November 17, 1961

electronics

A McGraw-Hill Publication
75 Cents

SPECIAL REPORT

Missile and Space Electronics

Ranger III landing on moon

This new hp 120B Oscilloscope combines probably more actual measuring help and desirable features than any 450 KC scope ever produced.

Not only is reading error from parallax ended and not only are distracting reflections eliminated (the CRT has a new, non-reflecting face developed by hp); but you also have a genuinely unique array of electrical and convenience features for measurements from dc to 450 KC.

Details of the 120B's electrical capabilities are given in the specs below. You may particularly wish to note such features as direct reading calibration, "times-5" sweep expander, linear integrator for accurate sweeps and built-in amplifier calibrator. Also the slow sweep speeds for mechanical or medical work, and fast sweeps for transient measurements.

Many engineers who have tested the new 120B feel it is perhaps the easiest-to-use, most widely versatile, and highest value commercial 450 KC scope ever offered. Why not confirm their opinions with a test on your own bench.

Accessories available:

- hp AC-83A Viewing Hood; face-fitting molded rubber, $5.00
- hp 196A Oscilloscope Camera, $440.00
- hp 456A AC Current Probe, $190.00
- hp AC-21J Probe, $9.00

Price:

- hp Model 120B Oscilloscope, $475.00

Supplied with rack-mounting hardware.

Data subject to change without notice. Prices f.o.b. factory.

HEWLETT-PACKARD COMPANY

1095A Page Mill Road Palo Alto, Calif., U.S.A.
Cable "HEWPACK" DAvenport 6-7000

Sales representatives in all principal areas

HEWLETT-PACKARD S.A.

Rue du Vieux Billard No. 1 Geneva, Switzerland
Cable "HEWPACKSA" Tel. No. (022) 26. 43. 36

Further, the 120B has automatic triggering which ends trigger adjustment and insures a bright, clear baseline even without a sync signal. For manual level adjustment 10 to -10 volts, a panel control overrides the automatic trigger.

The 120B is also a boon physically. The front panel reads easily, and controls are where you expect them—simple, logical. When the trace strays, a push-button finds it instantly. The whole arrangement is such that, in an engineer's hands, the instrument is quick and sure; yet it is readily understood and used by non-technical personnel.

Finally, Model 120B is either a sleek, modern bench instrument or (with a handful of hardware supplied) a precision-fit rack mount unit. Access to the inside is instantaneous, and the top cover contains a complete adjustment guide.

SPECIFICATIONS

SWEEP

Sweep Range: 1 μsec/cm to at least 0.5 sec/cm. 15 calibrated sweeps, accurate within ±5%, in a 1, 2, 5, 10 sequence, 5 μsec/cm to 200 msec/cm. Vernier for continuous adjustment of sweep time between calibrated steps, extends slowest sweep to at least 0.5 sec/cm.

Sweep Expand: x5 sweep expansion usable on all ranges, expands fastest sweep to 1 μsec/cm, accuracy ±10%.

Synchronization: Automatic, 50 cps to 450 KC.

Trigger Point: Zero crossing, negative slope of external sync signals, zero crossing, positive or negative slope of vertical deflection signals. Front panel control locks out automatic and permits trigger point to be set between −10 to +10 v.

VERTICAL AMPLIFIER

Bandwidth: DC coupled: dc to 450 KC; ac coupled: 2 cps to 450 KC.

Sensitivity: 10 mv/cm to 100 v/cm. 4 calibrated steps with attenuator accuracy of ±3%, 10 mv/cm, 100 mv/cm, 1 v/cm, 10 v/cm. Vernier for continuous adjustment of sensitivity between steps and extends 10 v/cm step to at least 100 v/cm.

Internal Calibrator: Calibrating signal automatically connected to vertical amplifier for standardizing of gain, accuracy ±2%.

Input Impedance: 1 megohm, approx. 50 pf shunt.

Balanced Input: On 10 mv/cm range. Input impedance 2 megohms shunted by approx. 25 pf.

Common Mode Rejection: At least 40 db, should not exceed ±3 volts peak.

Phase Shift: Vertical and horizontal amplifiers have same phase characteristics within ±2° to 100 KC when verniers are in CAL.

HORIZONTAL AMPLIFIER

Bandwidth: DC coupled: dc to 450 KC; ac coupled: 2 cps to 450 KC.

Sensitivity: 0.1 v/cm to 100 v/cm. 3 calibrated steps, accurate within ±5%, 0.1 v/cm, 1 v/cm, 10 v/cm. Vernier for continuous adjustment of sensitivity between steps and extends 10 v/cm step to at least 100 v/cm.

Input Impedance: 1 megohm, nominal, shunted by approx. 100 pf.

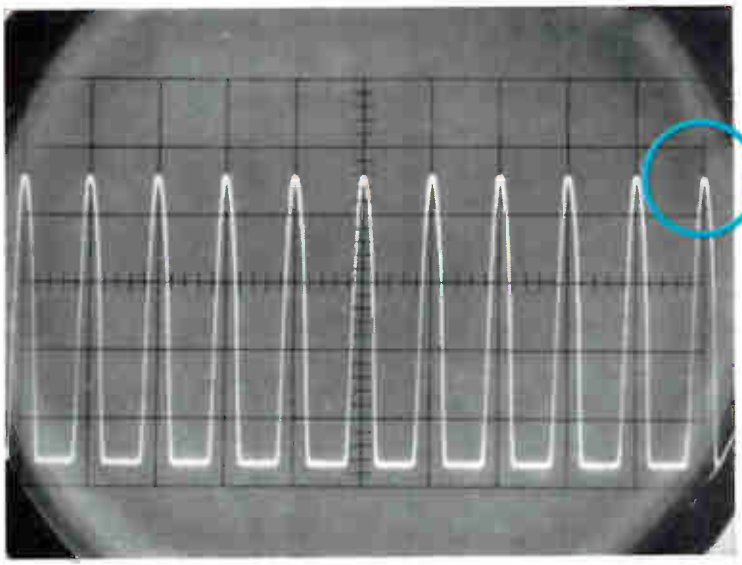
GENERAL

Internal Graticule: 10 cm x 10 cm marked in cm squares.

New standard of oscilloscope reading accuracy

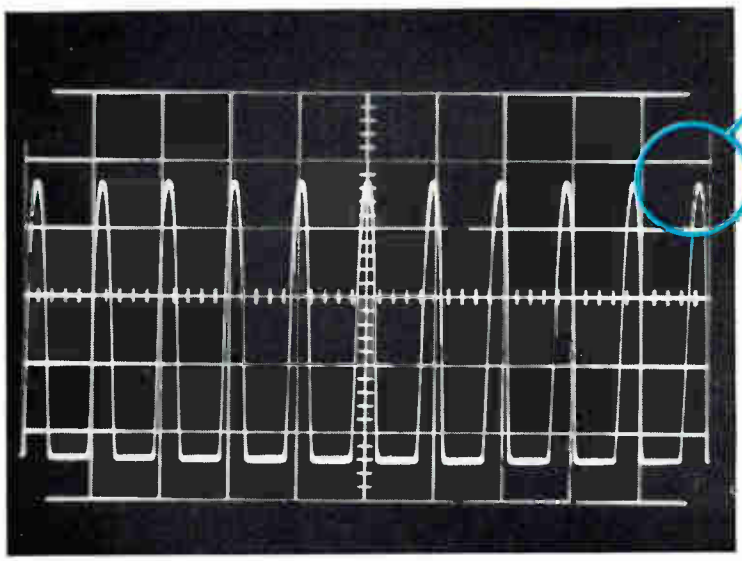
Revolutionary hp CRT'S

ELIMINATE SCOPE PARALLAX ERROR



NEW WAY!

Perfectly linear signal reads perfectly. Each wave peak appears, and is, precisely on proper graticule line.



ERROR-PRONE OLD WAY!

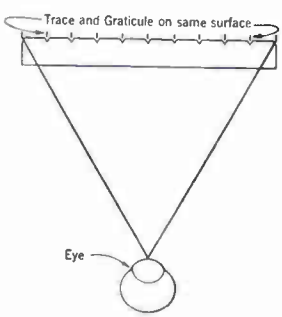
Identical signal on old-type cathode ray tube. Note apparent non-linearity caused by scope face parallax!

Turn the page

to see how hp does it... and read about the versatile new hp 120B 450 KC oscilloscope

New, no-parallax hp 120B... easiest-to-use, surest-reading, 450 KC oscilloscope!

HERE'S HOW hp DOES IT!

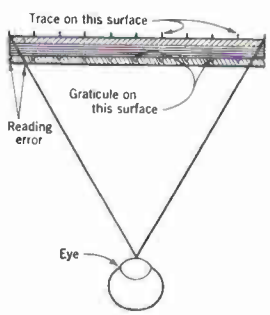


NEW WAY!

Exclusive hp development scribes calibrating graticule in identical inside plane with trace. No layers of glass, filter or plastic optically alter perfect reading. What you see —IS! Parallax is eliminated at last!

OLD WAY!

Conventional oscilloscopes have calibrating graticule a full ¼ inch in front of trace. Between are optically confusing plastic graticule body, filter, and CRT envelope end. Parallax is inescapable; errors up to 5% are possible.



November 17, 1961

electronics

A McGraw-Hill Publication *75 Cents*

VECO PIONEERS NEW THERMISTOR FRONTIERS

It's mighty important to know if you're working on sub-zero human survival programs for the Armed Forces. That's why scientists tape VECO Thermistors to penguins ... even bury them in penguin eggs ... to record the precision temperature data on living cells that can save lives in Antarctic-type environments.

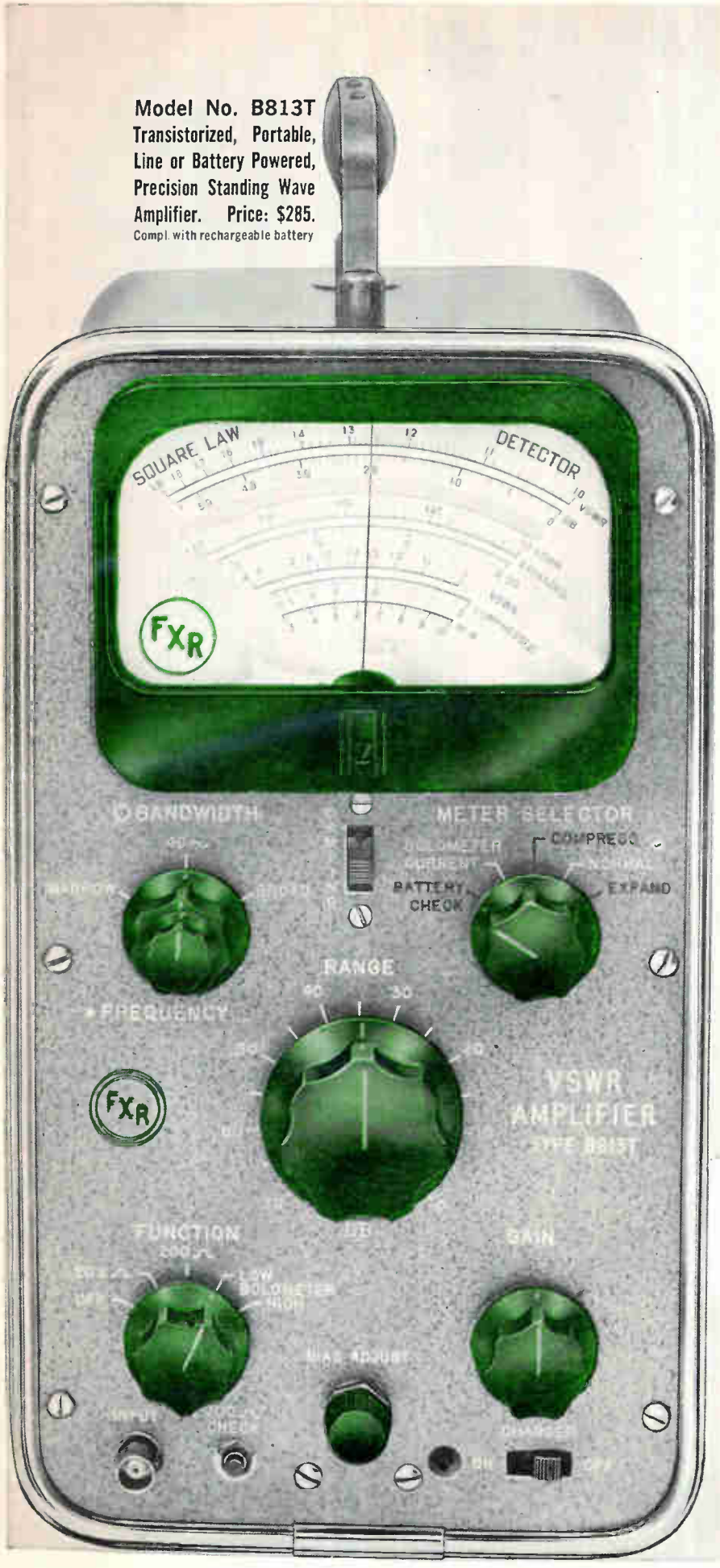
You may never have to Thermistorize a penguin, but when reliability counts, it's good to know you can count on VECO. Reliability is the reason engineers in every field specify VECO Thermistors and Varistors where precision thermal or electrical measurement and control are critical. They know their Thermistor and Varistor reliability programs begin at Victory. Unsurpassed quality control is the reason. Not one VECO product ever leaves the plant until it individually passes tests for reliability far exceeding applicable specifications. VECO quality control processes are accepted under MIL-Q-9858 standards.

FREE: If you want to control, measure, or use temperature for any project between the North and South poles, you'll find VECO's Thermistor-Varistor Catalog valuable in producing high-reliability circuitry.

VICTORY
ENGINEERING CORPORATION
122 Springfield Ave., Springfield, N. J.

THERMISTORS • VARISTORS • CHOPPERETTES • COMBUSTION ANALYZERS
THERMISTOR CATHETERS AND NEEDLES • THERMAL CONDUCTIVITY CELLS
MATCHED THERMISTORS • THERMISTOR AND VARISTOR KITS
HYPSOMETERS • LOX THERMISTORS • AND MANY OTHER PRODUCTS

how cool is a penguin?



Model No. B813T Transistorized, Portable, Line or Battery Powered, Precision Standing Wave Amplifier. Price: $285.
Compl. with rechargeable battery

the new FXR transistorized precision standing wave amplifier has exceptional accuracy of ±0.05 db

This ±0.05 db accuracy, the most precise in the industry, holds true for both the full scale meter movement and for each 5 db step on the range switch. The specially designed meter and linear amplifier give a full scale maximum error at 5 db of only ±0.05 db. This marks a significant increase in accuracy over any existing Standing Wave Amplifier. Calibrated range of the B813T is 75 db.

While extreme measurement accuracy was the major design criterion for this transistorized, portable instrument, many other design features are worthy of note: special circuitry and controls for normal, expanded and compressed scale readings (gain normalized on switching) . . . bolometer resistance checking, protection and current adjustment . . . selective meter damping . . . bandwidth selection and frequency peaking . . . range selection in 5 db steps . . . battery voltage checking and self-contained battery charging.

Write or call for Bulletin B813T for details on the most accurate Standing Wave Amplifier available for microwave measurements.

FXR

THE RF PRODUCTS AND MICROWAVE DIVISION
AMPHENOL-BORG ELECTRONICS CORPORATION

MICROWAVE

- components
- test equipment
- high power electronics
- systems

25-26 50th Street, Woodside 77, N.Y.
RAvenswood 1-9000 • TWX: NY 43745

Sales Offices Throughout The World

electronics
November 17, 1961 Volume 34 No. 46

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

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

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

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

Subscriptions are solicited only from those actively engaged in the field of the publication. Position and company connection must be indicated on orders. Subscription rates: United States and Possessions, $6.00 one year; $9.00 two years; $12.00 three years. Canada, $10.00 one year. All other countries $20.00 one year. Single Copies, United States and Possessions and Canada 75¢; Buyers' Guide $3.00; Single copies all other countries $1.50; Buyers' Guide $10.00.

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

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

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

Audited Paid Circulation

CROSSTALK

Defense Doesn't Win

WHILE PREPARING the special report about Missile and Space Electronics appearing in this issue the editors studied histories of hundreds of projects. We noted when they were started and when they were stopped, when we poured money into one and eased up on another, when cancelled projects were revived.

It is apparent that achievement of our present position in the missile and space era has been sporadic. It is marked by stops and goes, waste and tight-fistedness, haste and apathy. It has certainly not been an effort that flowed from conscious, continued planning. Rather, it appears to have been largely dictated by what the Russians did.

It is as if our production line were hooked up to the power source of the competitive factory next door. We operate when they choose to throw the switch. Such an arrangement, shaky even with the best of neighbors, is particularly unsound with a neighbor who has said he will put us out of business, one who long ago assessed the peculiar political relationship and manipulates it to his advantage.

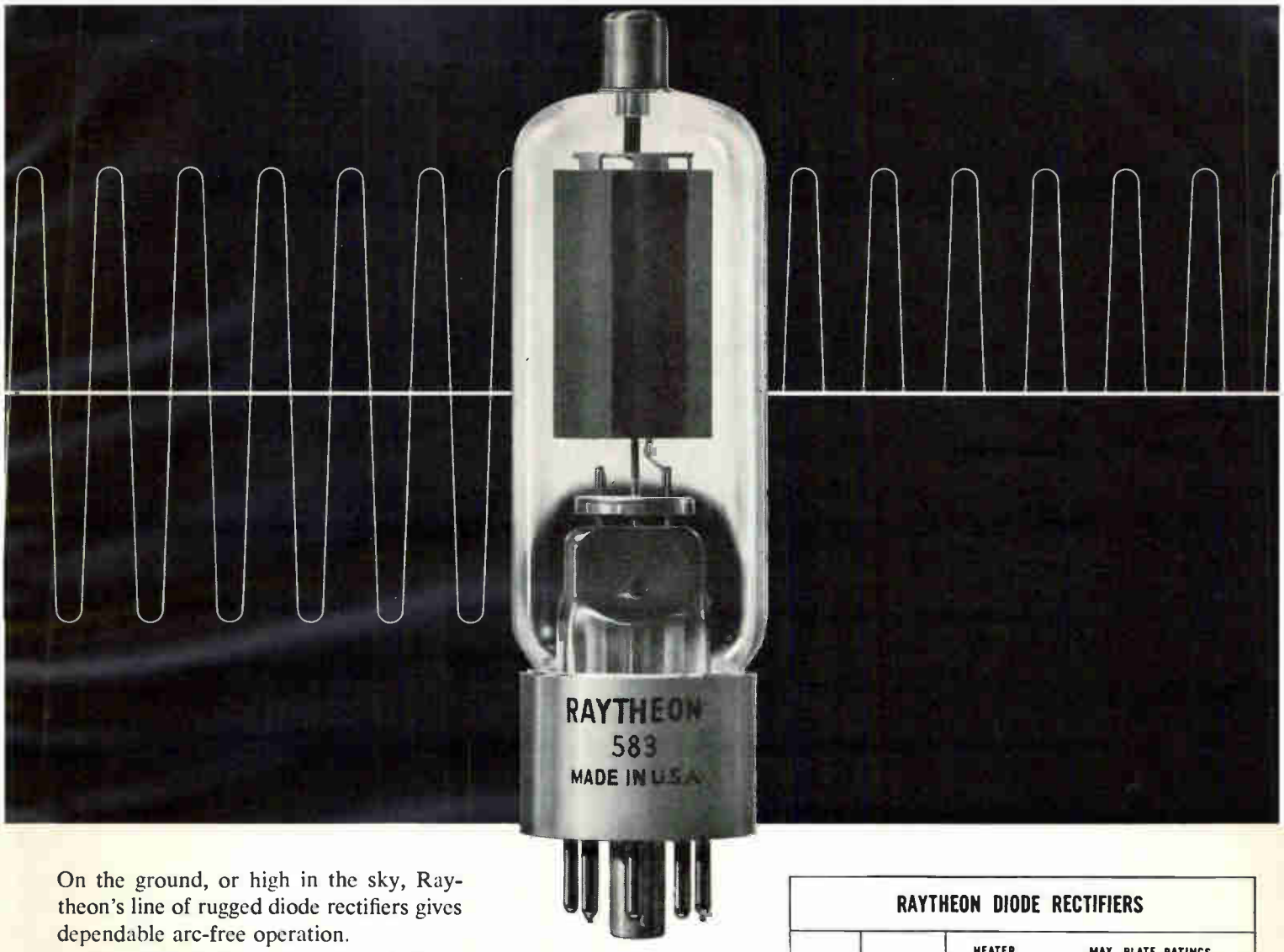
We are constantly and characteristically on the defensive, exhausting ourselves in reaction rather than moving with strength in action. We begin working on new offensive weapons after the Russians reveal that they have them. Our tremendous talent and energy does not often go into developing a striking force beyond matching known Soviet capabilities. We wait "until there is a need."

Our defensive measures should of course be continued with all speed. They will give us some protection. But they will not knock out an aggressive enemy if he attacks. We must emotionally crawl out of our fallout shelters and be prepared to strike hard and by novel as well as conventional means if attacked. We must not only have a superior defense system but we must also develop a superior offense.

Especially in outer space.

Coming In Our November 24 Issue

SUPERCONDUCTIVITY. One of the most active areas is cryogenics. The usefulness of superconductive elements in, for example, computers is being explored in a number of research and development laboratories. Next week, New England Editor Maguire focuses on superconductive computer elements in a progress report on cryogenics. He assesses the state-of-the-art as revealed through new approaches to design of cryotron memories and other components that will go into future all-superconductive computers. And, he tells how these new elements compare with conventional semiconductor and magnetic devices.



On the ground, or high in the sky, Raytheon's line of rugged diode rectifiers gives dependable arc-free operation.

Example: Raytheon 583, one of six Raytheon half-wave rectifier types. Operating as a clipper diode at altitudes to 36,000 feet, maximum ratings are 15,000 volts PiV, 8 amperes peak plate current. Arc-free clipping action makes sure a magnetron can be fired once *without* refiring automatically or uncontrollably!

The reliability of Raytheon diode rectifiers is the result of exceptional care in design and manufacture . . . with no compromise in quality control. Gold-plated plates and zirconium coatings assure reliable operation at high voltages. Cathodes are heliarc welded. Higher exhaust temperatures mean less gas and longer life. For more information on Raytheon's growing line of dependable diode rectifiers, please write: Raytheon, Industrial Components Division, 55 Chapel Street, Newton 58, Massachusetts.

GET PEAK POWER WITH RAYTHEON RUGGED, ARC-FREE DIODE RECTIFIERS

RAYTHEON DIODE RECTIFIERS

TYPE	SERVICE	HEATER		MAX. PLATE RATINGS		
		VOLTS	AMPS	PEAK INVERSE (VOLTS)	PEAK CURRENT (AMPERES)	AVERAGE CURRENT (AMPERES)
583*	H. W. RECT. (to 36,000 ft.)	2.5	4.9	17,000	0.250	0.065
	CLIPPER DIODE (to 36,000 ft.)	2.5	4.9	15,000	8.0	0.240
3B24W 3B24WA*	H. W. RECT. (HALF FIL.)	2.5	3.0	20,000	0.150	0.030
	(FULL FIL.)	5.0	3.0	20,000	0.300	0.060
3B26	CLIPPER DIODE	2.5	4.75	15,000	8.0	0.020
3B29	H. V. RECT. (OP. 1)	2.5	4.9	16,000	0.250	0.065
	(OP. 2)			7,700	0.300	0.080
	(OP. 3)			5,000	0.300	0.095
	CLIPPER DIODE	2.5	4.9	10,000	8.0	0.018
4B31*	H. W. RECT.	5.0	5.0	16,000	0.470	0.150
	CLIPPER DIODE	5.0	5.0	16,000	12.0	0.060

*Mil-Std-200E Preferred Type

For Small Order or Prototype Requirements, See Your Local Franchised Raytheon Distributor

RAYTHEON COMPANY

INDUSTRIAL COMPONENTS DIVISION

RAYTHEON

COMMENT

Semiconductor Progress

As an Alice in the wonderland of epitaxial layers, undercut mesas, post-alloy diffusion and the rest, I found your What's New In Semiconductors (Sept. 29, p 89) to be an informative guide. The article provides perspective on the rapidly advancing semiconductor field. Prospects for further technical progress are especially exciting in view of the substantial effort being devoted to the study of new materials that hold promise as semiconductors.

Technical journal articles of a tutorial or survey nature represent a significant service to the electronics profession. With the rapid growth of the industry, intensive technical specialization has inevitably occurred. Articles such as this are a step toward ensuring that cross-fertilization of ideas takes place between the specialities in electronics. Such articles also serve as effective educational tools for use at the undergraduate level, and help to interest young people in electronics.

Your special report was of particular interest to us in the West, since it is estimated that western semiconductor manufacturers are expected to produce $275 million worth of transistors, diodes and other semiconductors in 1961, or about 55 percent of the projected total national output. This fact is evidence of the leadership that the vigorous western electronics industry is showing in the forward-looking areas in electronics.

STANLEY F. KAISEL
President
Microwave Electronics Corp.
Palo Alto, California

Ions, Humans and Plants

I was interested in a letter from Ralph E. White in Comment (Aug. 25, p 6), referring to the biological effects of atmospheric ions.

Here at the university we are concerned with the effects of the hamsin, a meteorological condition characterized by a wind of desert origin, in some respects similar to the foehn, chinook and mistral. It is commonly accepted that the hamsin has a physiological and/or psychological effect on the human system, and the university's Department of Botany has found a definite correlation with certain plant processes. We are interested in the exact cause of such effects and are at present engaged in a program that involves measuring atmospheric electrical parameters including ion content.

F. J. GOLDWATER
The Hebrew University
of Jerusalem
Jerusalem, Israel

To save our readers a trip to the dictionary, foehn is a Swiss word for a warm dry wind blowing down the side of a mountain. Chinook can be either a warm, moist, southwest wind of the coastal regions of Oregon and Washington, or a warm, dry, foehn-like wind that descends the Rocky Mountains. The mistral is a violent, cold, dry northerly wind of the Mediterranean provinces of France. Hamsin is not in our dictionary.

