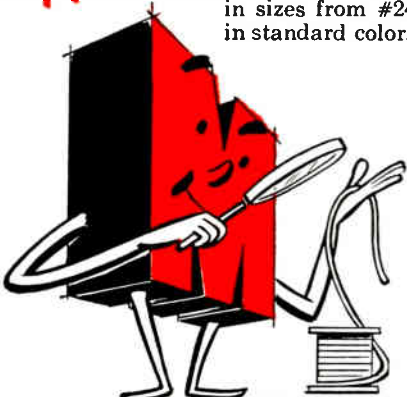

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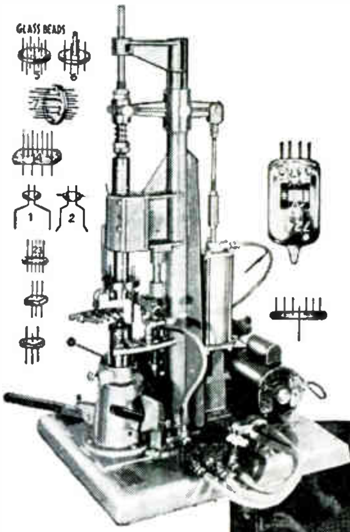

At left: No. 105-BSTI single position Button Stem and Wafer making machine—Fully automatic. Designed for small production runs on special tube parts or for laboratory use. Produces button stems up to 1¼" diameter. Machine can be supplied with up to 24 positions.

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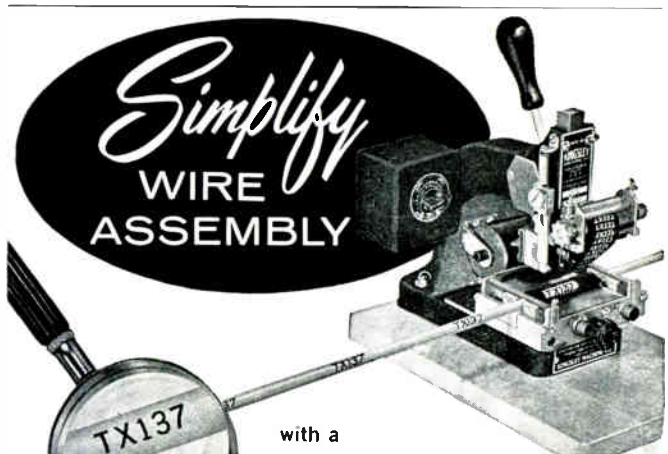

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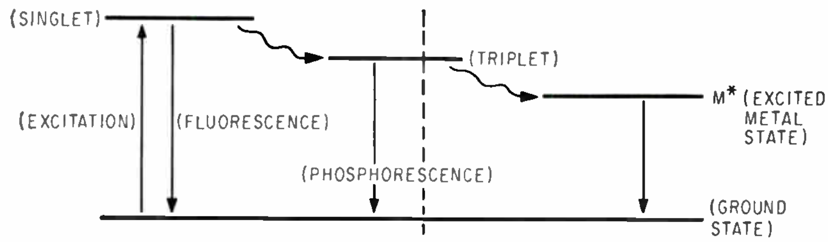
Bright Future Seen for Organics

They strike out as semiconductors, but open up designs for new functions

By MICHAEL F. TOMAINO
Associate Editor



ENERGY level diagram. Organic portion of molecule offers an extremely wide pump band for excitation of rare-earth atoms. The light-induced triplet state in organic compounds is analogous to a three-level maser or laser scheme

NEW YORK—Investigations of organic materials have taken a 180-degree turn. Rather than trying to squeeze semiconductor properties out of organics, these materials are now being exploited for the generation of coherent radiation, piezoelectricity, optical phonemena, acoustical interactions, infrared transistions, and dielectrics.

Last week, at Electrochemical Society Symposium, Texas Instruments' R. R. Neiman and R. E. Johnson dusted off some "old hat" concepts about organic materials. They clarified some rather far-fetched ideas some electronics people have about organics. Most important, they presented an exciting picture of some areas opening up in electronics that are now close to fruition.

Authors of paper on organic materials for electronic applications define organic materials as any material that contains at least one carbon atom. Thus they include metal-organics and chelates.

Little Hope—The Texans believe that organic structures now offer little hope of being used successfully as semiconducting materials. Their reasoning: organics have low mobilities, apparent absence of n-type carriers, and our lack of knowledge of doping these materials.

Why then are they and other workers sticking to organics?

They say organic materials are easy to prepare. Large numbers of materials are available. Many organics have different properties, and they offer potential of precise control over material properties by substituent group synthesis.

The latter is the foremost reason for considering organics, speakers say. Organics offer the molecular tuning which is one of the bright hopes for electronic materials.

The authors looked at the opposite side of the coin. Organics are difficult to purify to the degree necessary for device operation. They are difficult to manipulate. They are difficult to understand.

Useful materials for electronics are usually assessed upon the availability of high-purity materials, consistent and reliable electrical measurements on single-crystal samples, and a detailed understanding of electron-transport mechanisms.

It is now difficult to obtain the purities usually discussed in semiconductor operations. The technology of making contacts to organic materials is almost completely unknown. Knowledge of electrical properties has been slow in coming.

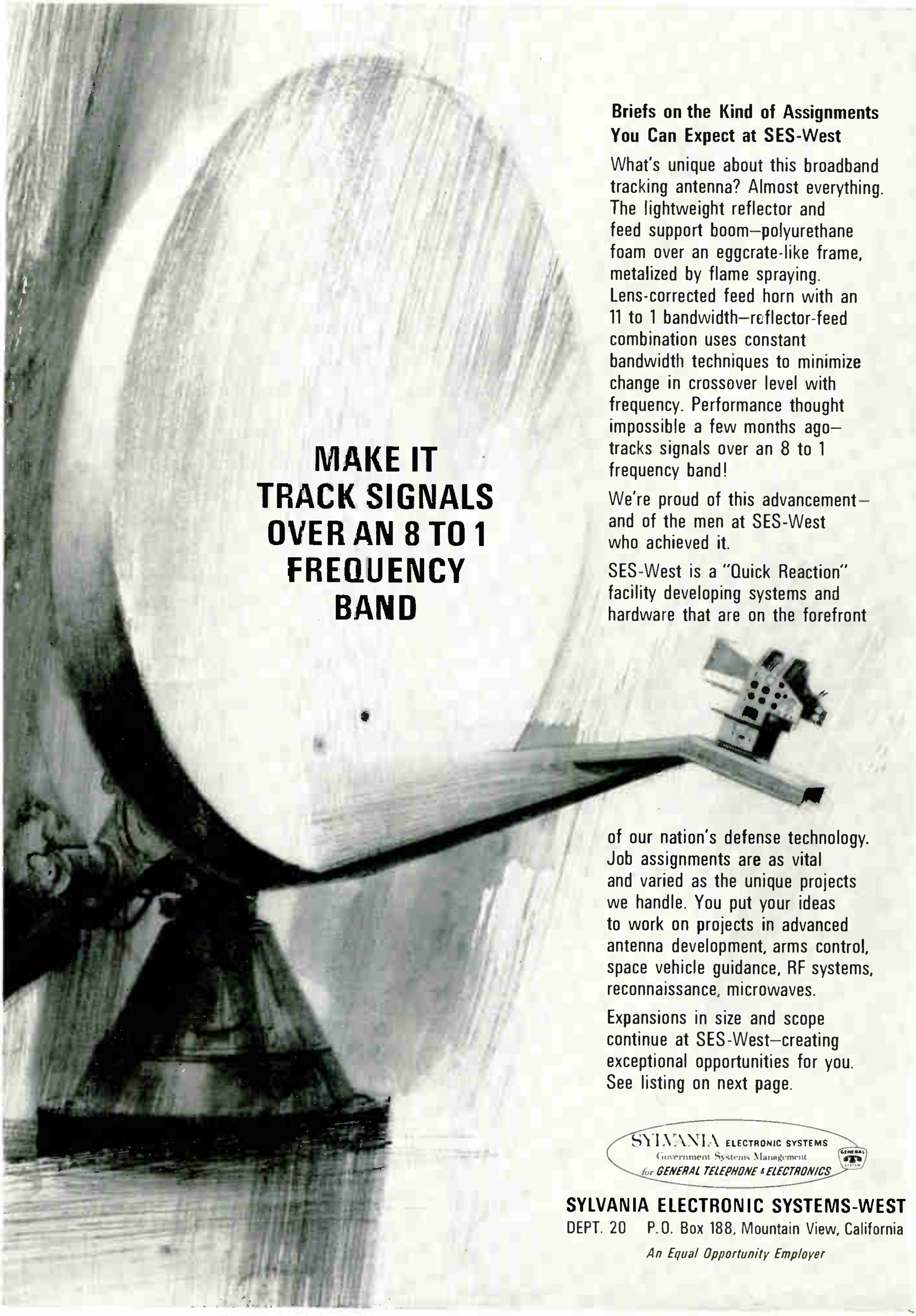
Why, then, do organics warrant serious consideration in electronics?