Photomicrograph

I have enjoyed your excellent technical publication for many years and have not so far felt inclined to pass comment, but do feel compelled to point out an error on the front cover of your September 29 issue.

The word *microphotograph* relating to the surface of planar transistors is quite obviously a mistake, and should of course read *photomicrograph*.

As you are no doubt aware, a microphotograph is a minute reproduction by photographic means, whereas a photomicrograph is a photographic reproduction of a microscopical object.

I trust you will not think I am being too pedantic about this, but as a Fellow of the Royal Microscopical Society I feel it is important to use the correct terminology.

J. BILBROUGH
Managing Director
Microwave Instruments Limited
North Shields, Northumberland
England

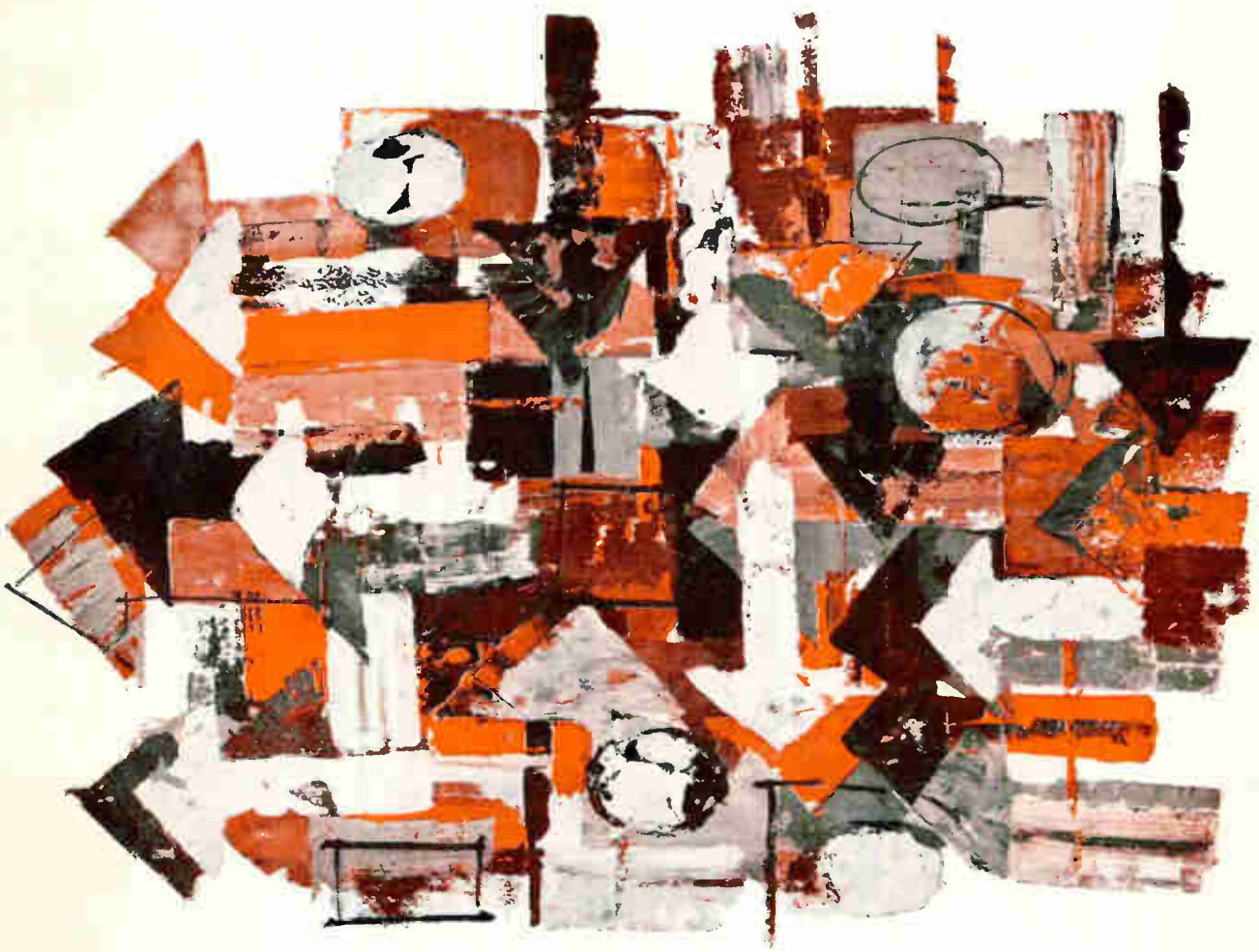
A simple case of microcephalism on our part.

DIGITAL SYSTEMS EXPERIENCE... AT PACKARD BELL COMPUTER, INCLUDES DEVELOPMENT AND MANUFACTURE OF A COMPUTER CONTROLLED CHECKOUT SYSTEM FOR THE SATURN SPACE VEHICLE... A MISSILE IMPACT PREDICTION SYSTEM... SYSTEMS FOR REDUCTION OF ACOUSTIC DATA FOR ASW STUDIES... FOR REDUCTION OF MISSILE TEST FIRING DATA... SYSTEMS FOR SEISMIC DATA REDUCTION ☐ ON OR OFF LINE... ANALOG OR DIGITAL INPUT AND OUTPUT... ALL ACCOMPLISHED WITH STANDARDIZED EQUIPMENT DESIGNED AND BUILT AT PACKARD BELL COMPUTER ☐ FOR SYSTEMS DEVELOPMENT BY A POWERFUL TEAM... COMPOSED OF ENGINEERS RESPONSIBLE FOR DESIGN OF COMPONENT HARDWARE AS WELL AS THE COMPLETE SYSTEM. WRITE FOR SPECIFICATIONS ON COMPUTER SYSTEMS.

pb **Packard Bell Computer**

A SUBSIDIARY OF PACKARD BELL ELECTRONICS

1905 ARMACOST AVENUE • LOS ANGELES 25 CALIFORNIA



ONLY A POLARAD MICROWAVE THROUGH 4,200 to 11,000 mc

Which Polarad Generator Solves Your Problem?—500 to 50,000 mc.

Model PMR
500 to 1,000 mc

Interchangeable FM or pulse modulators. FM modulator provides low distortion wide-range, sine-wave deviation. Pulse modulator provides pulse, square wave and sawtooth FM. (10-10,000 pps). Calibrated power output: 1 mw

All Polarad Signal Generators (500 to 21,000 mc) offer:

Continuously variable attenuators calibrated directly in —dbm.

Internal pulse, FM and square wave modulation, external pulse and multi-pulse modulation.

Delayed and undelayed sync outputs.

UNI-DIAL® tuning with direct-reading frequency dials accurate to ± 1%.

High stability non-contacting klystron cavity chokes for noiseless tuning and accurate calibration.

Model MSG **950 to 4,600 mc**

	Frequency	Calibrated Power Output	Internal Pulse Modulation: Internal Square Wave	Width in μ sec.	Pulse Repetition Rate in pps	Delay in μ sec.	FM deviation in mc minimum
MSG-1	950-2,400 mc	1 mw (0 dbm)	40- 4,000 pps	0.5-10	40- 4,000	2.5-300	±2.5
MSG-1P*	950-2,400 mc	10 mw (+10 dbm)	10-10,000 pps	0.3-10	10-10,000	2-2,000	±2.5
MSG-1R	950-2,400 mc	1 mw (0 dbm)	10-10,000 pps	0.3-10	10-10,000	2-2,000	±2.5
MSG-2A	2,000-4,600 mc	1 mw (0 dbm)	40- 4,000 pps	0.5-10	40- 4,000	2.5-300	±2.5
MSG-2R	2,000-4,600 mc	1 mw (0 dbm)	10-10,000 pps	0.3-10	10-10,000	2-2,000	±2.5
MSG-2P*	2,000-4,600 mc	10 mw (+10 dbm)	10-10,000 pps	0.3-10	10-10,000	2-2,000	±2.5

*Attenuator Accuracy: ±3 db between 0 and +10 dbm. ±2 db below 0 dbm.

Model PMX
4,450 to 8,000 mc
6,950 to 11,000 mc

Two interchangeable r-f generator units.

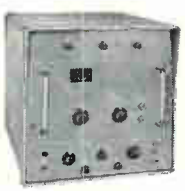
Internal pulse and square wave modulation (10-10,000 pps); 0 to —127 dbm power output.

Model KSS
GENERATOR SOURCE
1,050 to 11,000 mc
in 4 tuning units

Power output: 14 to 400 mw, depending upon frequency; internal square wave 10-10,000 pps; external pulse, square wave or FM modulation; adjustable attenuator.

Model MSG-34
4,200 to 11,000 mc
in one instrument

Internal pulse and square wave modulation (10-10,000 pps); 0 to —127 dbm power output; DIGITAL frequency indicator.



Model CSG
SWEEP GENERATOR
1,000 to 16,000 mc
in 5 interchangeable tuning units

Provides high-power microwave signal adjustable from single frequency to 2:1 frequency range; .001 to 100 cps sweep rate; internal modulation: 1,000 cps and 456 kc square wave; external modulation: square wave, FM and pulse.

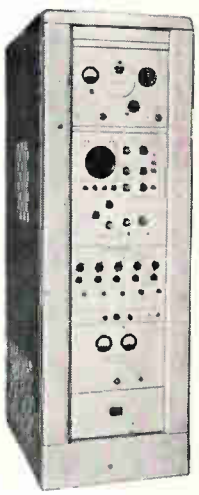
Model PMK
10,000 to 21,000 mc
in 2 tuning units

Two interchangeable generator units.

Calibrated power output: + 10 dbm (10 mw); internal pulse and square wave modulation (10-10,000 pps); DIGITAL frequency indicator.

EHF SIGNAL GENERATOR AND SOURCE
12,400 to 50,000 mc

Units in this range provide cw signals, 1,000 cps internal square wave, external modulation provisions, accurate frequency calibration. EHF SIGNAL GENERATOR 18,000 to 39,700 mc, 7 plug-in units. Accurate power calibration. EHF SIGNAL SOURCE 18,000 to 50,000 mc, 9 plug-in units. High power output.



Model B
CODE MODULATOR MULTI-PULSE GENERATOR
950 to 10,750 mc
in 4 interchangeable tuning units.

Provides 5 independently adjustable pulse channels, each with variable pulse width and delay. Built-in precision oscilloscope.

Because each of these fine test instruments has something special about it, a feature or capability that can suit your test requirements exactly, check through this ad—then get complete specifications from your local Polarad representative.

POLARAD

ELECTRONICS CORPORATION

43-20 34TH STREET, LONG ISLAND CITY 1, NEW YORK

FREE LIFETIME SERVICE

CIRCLE 8 ON READER SERVICE CARD

SIGNAL GENERATOR CAN TUNE WITH ONE CONTROL

This Polarad patented* tuning cam is one of the many ingenious devices that make possible continuous tuning from 4,200 to 11,000 mc in the Polarad Model MSG-34 Signal Generator.

*(U.S. Patent No. 2,824,466)

Model MSG-34 Because of its unique electromechanical design, only the MSG-34 Microwave Signal Generator offers such a wide frequency range in one unit—with 1 mw calibrated power output from 4,200 mc to 11,000 mc.

The printed circuit modulator is important, too. A single unit offers 10 to 10,000 cps rates for pulse, FM and square wave rf outputs. All with the shortest pulse width available—0.2μ sec.

SPECIFICATIONS

Frequency Range	4,200 mc to 11,000 mc
Frequency Accuracy	± 1%
Power Output	1 milliwatt (0 dbm) calibrated
Attenuator Output Accuracy	± 2 db from 0 to −127 dbm
Modulation	Internal or external pulse, square wave or internal FM

Internal Pulse Modulation:

Width	0.2 to 10 microseconds
Repetition Rate	10 to 10,000 pps
Delay	2 to 2,000 microseconds

POLARAD

Ready for you now!

Primary standard accuracy for power measurements to 1,000 watts!

Sierra 290B Test Set

Frequency coverage dc through 12.4 KMC.

Precise ac wattmeter, calorimeter and heat exchanger in one neat, rack unit. Separate dual loads for dc to 4 KMC, also C, XB, X bands. Direct reading linear scale.

Above are highlights of the new Sierra 290B Calorimetric Wattmeter Test Set—the industry's closest approach to absolute power measurements in this range.

Model 290B measures power in three distinct modes.

1. For power levels 30 to 1,000 watts, a null-balance mode provides measurement accuracies of 1% or better, with probable error as low as 0.5%.

2. For wider range power levels from 10 to 1,500 watts, a direct-reading mode provides excellent linearity in thermal readout and 2% to 3% accuracy. Readout is fast—60 seconds or less.

3. For expanded scale readings of highest resolution, the above two modes may be combined in a third mode to obtain the order of accuracy of the null-balance mode, together with the time-saving convenience of the direct readout mode.

Model 290B, $4,500.00. (Water loads, extra.)

Data and prices subject to change without notice. Prices f.o.b. factory.

Laboratory setup above shows Sierra Model 215 Power Source being used in conjunction with Model 290B Calorimeter to calibrate Sierra Bi-Directional Power Monitor. Designed specifically for calibration purposes, 215 series Sources include four 50 watt models covering, collectively, 25 to 1,000 MC. Model 215A, 25 to 50 MC; Model 215B, 50 to 150 MC; Model 215C, 150 to 470 MC; Model 215D, 470 to 1,000 MC. Price (any model) $3,300.00.

For complete details, see your Sierra representative or write direct

SIERRA ELECTRONIC CORPORATION
A Division of Philco Corporation
6560A BOHANNON DRIVE • MENLO PARK, CALIFORNIA • DAvenport 6-2060
Sales representatives in all principal areas
Canada: Atlas Instrument Corporation, Ltd., Montreal, Ottawa, Toronto, Vancouver.
Export: Frazar & Hansen, Ltd., San Francisco, California. 6560

sierra

ELECTRONICS NEWSLETTER

Pert Is Extended to Control Project Costs

PERT, Program Evaluation and Review Technique now being used to manage development and production schedules of many major military systems (see p 30, this issue) is being extended to cost appraisal and control. Vice Adm. W. F. Raborn disclosed progress in this new use at a meeting in New York last week of the National Security Industrial Association.

Raborn—whose Special Projects Office devised Pert for the Polaris program—said trials of Pert-Cost have been "very gratifying". Just as Pert quickly pinpoints schedule problems, Pert-Cost rapidly isolates cost problems.

Pert-Cost uses planning, scheduling, cost estimating and accounting techniques to anticipate cost overruns or underruns and provide a basis for making trade-offs among time, resources and performance specs. Contractors obtain the best combination of time, technical and cost factors, he said.

As an example, Raborn showed a progress chart which indicated early phases of a project were right on schedule. But Pert-Cost analysis revealed that early phases were eating up funds allocated to later phases. Even though the project was on schedule, it was in serious trouble.

Plans to Launch Near System Hit Early Snag

CIVIL DEFENSE plans to have a warning buzzer installed in 50 million homes are being pushed by the Pentagon. *Electrical World*, McGraw-Hill publication, reported last week that the Office of Civil Defense is dropping plans for two years of further testing and wants to go ahead.

National Emergency Alarm Repeater (Near) system would have house buzzers triggered by 240-cycle tone on electric power lines. Electric utilities are being asked to pay costs, estimated at $50-$60 million for transmitting equipment and as high as $1 billion for alarms.

California is one of five states the government hopes to blanket with Near as a start. A few days ago, a conference in Sacramento between OCD and utilities representatives bogged down when it was decided more time was needed to study legal and technical problems. Problems include how to get all customers to install the buzzers.

Thin Film Sandwich Switches in 10 Nsec

THIS WEEK at the 1961 Conference on Magnetism and Magnetic Materials, in Phoenix, IBM reported a development that may pave the way to large-scale thin-film computer memories.

Sandwich configuration, said J. C. Suits and E. W. Pugh, switches a bit in 10 nsec with higher output signal than a single-film equivalent. For a given driving current, switching is 10 times faster than a single film, they said.

Layers, deposited as dots on glass, are Permalloy, insulator, aluminum (for driving), insulator and a second layer of Permalloy. Speed was measured through the Kerr magneto-optic effect, as detected by a photomultiplier tube.

Pugh, and B. E. Argyle also reported on new experiments which substantiate the spin-wave theory of the nature of magnetism. Experiments were performed, at temperatures near absolute zero, with an instrument they call a Pyromagnetometer.

Needles Thaw Needed

PROJECT WEST FORD teams are digging in for a long-haul effort to locate 350 million tuned dipoles launched Oct. 21.

Trackers were encouraged by telemetry tape analyses which showed that the dipole dispenser definitely separated from the Midas satellite at the proper time and speed.

The dipoles were to be slowly released from a naphthalene binder as the dispenser orbited. One theory is that the binder is frozen and that solar radiation will eventually thaw it out.

Magnets on Delay Line Form Function Generator

DIGITAL function generator introduced last week by Consolidated Avionics uses small magnets held near a magnetostrictive delay line. The design is reported to give high flexibility at low cost.

When a wave created by an induced pulse meets a magnetic field, an output pulse is induced. Delays can vary from 10 to 100 μsec. Pulses can be as close as 4 μsec and up to 248 adjustable magnets can be used.

The delay can be used for generation of pulse patterns or words, frequency generation, multiplication or division, dynamic storage and other applications as well as delay, the company says.

Navy Orders Inertial Ship Navigation System

VERTICAL REFERENCE, navigational and gyrocompass system for fast, highly-maneuverable ships is being built for the Navy by United Aircraft's Norden division. Prototype is to be delivered in early 1962. Incorporating a computer and inertial platform, the system is to handle navigational and weapons fire control functions ordinarily handled by separate equipments.

"Gaussian Horse Race" Ends Magnetics Meet

BOSTON—International Conference on High Magnetic Fields, at Massachusetts Institute of Technology, closed with Bell Telephone Labs winning a "horse race" to announce the highest magnetic field obtained with a superconducting niobium

zirconium magnet.

Bell reported a 67-kilogauss field. However, researchers pointed out that it makes little difference who has the highest field at a given moment. With some materials, field strength merely indicates amount of wire on hand. Attainment of 150-kilogauss fields in a year with niobium zirconium was seen.

Another Bell Labs report indicated that vanadium gallium may yield fields up to 500 kilogauss. This was indicated by extrapolating data gathered with fields up to 80 kilogauss.

Information Retrieval $200 Million in 1968

BOSTON—Prediction that information retrieval market would be $200 million in 1968 was voiced last week at the annual convention of the American Documentation Institute. Many attendees interviewed by ELECTRONICS thought even that figure too conservative. It was pointed out that more than $1 billion is spent annually in the U. S. to find already printed information.

Other points made by speakers included: people who need to know should be kept informed by active rather than passive dissemination of information if we are to keep up with Russia; application of searching systems should be where they are economically feasible and necessary, rather than conceptually attractive; fields of information retrieval and teaching machines, now considered by most as distinct areas, will eventually merge.

EIA Protests Goldberg's Industry Wage Figures

WASHINGTON—Data on which the Secretary of Labor proposes to determine Walsh-Healey Act minimum wages "seriously distorts" the wage picture in the electronics industry and contains "built-in inflation", EIA charges.

The association says that by eliminating small plants (which generally pay less) from data, the minimum wage in the median establishment becomes $1.51 an hour instead of $1.35. This would require three-fourths of the industry to raise wages and would place small firms at a disadvantage, EIA says.

EIA also wants wage determinations made regionally, rather than nationally. Under the "median formula" a national rate would be about $1.60. This rate may prevail in Middle Atlantic states, but would be unfair to other regions, EIA said.

A 30-day notice after determination is also requested. Present plan to give seven days notice is inadequate, EIA says. A Walsh-Healey determination would affect all plants with more than $10,000 in government contracts.

Broadband Paramps Are Not Far Off

BOSTON — Diode-type parametric amplifiers with gain-bandwidth products near 1,000 Mc are no longer exceptional. In fact, recent disclosures of lab work show single-diode amplifiers are not inherently narrow-band. Practical broadband amplifiers are not far behind lab devices.

So said Robert Adler, of Zenith, in a status report to NEREM on the amplifiers. Electron-beam parametric amplifiers are used at 400 to 1,700 Mc. Their unusual overload capacities is valuable in L-band radar; two other strong points, phase and gain stability, have put them into monopulse radar, phased arrays and interferometers.

A. Yariv, S. P. S. Porto and K. Nassau, of Bell Telephone Labs, reported that trivalent praseodymium in calcium tungstate is a promising new material for c-w lasers. Using only 20 joules of excitation, with the crystal placed at the center of a xenon flash lamp, they obtained coherent emission at 1.047 microns.

Material's energy spacing makes possible a four-level maser operation at temperatures below that of liquid nitrogen (78 K). Low excitation level and weakness of the absorption band warrants further investigation into the continuous mode of operation, the authors stated.

In Brief . . .

MITSUBISHI ELECTRIC is negotiating with Yugoslavia for delivery of advanced rocket-tracking radar with 1,500-km range. Nippon Electric is supplying Yugoslavia five Kappa-6 rockets, meteorological and telemetering gear.

FCC HAS extended time for comments on its uhf-tv proposals, to 60 days from Dec. 4.

INTERNATIONAL ELECTRIC, an ITT subsidiary, enters data processing services and communications field with a $3.5 million center.

PHILLIPS, of Holland, is testing a novel, all-transistor, 8-mm radar set on a French river vessel.

ADVANCED Research Projects Agency has awarded System Development Corp. a $4.5 million contract for command and control R&D.

AIR FORCE contracts include $6 million to ITT for R&D on worldwide communications system; $5.5 million to Avco, reentry physics research; $2.5 million to RCA, Bmews; $1 million to Burroughs, DynaSoar radio guidance.

ARMY is buying $750,000 of mobile receivers from Marcon Electronics; $127,000 in radiotelephones from Martin-Orlando. Latter is for 10 test units of a new system called Racep.

NAVY has contracted with Magnavox for $10 million in sonobuoys, bringing asw backlog to $50 million; $3 million to RCA, miniature computer development; $2.4 million to Yardney Electric, silver-zinc batteries.

AVCO has Navy contract to install command communications system in eight Polaris submarines.

SANDERS ASSOCIATES has $4.6 million subcontract from Space Technology Laboratories for amplifiers.

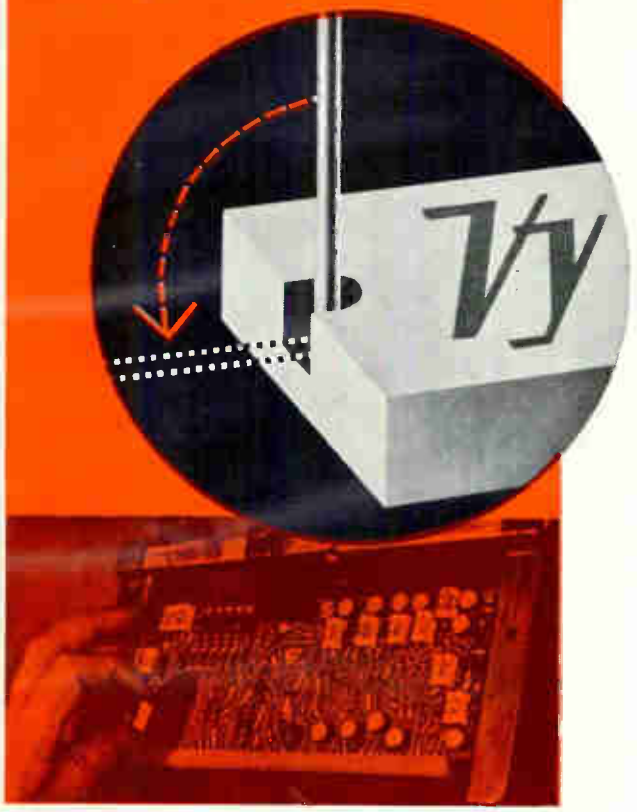
EIA PLANS wire-wound resistor standardization program, seeks industry participation.

SAVE up to 40% in board space!

. . . . with unique design that offers

TRUE VY RADIAL LEAD CONFIGURATION

Plus Provision For Axial Lead Application



VY™ Axial-Radial Capacitors vs. Axial Lead Capacitors

VY 12 Axial-Radial Capacitor

Length 3/8"
Board Space Required 3/8"
(No allowance necessary for lead bend)

VY 13 Axial Capacitor

Length 3/8"
Board Space Required 5/8"

Brand "X" Axial Capacitor

Length 11/32"
Board Space Required 19/32"

1/4" multiplied by the number of capacitors used on your circuit boards is the amount of space you can save by substituting "VY" Axial-Radial Capacitors for the axial units you may now be using.* Leads are *inboard* the body in radial configuration, yet may be moved to a *straight* axial position when required. Available in four sizes, 0.5 to 5600 mmf, 300 and 500 v ratings.

** Assuming minimum allowance of 1/8" for lead bend at each end of body for axial capacitors*

CONFORMS TO MIL-C-11272B

Vitramon®
INCORPORATED
P.O. Box 544 Bridgeport 1, Connecticut

WASHINGTON OUTLOOK

FEDERAL AVIATION AGENCY is switching its efforts to improve and automate air traffic control. FAA's new course, to make radar and altitude-reporting radar beacons the primary traffic control mechanism, is based on recommendations of a presidental task force headed by R. R. Hough, of AT&T. The proposals—which got a Kennedy go-ahead this week—would have a capital cost of $500 million, twice the current plan.

PRESENT OUTMODED control system was originally set up in 1938 when planes were fewer and slower. Traffic controllers work from flight progress strips on which plane routing information is entered by hand. Initial position information from flight plans is updated manually as the plane crosses check points. Controllers do a vast amount of bookkeeping and routine communication with pilots aside from vital tasks of watching for conflict and sequencing flow.

In a four year search for a more efficient system, FAA designed a semiautomatic computer and display system known as Data Processing Central and contracted with General Precision Laboratories to build it. The system was to accept and automatically print out flight progress strips, update them, probe for flight conflicts, determine flow control and perform other functions. DPC was to be partially operational next year and fully operational in late 1963. As an alternative FAA, Air Force and Mitre Corp. explored feasibility of adapting the Sage air defense system for traffic control.

TASK FORCE, known as Project Beacon, objected to the DPC system's printing of flight progress strips and asked for greater reliance on electronic data display. As for Sage , it said (1) long-run adapting costs would be greater than perfecting a new system, and (2) it is too uncertain how long Sage will be used for defense, which would take priority over traffic control.

The task force concluded that DPC and adaptation of Sage's computers and data processing should be dropped. However, it did recommend further integration of Sage and FAA radars. Thirteen are now in joint use and plans call for 35 more.

RADAR thus would become the prime traffic control tool, giving controllers continuous position information on all aircraft. Radar data would be displayed electronically to provide a complete and accurate air picture at all times. Computers would process flight plans, issue clearances, make conflict probes, generate display information and establish landing sequences. But these would be general purpose, off-the-shelf computers rather than special purpose computers as in DPC.

The task force, seeing no early prospect of three-dimensional radar, recommends altitude-reporting beacon transponders be carried in aircraft. FAA has invited bids on development of a beacon with an installed cost of $500. FAA hopes to have the radar-oriented traffic control system in operation in five years.

With complete position information available on the ground, communications with pilots would be drastically reduced. This is expected to result in curtailment of FAA research on automatic position-reporting communications.

NOW! 30 DAY DELIVERY

SIZE 8 & 10 INTEGRAL GEARHEAD MOTORS

3 Times Torque Load Capacity*

of comparable size 8 gearheads

*Will sustain 20 in-oz torque load for 1,000 hours operation and 100 in-oz momentary overload at the maximum ratios.

CPPC one-piece gearhead housing eliminates separate gear plates and fastening posts, improves and maintains accuracy through exact alignment of gear clusters, assures smoother operation and more expedient inspection and servicing.

Gearhead and motor are selectable, individual parts enclosed in the same common motor housing.

Clifton Precision, pioneers in postless gearhead construction, introduces the finest in gearhead design—cage-type, one-piece gearhead housing machined from a single block of metal. In these units, exact duplication of gear centers is accomplished through simultaneous boring of permanently integrated bearing plates (patent pending). Positive and permanent alignment of gear clusters composed of AGMA precision Classes II and III hardened-steel gears integral with shafts journaled at both ends in ABEC class 5 bearings, minimize deflection and backlash, maximize torque load capacity, insure smoother operation and continued reliability of performance beyond normal endurance life requirements. Cage-type construction facilitates inspection and lubrication while gearhead is mounted simply by removing motor.

CPPC motors will stand greater heat than ever before due to the use of new materials. See box at lower right.

Write for our free pamphlet which gives detailed specifications of our entire gearhead motor and motor-tachometer line, sizes 8, 10 and 11.

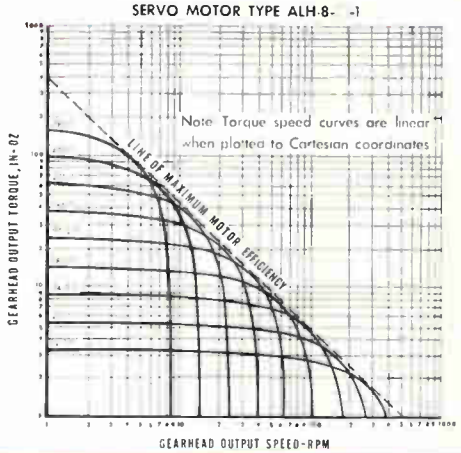
STANDARD TYPES

RATIOS		No. of	Dir. of
Size 8	Size 10	Clusters	Rotation
12.09	19.98	2 (3 pass)	reverse
20.63	32.19	3 (4 pass)	direct
34.26	58.28	3 (4 pass)	direct
58.44	93.89	4 (5 pass)	reverse
97.07	169.97	4 (5 pass)	reverse
165.58	273.84	5 (6 pass)	direct
275.02	495.74	5 (6 pass)	direct
469.15	798.70	6 (7 pass)	reverse
779.22	1445.92	6 (7 pass)	reverse

Notes: 1. Any ratio (±3%) is available within the limits of the ratio range at additional cost and may require longer delivery time. 2. Max. backlash = 30 minutes at 2 in-oz reverse gauge load in above units. Inquire if special tolerance is required.

PERFORMANCE CHARACTERISTICS

SIZE 8 INTEGRAL GEARHEAD MOTOR
SERVO MOTOR TYPE ALH-8- -1



MOTORS

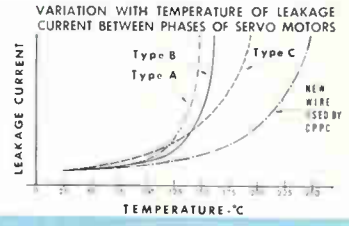
The following CPPC standard motors, electrical characteristics of which can be found in the current CPPC Rotary Components catalog, are offered with our gearheads:

SIZE 8		SIZE 10	
ACH-8-☐-1	AMH-8-☐-3	ACH-10-☐-1	ALH-10-☐-1
ACH-8-☐-4	ALC-8-☐-1	ACH-10-☐-4	ALH-10-☐-5
AMH-8-☐-1	ALC-8-☐-4		

CURRENT LEAKAGE

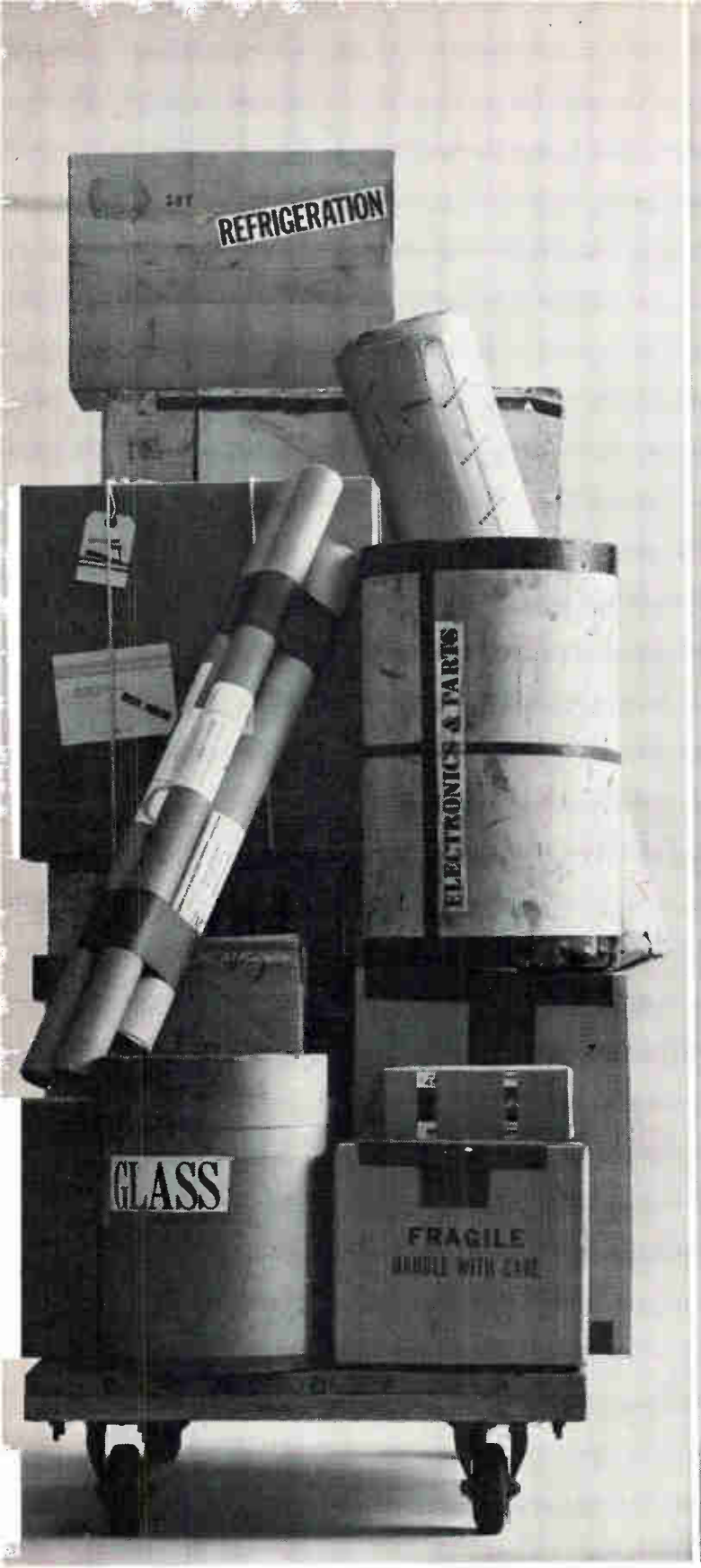
Superiority of insulation in CPPC motors is illustrated by actual comparative curves shown at the right.

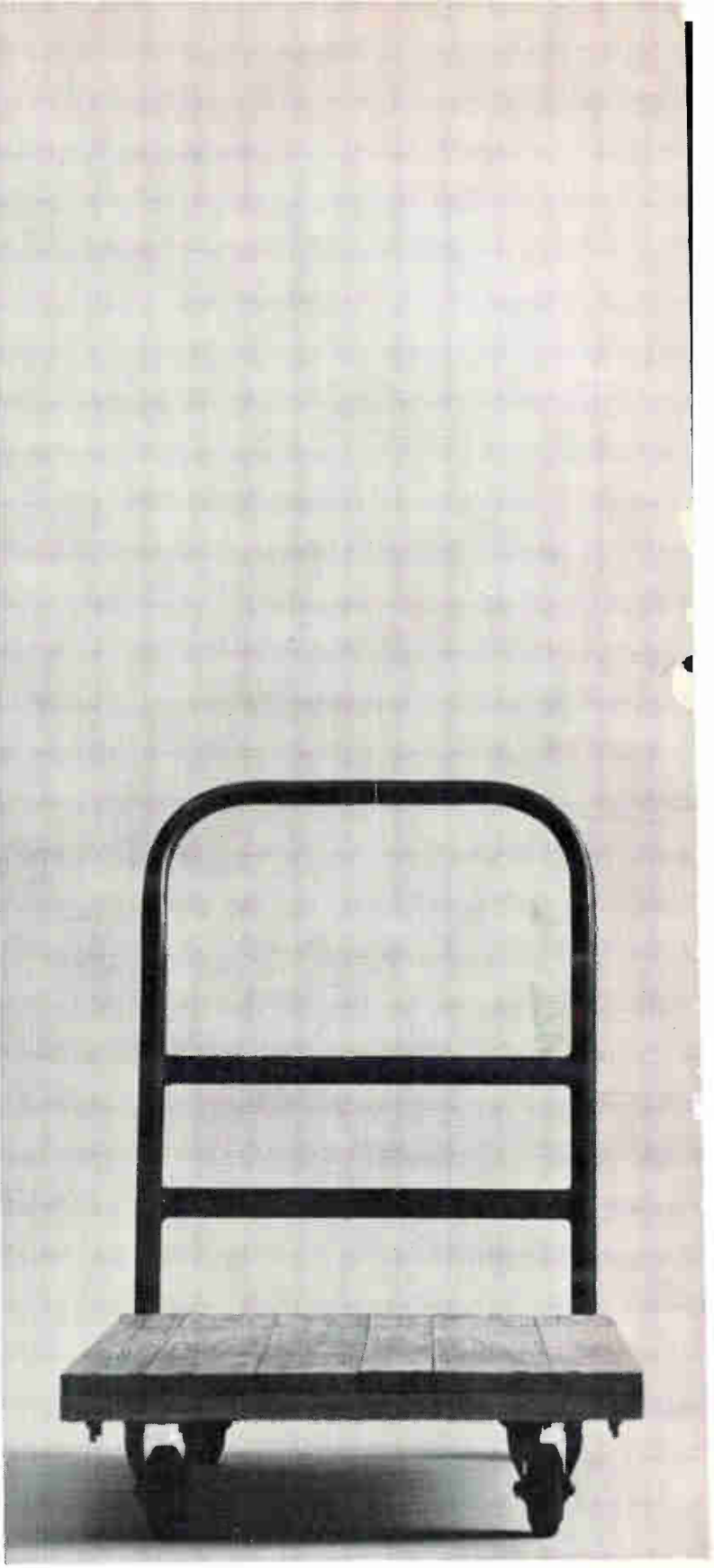
VARIATION WITH TEMPERATURE OF LEAKAGE CURRENT BETWEEN PHASES OF SERVO MOTORS



CLIFTON PRECISION PRODUCTS CO., INC.
CLIFTON HEIGHTS, PENNSYLVANIA

cppc





All gone

Here in Zurich's new cargo terminal, transshipping time is measured in minutes—not hours. There are 27 reasons why. One is the terminal itself—120,000 square feet of the world's most complete jet-age cargo facilities. The other 26 reasons are the 26 major international airlines that link Zurich with all Europe, Africa, the Middle East and the Orient. At the head of the list—Swissair, whose jet fleet serves 56 cities on 5 continents. Next time you ship cargo, take advantage of Zurich's unique facilities—including high-speed conveyor systems, refrigerator rooms, animal hostels, 9,000-square foot free trade zone, radiation storage, guarded vaults, plus all forwarders, agents and airline offices all under one roof. Phone your cargo agent, forwarder, or Swissair. 10 West 49th Street, New York 20, New York, FAculty 2-8600

SWISSAIR
SWISSCARE • WORLDWIDE

new twist in extreme temperature wire and cable

SILICONE RUBBER!

Synkote® Silicone Rubber insulated wire and cable is the answer for extreme temperature applications. It combines some of the best physical and electrical properties of rubber and plastics in one insulation. Flexible even after long exposure to temperatures from −130°F to +500°F, ozone and corona resistant, non-flammable, high dielectric strength and insulation resistance, low dissipation factor and dielectric constant, good tensile strength and elongation. Can be manufactured in watertight constructions. Ideal for outstanding performance under difficult operating conditions—in aircraft, missiles, electronic equipment, motor and transformer leads, high tension ignition leads. Synkote® Silicone Rubber insulated wire and cable—a new twist you should know more about! Write today.

PLASTOID
CORPORATION
42-61 24TH STREET / LONG ISLAND CITY 1, N. Y. / ST 6-6200

←CIRCLE 16 ON READER SERVICE CARD

CIRCLE 17 ON READER SERVICE CARD

CIRCLE 18 ON READER SERVICE CARD→

Hardware?

Maybe connectors were "hardware" twenty years ago.

That's when the P-38 was the hottest fighter plane we had. Pilots were proud when they could hit 300 MPH and go up to 50 or 60 thousand feet. With this kind of performance requirement, most connectors worked without a hitch. You just connected them and forgot about them, like nuts and bolts.

HOW TIMES HAVE CHANGED

Now we're up around Mach 5 and altitude has been pushed into outer space. Nose cones light up like giant soldering irons and components have to operate in a near vacuum.

Fortunately, Amphenol engineers saw that the old "hardware" concept was headed out the window. Programs coming up were going to need connectors that could put up with terrific environmental conditions of heat and altitude cycling. For example, at high temperatures most of the elastomers used as insert materials or connector seals either melt into a puddle, turn into a cinder, or set-up and lose compression.

What's more, connectors now have to keep on functioning *all* the time, with no allowance for failure. So—Amphenol designers went to work developing a connector to meet the new space-age standards.

DISSECTING MOLECULES

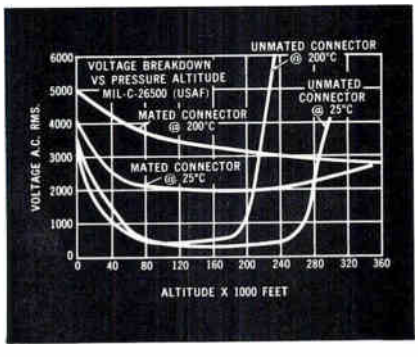
The Amphenol Materials Lab, with the help of a shiny new infra-red photospectrometer, began dissecting elastomer molecules. They were able to pinpoint the weak spots in molecular structure where breakdowns begin. Then they were able to plan and build new molecules, with built-in "armor" to protect against failure. Result: an exclusive silicone rubber compound that maintains its integrity and elasticity under severe temperature extremes and also withstands exposure to violent new propellants like hydrazine and nitrogen tetroxide.

At the same time, Amphenol design engineers were hard at work perfecting metal-to-metal shouldering of mating shells that allowed precision control over compression of the sealing ring. In addition, the metal-to-metal design damped vibrational stress nine times more effectively than resilient damping. Finally, they incorporated a semi-rigid anti-deflection disc to control insert expansion under thermal stress.

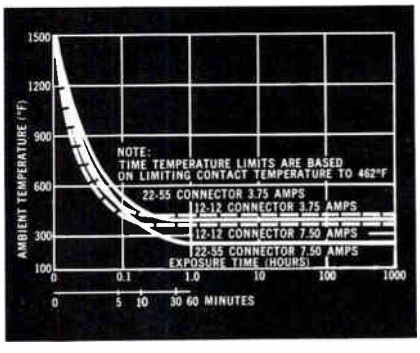
Having all the pieces, we put them together, called it the Amphenol 48 Series, and started testing. In the vacuum chamber, 48 Series connectors operate very nicely at a simulated altitude of 500,000 feet. They are quite comfortable in the hot box at 200°C ambient, *carrying full rated current.* They don't even mind going up to 600°C, if they don't have to stay too long. In short, Amphenol 48's can take almost anything you throw at them.

PROJECTS WANTED

Amphenol designers have established criteria for determining connector time-temperature-current capability. This information will be especially valuable to engineers presently engaged in "exotic" projects, perhaps the kind of project where previous connectors have failed to measure up to the new space-age standards. If this is the case, contact an Amphenol sales engineer. He's a "space-age hardware" expert. Or, write directly to Bob Dorrell, Vice President, Engineering, Amphenol Connector Division, 1830 South 54th Avenue, Chicago 50, Illinois.



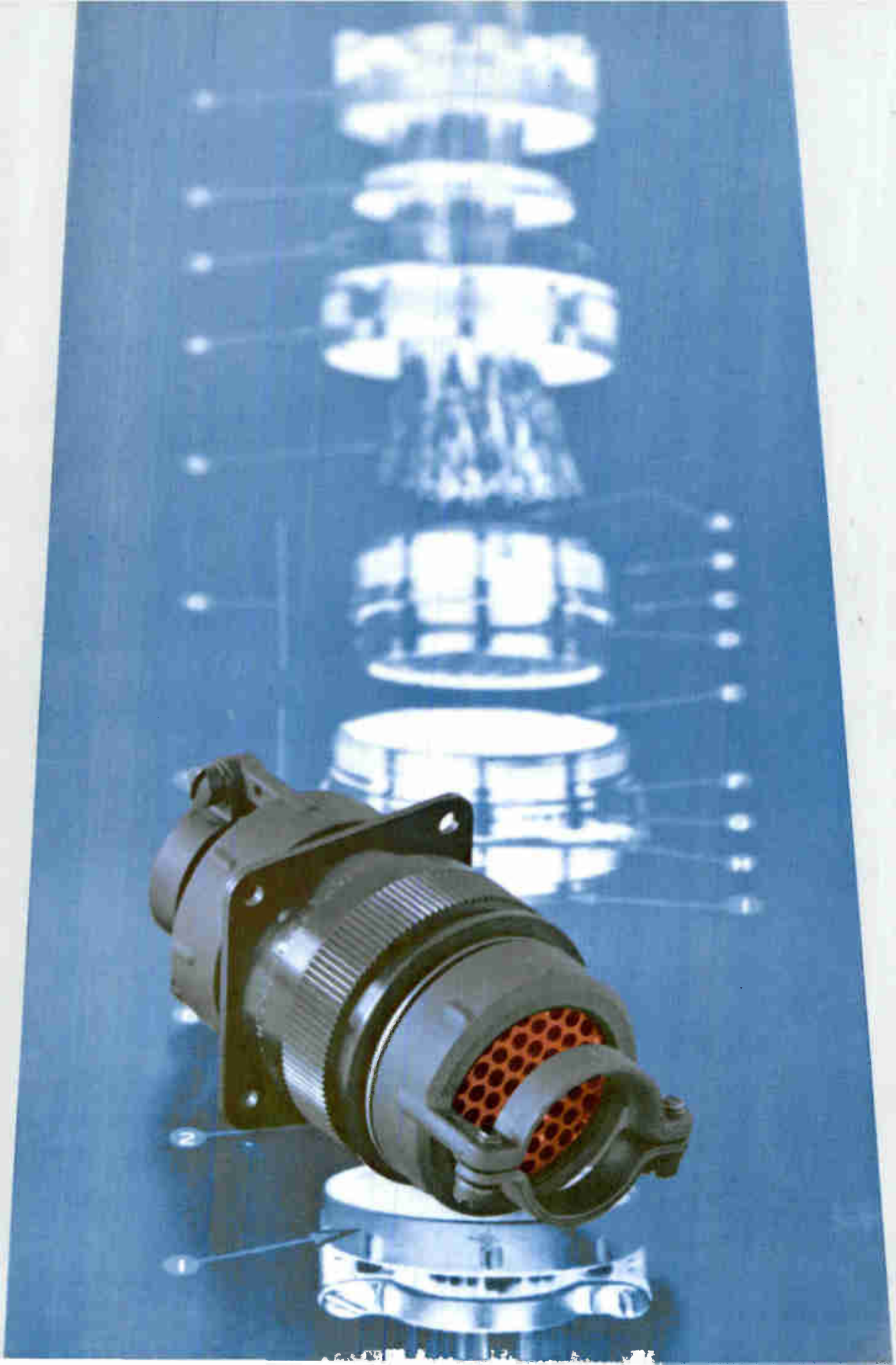
High altitude air has low dielectric strength. By maintaining an air-tight seal 48 Series Connectors enjoy extremely high voltage safety factors.

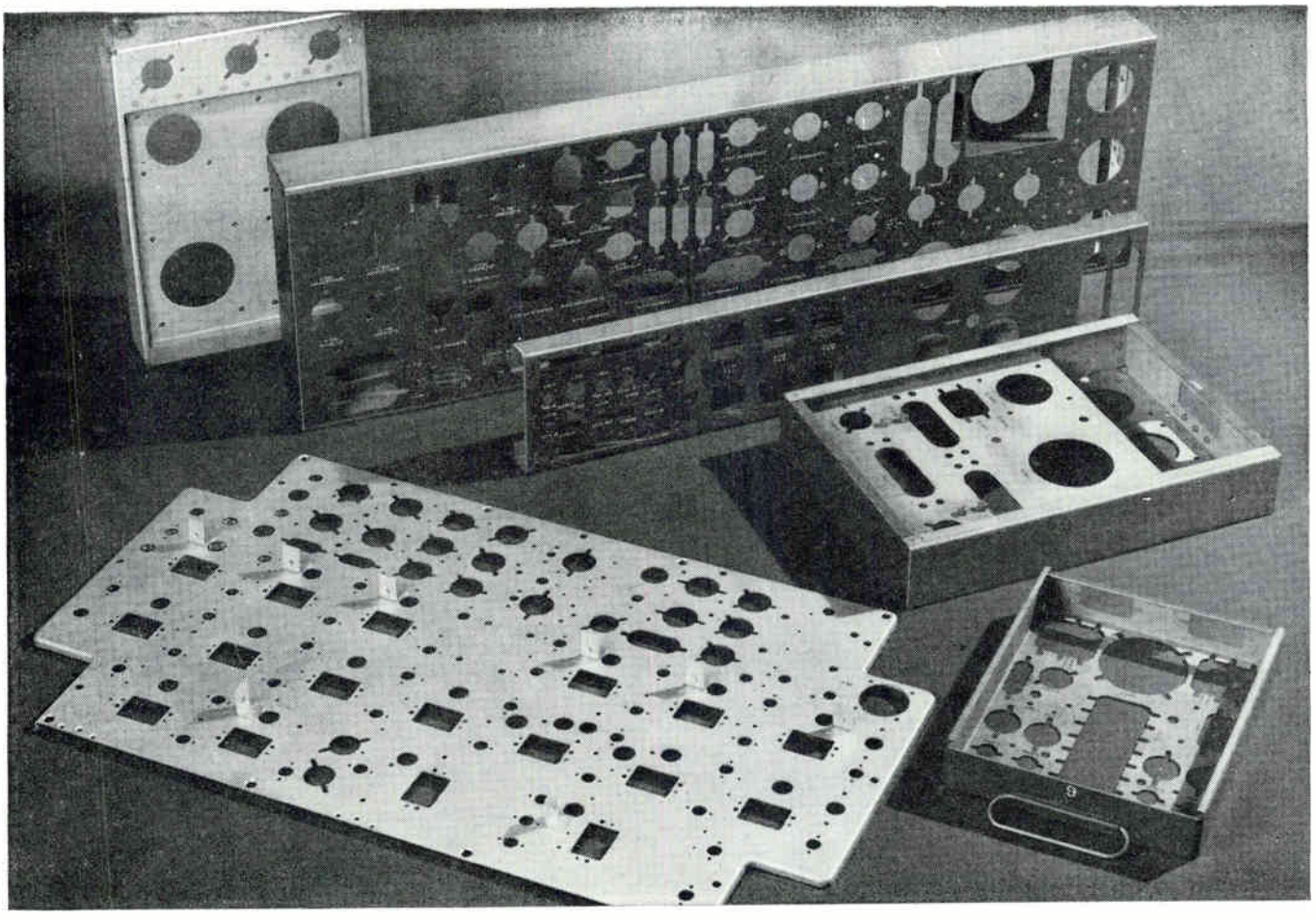


While Amphenol 48 Series Connectors are nominally rated at 200° C, they can also withstand considerably higher short-time temperature exposures.

Amphenol 48 Series Meets Mil Spec C 26500 (USAF).