Bright Hope—The key to this question, authors say, lie in several areas. The generation of coherent radiation. Their use as piezoelectric or piezoresistive elements, optical phenomena, and their use as circuit elements.

Texas Instruments workers believe that organic materials can be exploited for all these applications. They recommend that increased efforts should be directed in all these areas. Aeronautical Systems Division, USAF, has gone all out for these recommendations. The Air Force now has two important programs under contract to investigate organics. Programs are with Texas Instruments and RCA.

Workers at both firms believe that the use of rare-earth chelates as laser materials have a decided edge over other materials. The organic portion of the molecule offers an extremely wide pump band for the excitation of the rare-earth atom, according to TI. They say that the chelates will assume a prominent place in optical maser devices. Workers at General Telephone Laboratories have shown laser action in europium benzoylacetonate, for instance. These rare-earth chelates have longer decay time than corresponding inorganic salts. Chelates have narrow line-width, high quantum efficiency.

Beam-type masers utilize transitions in the millimeter wavelength region. The light-induced triplet state in organic compounds bears a formal analogy to a three-level maser or laser scheme. Maser action could be possible in such organic compounds as the nitrines. Hope is offered for many new laser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frequencies. The Raman-effect lasers, discovered by Hughes, also offer the possibility of new laser frequencies.

Neiman and Johnson considered piezoelectrics. They said that organics could be used as crystal filters or could act as inductors. Ease of growth on substrates make organics suitable for truly integrated circuits sought by the Air Force. Organic piezoelectrics, include benzophenone, acetone oxime and hexamethylene tetramine.

Color Changes—Going into optical phenomena, color changes produced by exposure of organics to light offer possibilities for many applications: switches, computer elements, microfilms, ultraviolet-sensitive glasses, and display systems.

Organics, particularly hexamethylene tetramine (HMTA), may possess real advantages over inorganic crystals for linear optical-electro effects (LOEE). This is due to their ease of growth and in some cases their higher melting points. The LOEE can be used for light-modulation devices.

Conductive plastics can be used as interconnections in electronic devices. There is increasing evidence that organic as well as inorganic thin films may contribute to metal-insulator-metal device technology. Free radicals of organics can be used as microwave detectors. Mims has shown that chirped radar signals can be detected by electron spin echoes. This method is similar to a two-level maser. A suitable material, could be the free radical, diphenylpicrylhydrazvl TI says.

At RCA, S. E. Harrison, G. E. Heilmeier and G. Warfield also point out that explorations into the organics may give new insights to the life processes with may depend upon electronic motion.

The study of the mechanisms of energy transfer and charge flow in organics may shed light on the operation of biologically important compounds. The electronic structure of both materials are similar.

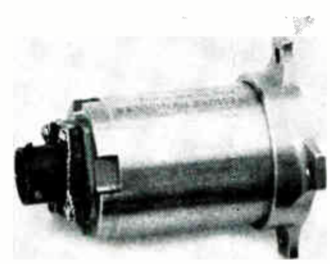
Rolled Metal Strips Compete with Thin Films

LONDON—Nickel-iron alloys, cold rolled down to a thickness of 1.5 microns, show properties akin to evaporated films for electronic applications, according to researchers at Britain's General Post Office Research Station, Dollis Hill, London. Advantages of thin-film devices manufactured by this technique are compactness and versatility—since there is no cumbersome substrate—and the capacity of using any alloy—at present, only alloys that evaporate at temperatures low enough not to damage substrates can be used for thin-film devices.

Although theoretical calculations show that rolled metal strip should not show anisotropic characteristics at thicknesses above 0.5 microns, the thinnest strip made so far—1.5 microns—is definitely anisotropic, although switching speed is not comparable with evaporated devices. GPO Researchers predict, however, that switching speed will increase as thickness is decreased.

Manufacturing processes have limited thickness so far, because dust captured during rolling operations makes the final product "like a lace curtain." Further attempts—using glove-boxes and clean-rooms—are planned, and strips of 0.5-micron thicknesses should be possible.

Device Lasts ½ Second In Titan Exhaust Flames



THE LIFE expectancy of this Fairchild 3S-G transducer is approximately one-half second. Before it is consumed in the heat of Aerozone 50 and nitrogen tetroxide—igniting to separate the first and second stages of Titan II—the high frequency response pressure transducer will report on the shock pressure encountered during the separation firing. By analyzing this data, in conjunction with other information, the performance of the Gemini launch vehicle's 100,000-pound-thrust second stage—and its adherence to the programmed flight plan—can accurately be determined.

Microprobe Finds Failure Modes at Micron Level

CHICAGO—Use of an electron microprobe analyzer as a technique for studying failure modes of components was cutlined by Paul Pietrokowsky of Autonetics. Talk was given at the Symposium on Physics of Failure. Meeting, held last week, was sponsored by ITT Research Institute and Rome Air Development Center.

The electron microprobe analyzer scans increments as short as one micron. It has tracked complex atomic dispersions of gold and nickel inside switching diodes. Instrument used in Autonetics' work was manufactured by Applied Research Laboratory, Glendale, California. Objective of the study was to determine how the analyzer could be used to study semiconductor devices and device process technology.

The scanning beam instrument can investigate an area which is the size of the device itself. Vast amount of data can be collected in a relatively short time. The large area display reveals information which would be time consuming to obtain by point analysis techniques.

In another paper, delivered at same meeting, H. Stuart Dodge of Burroughs pointed out that electrical flaws cause about one failure in every three semiconductor failures. Mechanical faults account for about 65 percent of failures. Most failures are detected at early qualification stages. Lifetimes are predicted and potential trouble makers are eliminated before they cause failures.

A fundamental failure mechanism in thin metal-dielectric-metal structure is observable as a generated voltage. This galvano-diffusion effect was discussed by J. J. Wortman and R. M. Burger of Research Triangle Institute. Authors suggest several measures can be taken to minimize this effect, including use of gold and platinum electrodes, use of thick electrodes, dense dielectrics, low temperaure operation, use of efficient getters in hermetic enclosures, and adjustment of electric field polarities.