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





PUNCH COMPLICATED PATTERNS FAST

With the new improved STRIPPIT 15-A Fabricator, complicated patterns of round and shaped holes can be produced quickly and accurately in sheet material. A high speed punch press that enables you to produce finished pieces directly from drawings, the versatile STRIPPIT 15-A eliminates slow "in-between" tool designing and die making... saves you days or even weeks of valuable time.

The STRIPPIT 15-A features a unique multiple-stop gauging system for positioning work to exact layout specifications. Punches and dies... within easy reach in built-in file drawers...can be switched from one size to another in less than 20 seconds. Designed especially for prototype and short production runs, the STRIPPIT 15-A is easily converted to a high speed production punching unit with the STRIPPIT Duplicator.

The STRIPPIT 15-A:

- **PUNCHES** any round or shaped hole up to 3½″ diameter. Maximum material thickness is ¼″.
- **NOTCHES** 90° corners—rectangular, radii, vee and special shape edge notches—up to ⅛″ capacity in mild steel.
- **NIBBLES** straight line or contour shearing up to 38″ diameter circle, at 165 strokes a minute, ⅛″ mild steel.

Send now for 15-A catalog. Free demonstration can be arranged right in your plant.

WALES **STRIPPIT** INC.

A UNIT OF HOUDAILLE INDUSTRIES, INC.

225 Buell Road • Akron, New York

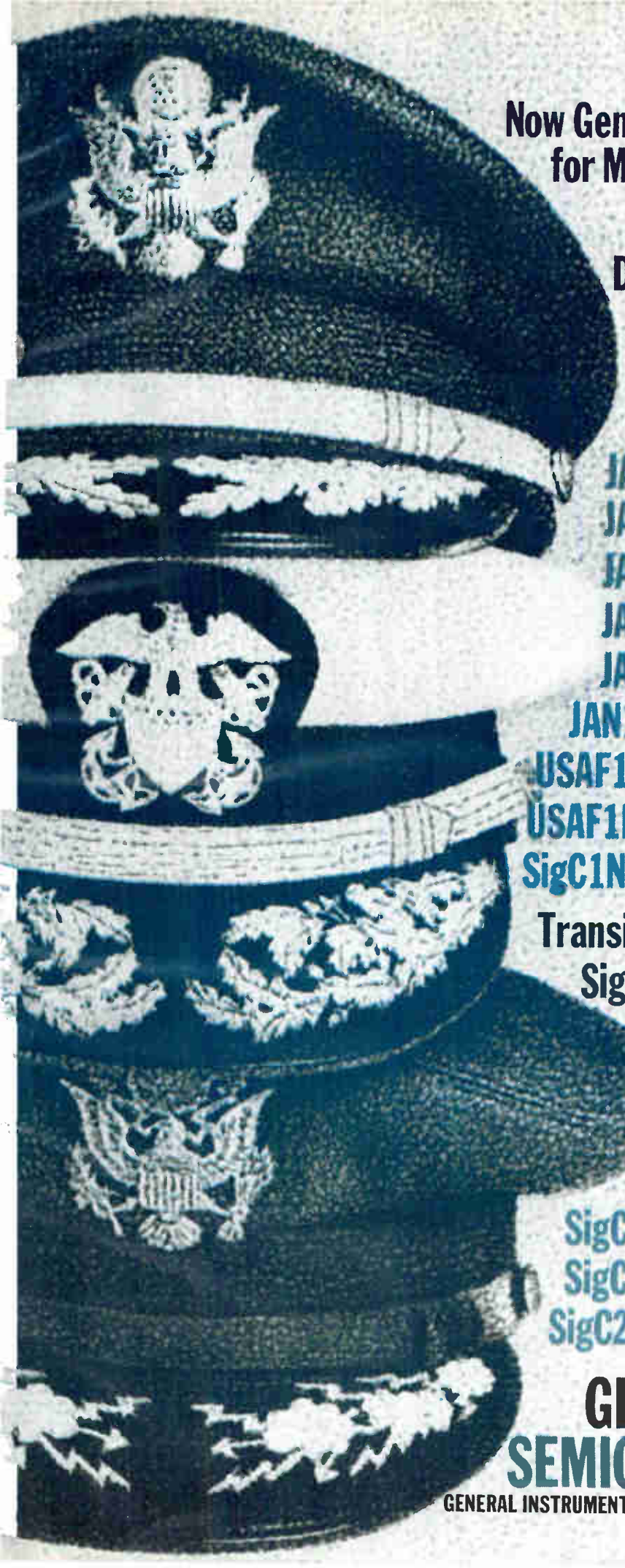
In Canada: Strippit Tool & Machine Company, Brampton, Ontario

In Continental Europe: Raskin, S.A., Lausanne, Switzerland *In the British Isles: E. H. Jones (Machine Tools) Ltd., Hove, Sussex, England*

CIRCLE 20 ON READER SERVICE CARD

←CIRCLE 19 ON READER SERVICE CARD

CIRCLE 21 ON READER SERVICE CARD→



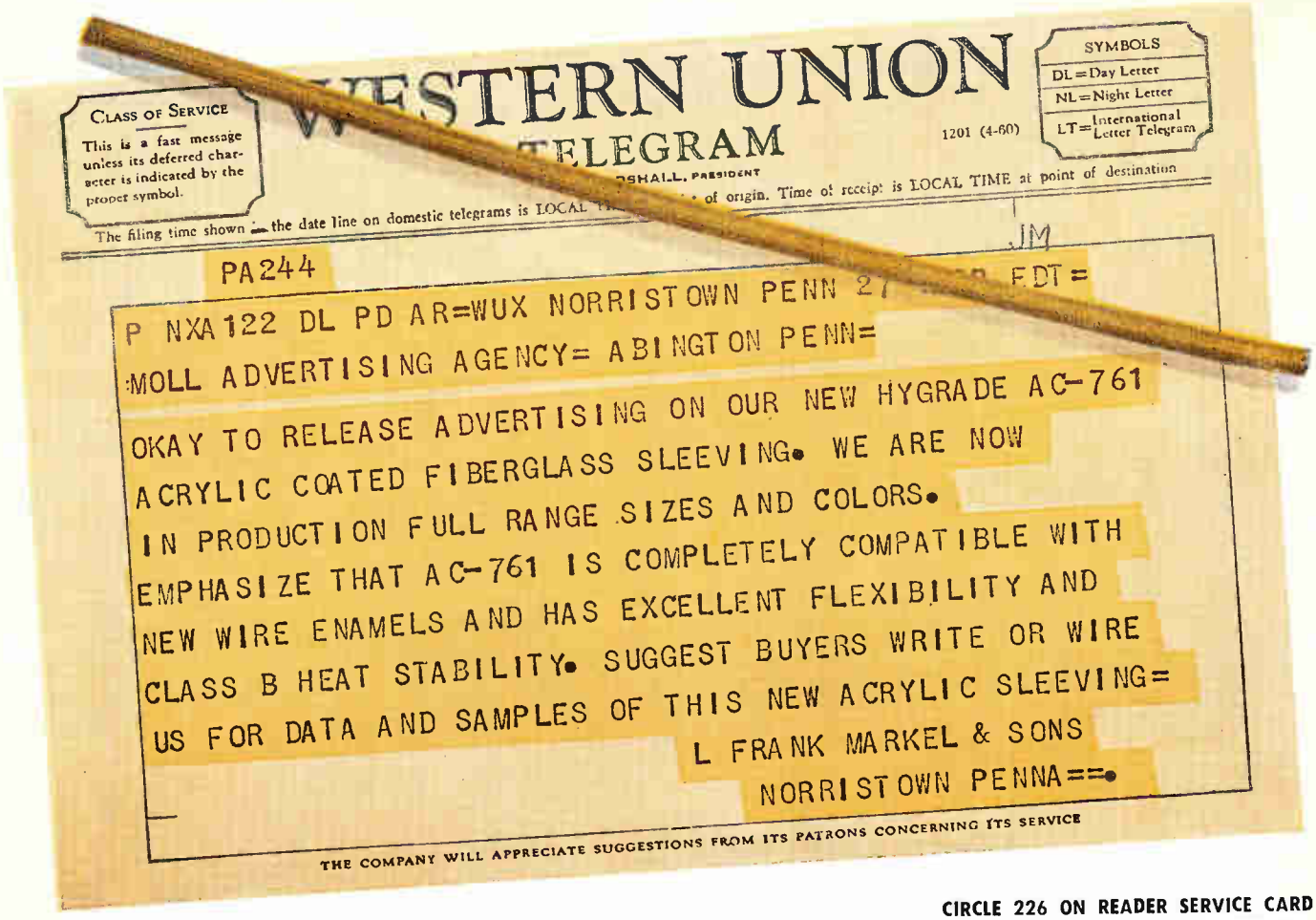
Now General Instrument is top source for Mil types for all your transistor, diode and rectifier needs.

Diodes-Rectifiers: SigC1N249B SigC1N250B NAVY1N483B NAVY1N485B NAVY1N486B NAVY1N914 SigC1N2135A JAN1N128 JAN1N198 JAN1N253 JAN1N254 JAN1N255 JAN1N256 JAN1N270 JAN1N276 JAN1N277 JAN1N281 JAN1N457 JAN1N458 JAN1N459 JAN1N538 JAN1N540 JAN1N547 SigC1N643 USAF1N645 USAF1N646 USAF1N647 USAF1N648 USAF1N649 SigC1N658-1N662-1N663 SigC1N1731 SigC1N1733 SigC1N1734

Transistors: JAN2N501A SigC2N706 SigC2N393 SigC2N696 SigC2N697 JAN2N331 JAN2N358A JAN2N428 JAN2N466 NAVY2N388 NAVY2N396A USAF2N404 SigC2N416 SigC2N417 SigC2N425 SigC2N426 SigC2N427 SigC2N464 SigC2N465 SigC2N467 SigC2N499 SigC2N1411

GENERAL INSTRUMENT
SEMICONDUCTOR DIVISION

GENERAL INSTRUMENT CORPORATION, 65 GOUVERNEUR ST., NEWARK 4, N.J.



WESTERN UNION

TELEGRAM

1201 (4-60)

CLASS OF SERVICE
This is a fast message unless its deferred character is indicated by the proper symbol.

SYMBOLS
DL = Day Letter
NL = Night Letter
LT = International Letter Telegram

The filing time shown — the date line on domestic telegrams is LOCAL TIME at point of origin. Time of receipt is LOCAL TIME at point of destination

PA244 JM

P NXA122 DL PD AR=WUX NORRISTOWN PENN 27 EDT=
:MOLL ADVERTISING AGENCY= ABINGTON PENN=

OKAY TO RELEASE ADVERTISING ON OUR NEW HYGRADE AC-761
ACRYLIC COATED FIBERGLASS SLEEVING. WE ARE NOW
IN PRODUCTION FULL RANGE SIZES AND COLORS.
EMPHASIZE THAT AC-761 IS COMPLETELY COMPATIBLE WITH
NEW WIRE ENAMELS AND HAS EXCELLENT FLEXIBILITY AND
CLASS B HEAT STABILITY. SUGGEST BUYERS WRITE OR WIRE
US FOR DATA AND SAMPLES OF THIS NEW ACRYLIC SLEEVING=
L FRANK MARKEL & SONS
NORRISTOWN PENNA==.

THE COMPANY WILL APPRECIATE SUGGESTIONS FROM ITS PATRONS CONCERNING ITS SERVICE

CIRCLE 226 ON READER SERVICE CARD

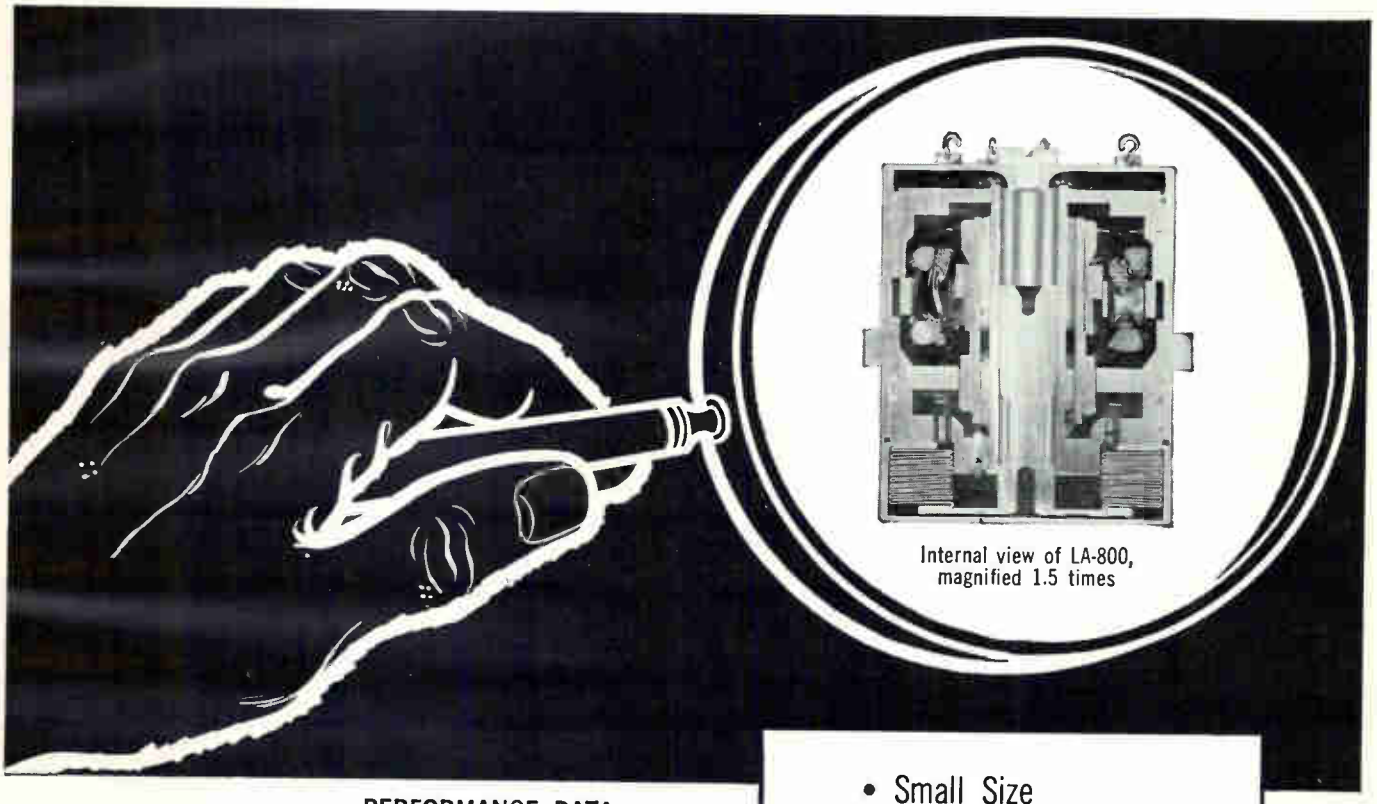
BIG ACCELEROMETER PERFORMANCE IN A SUBMINIATURE PACKAGE!

The LA-800 Series is the smallest non-pendulous linear accelerometer available today featuring a variable reluctance pickoff and essentially constant damping over the temperature range of −65°F to +250°F. It is the smallest instrument of its type that can measure acceleration forces up to 80 G.

Reliability through overall simplicity was the primary goal of the LA-800 design. An example is the seismic mass support which eliminates sleeve bearings and their inherent friction. The result of this basic design objective is an accelerometer which can be relied upon to operate instantaneously and for long periods, even after months of storage.

The combination of miniaturization, ruggedness, and high performance makes this instrument ideally suited for advanced aircraft and missile applications where space and weight considerations are critical.

Write for Technical Bulletin BM-SLA8-1 to Minneapolis-Honeywell, Boston Division, Dept. 7, 1400 Soldiers Field Road, Boston 35, Mass., or call your local Military Products Group Office. Sales and Service offices in all principal cities of the world.



Internal view of LA-800, magnified 1.5 times

- Small Size
- Simple Construction
- Reliable
- Self-Test Available

Subminiature Accelerometer LA-800, shown ¾ size

PERFORMANCE DATA

- **SIZE:** 1 inch in diameter by less than 1.5 inches (over terminals)
- **WEIGHT:** Approximately 3 ounces
- **DAMPING RATIO:** Any nominal ±20% from −65°F to +250°F
- **RANGE:** Up to 80 G
- **PICKOFF:** Variable Reluctance design provides infinite resolution and high signal-to-noise ratio
- **LOW THRESHOLD, EXCELLENT RESOLUTION:** 10^{-4}G
- **EXCELLENT LINEARITY:** ±0.5% to half-scale; ±2% to full-scale
- **LOW HYSTERESIS:** Less than 0.15% full scale
- **LINEAR ACCELERATION:** 10 G's or 3 times full-scale, whichever is greater.
- **LINEAR VIBRATION:** 15 G's to 2 kc for low G units; 30 G's to 2 kc for high G units

Consult Honeywell for your specific linear accelerometer requirements.

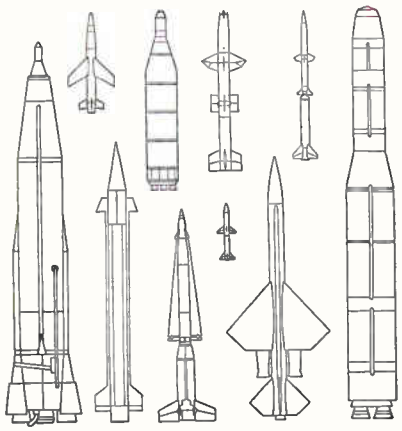
Honeywell

Military Products Group

FOR GSE, A GIANT CAPABILITY. ITT offers performance-proved facilities for complete handling of ground support equipment projects. Its comprehensive capability embraces concept evaluation, research, development, production, siting, installation, maintenance and overall system management. ■ Projects in which ITT has made major GSE contributions include ATLAS and TITAN (ground communications), BOMARC (test equipment, functional check-out and launching controls), LACROSSE (guidance and tracking equipment and flight control components), TARTAR (guidance components), TERRIER (beam rider guidance), and POLARIS (communication and navigation components). ■ Noteworthy, also, are ITT Federal Laboratories' successes with the Eglin Gulf Test Range 300-mile "electronic scoreboard" for testing accuracy of anti-aircraft missiles, and complete instrumentation for monitoring rocket tests at Edwards Air Force Base. ■ Currently, ITT Federal Laboratories' Ft. Wayne GSE Group is engaged in the development of advanced computer techniques for use in automatic test equipment. ■ Whatever the requirement in ground support equipment, here in a single, closely-knit organization are the talents, facilities and corporate strength to fulfill assignments of any magnitude.

AVIONICS • COMMUNICATIONS • MISSILE AND SPACE SYSTEMS • ELECTRONIC DEFENSE • GROUND SUPPORT SYSTEMS

FEDERAL LABORATORIES
500 WASHINGTON AVENUE, NUTLEY, NEW JERSEY
CLIFTON, N. J. • FORT WAYNE, IND. • SAN FERNANDO & PALO ALTO, CAL.
DIVISION OF INTERNATIONAL TELEPHONE AND TELEGRAPH CORPORATION



GSE

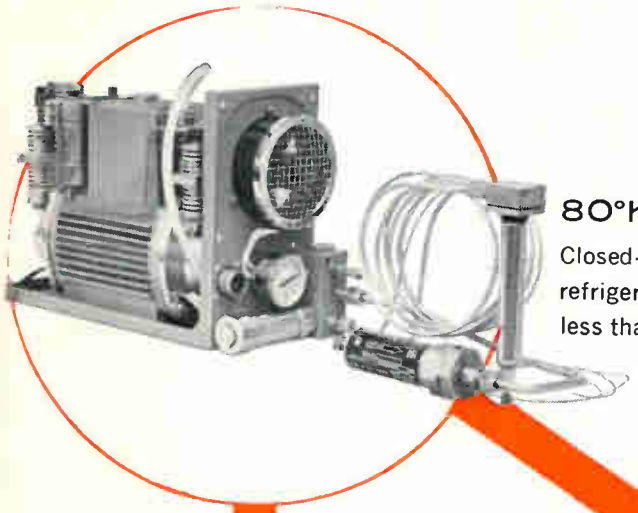
CIRCLE 24 ON READER SERVICE CARD

closed-cycle cryogenic refrigeration systems

2°K to 100°K

for

masers
I.R. detectors
super-conductors
cryo-magnets
cryo-pumps



80°K

Closed-cycle I. R. detector refrigerator weighing less than twenty pounds

Air Products builds a variety of closed-cycle cryogenic refrigeration systems, tailored to specific customer requirements. Let us put our cryogenic experience to work for you.

2°K

Miniature expansion engine developed for maser cooling systems

20°K

Miniature heat exchanger for experimental low-temperature investigations

DEFENSE AND SPACE DIVISION

Air Products and Chemicals INC.

ALLENTOWN, PENNSYLVANIA

Offices in Dayton, Ohio • Los Angeles, Calif. • Orlando, Fla. • Washington, D. C.

The words are "project engineer." He's celebrating—again. And every time he does free men shudder. Our job is different. Often cheerless. Because we in the defense business are charged with keeping fingers off buttons. Because the real business of the defense business is survival.

Advertisement

Microdot Awarded Contract on Midas

LOS ANGELES, CALIF.—Contracts in excess of $225,000 have been awarded to Microdot Inc. by Philco Corporation's Western Development Laboratories for UHF narrow-band data link transmitters and subassemblies to be flown in the Midas missile alarm satellites.

The Midas project, under cognizance of the United States Air Force, is aimed at development of a national early warning capability through multiple satellite coverage of the earth's surface via infrared detectors. Philco, with responsibility for the instrumentation, is an associate contractor to the Air Force. Lockheed Missiles & Space Company, prime system contractor, is responsible for the total vehicle and ground elements of the system, integrating associate and subcontractor efforts.

Microdot model 2406A UHF Telemetry Transmitter, similar to units now in production for the Midas satellite program.

In May, 1960, a Midas satellite was launched into near perfect orbit 300 miles in space. The 5000-pound satellite, over 21 feet high, carried a 3600 pound instrumented package. Then in July of this year, Midas III was placed into an 1850 nautical mile orbit. Again a near perfect circular orbit was achieved. Continuation of test firings are anticipated with the program remaining a high priority national development.

For Midas, Microdot will supply their Model 2406A Telemetry Transmitter modified to include self-monitoring and telemetering of its own operation. The transmitter is miniaturized, pressurized, and includes its own solid state power supply. Reduction in size is gained through use of a unique automatically stabilized circuit, with the output frequency referenced directly to a quartz crystal. The transmitter weighs 12 pounds. Similar Microdot telemetry equipment has been a part of such projects as Pioneer V, Jupiter, Atlas, Pershing, Redstone, and Echo I.

MICRODOT INC.

220 Pasadena Avenue
South Pasadena, California

CIRCLE 26 ON READER SERVICE CARD

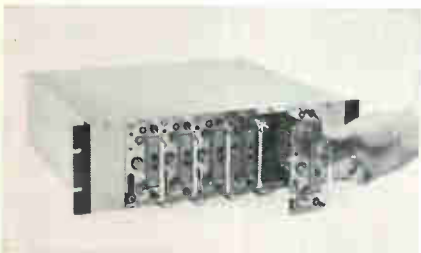
Advertisement

Airborne DC Amplifier

Small, solid state, direct-coupled DC amplifier weighs only six ounces. Less than five cubic inches in volume, this rugged, hermetically sealed instrument is available with solder, plug-in, coax or combination header arrangements and a variety of mountings. DC gain is 200 to 1000 ±0.75%. Input capability is 5 millivolts differential at maximum gain; output capability is ±5 volts into not less than 20K (single-ended).

Microdot Inc., 220 Pasadena Avenue, South Pasadena, California.

Transducer Signal Conditioning

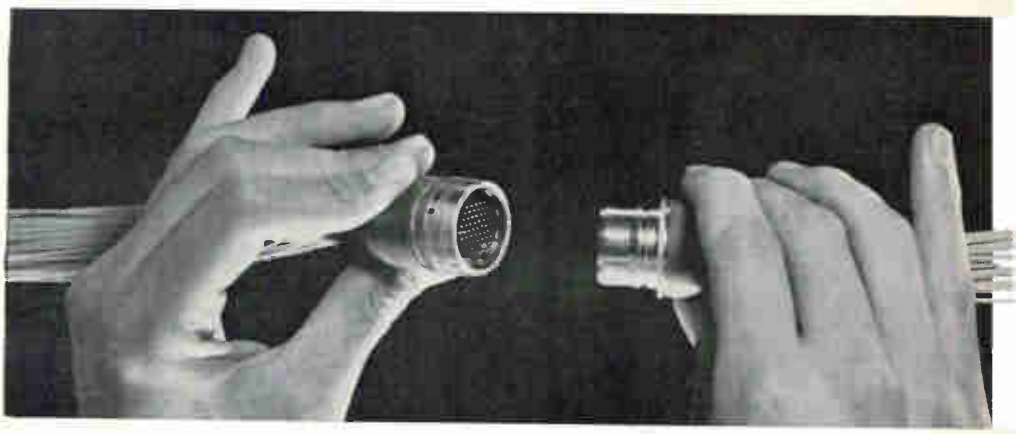


Two new transducer and strain gage signal conditioning units feature radically different packaging concept at low cost per channel. Both the PS-290 Power Supply and PB-290 Power and Balance Unit incorporate plug-in card circuits for up to eight channels in a 19" rack, 5¼" high. Bridge completion balancing, and calibration resistors are easily accessible from the front. Output ripple is less than 500 microvolts peak-to-peak, or 200 microvolts RMS. Line regulation is less than 0.02%. Isolation is less than 0.01 microamps of 60 cycle current. Output impedance is less than 0.05 ohm.

Microdot Inc., 220 Pasadena Avenue, South Pasadena, California.