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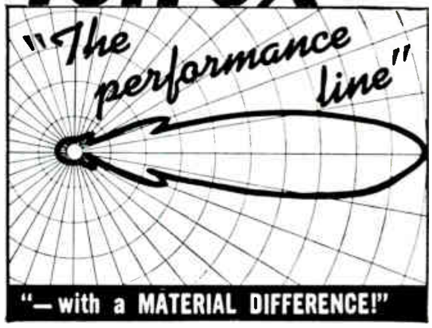

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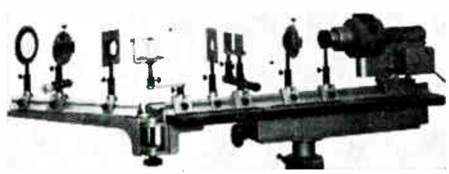

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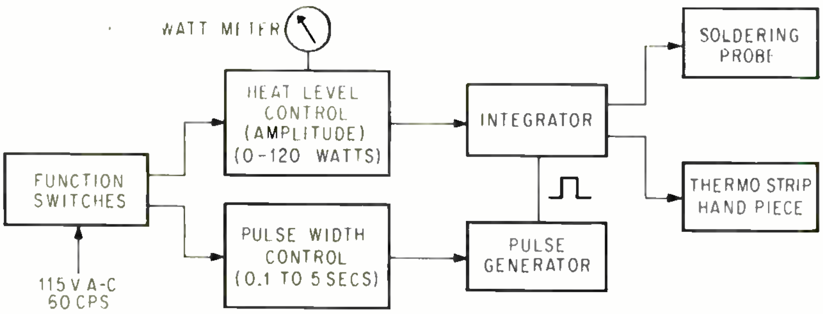
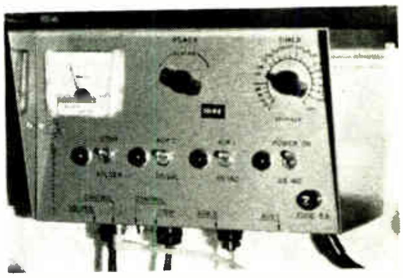


BLOCK PROGRAM of power supply. Pulse width (time duration) and heat level (current amplitude) are continuously variable



SOLID STATE supply provides adjustable current pulses to probe. A foot switch controls the supply but machine turns off at a predetermined time

Pulses Control Soldering Quality

Programmed control for resistance soldering assures good connections

PULSED resistance - soldering equipment developed by Electro-Miniature Corp., of Hackensack, N.J., enables inexperienced persons to make solder joints in miniature equipment with speed and reliability.

According to R. E. Wolfe, chief engineer, the equipment has made some 140,000 satisfactory solder joints with an increase in production speed of 50 percent.

The company has been using the resistance solderer to make terminal connections on miniature connectors for slip rings used in inertial guidance platforms and for soldering in the slip-ring assembly itself.

The soldering equipment also does double-duty as a thermostripper for wire insulation.

Operation—In resistance soldering, an operator would normally apply a current-carrying probe to the part being soldered until a solder preform melted. Heat is generated by the resistance of the part, such as a terminal pin, or in the chassis near the joint. The probe has two conductors, separated by a gap. The part being soldered completes the electrical path through the gap.

In Electro-Miniature's system, a similar probe is used. However, the power supply is programmed so the operator need not judge timing or solder flow to make a satisfactory connection. Current-pulse amplitude and width are predetermined and set up on the power supply's control panel. The pulse can be as long as 5 seconds.

All the operator need do is apply the probe to the part being soldered and start the soldering-pulse cycle with a foot switch.

Programming is done by a quality-control man experienced in soldering. He determines current

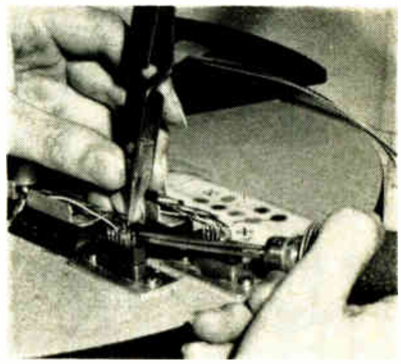
Furnace Seals Integrated Circuits

FINAL ASSEMBLY and packaging of integrated circuits manufactured by the Westinghouse Molecular Electronics Division, Elkridge, Md.: The Kovar alloy frames in the petri dishes are placed in the carbon casts on the workbench. Glass, Kovar alloy leads, and metallic or ceramic bases are then added. Weights from the boxes at lower right are placed on top. The entire assembly is fed into the inert gas furnace, top right, where the glass fuses to form an hermetic seal. Called Flat-Packs these circuits are functional blocks.

time and amplitude required for an optimum joint in a particular type of connection. Values can be pre-set within 1-percent accuracy. The control system is shown in the block diagram.

Application — One application for the equipment is soldering 70 size-28 conductors to a subminiature slip-ring assembly. Connector terminals are as close as 0.05 inch. The company says there have been no problems of solder running between pins or excessive heat conduction to other sections of the connector.

The units are assembled on a fixture with solder preforms and terminal pins in place. The operator inserts the connector wire into the hollow pin as soon as the solder flows.



MINIATURE CONNECTORS are easily soldered with preformed solder and programmed heat supply. Heat is developed by the flow of current through the connector terminal

The company adds that if changes or repairs should be needed in the assemblies, parts can be unsoldered quickly and without excessive heat by setting the controls to melt the solder in the joint.

Additional probes are provided for thermally stripping wire insulation.

Multiblade Saws Cut Wafering Heat

WORCESTER, MASS. — Multiblade wafering machine built here by Norton Co. is being tested in semiconductor plants in U. S., Europe, and Japan as a new approach to slicing of semiconductor crystals.

Principal advantage over annular saws may be in minimization of heat-caused surface damage to semiconductor material. The question of surface damage is relatively an unexplored field.

According to Thomas Bushman, of Norton Co.'s Machine Tool division, virtually no heat is generated and 25 microns is deepest penetration of damage detected so far from multiblade wafering machine.

The technique has its roots in the drag saws used in the marble-cutting industry. The machine goes through one inch of semiconductor material in six hours, instead of the typical one inch per minute for annular saws. But multiple cuts are being made. Blue-tempered steel blades work their way back and forth through a slurry composed of 9.5-micron grains of silicon carbide mixed with oil. As far as can be determined, the steel blades never touch the silicon or other semiconductor material.

Developers admit the technique is not as accurate as conventional saws in size and parallelism of cut, but point out that a lapping has to be done later anyway. Success of technique will probably depend on extensive studies now being undertaken in semiconductor laboratories to determine relative depth-of-damage caused by cutting methods.

Another application for the multiblade saws, now being investigated, is the fabrication of ferrite waffles for waffle-type computer memories, compact, high-speed memory devices recently developed by Bell Telephone Laboratories.

Indexing Machines Mold Plastic Parts

AUTOMATIC MOLDING process was outlined by George B. Rheinfrank, Jr., of Glasskyd Department of American Cyanamid Co., Perrysburg, Ohio, last week at the Cleveland Meeting of the Society of Plastic Engineers. The machine is designed for molding Glaskyd alkyd compounds, used in electrical and electronic applications.

The machine consists of a cold plunger section, used to inject a cold slug of Glasskyd alkyd-glass fibre compounds and a press with a rotary indexing table carrying four molds 90 degrees apart. Six-station machines have also been built.

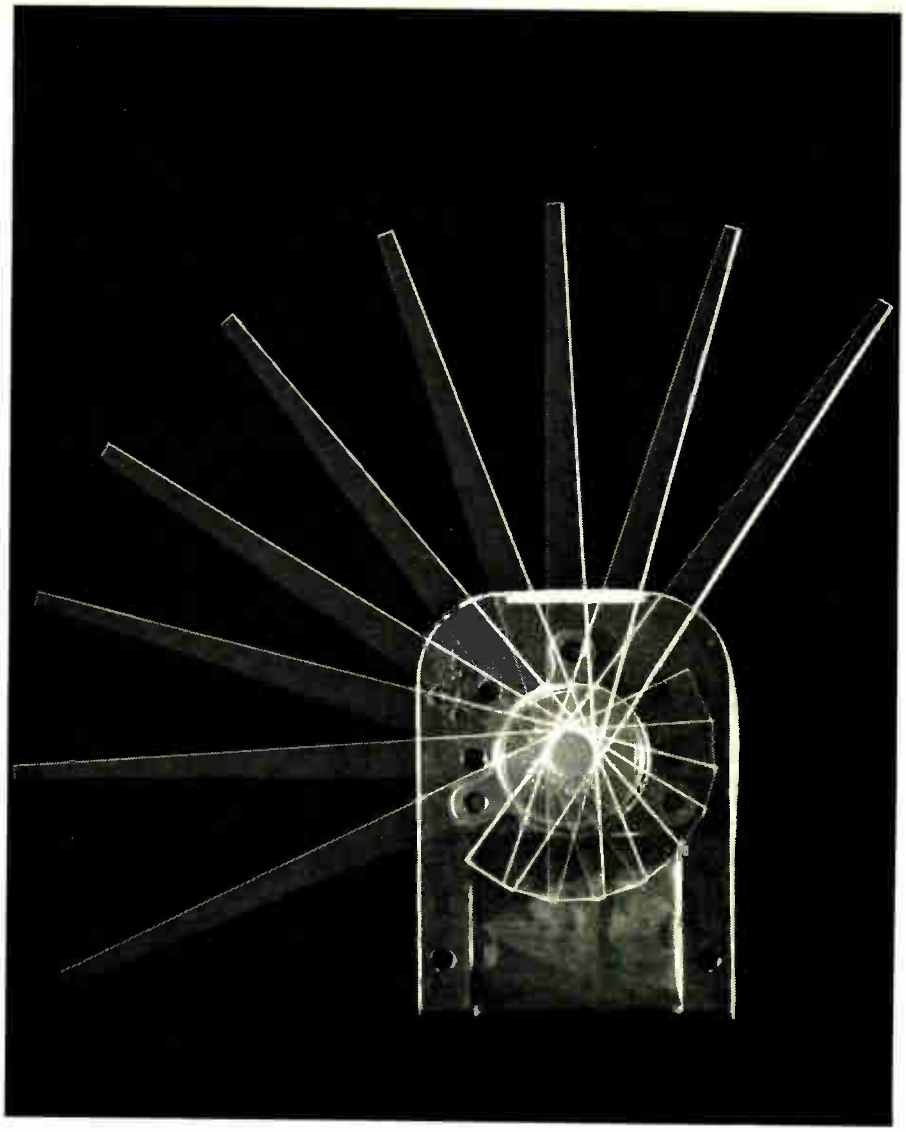
Process—The injection piston forces a 1-lb slug of molding compound from the loading well into an injection chamber heated to 150 deg F. At this temperature, the rope-shaped molding compounds become relatively fluid and remain stable for 24 hours. Rheinfrank added that the machine can be further automated by adding automatic feeding equipment.

When the mold rotates to the injection station, the injection cylinder advances until its nozzle engages the mold orifice. The compound is injected during an interval of ½ to 3 seconds at 5,000 to 8,000 psi. The mold is held closed by an air-intensified clamp. Injection pressure is then lowered to a holding pressure of 1,000 to 2,000 psi permitting cure of material at the mold gate. The resulting sealed cavity prevents escape of the injected compound.

Automatic withdrawal of the injection cylinder from the mold completes the injection cycle. Cure is initiated with injection of the compound into the mold cavity. Immediate release of full clamping pressure is followed by automatic mold rotation to the next station. Cure is completed when the mold reaches the third station. During cure only 200 to 400-psi hold pressure is needed to keep the mold closed.

Molded parts are automatically ejected at the fourth station. The closed, empty mold is then ready to start a new cycle. Total time to complete the entire cycle may run as low as 24 seconds. The rope-shaped alkyd molding compounds need not be accurately weighed before loading into the injection chamber. Waste of the compound is reduced since the cull is completely eliminated. Automation is easy since weighing of material before loading is not necessary.

This cold plunger process is patented by the American Cyanamid Company, but royalty free licenses will be granted to interested fabricators.



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What is a Stepping Motor?

A stepping motor is like a synchronous motor in principle, except that its rotor does not revolve smoothly and continuously when the motor is energized. Instead, on command from the input, the rotor travels an incremental step, stops instantly and locks magnetically in position. When a signal of opposite polarity is applied, the rotor advances another precise step, delivering torque in exact proportion to and at the same rate as the input.

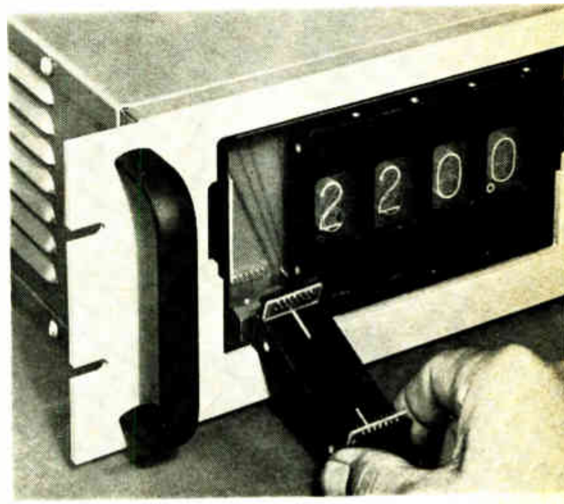
Printed-Circuit Readouts Feature Modular Design

Optical technique increases readability, reduces eye fatigue

MODEL 4W modular readouts provide rapid, error-free, high-contrast display of numerals and other symbols. Using twelve transparent lucite plates arranged one behind the other, units increase readability of digital display and minimize eye fatigue. Display symbols are engraved on lucite plates that are individually edge illuminated by miniature lamps. Energizing any of the 12 lamps causes the associated symbol to glow, while a Polaroid filter covering the readout reduces incident light reflections and contributes to figure definition and brilliance.

Construction of the 4W readouts allows the characters furthest from the front to be clearly seen without interference from nearer engravings. This is accomplished by shaping and positioning each character to minimize overlap and by forming the characters by impressing a series of dots into the lucite plates rather than forming characters by continuous engraving. The depth and diameter of each dot is designed to achieve greatest possible light transfer.

Any number of readouts may be arranged on a printed-circuit board to provide lengthy displays. Units plug in and out simply as shown in the photo. Readout lamps are mounted in the digital unit on two easily-removed printed-circuit cards that hold six lamps each. Lamps require 6, 14 or 28 volts and are therefore suited for transistor circuits. Normal lamp life is 5,000 hours representing 2½ years at



8 hours per day, 5 days per week. 10,000 hour and 50,000 hour lamps are also available. Price: $15 to $25 each, depending upon quantity. Non-Linear Systems, Inc., P.O. Box 728, Del Mar, California.
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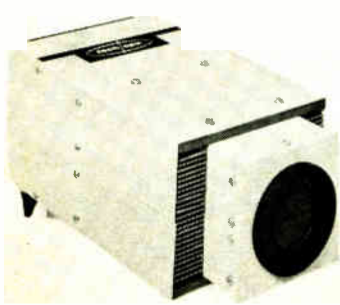
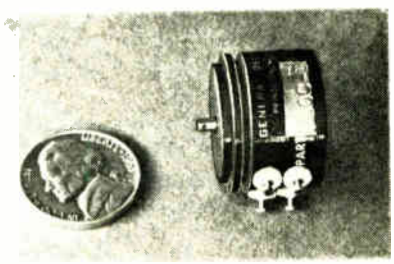
Chamber Cools Photomultipliers

THERMOELECTRICALLY refrigerated chamber permits operation of multiplier phototubes in a controlled-temperature environment.