CIRCLE 27 ON READER SERVICE CARD

MICROMINIATURE MULTI-PIN CONNECTORS



Visualize 61 contacts in the diameter of a dime . . . think of slashing connector weight requirements by 33% . . . estimate the dollar savings in time and inventory of a connector with complete interchangeability of parts. This unique combination of advantages—and more—are built-in features of Microdot's new multi-pins.

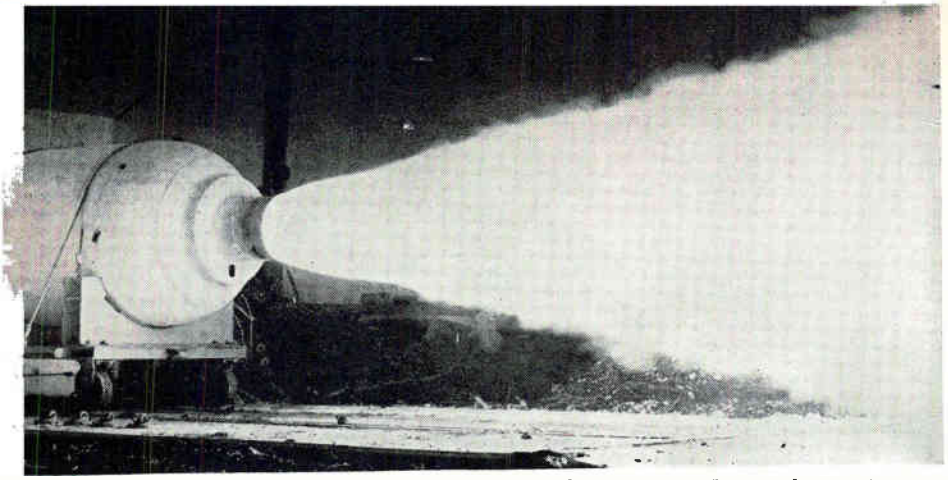
In airborne and ground support applications where size, weight and reliability are vital factors, Microdot's unique new multi-pin connector stands alone. Available in three shell sizes and a variety of mounting versions, these rugged connectors are adaptable to a wide range of specific applications (you specify from a wide variety of standard, interchangeable multi-pin component parts to arrive at a connector tailored to your specific application).

Inserts are available in a variety of straight power, straight coaxial, and power-coaxial layouts. Power contacts are interchangeable without changing inserts, allowing hermaphroditic contact arrangements (a mixture of male and female contacts within the same plug or receptacle, allowing hot leads to both plug and receptacle). Closed entry, pure coin silver socket contacts allow heavy currents with low temperature rise. Contact resistance is almost nil. Write today for detailed descriptive literature, Bulletin MP-O.

SIZE DESIGNATION	PLUG O.D.	NO. OF COAXIAL CONTACTS	NO. OF POWER CONTACTS
A	¾"	up to 7	up to 19
B	15/16"	up to 12	up to 37
C	1⅛"	up to 19	up to 61

Microdot Multi-Pins are available in disassembled "kit" form or, if you prefer, factory assembled with Microdot cable.

MICRODOT INC.
220 Pasadena Ave./South Pasadena, Calif.



At McGregor, Texas, Rocketdyne test fires at —75 F a rocket motor containing 3,500 lb of solid fuel

Space Lab

Texan industry and education expect NASA facility to ignite area's science drive

By MARVIN REID,
McGraw-Hill World News

DALLAS—National Aeronautics and Space Administration's selection of Houston as the site for its new $60-million Manned Space Flight Laboratory may touch off a much-needed "scientific awakening" in the Southwest, and help make the area a major space age center.

There seems to be little doubt that a business boom is coming.

Houston's Chamber of Commerce reports inquiries from business firms wanting more information about the city have doubled since NASA's announcement. Inquiries about office space throughout the city have tripled. The Houston chamber reports that the bulk of these inquiries are coming from electronics firms, or from firms allied to the electronics industry.

The Houston chamber says that three outside firms so far have taken steps indicating they will definitely locate there soon. They believe that the tempo of such announcements will pick up during the next few months.

"We expect to see a number of firms moving at least laboratories, technicians and representatives into the area," says W. F. Joyce, senior vice-president in charge of Texas Instruments' Apparatus division.

The region's present electronics industry, while concentrated 250 miles north of Houston in Dallas (TI, Collins Radio, Ling-Temco-Vought, Inc.), can expect to benefit. As Joyce puts it:

"I believe this lab, because of its geographical location, will improve communications between our Southwest firms and NASA. We can sit down with them and learn their problems, then work out means to solve them. And, the NASA people will become oriented with the electronics industry in this area."

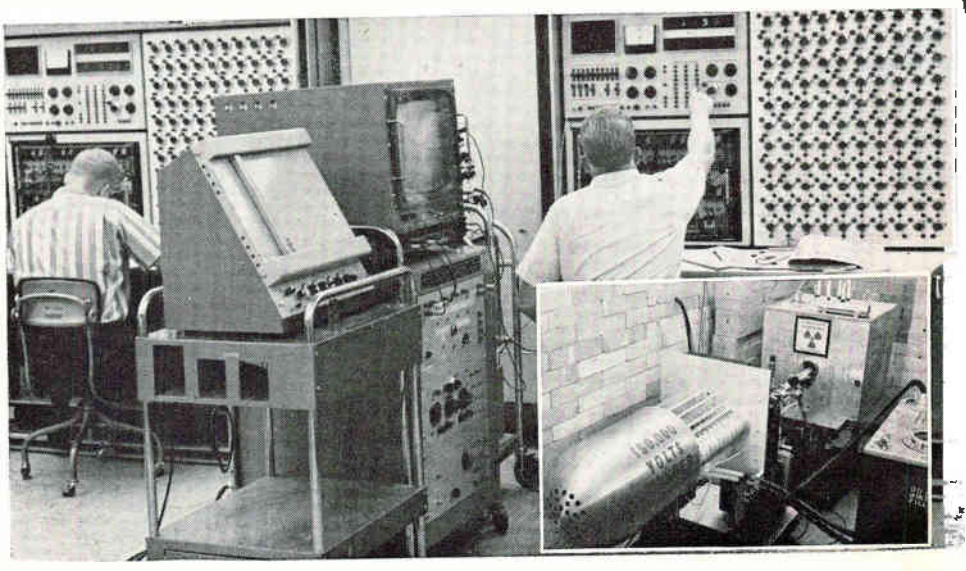
Gifford K. Johnson, president of Ling-Temco-Vought, Inc., thinks the Southwest has an excellent chance of becoming a major space center.

Johnson says the great open fields in the area are suitable for the large facilities and sprawling test sites that will be needed as the space program accelerates. He reports that site surveys have been conducted in this region by Aerojet General and other large booster system producers.

Johnson believes installations already in the Southwest region will complement work to be done in Houston. As he points out, North American Aviation (Rocketdyne) and Thiokol operate solid propellant plants in Texas. At San Antonio, Brooks AFB already has the Air Training Command's Aerospace Medical Center and its School of Aerospace Medicine. Johnson believes it is "reasonable to anticipate this area's becoming an Air Force space flight training center".

Many believe the NASA laboratory will make a tremendous impact on research in the Southwest area.

The lack of a "scientific climate" in this area has troubled the region's leaders for some time. Just recently, plans for the Graduate Reearch Center (GRC) of the Southwest, at Dallas, were revealed. The purpose of GRC, started with an initial endowment of $20-million, is to raise the standard of graduate research and study in a six-state Southwestern area. The center's backers, which include such people as Erik Jonsson, board chairman of TI, have been putting their money into it because they see danger in not developing such a climate.



Analog computer in Texas A&M's data processing center. Inset is Cockroft-Walton accelerator used in activation analysis lab

Warms Up Southwest's Scientific Climate

GRC, headed by Lloyd Berkner, envisions a central research facility providing advanced laboratories for scientists in the region. There has also been talk of GRC cooperating with Southwest universities and industries in locating research facilities.

The NASA facility in Houston should strengthen GRC's promotional efforts. Some of the region's educators believe the combination of the two will go far in providing the "climate" needed to attract more talent into the area.

Texas Agricultural & Mechanical College has perhaps moved as fast as any of the region's schools in up-grading its research facilities. However, an A&M spokesman admits, that "we have just been crawling so far." It has had difficulty in attracting all the top talent it wants.

"We believe the NASA move will help us greatly," this A&M spokesman says. "We believe we already have the facilities to get some of the projects they will be farming out. We think the space lab's location in Houston will help us in getting people we haven't been able to attract before."

There are 17 universities and colleges in the region. Texas Agricultural and Mechanical College (90 miles from Houston), the University of Texas (150 miles away), Rice University, which donated the land for the space lab, and University of Houston, have the type of research facilities and talent which should prove attractive to NASA.

Besides the schools and GRC, the Southwest Research Institute at San Antonio, a private research foundation, is expected to participate in NASA projects.

"This could be one of the most significant things that has happened to this area," says one educator. This will show our need for developing our own talent. There should be money for special projects which will make it easier to get research facility endowments. Top scientists should be coming in. You can see why we are excited."

Analog-Digital Complex Develops New Space Gear

By CLETUS M. WILEY,
Midwest Editor

MINNEAPOLIS—At dedication of its new $5 million aerospace facility this month, Minneapolis-Honeywell took the wraps off two examples of the products it will produce: a miniature electrically-suspended gyro and a self-adapting autopilot.

Designed to produce guidance equipment for missile and space vehicles and to develop spacecraft systems, the facility includes a computer center equipped with a Honeywell 800 data processing system combined with an array of 16 analog computers.

A hollow beryllium sphere, electrostatically suspended in vacuum in a ceramic casing, is the gyro's only moving part. Friction is virtually eliminated. A rotating magnetic field spins the sphere, then cuts off. The sphere will spin unassisted for months. Space version requires less than 4 w power.

Position of the gyro's rotor is determined optically by a pickoff which resembles a small camera. Position is indicated by patterns scribed on the sphere's polished surface. The system can be instrumented to sense acceleration, opening up possibility of three-gyro inertial platforms.

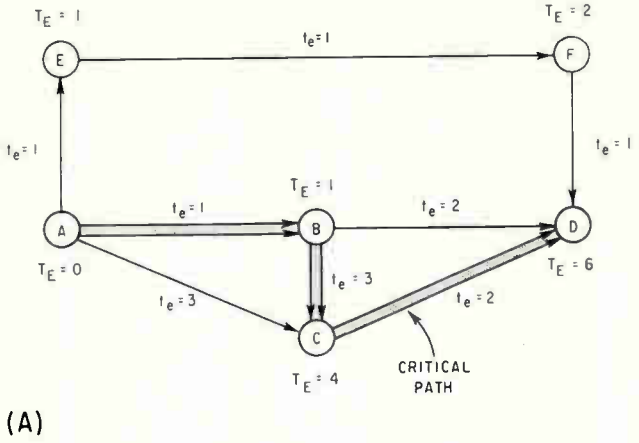
Two-ton space satellite simulator is reported to tilt if a fly lands

Diamond stylus scribes surface of spherical rotor for gyro

The adaptive flight system senses conditions around the vehicle it controls and automatically adjusts vehicle performance. Honeywell says the system can blend aerodynamic and reaction controls during the critical period when a vehicle emerges from the atmosphere.

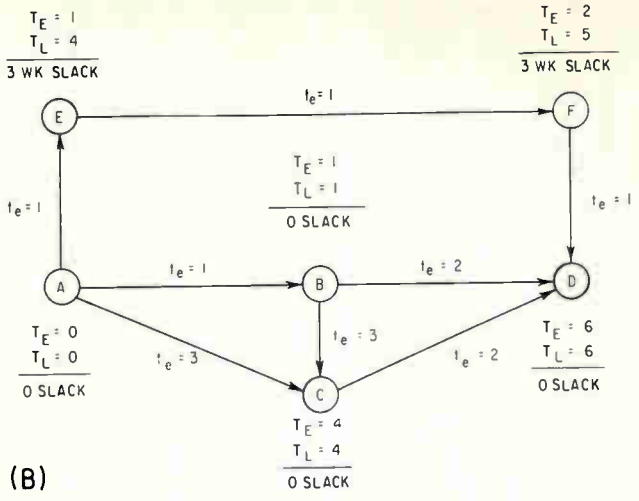
The system has been flight tested more than 300 hours in jets and is slated for a test this winter in the hypersonic X-15. The advantage of using the system in craft like the X-15 and Dynasoar is that research vehicles must work the first time despite unknown characteristics.

The computer center will handle scientific and business problems simultaneously, in about a 2:1 ratio. The digital 800 and the analog complex are linked by analog-to-digital converter and real time control units.



(A)

Pert network with mean times assigned each activity



(B)

Difference between estimated and latest times is slack

PERT Requirements on Increase

By JOHN M. CARROLL,
Managing Editor

DAYTON, OHIO—Defense contractors and would-be contractors are doing homework these days on Pert—Program Evaluation and Review Technique—a weapons system management tool that makes extensive use of electronic data processing.

Pert's ability to cope with uncertainties has also led to its use as a management tool in a growing number of R&D-minded companies for in-house projects.

Pioneered by Navy for the Fleet Ballistic Missile program, Pert is used for several BuWeps projects, including Polaris, Typhon, A2F aircraft, Shrike and the A3J's bomb-nav system. Numbers of single items run into the thousands. BuShips also has several projects Perted.

Submission of Pert networks with Air Force contract proposals was voluntary for the C-141 turbojet transport. It is mandatory for the TF-X tactical fighter, indicating a definite trend.

Air Force's Aeronautical Systems Division has nine Pert projects: Dynasoar with 12,000 items, Skybolt (GAM-87) with 12,000 items, F-105 RF, TF-K, C-141, B-70 (partial), ASD project 6287 and 912A.

Minuteman and site activation phases of Atlas and Titan are Perted at Ballistic Systems Division. Electronic Systems Division uses Pert for the 480-L global communications and 465-L SAC control systems.

Pert techniques have been used with Samos, Mauler and Nike Zeus. NASA operates Saturn under Pert. As of Sept. 1, all NASA's major R&D began to go under Pert.

Pert Network Synthesis

A Pert network is a diagrammatic representation of the program plan. Circles represent events (meaningful specified accomplishments such as "complete plans and specifications") and connecting arrows represent activities. Events are connected according to the sequence in which work must be performed. An event upon which several activities converge is a node.

For each activity, cognizant managers, usually project engineers, are initially required to supply three times for accomplishment: optimistic (a), most likely (m) and pessimistic (b). Time is usually given in weeks for R&D work. A mean or estimated time (t_e) is found for each activity by the formula.

$$t_e = (a + 4m + b)/6$$

This gives the mean of a beta distribution that is skewed on the high end and takes into account the tendency of most engineers to underestimate time required to do a job. The standard deviation of the distribution can be found from

$$\sigma = (b - a)/6$$

The standard deviation is useful in determining the probability of meeting a given schedule date.

A network with mean times assigned to each activity is shown in the first figure. The job here might be design of a simple servo system. Events signify completion of: plans and specifications (A), modular component boards (B), amplifier (C), final assembly (D), servo motor purchase order (E) and delivery of motor (F).

Point A is taken as the input, D as the output. A cumulative estimated accomplishment time T_E is assigned to each event by computing cumulative event times along the longest path to each node. The critical path, the longest time through the network, is closely watched in managing the system.

In the absence of a fixed schedule imposed from outside, the cumulative estimated time for the last event is taken as the latest time for that event. Latest times T_L are computed for each event by subtracting back along the longest path to each node. The difference between T_E and T_L at each event is called slack (S). Slack can be positive, as at events E and F in the second figure;

zero, as at A, B, C and D; or negative. If it is negative, the project is in trouble.

At Aeronautical Systems Division, Pert calculations are performed on an IBM 7090. Biweekly Pert updating reports are required from contractors. A simulation routine is used to find the best way to get a project out of trouble with minimum or zero slippage on the schedule.

In the new integrated Pert system, Pert updating reports are made available to all people in the network. Reports are shredded out for different levels of management. Each manager gets only the information he really needs. The detail in the reports is less for top management than for intermediate and working management.

EXAMPLES OF COMPUTATION

Compute t_e for activity B—D. Optimistic time a is 1 week, most likely time m is 2 weeks and pessimistic time b is 3 weeks. Therefore

$$t_e = (1 + 4 \times 2 + 3)/6 = 2 \text{ weeks}$$

and standard deviation is

$$\sigma = (3 - 1)/6 = 1/3 \text{ week}$$

Compute cumulative estimated time T_E for event C. There are two paths from A to C: A-B-C and A-C. Adding estimated times t_e around both paths

$$A\text{-}B\text{-}C = 1 + 3 = 4 \text{ weeks}$$
$$A\text{-}C = 3 \text{ weeks}$$

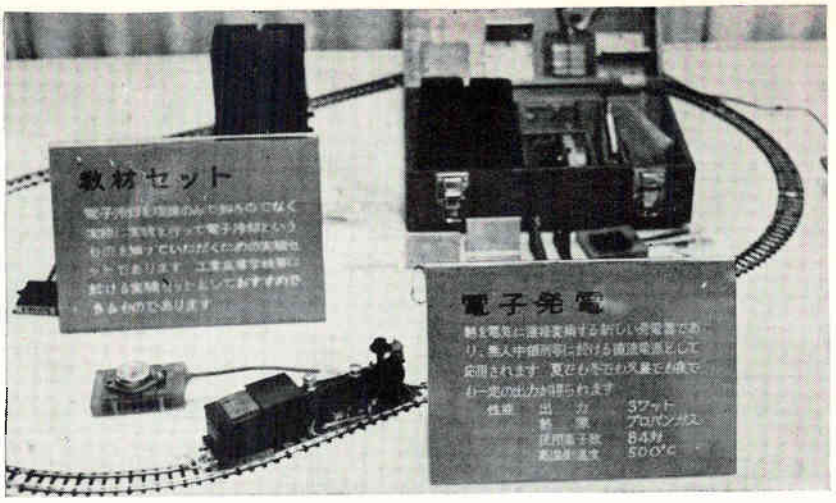
Therefore T_E for event C is 4 weeks.

Compute latest time T_L for event B. Working backwards through the network there are two paths from D to B: D-B and D-C-B. Subtracting estimated activity times t_e from the latest time of event D (equal to either cumulative estimated time T_E through the critical path or an imposed scheduled completion date)

$$D\text{-}C\text{-}B = 6 - 2 - 3 = 1 \text{ week}$$
$$D\text{-}B = 6 - 2 = 4 \text{ weeks}$$

the longest path is D-C-B therefore T_L for event B is one week yielding $T_L - T_E = 0$ weeks slack (S) for event B.

Note that when no schedule is imposed on a project ($T_L = T_E$ over the critical path) there is a 0.5 probability of meeting the target date. When a scheduled completion date is superimposed, probability of meeting it is found using the standard deviation and assuming a normal distribution



Sumitomo Electric Industry's table-top display has toy train powered by thermoelectric device

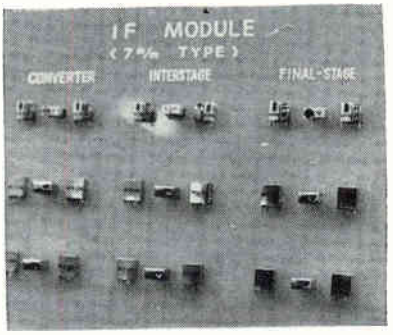
Japanese Stress Solid-State

By CHARLES L. COHEN,
McGraw-Hill World News

TOKYO — Japanese manufacturers switched emphasis from classical radio and tv parts to components of the future at the fourth annual Japan Electronic Parts Show here. Even the name was new. Previous shows had been known as Japan Radio and TV Parts Show. Attendance exceeded 40,000.

Microminiature module elements drew more attention than any other component. Among exhibitors of these modules were Tokyo Denki, Sanyo Electric, Matsushita Electric and Murata. Also featured were such semiconductor devices as thermoelectric converters, planar silicon transistors, epitaxial silicon mesa and alloy diffusion transistors and silver bonded diodes.

Considerable progress was shown in i-f and r-f components for transistor radios.



Toko Radio Coil Laboratories' 7-mm i-f modules

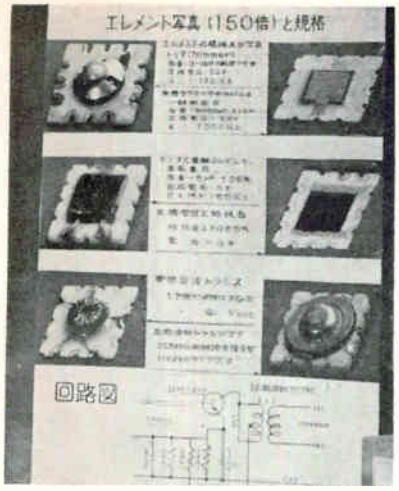
Microminiature modules are not in real production at any company, but a number of companies are preparing for what they feel will be the inevitable next stage of parts production. Wafer size is identical to that developed by RCA for the U. S. Signal Corps, but most manufacturers stated that technology for producing components was their own. Wafers of various materials are available from stock from several ceramics manufacturers.

Sanyo Electric showed a transceiver using the modules. Citizens band transceivers for export to the U. S. are rapidly becoming a hot item here so this bears watching.

Nippon Chemical Condenser, a leading manufacturer of electrolytic capacitors, displayed modules with components evaporated on glass substrates. One was a low-frequency amplifier, another an operating, free-running flip-flop.

Printed electronic circuits similar to Centralab's Packaged Electronic Circuits are in production.

Trend toward multiple components was also shown by the i-f and r-f modules from Toko Radio Coil Labs. The smallest mounts on an area only 7 by 14 mm, but contains a complete transistor i-f stage. Somewhat larger is a complete



Sanyo Electric photos of modules like Signal Corps'

Components

transistor broadband r-f stage.

Toko has a technical agreement with Murata Manufacturing, a leading manufacturer of ceramic capacitors and piezoelectric products, which enables it to produce a ceramic mechanical filter i-f transformer. This is reported to be the first agreement of this type between two companies in the same industry. It is widely thought here that with the growing complexity of electronic parts, further agreements and consolidations are inevitable. Taiyo Yuden also featured a ceramic mechanical filter i-f transformer.

Sumitomo Electric Industries showed several thermoelectric devices and products including a line of constant temperature chambers, an educational set containing everything needed for high-school experiments and a converter powered by a propane flame. The latter unit, said to be suitable for unattended repeater stations, provides 3 watts.

Fuji Communication Apparatus showed a three-electrode cold cathode gas discharge indicating lamp. It operates at low power levels and is considered especially suitable for transistor circuits. The additional amplifier stage normally required with neon lamps is unnecessary. The input signal can be negative, a-c or half-wave rectified a-c.

WOULD YOU INVEST FOUR CENTS TO PUT MILLIONS OF DOLLARS WORTH OF ADDED ENGINEERING KNOW-HOW BEHIND YOUR COMPUTER, APPLIANCE OR COMMUNICATIONS SYSTEM DESIGNS ?

If these are your fields of electronics — Teflon* insulated wire and cables must be of prime importance.

Most who know will agree that Brand-Rex has invested more in engineering talent and manufacturing facilities to design and produce Teflon insulated wires and cables than any other company. Result . . . you have at your beck and call (a 4¢ letter will do) a vast dimension of engineering capability. It gives you engineering help that backs up your designs with the wire or cable performance reliability that only unduplicated experience in Teflon insulation can give you. In return, you aren't even under obligation to buy from Brand-Rex.

But again, counting on our broad experience, we think you will. Why?

If the Teflon insulated wire or cable that meets your requirements is not a *standard*, Brand-Rex might well be the only manufacturer in the world that could make it for you economically. If it is a standard, chances are Brand-Rex can supply it to you fastest, right from inventory, from whichever of the three Brand-Rex plants is nearest you. U.L. approvals and military specifications aren't a problem either. Brand-Rex has all applicable U.L. approvals and has geared its line to meet applicable military specifications.

Don't get the idea this is a monopoly situation (FTC take note, please), because there are other people in the business. It's just that Brand-Rex has matched its interest in this type of wire and cable with the biggest investment. And don't get the idea, either, that Brand-Rex will prejudice its insulation recommendations to you because of this extensive Teflon capability, cause it isn't so. Brand-Rex also insulates with vinyl, polyethylene, neoprene and nylon. With the depth of the total Brand-Rex line you can be sure of objectivity!

SPECIFY TURBOTEMP®

TEFLON INSULATED WIRE & CABLE

*DuPont registered trade name.

BRAND REX

DIVISION OF

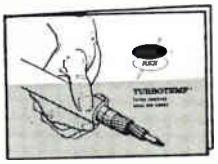
American ENKA Corporation

31 Sudbury Road, Concord, Massachusetts

Telephone: EMerson 9-9630

Vinyl, Teflon, Neoprene, Nylon, Polyethylene Wire and Cable—Electrical Tubing and Sleeving—Rexolite® Microwave Dielectrics

NEW! THIS COMPREHENSIVE BROCHURE DESCRIBES AND CHARTS THE ENTIRE TURBOTEMP LINE — **PLUS**, THE COMPLETE STORY ABOUT HOW THE INSULATION ADVANTAGES OF TEFLON CAN HELP YOU DESIGN MORE EFFECTIVELY. **WRITE** FOR YOUR COPY TODAY.



Europeans Plan Space Programs

LONDON—Delegates from nine nations have agreed on a tentative European space plan for communications satellite launchings. They set 1963 as the date for the first De Haviland Blue Streak firing, and 1965 as initial satellite launch.

Draft convention to form a joint launcher organization will be presented to various governments, with a reporting date to Britain and France, the organizers, Nov. 27 at the latest.

The convention also made provisions for an advanced research study department which, in the first two years of the initial program, will establish proposals for the Eurospace team's second program.

Minister of Aviation Peter Thorneycroft termed the European space consortium the biggest international technological effort ever attempted.

In the 1965 launch, a British Blue Streak will be the first stage and a French Veronique the second stage. West Germany is to develop the third stage.

Delegates now reporting to their governments are from Australia, Belgium, Denmark, the Netherlands, Federal Republic of Germany, Italy, Spain, and three uncommitted nations, Sweden, Norway and Switzerland.