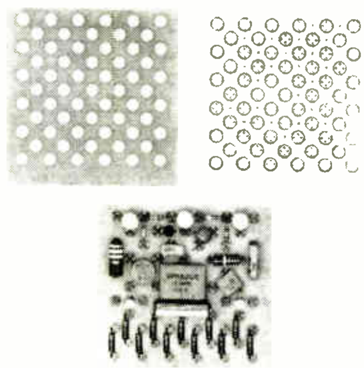
Believed by the manufacturer to be the first device of its kind to be offered on a standard product basis, the unit allows the operating temperatures of tube photocathodes to be selected in the range from 20 C to −10 C and stabilized to ±0.25 C for extended periods. A thermally-insulated window prevents dewing of the tube face and a cylindrical mu-metal shield that surrounds the tube envelope is arranged for operation at the tube's cathode potential. Total power consumption is less than 100 watts, permitting convenient portable operation. Technical Operations Research, Burlington, Mass. **(302)**



Tiny Switch Provides High-Speed Programming

SUBMINIATURE multi-channel programming switch designed for military and commercial applications provides a multitude of accurately related switching functions with shaft rotation. In addition to greatly reduced size, unit features low driving torque, low contact noise and dynamic resistance and high timing accuracy for its size. Called Programmite, the switch is capable of reliable operation for long periods of time over a wide speed range and is particularly adaptable to high-speed programming applications where contact bounce must be avoided. Although available in a variety of standard and special configurations, the unit shown in the photo is a 3-pole commutating switch capable of up to 50 on-off functions per pole, per rotation. Prices of production quantities are less than $100 each. General Devices, Inc., P.O. Box 253, Princeton, N.J.

CIRCLE **303**, READER SERVICE CARD



Circuit Boards Use Four-Hole Etched Pads

STANDARD prefabricated circuit boards employing four-hole etched pads, with or without ground plane combinations, provide a quality and effective method of packaging a complete high or low frequency circuit. Standard and miniature sizes ranging from 1 by 2 to 4 by 8 in. are available in a glass epoxy, paper epoxy and phenolic materials. Transparent facsimile lay-out sheets are supplied to match each stock size board. Price range: $2.32 to $4.63. Availability: from stock in phenolic materials, 20 days for epoxy materials. Aero Circuits Co., Box 209, Fairfield, Conn. **(304)**

Conductor Ribbon Designed for H-F Use

ANNOUNCEMENT is made of Silver-Sted, a silver-plated copper conductor ribbon in sizes to ⅛ in. wide

and as thin as 1½ mils. The ribbon, with uniform cross sectional characteristics, fully plated edges, and at popular prices, should permit the electronic designer a new approach to many silver-coated conductor problems. Some of the applications lie in high temperature conductors, laminated flat tape conductors, high-frequency coaxial cable designs, drain wires and flexible cordage. Substitution of such materials can effect savings as much as 30 percent in silver alone when substituted for silver-coated stranded fine wire. Steel Heddle Mfg. Co., Philadelphia, Pa.

CIRCLE **305,** READER SERVICE CARD

Crystal Oscillator Is Small and Light

CRYSTAL OSCILLATOR replacement for tuning forks and other less stable devices is announced. It offers high stability at very low cost. The 439 series has output frequencies available from 10 kc to 100 kc; calibration tolerance of ± 50 ppm; and a stability of ± 10 ppm/week over an ambient operating range of − 40 C to + 60 C. Gibbs Mfg. and Research Corp., 450 North Main St., Janesville, Wisc. **(306)**

Bulk Tape Eraser Cleans Up Noise

NOW AVAILABLE is the Magneraser Senior, which completely erases tapes on the reel with a once-around revolution of the reel. It is designed for use with audio, computer, telemeter, and machine-control tapes; and with 8, 16, and 35-mm sound strips. It completely erases the most severely overloaded tapes, and ac-

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tually lowers background noise levels 3 to 6 db less than some new (unused) tapes. There are no missed spots, no partial erasure, no track overlap, and no reel turnover for ¼-in. tapes on plastic or aluminum reels. The eraser saves wear and tear on heads, pressure pads, tape guides and clutches. Single spindle position accommodates 3, 5, 7, and 10½-in. reels without spindle shifting. Price is $24.95. Amplifier Corp. of America, 398 Broadway, N. Y. 13, N.Y.
CIRCLE **307,** READER SERVICE CARD

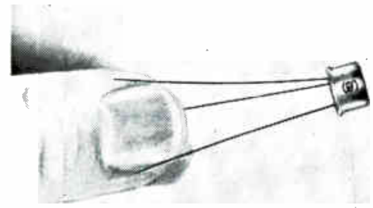
Digital Device Measures Time Interval

DIGITAL timing device 2000D can be used to measure or control time interval. It features in-line digital presentation of both elapsed and preset time. The built-in time base is available with resolutions of 1 sec to 1/1000 minute. Total time that can be measured on the 1-sec version is greater than 27 hr. Accu-

racy is equal to the power line frequency accuracy; ± 1 digit in the measuring mode and 0, — 1 digit in the controlling mode. Price is $129. NHL, P. O. Box 1051, Bristol, Conn. **(308)**

Transistor Develops Very High Beta

MODEL SST 610 is a three-terminal device containing a matched pair of hermetically-sealed *npn* diffused-mesa silicon transistors in a composite configuration permitting attainment of very-high current gain with high stability and reliability. Unit has features that include: Current gain (Beta) of 5,000, current range from 1 ma to 500 ma, dissipation of 1 watt at 25 C case temperature, low saturation voltage at high collector current, temperature range from —55 C to ±150 C and high collector-emitter and emitter-base voltage. Applications include high gain and input impedance, low-level amplifiers, negative feedback stabilization, buffer amplifiers, sensitive switches and relays. Model SST 610 is designed to meet MIL-S-19500B specifications. Solid State Electronics Co., 15321 Rayen St., Sepulveda, California. **(309)**



LITERATURE OF THE WEEK

COOLING DEVICES Dynacool Mfg. Co., P.O. Box 132, West Hurley, N. Y., has published a six-page brochure illustrating and describing a complete line of cooling devices for the industry. Prices are included.

CIRCLE **401**, READER SERVICE CARD

CRYSTAL CAN RELAY C. P. Clare & Co., 3101 Pratt Blvd., Chicago, Ill. Crystal can relay reliability manual 710 is now available. **(402)**

SOLID-STATE RELAYS Hi-G, Inc., Bradley Field, Windsor Locks, Conn. Catalog SS-1 contains data on operational and environmental characteristics of the series 2000 solid-state relays. **(403)**

LOG-VOLTMETER-CONVERTER Houston Instrument Corp., 4950 Terminal Ave., Bellaire 101, Texas, has published an 8-page bulletin on the model HLVC-150 log-voltmeter-converter. **(404)**

PRECISION FACE PLATES Precision Optics Division, Pennsylvania Optical Co., Reading, Pa. Bulletin 201 describes products and facilities for producing a wide variety of precision face plates for image orthicons, readout tubes, crt's and other electronic applications. **(405)**

SERVO AMPLIFIERS Feedback Controls, Inc., 8 Erie Drive, Natic, Mass. A series of solid-state servo amplifiers for industrial applications are described in a technical data sheet. **(406)**

CERAMIC CAPACITORS The Scionics Corp., 8900 Winnetka Ave., Northridge, Calif. A series of data sheets describe a complete line of microminiature ceramic capacitors. **(407)**

DIGITAL SYMBOL GENERATOR Digital Equipment Corp., 146 Main St., Maynard, Mass. Brochure describes symbol generator type 33, which automatically translates digital words into symbol format information. **(408)**

CIRCUIT DESIGN AIDS Magnetics Inc., Butler, Pa. A 10-page booklet has been prepared to aid circuit design engineers who are interested in inverters, magnetic amplifiers, and transformers. **(409)**

DELAY LINES The Gudeman Co. of California, Inc., 7473 Avenue 304, Visalia, Calif. Catalog sheet describes miniature lumped constant delay lines with packaging densities up to 60 sections per cu. in. **(410)**

METAL FILM RESISTORS Pyrofilm Resistor Co., Inc., 3 Saddle Road, Cedar Knolls, N. J., has issued a data sheet describing a line of ultra-stable Pyromet series oxide-protected film resistors. **(411)**

PRECISION SWITCHES Haydon Switch, Inc., 1500 Meriden Road, Waterbury, Conn., has completed a new Catalog No. 7 covering hermetically-sealed and high-temperature precision switches and switch assemblies. **(412)**

MICROWAVE TERMINATIONS SM Electronics, P.O. Box 397, La Canada, Calif. Bulletin describes liquid nitrogen-cooled matched microwave terminations useful for evaluating the equivalent noise temperature of low noise receivers and antenna systems. **(413)**

COOLING UNITS Lear Siegler, Inc., 241 South Abbe Road, Elyria, O. Cooling units for space, airborne electronics and ground guidance are described in a six-page brochure. **(414)**

MAGNETIC TAPE HEAD The Nortronics Co., Inc., 8101 10th Ave. North, Minneapolis 27, Minn. Data sheet on 4-track, 4-channel magnetic tape head for ¼-in. tape is released. **(415)**

DIGITAL LOGIC MODULES Wyle Laboratories, 128 Maryland St., El Segundo, Calif. Condensed Catalog F describes a comprehensive line of solid-state logic cards and accessory equipment such as power supplies and mounting cases. **(416)**

SENSING DEVICES Victory Engineering Corp., 122-48 Springfield Ave., Springfield, N. J. Catalog SB-53 is designed to serve as an engineer's guide to a line of thermistors, varistors and related products for civilian and military applications. **(417)**

INTEGRATED MICROWAVE COMPONENTS Microlab, 570 West Mt. Pleasant Ave., Livingston, N. J. A 20-page brochure illustrates the Microlab/Bogart capabilities in the area of integrated microwave components. **(418)**

ZENER DIODES General Instrument Corp., 65 Gouverneur St., Newark 4, N. J. A complete 36-page catalog and specifications on all EIA registered Zener diodes is now available as an aid to design engineers. **(419)**

SOLDERING IRONS Caig Laboratories Inc., 46 Stanwood Road, New Hyde Park, L. I., N. Y. Bulletin E-501 covers a line of Ersa miniature, precision 10-20-30 w, 6 v soldering irons. **(420)**

WELDING EQUIPMENT Ewald Instruments, Route 7, Kent, Conn. Catalog S2 on welding equipment for small parts, covers miniature and bench welding heads, stored energy power supplies, a-c precision and non-synchronous timer power supplies and special portable welders. **(421)**

SNAP-ACTION SWITCHES Cherry Electrical Products Corp., 1650 Old Deerfield Road, Highland Park, Ill. A 24-page catalog of snap-action switches provides complete engineering drawings, specifications and operating characteristics. **(422)**

HEAT SINKS PinFin, Inc., 681 Main St., Waltham, Mass. Brochure describing heat sinks is available to design engineers interested in maximum heat dissipation while conserving space and weight. **(423)**

TIMING DEVICES Eagle Signal, division of E. W. Bliss Co., 202 20th St., Moline, Ill. Bulletin 851 covers electronic timing devices for military and aerospace programs. A glossary of terminology is included. **(424)**

CAPACITORS General Electric Co., Schenectady 5, N.Y. Bulletin GET-2984A describes porous anode liquid electrolyte Tantalytic capacitors. **(425)**

Esterline Angus Elects V-P's



Edwin H. Baldrige — Hugh C. Cameron — Robert L. Adams

THREE KEY FIGURES in the recent acquisition of two companies by Esterline Angus Instrument Co., Inc., Indianapolis, have been elected vice presidents by the board of directors. They are Edwin H. Baldrige, Hugh C. Cameron and Robert L. Adams.

Baldrige continues as treasurer and a director of the company. Cameron remains in charge of sales. Adams continues to hold executive responsibility for engineering, research and development.

The fiscal, sales and engineering responsibilities of all three men were greatly increased when Esterline Angus purchased the assets of Lumen, now known as Lumen Electronics, a division of Esterline Angus Instrument Co., Inc., and the graphic recording line of instruments from Weston Instruments and Electronics, a division of Daystrom, Inc.

IRC Establishes New Division

INTERNATIONAL RESISTANCE Company has established an Instrumentation & Systems division to design, manufacture, and market electromechanical/electronic subsystems and associated equipment and circuitry.

The new organization was formed by integrating the firm's Control Components division with its recently merged Frontier Electronics and Plastic Products divisions. It will be located in Philadelphia.

O. C. Kebernick, formerly manager of Plastic Products, has been appointed division general manager. Marketing activities will be managed by Terry Halpern, former head of Control Components. Chief engineer is Patrick Lannan who held a similar position in Frontier Electronics.

Univac Promotes McDonald

R. E. MCDONALD, general manager of Univac Operations in the Twin Cities, has been named a vice president of the Univac division of Sperry Rand Corporation in an announcement made by Louis T. Rader, president.

"This new position has been established in recognition of the increasingly important role that our Twin Cities facilities play in the profitable growth of the Univac division", Rader said.

As vice president and general manager, Univac Operations, McDonald will continue as chief operating officer of Univac's extensive research, development and production facilities in the Twin Cities area and will assume added responsibilities with respect to overall Univac objectives.

ITT Division Hires Steeg

APPOINTMENT of Carl W. Steeg, Jr., as director of new product planning and development at ITT Industrial Laboratories, Ft. Wayne, Ind., division of International Telephone and Telegraph Corp., is announced.

Steeg comes from RCA, where he managed aerospace communications and controls programs.

O'Donnell Accepts Kollsman Post

CHARLES J. O'DONNELL has been appointed vice president of operations for the Kollsman Instrument Corp., Elmhurst, N. Y., subsidiary of Standard Kollsman Industries Inc. He will be in charge of all activities of the Instrument division at Elmhurst and the Guidance, Display and Armaments division at Syosset, N. Y.

O'Donnell was formerly general manager of the Belock Instrument Corp., College Point, N. Y.

Precision Line Names Lyon

PRECISION LINE INC., Maynard, Mass., has appointed William W. Lyon chief engineer in charge of design, development and production of precision, ultra-precision, and trimmer potentiometers and related electronic components.

For the past few years Lyon was engineering manager for New England Instrument, Waltham-Natick, Mass.

Franklin Joins GI Sickles Division

S. EDWARD FRANKLIN has joined the F. W. Sickles division of General Instrument Corporation in Chicopee, Mass., as vice president in charge of operations. He will be responsible for all phases of manufacturing and related operations, as well as design engineering, in the division.

The division, with headquarters plant at Chicopee, manufactures uhf tv tuners and other radio-tv components, as well as devices for military end use.

Franklin comes to his new post from Canadian Aviation Electronics Ltd., where he was vice president of manufacturing, in charge of both commercial and military products.

Rixon Reassigns Executives

J. L. HOLLIS, president and board chairman of Rixon Electronics, Inc., Silver Spring, Md., has announced that C. J. Harrison, senior vice president, engineering and operations, and L. Lerner, vice president for engineering, are assuming new responsibilities.

Harrison has been appointed administrative vice president, a newly established key management position, and Lerner has been named vice president for engineering and manufacturing.

McRann Moves Up At Telemetrics

ELECTION of Robert McRann to the newly created post of vice president, operations of Telemetrics, Inc., Gardena, Calif., is announced. Telemetrics is a subsidiary of Technical Measurement Corp., North Haven, Conn.

In his new position, McRann will be responsible for all manufacturing, planning, and materiel control. Before this, he had served as director of operations.

Astropower Elects Vice President

WILLIAM R. MONROE has been elected vice president of engineering of Astropower, Inc., Newport Beach, Calif. He was formerly chief electronics engineer at General Dynamics in San Diego.

As vice president, Monroe will direct the Astropower audio information display project, the electronics, electromechanical, optical and mechanical-ordnance engineering sections and the hydro engineering group. Astropower is a subsidiary of Douglas Aircraft Co.

Hurletron Incorporated Promotes Crew

DAVID O. CREW has been named vice president and manager of operations of Hurletron Inc., Chicago, Ill. He will be responsible for coordinating operations of the company's three plants at Whittier, Calif.; Danville and Wheaton, Ill.

Crew joined Hurletron in 1962 as manager of the Wheaton plant.