Aerial Magnetic Charting Group To Develop New Gear

AUTOMATIC airborne magnetometer-navigation system is being planned by the Navy Hydrographic Office to help chart the earth's magnetic field. These plans, as well as a progress report on the undertaking, known as Project Magnet, were described by H. W. Geddes at the Mountain States Navy Research and Development Clinic.

Forty percent of the world-wide survey is complete. In 1965, the Hydrographic Office and the U. S. Coast and Geodetic Survey will publish a series of world magnetic charts that will be based on detailed observational data.

Several aircraft are used in the survey. The latest, now being modified, is a WV-2 Lockheed Super Constellation.

The new automatic system will produce a magnetic tape for each flight. All magnetometer and navigation data will be recorded in digital form suitable for direct analysis on high-speed computers. The heart of the system will be an inertial navigation system with its associated aircraft computers. The inertial system is expected to supply coordinate references to the aircraft autopilot, radio navigation system, doppler radar navigator and the magnetometer.

The magnetometer-navigation system will be built around a precise inertial platform. The system will require a photoelectric sextant to supply a horizontal reference system. Doppler radar will supply velocities for damping the inertial system.

Scattered Sunlight Can Reveal A-Bomb Blasts

PROJECT VELA contract to develop ground-based optical techniques of detecting nuclear explosions in space has been awarded Geophysics Corp. of America by Air Force.

GCA said scattering of sunlight by an explosion's space debris can be detected at great distances by photometric techniques. The company also has military contracts to study effects of debris motion and to measure infrared radiation from nuclear explosions.

Radio Turns On for Civil Defense Alarm Broadcasts

PHILCO is demonstrating an automatic radio warning system to Civil Defense authorities. Company says that it can alert 95 percent of the population within seconds of an alarm. Sentinel system consists of $10 circuit addition to transistor-battery radios. Circuit turns on radio for alarm, returns it to standby after broadcast. Radio station transmitter could be modified for system at nominal cost.

MEETINGS AHEAD

MAGNETISM & MAGNETIC MATERIALS, IRE, AIEE, AIP, ONR, AIME; Westward to Ho Hotel, Phoenix, Arizona, **Nov. 13-18.**

MATERIALS and DESIGN Exhibition Conf., Earls Ct., London, **Nov. 13-18.**

AEROSPACE ELECTRICAL Society, Pan Pacific Auditorium, Los Angeles, California, **Nov. 15-17.**

VEHICULAR Communications, PGVC of IRE; Madison Hotel, Minneapolis, Minn., **Nov. 30-Dec. 1.**

COMPUTER Conference. Eastern Joint, PGEC of IRE, AIEE, ACM; Sheraton-Park Hotel, Wash., D. C., **Dec. 12-14.**

RELIABILITY AND QUALITY CONTROL, Eighth National Symposium, PGRQC of IRE, AIEE, ASQC, EIA; Statler Hilton Hotel, Washington, D.C., **Jan. 9-11, 1962.**

MILITARY ELECTRONICS, 3rd Winter Convention PGMIL of IRE (L. A. Section); Ambassador Hotel, Los Angeles, Calif., **Feb. 7-9, 1962.**

SOLID STATE CIRCUITS, International Conference, PGCT of IRE, AIEE; Sheraton Hotel and U. of Penn., Philadelphia, Pa., **Feb. 14-16, 1962.**

APPLICATION OF SWITCHING THEORY TO SPACE TECHNOLOGY Symposium, USAF, Lockhead Missiles and Space; at Lockhead, Sunnyvale, Calif., **Feb. 27-Mar. 1, 1962.**

SCINTILLATION AND SEMICONDUCTOR Counter Symp, PGNS of IRE,, AIEE, AEC, NBS; Shoreham Hotel, Washington, D. C., **Mar. 1-3, 1962.**

IRE International Convention, Coliseum & Waldorf Astoria Hotel, New York City, **Mar. 26-29, 1962.**

SOUTHWEST IRE CONFERENCE AND SHOW; Rice Hotel, Houston, Texas, **April 11-13, 1962.**

JOINT COMPUTER CONFERENCE, PGEC of IRE, AIEE, ACM; Fairmont Hotel, San Francisco, Calif., **May 1-3, 1962.**

HUMAN FACTORS in Electronics, 3rd National Symposium, PGHFE of IRE; Los Angeles, Calif., **May 3-4, 1962.**

ELECTRONIC COMPONENTS Conference, PGCP of IRE, AIEE, EIA; Marriott Twin Bridges Hotel, Washington, D.C., **May 8-10, 1962.**

ADVANCE REPORT

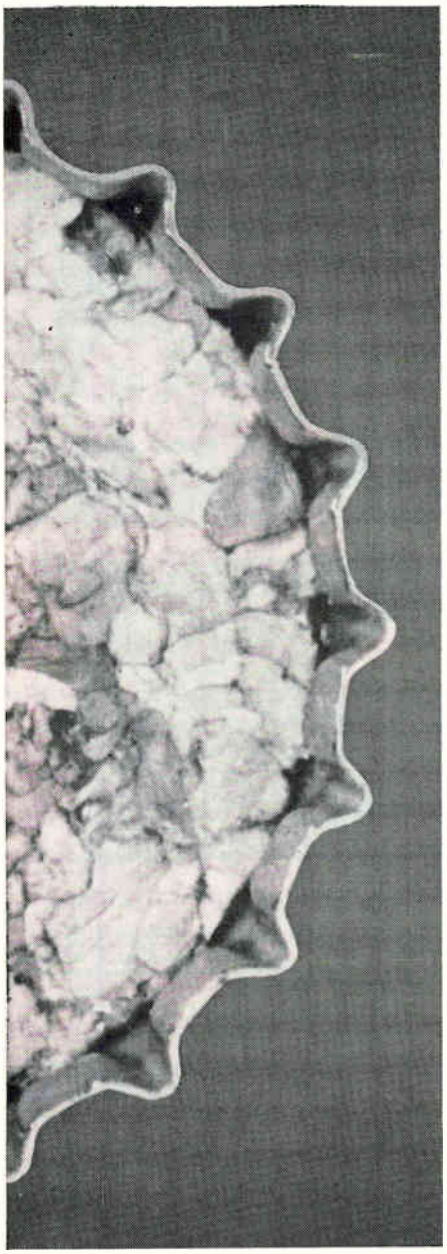
INFORMATION THEORY. International Symposium, PGIT of IRE: Brussels, Belgium, Sept. 3-7, 1962. Call for papers in the following areas: coding and decoding of digital and analog communication studies of random interference and of information bearing signals compression, analyses and design of communications and detection systems, pattern recognition, learning, adaptive filters, automata and other forms of information processing systems, processing of nervous information, human operators, linguistics, scientific methods. Submit abstracts of 500-1,000 words not later than Jan 15 to F. L. Stumpers, Philips Research Labs., Eindhoven, Netherlands.

unmatched peak in penmanship...

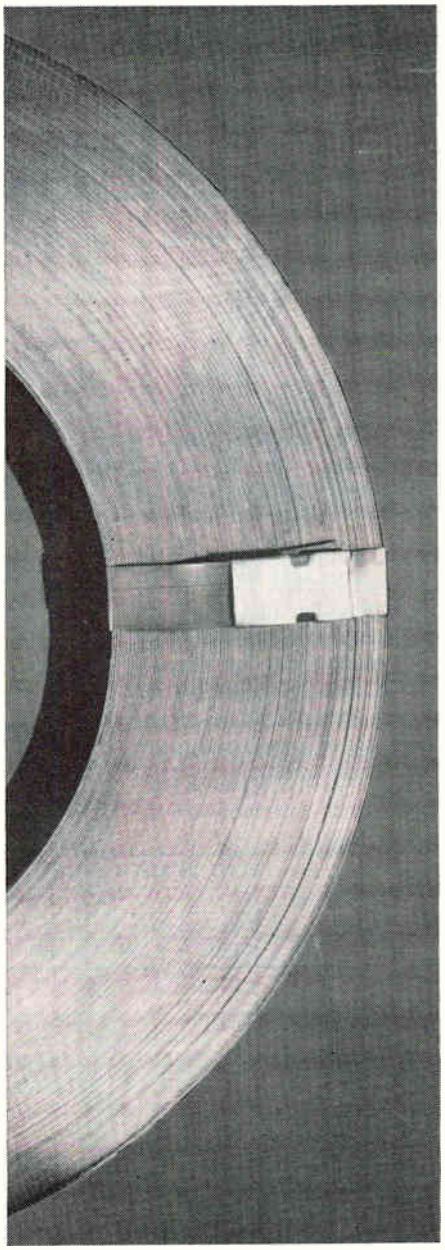
The totally new Brush Recorder Mark 200 made these incredibly crisp tracings. No other recorder in existence can match them. Note the line width. It never varies . . . regardless of writing velocity, regardless of chart speed. The writing mechanism is electrically signaled by the position-seeking "Metrisite" transducer . . . no parts to wear, infinite resolution, verifiable dynamic ½% accuracy. Traces are permanent, high-contrast, reproducible . . . on low cost chart paper. The Mark 200 has but three standard controls . . . attenuator, pen position, chart speed. Such fidelity, simplicity and economy are possible with no other direct writing recorder. Write for details . . . they'll speak for themselves.

brush INSTRUMENTS
DIVISION OF CLEVITE CORPORATION
37TH AND PERKINS CLEVELAND 14, OHIO

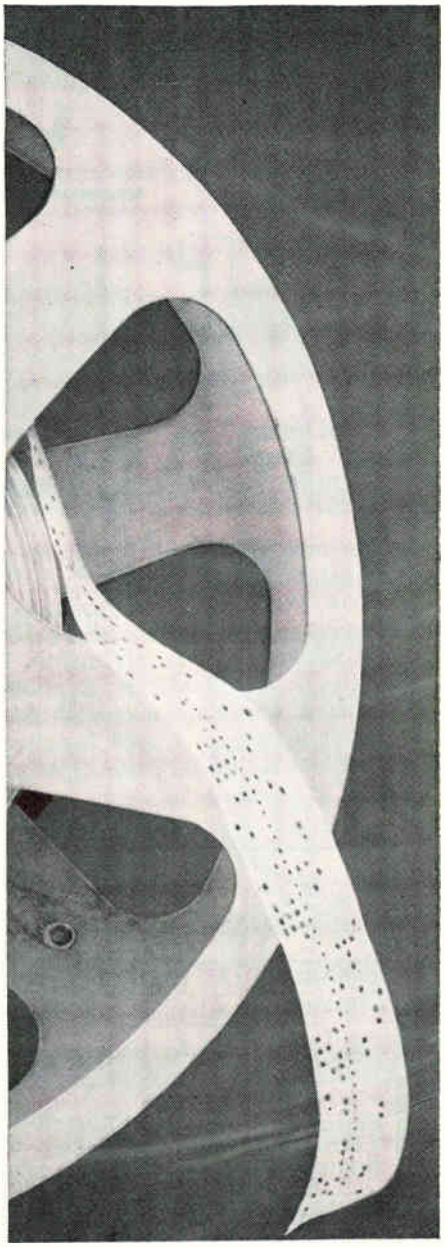
counting controls for industry, defense and space exploration



Counting bottle caps, pills or tiles . . . Veeder-Root electronic counters with photo-electric input record up to a surprising 300,000 units per minute.



Operators in the remote control booth of high-speed strip mills get automatic readings of steel production on Veeder-Root electrical counters.



In industrial automation systems, Veeder-Root remote digital readout coordinates control, makes operating data instantly, constantly available.

Indicate, coordinate, automate...with Veeder-Root counters! Now get facts fast—facts you can use for stepping up your operation, for integrating parts of it, for activating other equipment, automatically. Veeder-Root makes facts like these surprisingly economical to come by. For details, write Veeder-Root Inc., Hartford 2, Conn. count on...Veeder-Root

unmatched peak in penmanship...

The totally new Brush Recorder Mark 200 made these incredibly crisp tracings. No other recorder in existence can match them. Note the line width. It never varies . . . regardless of writing velocity, regardless of chart speed. The writing mechanism is electrically signaled by the position-seeking "Metrisite" transducer . . . no parts to wear, infinite resolution, verifiable dynamic ½% accuracy. Traces are permanent, high-contrast, reproducible . . . on low cost chart paper. The Mark 200 has but three standard controls . . . attenuator, pen position, chart speed. Such fidelity, simplicity and economy are possible with no other direct writing recorder. Write for details . . . they'll speak for themselves.

brush INSTRUMENTS
DIVISION OF
37TH AND PERKINS CLEVITE CORPORATION CLEVELAND 14, OHIO

Shop here for Relays

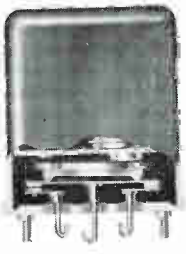
Complete line of subminiatures for sale

Leach crystal can relays give you big performance in small packages in every standard relay configuration. Standard, Half-Size, Sensitive and Magnetic Latch in 0.20 inch grid spacing and "lazy S" header. Each type is capable of switching loads from low level to 2 amp in aerospace and electronic control applications. Bulletin CC-861.

Block that shock!

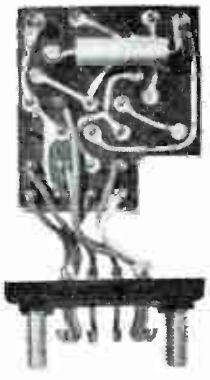
Leach balanced-armature relays provide high resistance to shock (50 G's) and vibration (15 G's to 2000 cps) in 5 to 15 amp switching. They meet or exceed MIL-R-6106C, MIL-R-25018, and MIL-R-5757C. Choose from 4,000 variations of 20 basic types!

Bulletin BA-859.



It's what's inside that counts in time delay relays

Especially when milliseconds count! Note the printed circuit construction of Leach's optional output time delay relays. This economical line of off-the-shelf electronic units includes time delays on release and time delays on operate—in a timing range of 100 milliseconds to 60 seconds. These standard components are available with fixed or adjustable timing to meet your most critical requirements. And they're all 100% inspected during manufacture for highest reliability! Bulletin TD-200.



LEACH literature anyone?

Write for bulletins, write for information, write for details and specifications. Or mail your request on the Reader-Service Card.

Not a square in the whole family!

When only a round can relay will fit your need, Leach offers this family group in contact configurations of 2, 4 and 6 PDT and in contact ratings ranging from dry circuit to 10 amps.

Bulletin RC-300

Need help fast?

Sales engineers in Leach District Sales Offices are eager to help you with critical application problems, or to see that you get fast delivery on prototype quantities from nearby Leach Distributors.

Seattle 8, Washington
South Annex Bldg., Room 201
King County Airport
Boeing Field
PArkway 5-6978

Palo Alto, California
814 San Antonio Road
YOrkshire 8-4408

Los Angeles 17, California
1101 Wilshire Blvd.
HUntley 2-0790

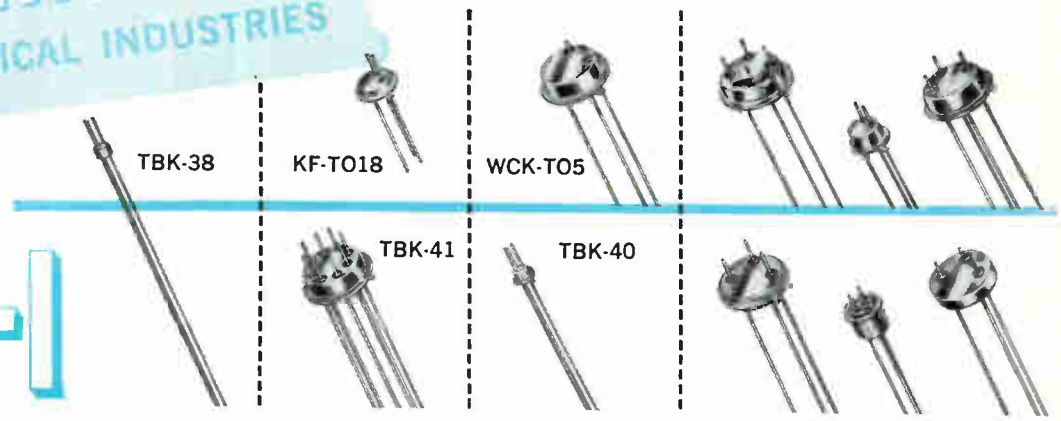
Dayton 2, Ohio
333 West First Street, Room 250
BAldwin 2-8652

New York, New York
405 Lexington Avenue,
Suite 3204
YUkon 6-2520

Washington, D.C.
Suite 307
1700 K Street, N. W.
STerling 3-1147

LEACH CORPORATION

18435 SUSANA ROAD, COMPTON, CALIFORNIA
EXPORT: LEACH INTERNATIONAL S. A.



NEW E-I

TRANSISTOR BASES

The new Electrical Industries line of hermetically sealed transistor bases includes types for Jedec Series TO5, TO9, TO18, TO33 and TO46 packages, miniatures for hearing aids and other applications, and bases for practically all military and commercial requirements. MIL types equal or exceed military specifications. Available in a broad selection of terminal configurations with finishes of Brite Gold, electro-tin or high purity gold for direct fusion of semiconductor elements to header base. Special plating on order.

TERMINAL CONFIGURATIONS

CODING:
X = No Lead
G = Ground Lead
L = Lead Thru Glass
T = Weld Tab

FIGURE 1

	CODE NUMBER	TERMINALS (SEE FIGURE 1)				LEAD LENGTH IN INCHES (See Figure 2)								
						STANDARD TYPES		MODIFICATIONS AVAILABLE						
								MOD. A	MOD. B	MOD. C	MOD. D	MOD. U	MOD. V	MOD. W	MOD. X
		1	2	3	4	A DIMENSION	B DIMENSION	A DIM.	A DIM.	A DIM.	A DIM.	A DIM.	A DIM.	A DIM.	A DIM.
STRAIN-FREE TYPES	K-TO5-XGLL	X	G	L	L	13/64	1.500-1.532	.020-.025 B DIMENSION = 1.500-1.532	.050-.060	.095-.105	.105-.110				
	K-TO5-XLLL	X	L	L	L										
	WCK-TO5-XGLL*	X	G	L	L										
	K-TO5-TLLL	T	L	L	L										
	K-TO18-XGLL	X	G	L	L	.110-.130	.500-.520	.017-.022 B DIMENSION = .500-.520	.025-.030	.045-.055		.110-.130 B DIMENSION = 1.500-1.532	.017-.022	.025-.030	.045-.055
	K-TO18-XLLL	X	L	L	L										
	KF-TO18-XGLL	X	G	L	L	.110-.130	.500-.520	.017-.022 B DIMENSION = .500-.520	.025-.030	.045-.055					
	K-TO33-GLLL	G	L	L	L	.090-.110	1.500-1.532	.020-.025 B DIM. = 1.500-1.532	.050-.060						
	K-TO33-LLLL	L	L	L	L										
	TBK-38	3 SPACED 120				5/32	1-5/8								
	TBK-40	3 SPACED 120				5/32	1-5/8								
	TBK-41	8 SPACED 45				13/64	1.500-1.532								
COMPRESSION TYPES	WSF-TO5-XGLL	X	G	L	L	.090-.110	1.500-1.532	.020-.025 B DIM. = 1.500-1.532	.050-.060						
	WSF-TO5-XLLL	X	L	L	L										
	WSF-TO5-GLLL	G	L	L	L										
	WSF-TO5-TLLL	T	L	L	L										
	WS-TO9-XLLL	X	L	L	L	.095-.105	1.500-1.532								

LEAD DIMENSIONS

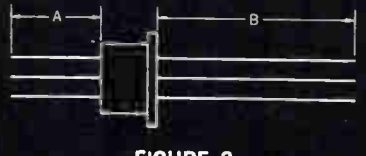


FIGURE 2

* COPPER CLAD

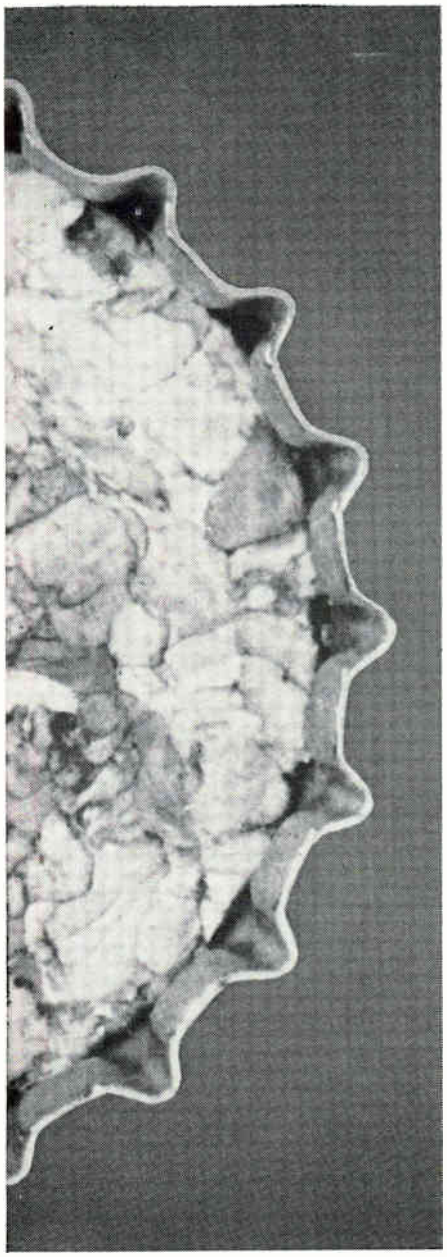
ALSO AVAILABLE – Hermetically sealed clear glass caps for photo-sensitive devices utilizing TO5 and TO18 type bases.

PTC SERIES

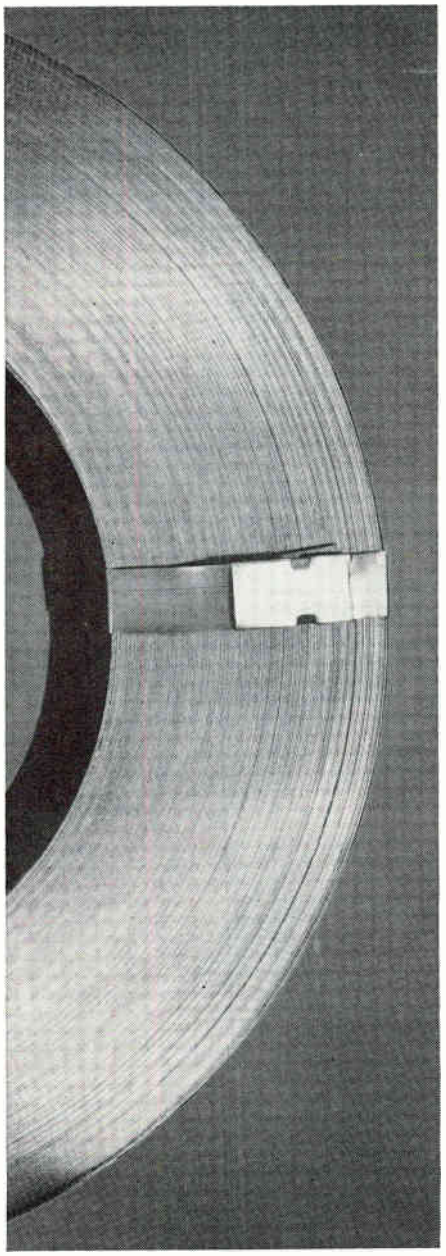
ELECTRICAL INDUSTRIES
MURRAY HILL, NEW JERSEY, U. S. A.
A Division of Philips Electronics & Pharmaceutical Industries Corp.

PATENTED IN CANADA, No. 523,390; IN UNITED KINGDOM, No. 734,583; LICENSED IN U.S. UNDER No. 2561520

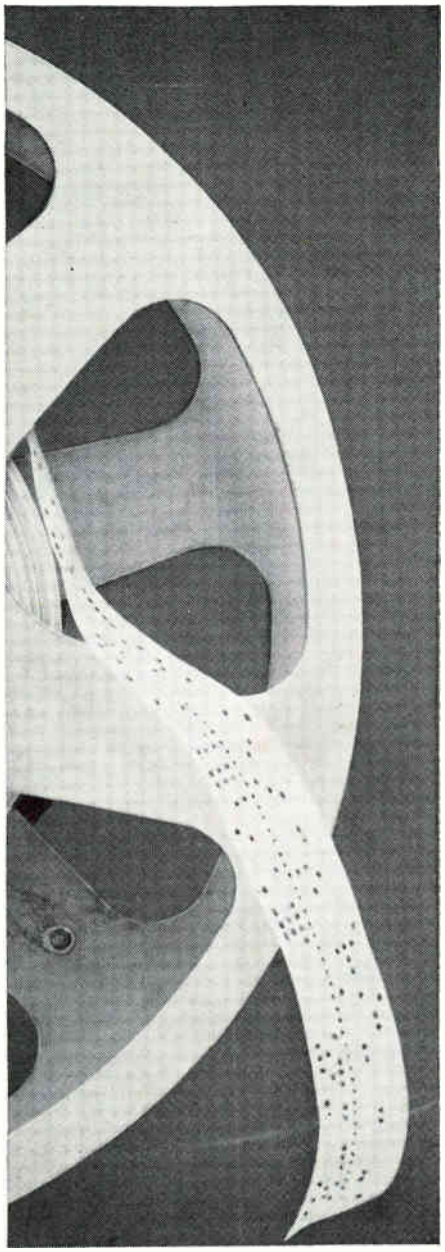
counting controls for industry, defense and space exploration



Counting bottle caps, pills or tiles . . . Veeder-Root electronic counters with photo-electric input record up to a surprising 300,000 units per minute.



Operators in the remote control booth of high-speed strip mills get automatic readings of steel production on Veeder-Root electrical counters.



In industrial automation systems, Veeder-Root remote digital readout coordinates control, makes operating data instantly, constantly available.

Indicate, coordinate, automate...with Veeder-Root counters!