PEOPLE IN BRIEF

Jack Rosenberg, formerly with Hughes Aircraft, named chief engineer for the Manufacturing div. of Wyle Laboratories. **G. Sherwood Smith** promoted to div. mgr. for Technical Dynamics. **Robert J. Stahl** advances to mgr. of product planning for Sylvania Electric Products Inc. **T. C. Parker,** ex-Northrop Corp., appointed director of engineering of Telemetrics, Inc. **James H. Smith** moves up to product mgr., advanced developments, of Dalmo Victor Co. **Robert L. Tanner,** v-p of TRG, Inc., elected to the board of directors. Promotions in the Microwave Tube div. of Hughes Aircraft Co.: **William M. Mueller** to mgr. of mfg. and **Bruce A. Highstrete** to mgr. of R&D. **Leonard L. Rosenfeld** elevated to mgr. of mfg. for The Jerrold Corp. **Richard W. Vieser** advances to g-m of the Chatham div. of Tung-Sol Electric Inc. **Manfred Eimer,** previously with Jet Propulsion Laboratory, joins Space-General Corp. as director of engineering. **Robert P. Greene** raised to exec v-p of Ovenaire, Inc. GE ups **Robert L. Casselberry** to mgr. of planning for standard products at its Communication Products dept. in Lynchburg, Va. **Edward P. Burns,** formerly with Burmac Electronics, named chief of magnetics engineering at Manson Laboratories. **I. T. Burney,** with Westinghouse since 1951, appointed mfg. mgr. of its Cryogenic Systems dept. **Robert L. Ashley,** former president of Silicon Transistor Corp., joins Thompson Ramo Wooldridge Inc. electronics group as director of marketing. **E. I. Little,** previously with Molecular Research, Inc., now material mgr. at Lockheed Propulsion Co. **Jackson W. Granholm** leaves Mellonics Audio-Visual Inc. to become v-p of Informatics, Inc.

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

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

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1. Review the positions in the advertisements.
2. Select those for which you qualify.
3. Notice the key numbers.
4. Circle the corresponding key number below the Qualification Form.
5. Fill out the form completely. *Please print clearly.*
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CHEMSTRAND COMPANY Pensacola, Florida	66*	3
CORPORATE SYSTEMS CENTER United Aircraft Corp., Farmington, Conn.	62*	4
GENERAL DYNAMICS/ELECTRONICS Rochester, New York	67*	5
HONEYWELL St. Petersburg, Florida	60	6
MELPAR INC. Sub. of Westinghouse Air Brake Co. Falls Church, Virginia	54	7
PAN AMERICAN WORLD AIRWAYS INC. Guided Missiles Range Division Patrick Air Force Base, Florida	77	8
SNELLING & SNELLING Boston, Mass.	66*	9
SPACE AND INFORMATION SYSTEMS Div. of North American Aviation Inc., Downey, California	70	10
SYLVANIA ELECTRONICS SYSTEMS—WEST Mountain View, California	52, 53	11

* These advertisements appeared in the October 4th issue

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Personal Background

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

HOME TELEPHONE ....

Education

PROFESSIONAL DEGREE(S) ....

MAJOR(S) ....

UNIVERSITY ....

DATE(S) ....

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- ☐ Operations Research
- ☐ Optics
- ☐ Packaging
- ☐ Radar
- ☐ Radio—TV
- ☐ Simulators
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- ☐ Other ....
- ☐ ....
- ☐ ....
- ☐ ....

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Please indicate number of months experience on proper lines.

	Technical Experience (Months)	Supervisory Experience (Months)
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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

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DISCOUNT of 10% if full payment is made in advance for four consecutive insertions of undisplayed ads (not including proposals.)

The publisher cannot accept advertising in the Searchlight Section, which lists the names of the manufacturers of resistors, capacitors, rheostats, and potentiometers, or other names designed to describe such products.

Send NEW ADS or inquiries to Classified Adv. Div. of Electronics P. O. Box 12, N. Y., N. Y. 10036

FOR SALE

For sale: Used Model 3490 Triplett Transistor Analyzer. $250.00. Excellent condition. Tennelec Instrument, Box 964, Oak Ridge, Tennessee.

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—to help you get what you want—to help you sell what you no longer need.

Take Advantage Of It

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For Every Business Want

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No Cost or Obligation

This service is designed to help you, the reader of SEARCHLIGHT SECTION, to locate used or rebuilt equipment not currently advertised.

HOW TO USE: Check the ads in this SEARCHLIGHT SECTION to see if what you want is advertised. If not, print clearly the specifications of the equipment and/or components wanted on the coupon below, or on your own letterhead.

THIS IS A SERVICE TO OUR READERS. THIS PUBLICATION DOES NOT BUY, SELL OR STOCK EQUIPMENT OR MATERIALS OF ANY TYPE. Your requirements will be brought promptly to the attention of the used equipment dealers advertising in this section. You will receive replies directly from them.

Obviously, the list of such advertisers is limited by comparison with the over 57,000 subscribers to ELECTRONICS, all directly engaged in the electronics industry. A small 'EQUIPMENT WANTED' advertisement in the SEARCHLIGHT SECTION will bring your needs to the attention of ALL who read ELECTRONICS. The cost is low . . . just $27.25 per advertising inch—7/8" x 2-3/16"

SEARCHLIGHT EQUIPMENT LOCATING SERVICE
CLASSIFIED ADVERTISING
c/o Electronics
P. O. Box 12, N. Y., N. Y., 10036

Please help us to locate the following used equipment:

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NAME . . . .

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STATE 10/11/63

ELECTRONIC

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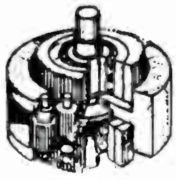
WRITE OR WIRE FOR INFORMATION ON OUR COMPLETE LINE OF SURPLUS ELECTRONIC COMPONENTS. ALL PRICES NET F.O.B. PASADENA, CALIFORNIA

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

SIMPLE DIFFERENTIAL WITH BALL-BEARING SUN GEARS



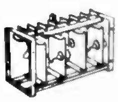
The 1:1 reverse ratio spur gears are 48-tooth, 32 pitch brass with 3/16" available face. On one side, the shaft is 23.64" dia. for 11/16" and has a pin hole, then increases in dia. to .377" for the remaining 3/16" of length On the other side, the shaft is .377 dia. 1/4" lg. 2-13/16" dia. is required to clear the body. Stock no. A6-115 .... each $15.00

RCA 6032 IMAGE-CONVERTER TUBE

Combined with suitable optical systems, this 3-electrode tube permits viewing of scene with infrared radiation. Scene to be viewed is imaged by optical objective upon semi-transparent photo-cathode. Spectral resp., S-1; good response up to about 1200A. Max. ratings, absolute, grid ±2, 20,000VDC or peak AC, grid ±1,2700.
$9.95 ppd.

MINOR SWITCH 10-position, 3-pole, with stopper & reset coil 6-12 V. D.C. off-normal non-bridging wiper. wt.: 1 lb $9.95

GENERAL ELECTRIC FULL WAVE BRIDGE GERMANIUM RECTIFIER

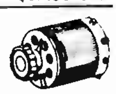


input 117 volt AC, output 115 volt DC at 10 amperes approximate dimensions: 4¾" x 4¾" x 7½" long, weight: 3½ lbs.
PRICE $9.95 each

VARIAC TYPE V20

input 120 volt AC, 50/60 cycles output range 0-140 volts, 20 amperes.
PRICE $37.50 each

POWERSTAT TYPE 20

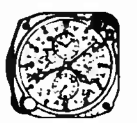


input 120 volt AC, 50/60 cycle output range 0-140 volts AC, 3 amperes.
PRICE $9.95 each

POWERSTAT TYPE 116

input 120 volts, 50/60 cycle output range 0-140 volts AC, 7.5 amperes.
PRICE $16.95 each

8-DAY ELAPSED-TIME SURPLUS AIRCRAFT CLOCK



Here's an 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/Black 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. 5¾" 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. ⅝" 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

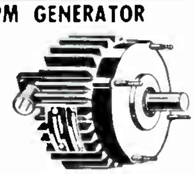
No. 146 Forward & Reverse 4-0-4. Input shaft 5/16" dia. x ¾" long; Output shaft 15/64" dia x 9/16" long. Control shaf 11/64" dia. x 11/16" long. Cast aluminum construction. Approx. size 4½" x 4½" x 4". **$18.50 ea.**

SMALL DC MOTORS

(approx. size over 3¼" x 1¼" dia.:

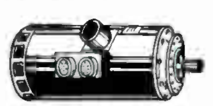
5067043 Delco 12 VDC PM 1" x 1" x 2", 10,000 rpm. $7.50
5067126 Delco PM, 27 VDC, 125 RPM, Governor Controlled 15.00 ea.
5069600 Delco PM 27.5 VDC 250 rpm 12.50
#5069625 120 rpm, mfr. Delco, 27 VDC governor controlled $15.00
5069230 Delco PM 27.5 VDC 145 rpm 15.00
5068750 Delco 27.5 VDC 160 rpm w. brake 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. 26 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

9KVA 400-CYCLE GENERATOR



120/208 volts, 3-phase power factor 1.0 CCW rotation. Approx. 13½ lg. x 8" dia. 4000 rpm, mfg. Bendix Aviation P/N 1633-1A.
$150.00

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
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5F Syn. Mtr. 115/90 VAC 60 cy.	34.50
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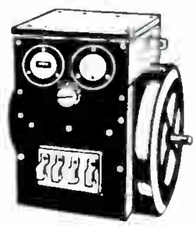
5HCT Cont. Trans. 90/55V 60 cy.	37.50
5SDG Diff. Gen. 90/90V 400 cy.	12.50
6DG Diff. Gen. 90/90V 60 cy.	25.00
6G Syn. Gen. 115/90VAC 60 cy.	34.50
7G Syn. Gen. 115/90VAC 60 cy.	42.50
C56701 Type 11-4 Rep. 115V 60 cy.	20.00
C69405-2 Type 1-1 Transm. 115V 60 cy.	20.00
C69406 Syn. Transm. 115V 60 cy.	20.00
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 Star 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

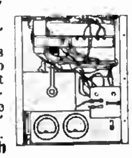
OIL CAPACITORS

1 MFD. 25,000 V. DC Westinghouse interteen type FP style 1313854.
$39.95 each
10 or more, $35.00 each.

HONEYWELL VERTICAL GYRO MODEL JG7044A17

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-cm²/sec. Erection system 27 VAC, 400 cycles, time 5 min. to ½°; caging mechanism operates on 24 VDC.
$49.50

24 VOLT DC POWER SUPPLY



input: 115/440 volts A C, 60 cycle, single phase.
Output: 24 volts D C at 25 amps tapped primary and secondary to vary voltage unit contains 0-30 volt D C meter and 0-30 amp meter, circuit breaker, filtered, selenium type rectifier approx. dim: 16" wide, 18" long, 8½" high, approx wt.: 70 lbs.
PRICE ....$49.50 each

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(Act of October 23, 1962, Section 4369, Title 39, United States Code)

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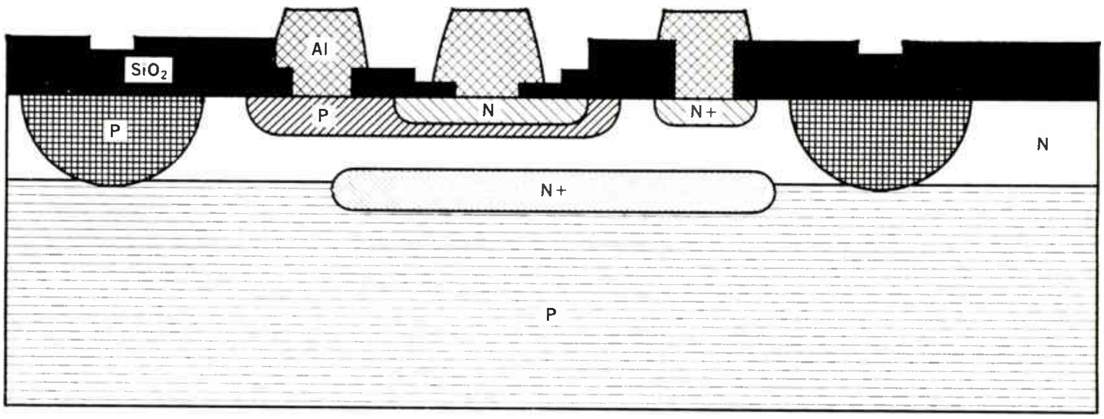
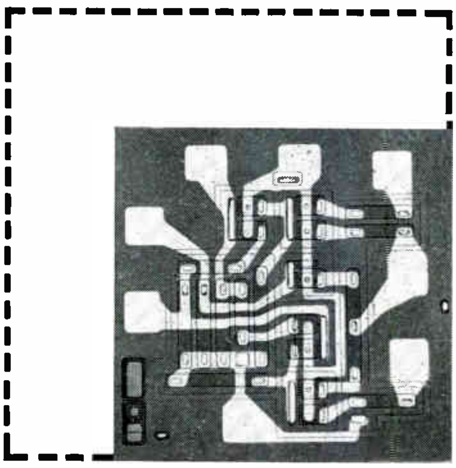


SILICON PLANAR EPITAXIAL MICROLOGIC CROSS-SECTION



New Planar epitaxial construction doubles both switching speeds and DC noise immunity in Fairchild's Micrologic family of digital integrated microcircuits. In addition, the new elements offer an increase of more than 30% in logic level separation throughout the temperature range. Circuit designers can take advantage of epitaxial Micrologic to improve performance in both pulsed and linear circuits. In a pulsed circuit, the results are faster switching speeds, increased useful current range and improved DC level control. Linear circuits benefit from increases in both frequency range and current range. The functions of elements in epitaxial Micrologic and the original Micrologic family are identical. Epitaxial units can directly replace units now in use, doubling both speed and worst case noise margins. No design changes are needed. The photograph to the left is an epitaxial "S" element chip. The dotted line indicates size of the original Micrologic "S" element chip. Although smaller in area, the epitaxial chip is made thicker with no change in electrical characteristics, adding to the ruggedness of the device. Epitaxial Micrologic is available directly from distributor stocks. Write for data sheets and application notes.

PLANAR: A PATENTED FAIRCHILD PROCESS

RCA-A15288 PENCIL TRIODE

MORE TUBE POWER FOR MINIATURIZED MICROWAVE DESIGNS

Increased power per unit weight—that's the challenge successfully met by the RCA-A15288. An excellent example of recent advances in Microwave tube design, this tiny pencil triode can provide I Kw of useful peak power output at 5 Gc as a plate-pulsed oscillator.

For use in telemetry, altimeters, and UHF transceivers, the ceramic-metal RCA-A15288 is designed to operate at altitudes up to 25,000 feet at 3.5 Kv without pressurization. Furthermore, the coaxial arrangement of electrodes around the RCA-A15288 heater practically eliminates tube characteristic changes caused by heater-voltage variations.

If your design involves miniaturized Microwave equipment for application in the 5 Gc region, consider the RCA-A15288. It offers exceptional reliability in vibration and shock environments. Heater power requirement is a low 1.6 watts; warm-up time is 4 seconds.

For information on how the RCA-A15288 can be used in your design circuits, see your RCA Industrial Field Representative, or write: Manager, Microwave Marketing, RCA Electronic Components and Devices, Harrison, New Jersey.

RCA-A15288

Plate-Pulsed Oscillator at 5 Gc	Typical Operation
Peak Positive Plate Supply Voltage	2,500 volts
DC Plate Current	0.0022 amp
DC Grid Current	0.0015 amp
Grid Resistor	2,000 ohms
Useful Power Output at Peak of Pulse	1,000 watts
Pulse Duration	1.0 µsec
Pulse Repetition Rate	1,000 pps
Plate Efficiency	20%

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