Now get facts fast—facts you can use for stepping up your operation, for integrating parts of it, for activating other equipment, automatically. Veeder-Root makes facts like these surprisingly economical to come by. For details, write Veeder-Root Inc., Hartford 2, Conn. count on...Veeder-Root

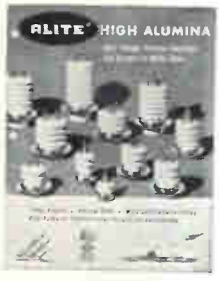
ONE INTEGRATED SOURCE for Ceramic-to-Metal Seals

In all phases of planning for high-alumina ceramic-to-metal seals you can rely on Alite for the "know-how" and "do-how" required to produce highest quality for critical applications.

From design to finished part, every manufacturing step — including formulating, firing, metalizing and testing — is handled within our own plant and carefully supervised to assure strict adherence to specifications, utmost uniformity and reliability.

To simplify design problems and speed delivery, Alite terminals, feed-throughs and cable end seals are available in over 100 standard sizes.

INSIDE LOOK AT ALITE—



Write today for Bulletin A-40R—Full technical data on standard and special Alite ceramic-to-metal seals.

ALITE DIVISION

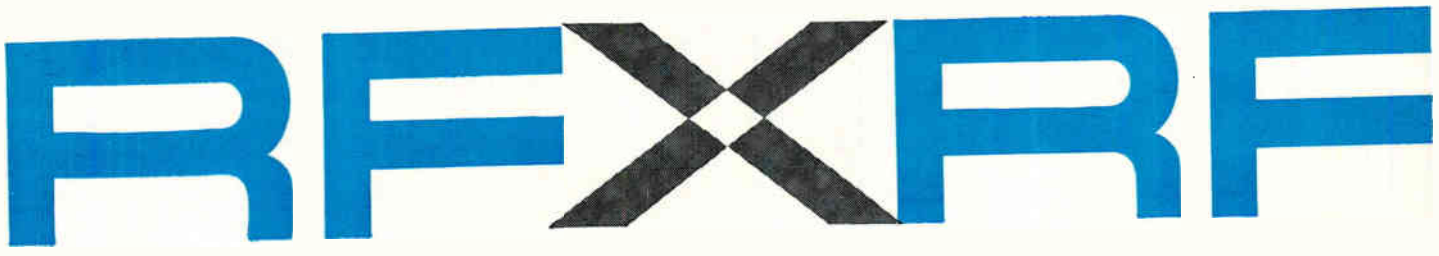
U. S. STONEWARE

Box 119 • Orrville, Ohio

88-H

FXR a new symbol in electronics for your single source of rf components, microwave test equipment and sub-systems

On September 22nd, Amphenol-Borg Electronics Corporation unified two of its divisions... RF PRODUCTS and FXR. The name of the new division is FXR.



What does this mean to you?

It means that in the future you can expect components that meet not only mechanical requirements but also the exacting electronics specifications of the systems and sub-systems in which they are used. It means that the specialized capabilities that have made AMPHENOL, FXR, ipc and DK hallmarks of reliability have been combined to give you integrated design across the rf spectrum. From hardware to microwave sub-systems, the new FXR insures you of more advanced, more authoritative design and engineering.

Is this important to you?

We believe that it is.

The full implications of this change are subtle and progressive. At FXR we're building for tomorrow—but our customers can profit from it today. The same representatives who served you when we were two separate organizations will continue to serve you.

If you have any questions about the products and services we can now offer, we invite you to write to us. Address your inquiries to: Vice President—Marketing, FXR, 33 East Franklin Street, Danbury, Connecticut.

Now... a single source of supply for

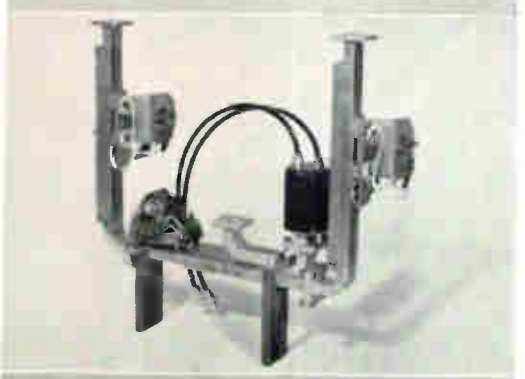
DK* Coaxial Switches and FXR Waveguide Switches

AMPHENOL* and ipc Coaxial Connectors

AMPHENOL Cable and Wire

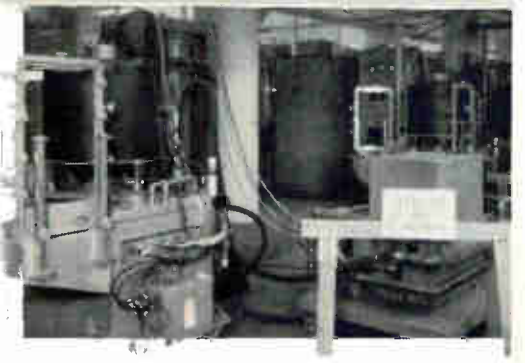
FXR

THE RF PRODUCTS AND MICROWAVE DIVISION AMPHENOL-BORG ELECTRONICS CORPORATION



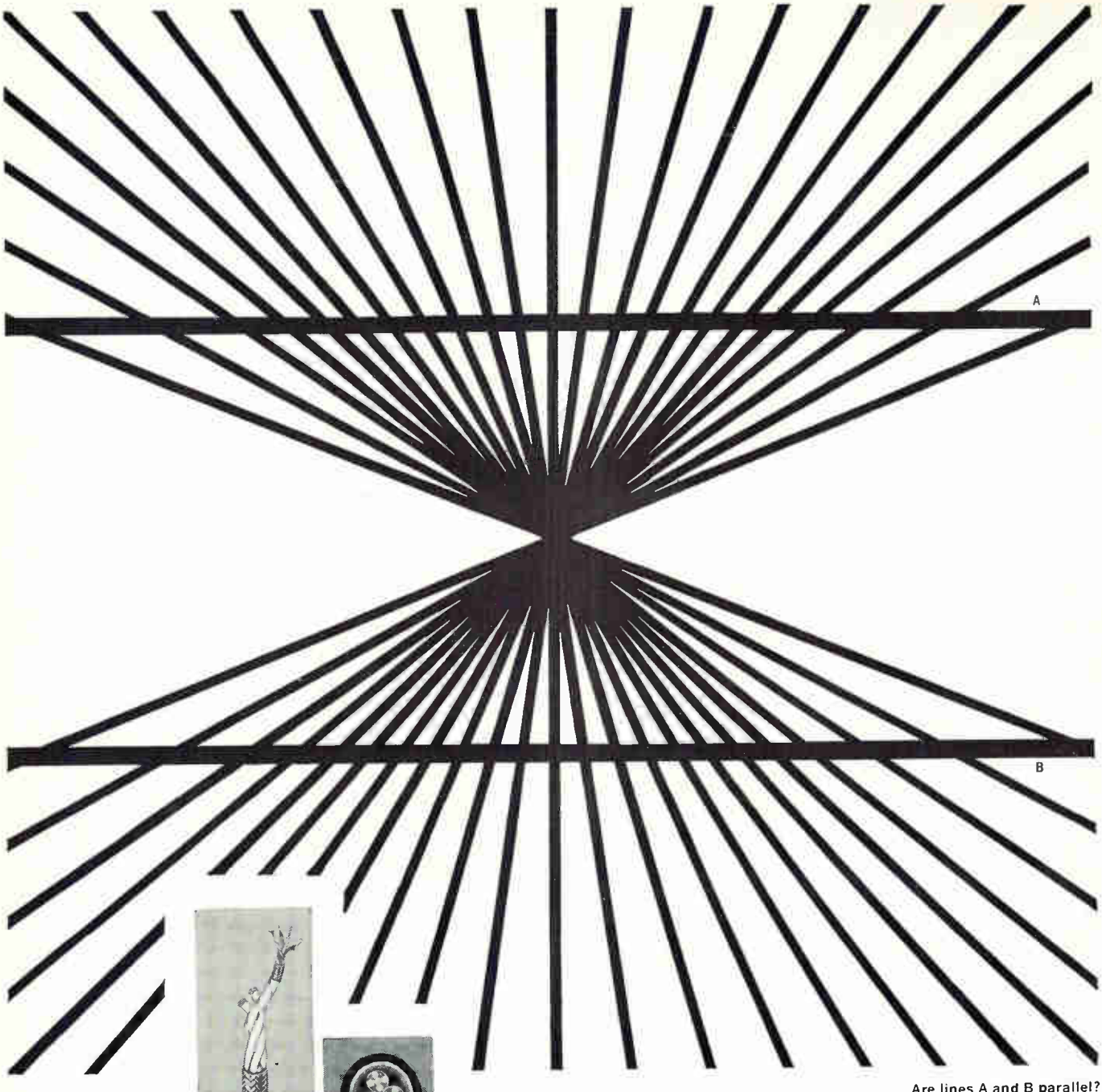
FXR Microwave Components

FXR Microwave Test Equipment

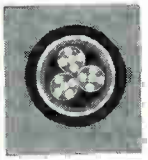


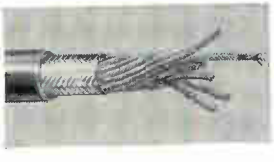
FXR High-Power Electronics and Microwave Sub-Systems

*Registered Trademark



Are lines A and B parallel?





At Hitemp–Quality is not an illusion

Examine with the naked eye and handle several different brands of wire and cable. They look and feel identical, don't they? Their similarity with regard to quality, however, is just as much an illusion as the art form above.

Though different brands may be made with similar materials and equipment, one brand of wire and cable will outlast, outperform all others. That brand is Hitemp.

Why? Because Hitemp has the greatest store of experience in the industry—two modern production facilities that are second to none—and more than one-fourth of its entire work force devoted solely to inspection and quality control.

Hitemp products are for you, the wire and cable user who requires quality and reliability that is fact, not illusion.

Hitemp is a Division of Simplex Wire & Cable Co.

HITEMP WIRES CO.

1200 SHAMES DRIVE, WESTBURY, NEW YORK
1532 S. CALIFORNIA AVE., MONROVIA, CALIF.

DISPOSABLE "TRU-TOUCH" GLOVES

with the greatest fingertip sensitivity ever developed!

This revolutionary new Wilson glove gives you all three of the things you want most in a disposable industrial glove for inspection or small parts handling. **It's thin** . . . so sensitive you can feel your beard through it, tell whether a dime is heads or tails, feel every tiny dot in a book of Braille! **It's strong** . . . made of PVC with a tensile strength of approximately 1000 psi. **It's inexpensive** . . . 7c a glove, 14c a pair, even less in quantity! You get superior fit without the "snap" or constriction of latex. Touch is never numbed. Ask your Wil-Gard distributor for literature and samples.

STRONG!
Tensile strength:
app. 1000 lbs. psi

THIN!
Actual thickness:
.006 of an inch

DISPOSABLE!
Cost: only
7c a glove

SOLD ONLY THROUGH DISTRIBUTORS

WR-961-13

PROTECTION FOR THE HANDS OF INDUSTRY • SINCE 1918

WIL-GARD®

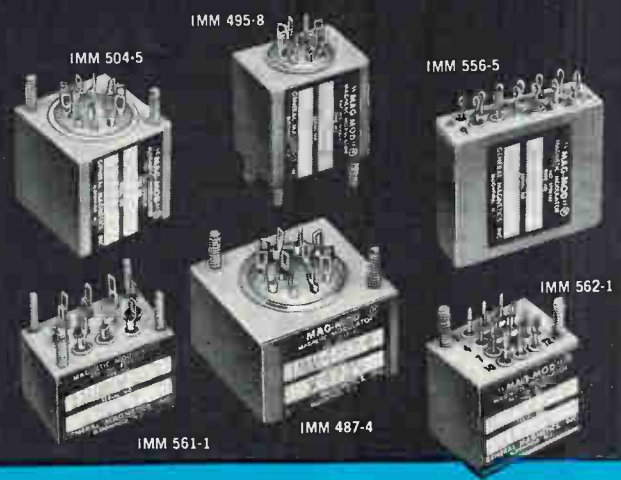
THE WILSON RUBBER COMPANY INDUSTRIAL DIVISION CANTON 6, OHIO

THERE IS NO SUBSTITUTE

Specify "MAG MOD"® miniaturized

For the ultimate in—

RELIABILITY
REPEATABILITY
SUPERIOR
PERFORMANCE



Amplitude Response Curve

Input Magnetic Modulator
Type No. IMM 487-4

Subminiature "MAG MOD"® featuring high input signal sensitivity and high AC output impedance. Male or female mounting.

(20 K Ohm Load)

Amplitude Response Curve

Input Magnetic Modulator
Type No. IMM 495-8

Subminiature "MAG MOD"® featuring wide band width, multiple signal input circuits, extreme zero stability from −65°C to +135°C, low null amplitude or noise level. Mounting available male or female.

(10 K Ohm Load)

Amplitude Response Curve

Input Magnetic Modulator
Type No. IMM 504-5

Subminiature "MAG MOD"® featuring low input and output impedance, resistance vs. temperature compensated input, extreme zero stability, repeatability and insignificant hysteresis. Supplied with male or female mounting.

(5 K Ohm Load)

Amplitude Response Curve

Input Magnetic Modulator
Type No. IMM 562-1

Subminiature "MAG MOD"® featuring 4 KC carrier operation, wide frequency band width, high output impedance and voltage range. Mounting male or female.

(100 K Ohm Load)

Amplitude Response Curve

Input Magnetic Modulator
Type No. IMM 561-1

Subminiature "MAG MOD"® featuring low carrier energy level operation, very wide frequency band width, wide output operating range, minimum size and weight. Mounting male or female. May be mounted directly on printed circuit boards.

Amplitude Response Curve

Input Magnetic Modulator
Type No. IMM 556-5

Subminiature "MAG MOD"® featuring high frequency carrier operation (35 KC), flat construction for printed circuit mounting, low output impedance and clean output fundamental frequency wave form. Mounting supplied male or female.

Designed for Subminiature
Circuit Assemblies and Printed Circuit Card Configurations

New miniature designs of these reliable "MAG MODS"® make them ideal for incorporation into transistorized printed circuit assemblies. There is no sacrifice of dynamic response. They offer the engineer/designer the solution to problems involved in a wide range of data systems where analog circuit operations are encountered. To insure complete flexibility, the mechanical mounting on any "MAG MOD" may be modified to conform to your particular packaging requirements.

- 1% repeatability throughout entire service life
- Negligible hysteresis
- Faster response time
- Extreme stability over a wide temperature range
- Infinite service life
- Extremely lightweight — compact design

GENERAL MAGNETICS • INC

FOR RELIABILITY...

MAGNETIC MODULATORS

TYPE NUMBER	IMM 487-4	IMM 495-8	IMM 504-5	IMM 562-1	IMM 561-1	IMM 556-5
Excitation Carrier Voltage and Frequency	115 V @ 400 cps	115 V @ 400 cps	115 V @ 400 cps	2.5 V RMS @ 4 KC	1.0 V RMS @ 10 KC	6 to 10 V RMS @ 35 KC
Control Signal Winding DC Resistance	Winding No. 1 6200 ohms Winding No. 2 7400 ohms	Signal Winding No. 1 550 ohms Signal Winding No. 2 600 ohms	1000 ohms	Signal Winding 1300 ohms Feedback Winding 160 ohms	200 ohms	5000 ohms
Input Control Signal Range	0 to ±40 μa Each Winding	0 to ±100 μa (Both Sig. Windings in Series)	0 to ±100 μa	0 to ± 100 μa 0 to ± 1 V Bipolar	0 to ±400 μa	0 to ±400 μa
Amplitude Modulated AC Output Range	3 V RMS @ 400 cps Phase Reversing	0 to 1 V RMS @ 400 cps Phase Reversing	0 to 1.5 V RMS @ 400 cps Phase Reversing	0 to 6 V RMS @ 4000 cps Phase Reversing	0 to 3 V RMS @ 4 KC Phase Reversing	0 to 1.8 V RMS @ 35 KC Phase Reversing
Differential Gain RMS mv AC Out/μa Signal In	100 mv/μa	15 mv/μa	10 mv/μa	200 mv/μa	10 mv/μa	4.2 mv/μa
Null Amplitude (Noise Level) mv RMS	25 mv RMS Maximum	5 mv RMS Maximum	10 mv RMS Maximum	30 mv RMS Maximum	10 mv RMS Maximum	20 mv RMS Maximum
Output Impedance	Approx. 30 K ohms	1600 ohms	1000 ohms	Approx. 70 K ohms	Approx. 40 K ohms	900 ohms Each Output Wind.
External Load (Suggested)	Approx. 20 K ohms	Approx. 10 K ohms	Approx. 5 K ohms	Approx. 100 K ohms	Approx. 100 K ohms	1000 ohms Each Output Wind.
Null Drift (In terms of Input Signal) −65°C to +135°C	Less than ±0.25 μa Over Temp. Range	Less than ±0.25 μa Over Temp. Range	±1 μa Maximum Over Temp. Range	±0.5 μa Maximum Over Temp. Range	±1 μa Over Temp. Range	±2 μa Over Temp. Range
Hysteresis (% of Input Control Signal)	0.5% Maximum	0.5% Maximum	0.5% Maximum	Approx. 0.5%	0.5% Maximum	0.5% Maximum
% Harmonic Distortion in Output AC Modulated Envelope	Approx. 40% (3rd Harmonic)	Approx. 25% (3rd Harmonic)	Approx. 30% (3rd Harmonic)	Approx. 15% (3rd Harmonic)	Less Than 10% (3rd Harmonic)	Approx. 5% (3rd Harmonic)
Overall Dimensions (In Inches)	1¼ x 1⅛ x ¾	¾ x 1 x 1	1 x 1 x 1	1 x 11/16 x ⅞	11/16 x 1 x ⅝	7/16 x 1⅜ x 1¼
Type of Mounting	4-40 Studs or Inserts	4-40 Studs or Inserts	4-40 Studs or Inserts	4-40 Studs or Inserts	2-56 Studs	4-40 Tapped Holes or Studs
Weight in Ounces	Approx. 1.25	Approx. 1	Approx. 1.1	0.75	0.6	1
Response Time (Band Width cps)	0.01 sec. for 15 K Sig. Source Imp. (12 cps Corner Frequency)	20 cps for 10 K Sig. Source Imp. 25 cps for 20 K Sig. Source Imp. (Both Sig. Windings in Series)	5 cps for 1 K Sig. Source Imp. 10 cps for 5 K Sig. Source Imp. 20 cps for 10 K Sig. Source Imp.	70 cps for 10 K Sig. Source Imp. (Time Constant Approx. 2 Milli-Seconds)	Corner Frequency 2 KC for Sig. Source Imp. of Approx. 6 K ohms	Corner Frequency 200 cps for 600 ohm Signal Source Imp. or 1000 cps for 5 K Source

Magnetic Multiplying Modulator Model MCM 515-1

Actual Size

The MAGNETIC MULTIPLIER is a miniaturized magnetic modulator specifically designed to deliver an analog output voltage which is the continuous product of two variable input voltages. One of these is an excitation voltage which varies over a pre-determined range; in this case, 0 to 1 VRMS 400 cycles per second. The other signal is a DC current which varies between 0 and ±400 μa. The output voltage is 400 cycles AC, and is always in phase or 180° out of phase with the variable excitation or fixed reference, i.e., in phase when the variable amplitude DC signal is positive, and 180° out of phase when the DC signal is negative. The general schematic is illustrated in Fig. 1. The relationship between variable alternating supply signal voltage E_S, variable direct current control signal E_C, and the alternating load voltage E_L having a sinusoidal wave shape is denoted by the equation—

E_L = Constant × E_S × E_C.

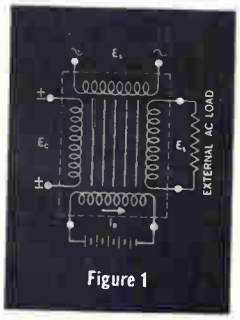


Figure 1

This expression, which defines the fundamental principle of the four quadrant MAGNETIC MULTIPLYING MODULATOR, can be clearly illustrated by linear transfer response curve families as shown at right, in Figure 2-A and Figure 2-B.

Illustrating:

(1) Load voltage E_L as a function of alternating supply signal voltage E_S with control DC signal voltage E_C as a parameter.

(2) Load voltage E_L as a function of control DC signal voltage E_C with alternating supply voltage, E_S as a parameter.

With linearity response curves held to within approximately 1 to 2% of theoretical straight lines, the product accuracy of the fundamental equation will be within 2 to 5% of the theoretical product.

SPECIFICATIONS MODEL MCM 515-1	
Variable Excitation Carrier Voltage and Frequency	Variable AC Signal 0 to 1 V RMS 400 cps
Control Signal Winding DC Resistance	DC Signal Winding Resistance 2650 ohms
Input Control Signal Range	Variable DC Signal 0 to ±400 μa
Amplitude Modulated AC Output Range	0 to 0.9 V RMS @ 400 cps Phase Reversing
Null Amplitude (Noise Level) mv RMS at Max. AC Excitation	5 mv RMS
Output Impedance	Approx. 3500 ohms
External Load (Suggested)	Approx. 25 K ohms
Null Drift (In terms of Input Signal) −65°C to +135°C	±2 μa over Temperature Range
Hysteresis (% of Input Control Signal)	0.5% Maximum
% Harmonic Distortion in Output AC Modulated Envelope	Less than 5%
Overall Dimensions (In Inches)	27/32 x 27/32 x 1 3/16
Type of Mounting	4-40 Insert or Stud
Weight	Approx. 1 Ounce

Amplitude Response Curve

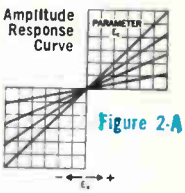


Figure 2-A

Amplitude Response Curve

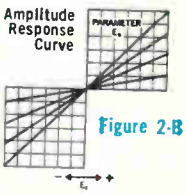


Figure 2-B

Typical "Mag Mod" Circuit Applications—

Include algebraic addition, subtraction, multiplying, raising to a power, controlling amplifier gain, mechanical chopper replacement in DC to fundamental frequency conversion, filtering and low signal level amplification.

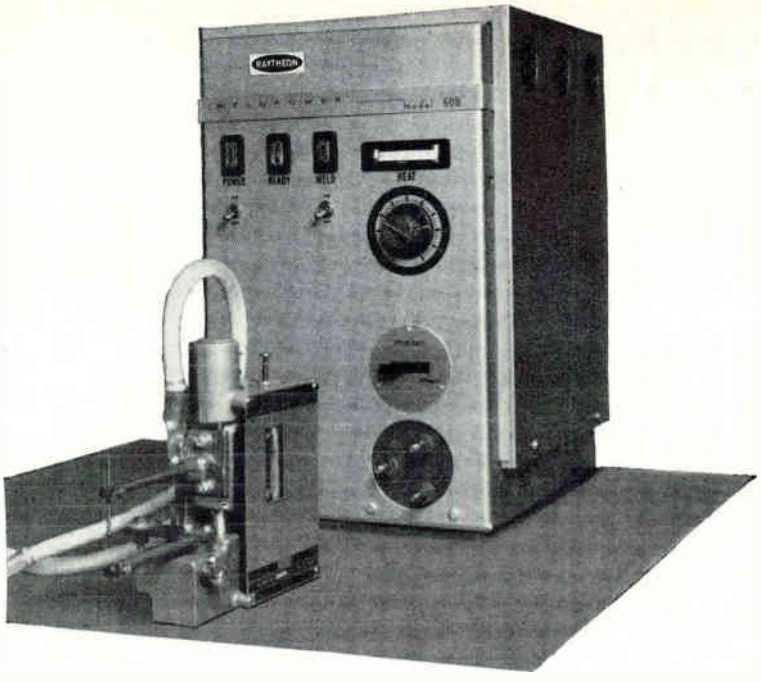
Consult General Magnetics for magnetic amplifier components of proven reliability. These dependable instruments are widely employed in automatic flight systems, fire control, analog computers, guided missiles, nuclear equipment, antennas, gun turrets, commercial power amplifiers and complete control systems. Miniature, subminiature, standard and customized types available.

Call or write for new Brochure 102 on "MAG MOD" Miniaturized Magnetic Modulators and Magnetic Multiplying Modulators. Please address inquiries on company letterhead.

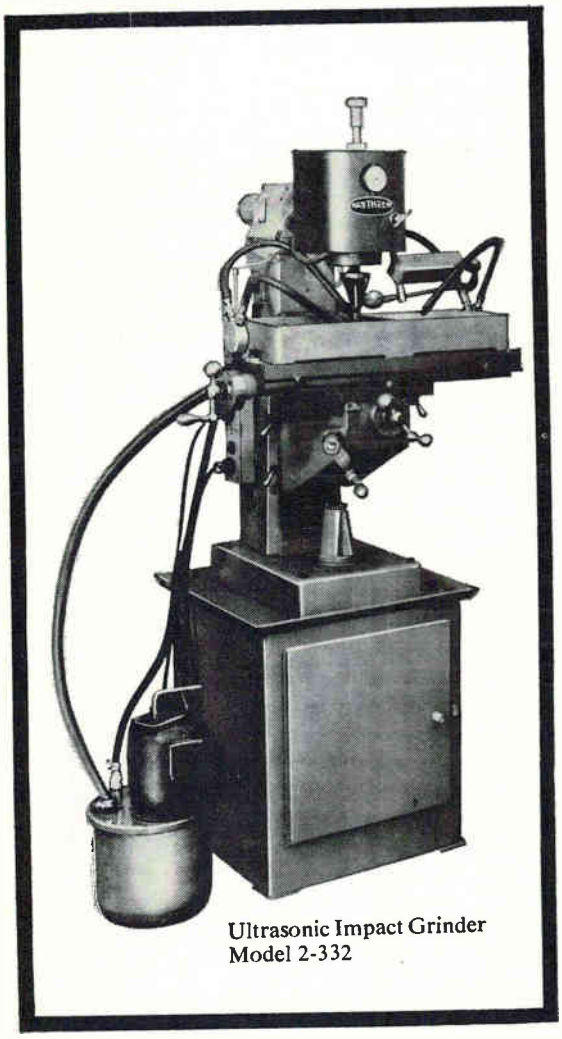
135 BLOOMFIELD AVE., BLOOMFIELD, NEW JERSEY

GM INC.

If your problem is electronic parts production...



New Model JA Welding Head with 60B Power Supply



Ultrasonic Impact Grinder
Model 2-332

Improve part reliability, reduce costs with Raytheon precision welding and ultrasonic machining equipment.

More reliable electronic parts, often at lower costs, are achieved through the use of Raytheon's high-speed precision welding equipment and ultrasonic machining equipment.

PRECISION WELDING EQUIPMENT—Raytheon makes and stocks a broad line of AC and DC welding controls, power supplies, welding heads, transformers, and accessories. Complete engineering and production facilities for the design of jigs, fixtures and semi-automatic welding equipment are also available from Raytheon.

ULTRASONIC IMPACT GRINDERS—Outstanding performance with economy in the machining of any shape in the hardest or most brittle materials and in many soft materials are offered by Raytheon's ultrasonic impact grinders. Ultrasonic machining provides the best method for machining silicon and germanium for use in transistors, diodes, and rectifiers.

Raytheon equipment and long experience in solving difficult joining and machining problems are at your service. For information, write to Raytheon Company, Commercial Apparatus & Systems Division, Production Equipment Department, 225 Crescent St., Waltham, Mass.

RAYTHEON COMPANY

COMMERCIAL APPARATUS & SYSTEMS DIVISION

RAYTHEON

New Bourns Precision Potentiometer Resolves the Quality-Price Dilemma!

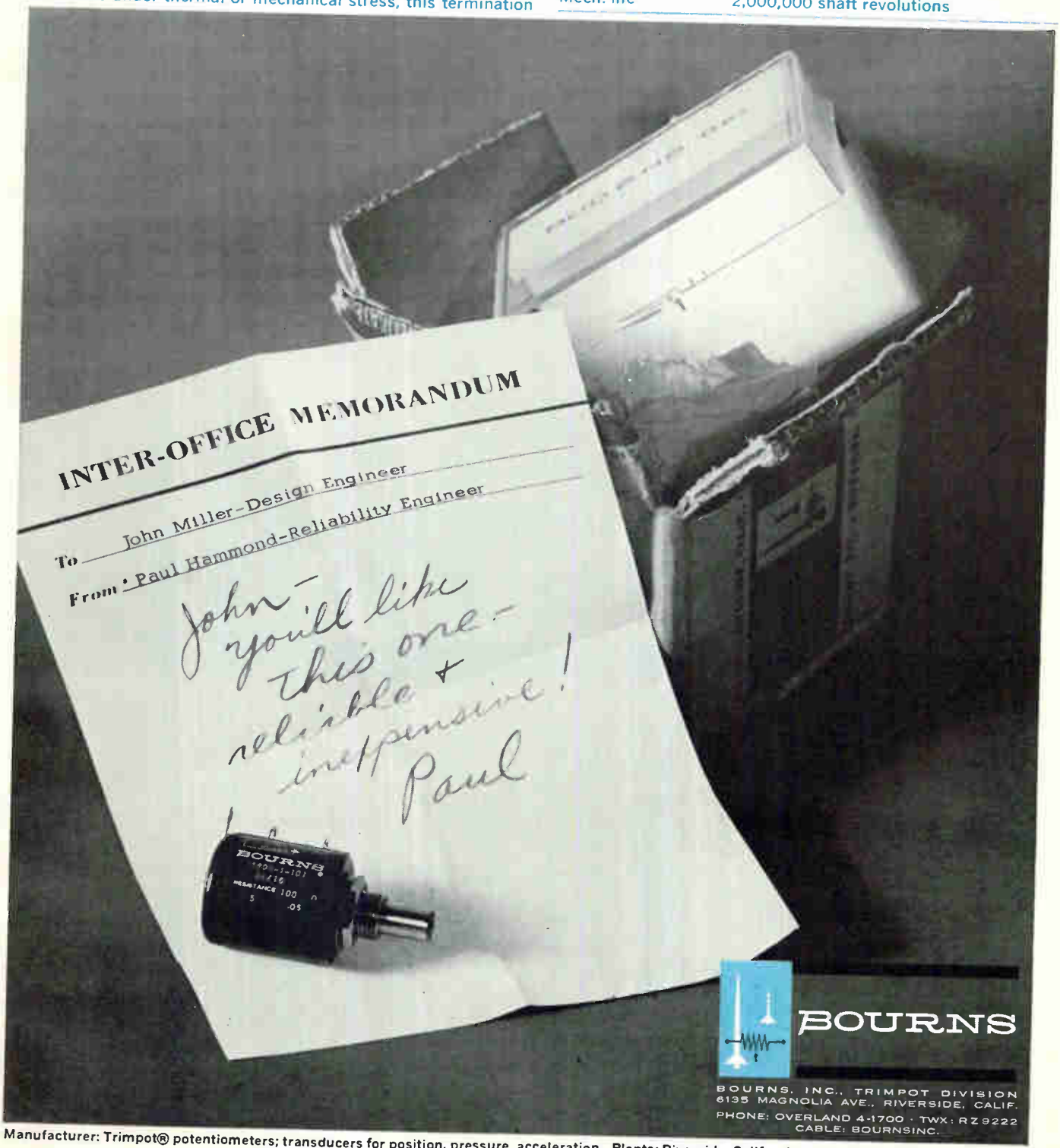
Here is military reliability in a competitively-priced industrial potentiometer. Bourns wirewound 10-turn Model 3500 measures just ⅞" in diameter by 1" long—shorter by ½" than units available elsewhere—yet has a resistance element 20% longer than that of comparable potentiometers.

Fully meeting military requirements for steady-state humidity, Model 3500 can also be provided at a 10% premium to meet the cycling humidity specs of MIL-STD-202, Method 106. It's the only ⅞" 10-turn potentiometer guaranteed to meet this spec. Its published characteristics incorporate wide safety margins.

Reliability insurance is provided by the exclusive Bourns Silver-weld® bond between terminal and resistance wire. Virtually indestructible under thermal or mechanical stress, this termination eliminates a chief cause of potentiometer failure. In addition, a special close-tolerance rotor almost completely does away with backlash.

Model 3500 is also subjected to the rigorous double-check of Bourns' exclusive Reliability Assurance Program. In short, every possible step is taken to ensure that the performance you specify is the performance you get. Write for complete data.

Resistances	500Ω to 125K, ±3%, std. (to 250K spl.)
Linearity	±0.25% std.
Power rating	2w at 70°C
Operating temp.	−65° to +125°C
Mech. life	2,000,000 shaft revolutions



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

New! Higher permeability, no extra cost...

in small transformer core laminations.

Pack extra performance into your miniature transformers *at no extra cost* with Magnetic Metals' new mite-size transformer core laminations. Use these carefully engineered laminations where you need high specific resistivity and low hysteresis loss, particularly where you require low core loss at high frequencies. They let you miniaturize your designs even further without sacrificing performance.

Supplied only by Magnetic Metals, these new small laminations are made of "Supermu 40"* which provides the highest permeability commercially available. Advanced manufacturing techniques now bring this premium line of laminations to you at no extra cost.

Write today for more information on our entire line of small transformer core laminations. Our engineers are ready to help you select, from the most comprehensive line of laminations in the industry, the best grade of material for the exact results you want.

MAGNETIC METALS

Hayes Avenue at 21st Street, Camden 1, New Jersey
853 Production Place, Newport Beach, California

transformer laminations • motor laminations • tape-wound cores
powdered molybdenum permalloy cores • electromagnetic shields

*79% nickel-iron molybdenum alloy

NEW PC CONNECTOR for critical computer applications

Now—*from Continental*—a printed circuit connector that combines all the advanced design features for rugged service in missile, ground support and other critical applications. Expressly designed for high speed automatic wire-wrap connection techniques which combine better reliability with maximum wiring density in minimum space. Type 600-83-10 meets all applicable specifications of Buships MIL-C-21097.

3/4 ACTUAL SIZE

Designed specifically for automatic wire-wrap connections. Solid square, sharp-edged brass terminations, gold plate over silver plate. Three #20 AWG wire-wrap connections can be made on each terminal.

64 contacts, bifurcated beryllium copper. Patented "Bellowform" construction accepts .054" to .075" printed circuit boards. Up to 192 connections in less than 7½" length.

Special molding geometry assures superior ruggedness under severe shock and vibration. Compound is glass filled Diallyl Phthalate per MIL-M-19833, Type GDI-30.

Polarizing slots in molding permit any required polarization by customer while retaining use of all 64 contacts.

DESIGNERS' DATA FILE

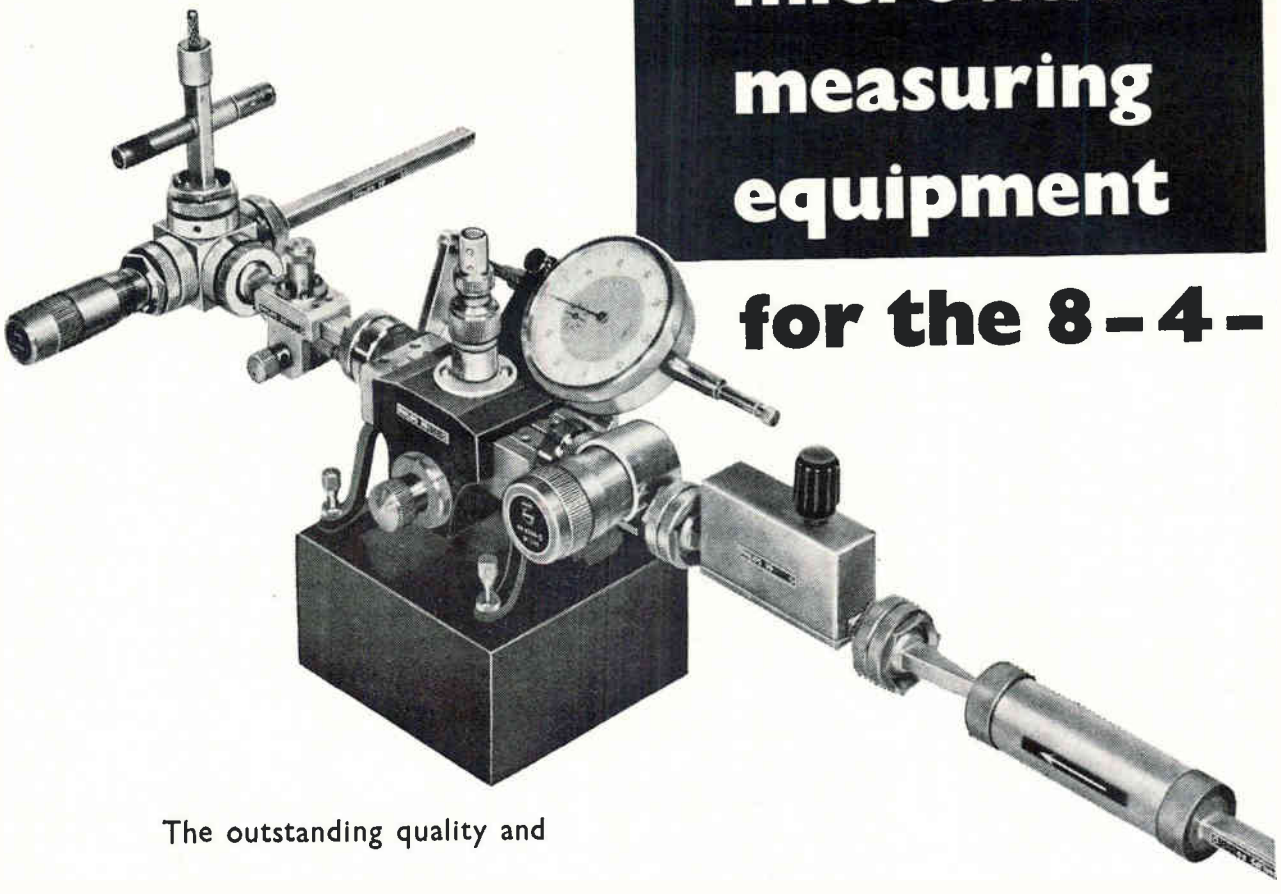
If you're designing around printed circuits you'll want to have Continental's Con-Dex File PC, compiled to help you select and specify the PC connectors best suited to your needs. For your copy, please write to: Electronic Sales Division, DeJur-Amsco Corporation, Northern Boulevard at 45th St., Long Island City 1, New York (Exclusive Sales Agent) RAvenswood 1-8000.

MICRO-MINIATURE • SUB-MINIATURE • MINIATURE • PRINTED CIRCUIT • RIGHT ANGLE PIN & SOCKET • CENTER SCREWLOCK

CONTINENTAL CONNECTORS

CONTINENTAL CONNECTOR CORPORATION • WOODSIDE 77, NEW YORK

microwave measuring equipment for the 8-4-



The outstanding quality and precision of Philips' microwave components for the 8, 4 and 2 mm bands are in accordance with the high standards set by advanced research. The range of components is continuously being extended.

8 mm band (31—36 kMc/s)

PP 4420Q	ferrite isolator
PP 4382Q	standing wave detector
PP 4300Q	broadband wavemeter
PP 4270Q	sliding screw tuner
PP 4260Q	calibrated short circuit
PP 4222Q	adjustable crystal mount
PP 4200Q	klystron mount
PP 4170Q	matched load
PP 4150Q	rotary attenuator
PP 4130Q	flap attenuator
PP 4090Q	directional coupler
PP 4080Q	horn
PP 4050Q	hybrid Tee
PP 4035Q	twist
PP 4030Q	H-plane bend
PP 4025Q	E-plane bend
PP 4020Q	straight waveguide sections
PP 4020Q/AR	adaptor to flange UG599/U
PP 4020Q/BR	adaptor to flange UG381/U

4 mm band (60—90 kMc/s)

PP 4422E	ferrite isolator
PP 4300E	wavemeter

PHILIPS *electronic measuring*

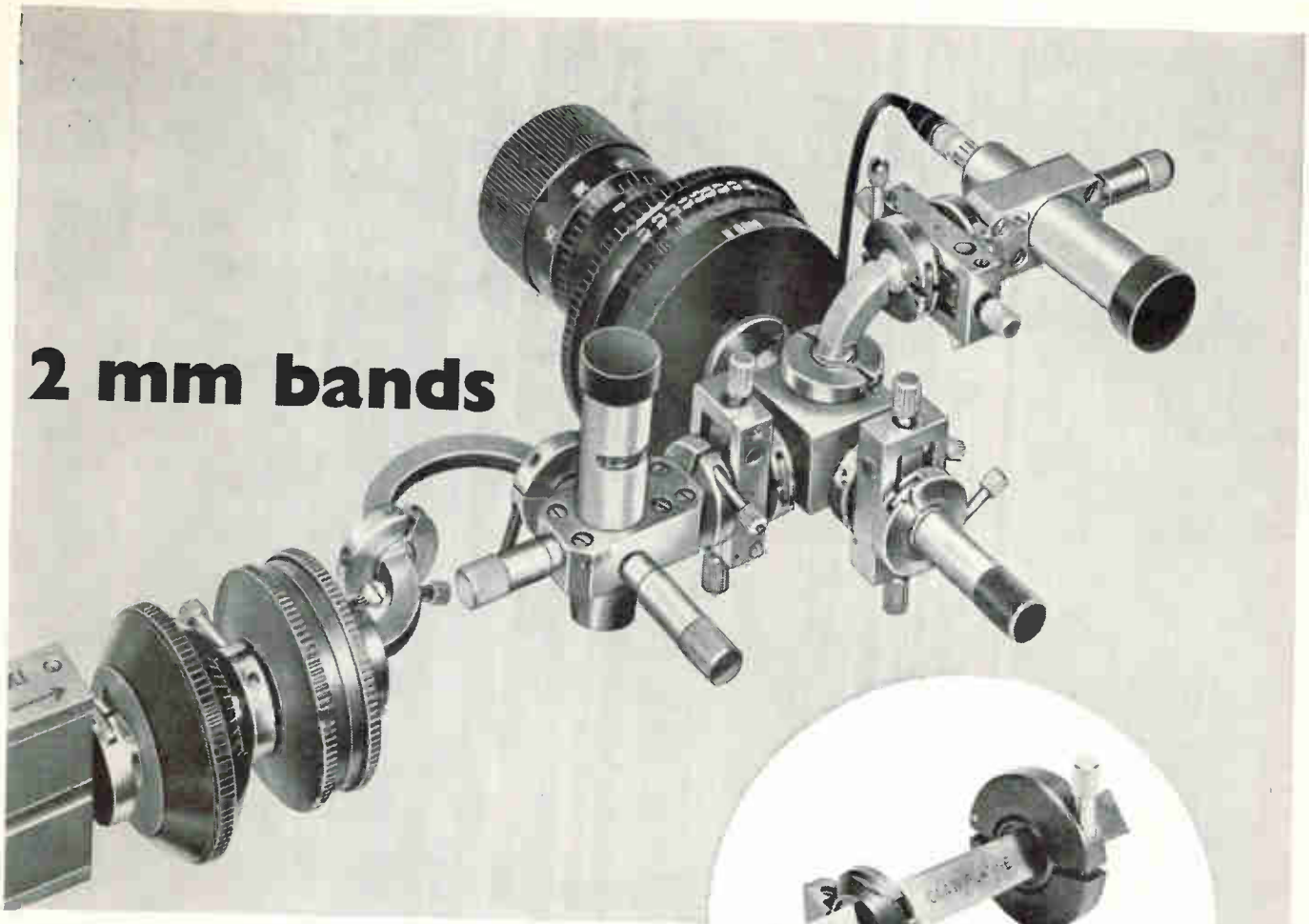
Sold and serviced by Philips Organizations all over the world

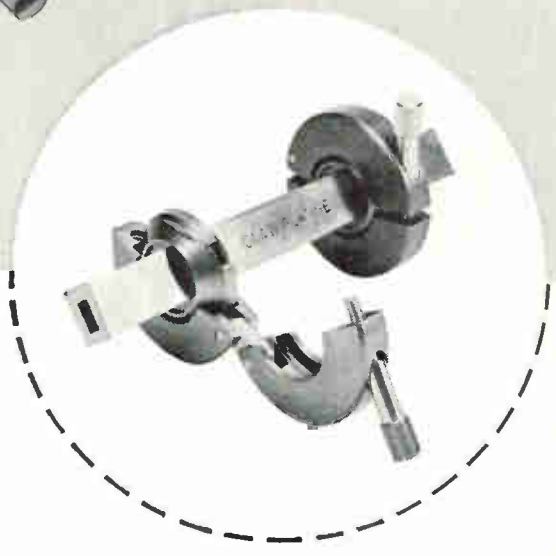
Further information will gladly be supplied by:

N.V. Philips' Gloeilampenfabrieken, EMA-Department, Eindhoven, the Netherlands

For Canada: Philips Electronics Ind. Ltd., 116 Vanderhoof Ave., Toronto 17, Ont.

2 mm bands





PP 4270E	sliding screw tuner
PP 4260E	adjustable short circuit
PP 4220E	crystal mount
PP 4200E	klystron mount
PP 4170E	matched load
PP 4130E	flap attenuator
PP 4080E	horn
PP 4050E	hybrid Tee
PP 4035E	twist
PP 4034E	H-plane bend 180°
PP 4030E	H-plane bend 90°
PP 4025E	E-plane bend 90°

2 mm band (110—170 kMc/s)

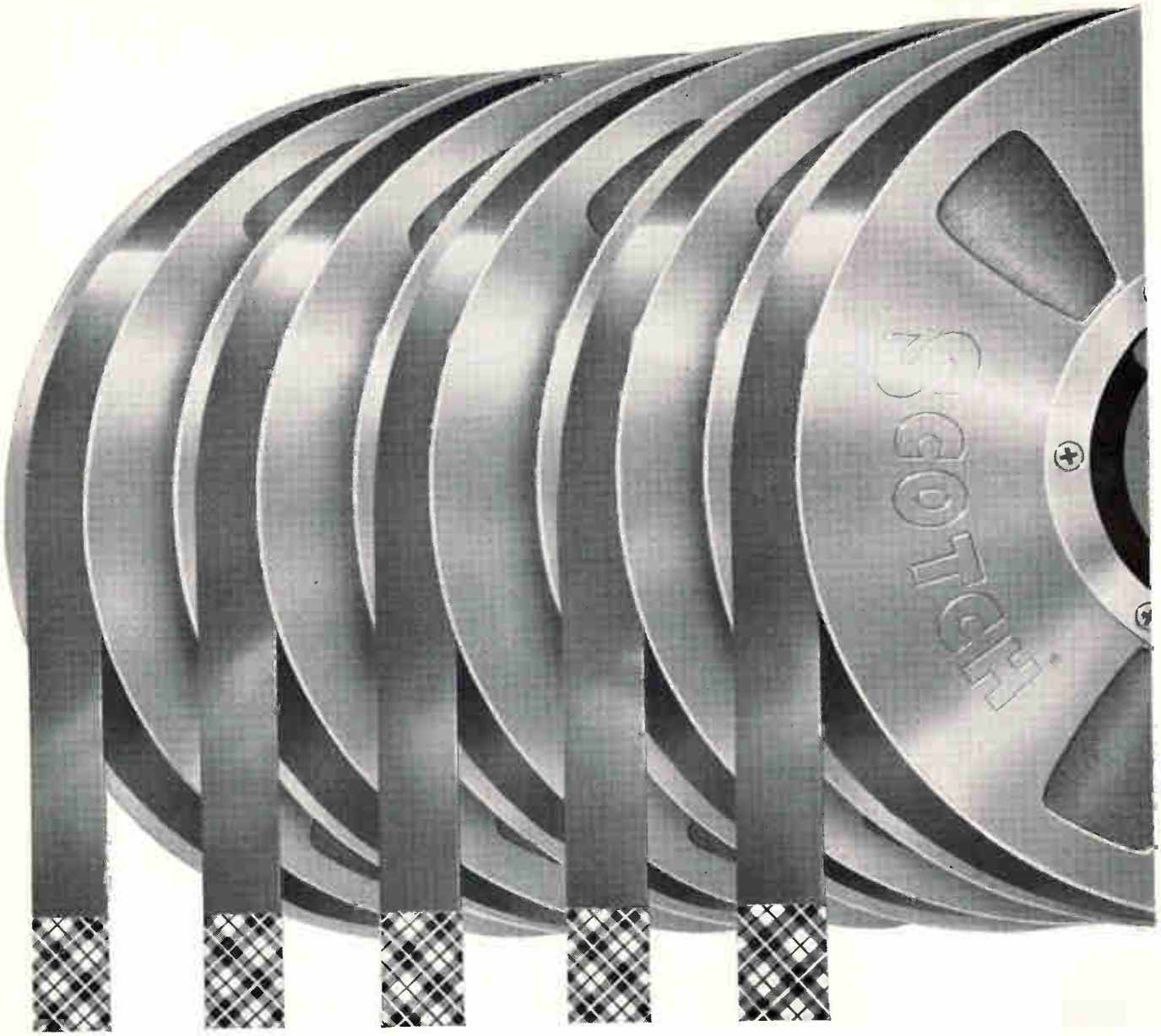
PP 4400B	calibrated variable impedance
PP 4270B	tuner
PP 4260B	adjustable short circuit
PP 4230B	harmonic generator 4 mm → 2mm
PP 4220B	crystal mount
PP 4170B	matched load
PP 4080B	horn
PP 4050B	hybrid Tee
PP 4015E	clamping ring for claw flange
PP 4010E	claw flange

For the 2 and 4 mm microwave components Philips Research Laboratories have developed a waveguide coupling which fully satisfies the special requirements of this frequency range.

The Claw Flange offers amongst other advantages very small reflections ($|R| < 0.005$), compact construction of the microwave component and universal and simple fixing.

instruments: **quality *tools* for industry and research**

PHILIPS



SCOTCH® BRAND MAGNETIC INSTRUMENTATION TAPES OFFER A RIGHT TAPE FOR EVERY APPLICATION

Knowledgeable tape users realize that magnetic tapes are not all alike—that it takes specific constructions to meet the needs of specific applications. And they've learned to rely on "SCOTCH" BRAND to supply the one right tape for each application. Not only does "SCOTCH" BRAND offer a complete line, it offers that something extra that makes all the difference in performance—the uniformity and reliability that result from 3M's experience, technical skill, and continuing research. Make the "SCOTCH" BRAND label your guide in buying instrumentation tapes. Your 3M Representative is close at hand in all major cities—a convenient source of supply and information. For details, consult him or write Magnetic Products Division, 3M Co., St. Paul 6, Minnesota.

The wide "SCOTCH" BRAND line provides many tapes, including these broad classifications:

SANDWICH TAPES 488 and 489—exclusive with "SCOTCH" BRAND, offering 30 times the wear of standard tapes, drastic reductions in head wear, elimination of oxide rub-off. In standard or extra-play lengths.

HIGH RESOLUTION TAPES 458 and 459—offering superior resolution in high frequencies, greater pulse density in digital recording. In standard and extra-play lengths.

HEAVY DUTY TAPES 498 and 499—offering exceptional life, good resolution, high resistance to temperature and humidity, reduction in the build-up of static charge. In standard and extra-play lengths.

HIGH OUTPUT TAPE 428—offering top output in low frequencies. Performs well even in temperature extremes.

STANDARD TAPES 403 and 408—offering the good all-round performance at low relative cost which has made them the standards of the instrumentation field.

Magnetic Products Division 3M COMPANY

"SCOTCH" BRAND MAGNETIC TAPES *FOR INSTRUMENTATION*

"SCOTCH" and the Plaid Design are registered trademarks of 3M Company, St. Paul 6, Minnesota. Export: 99 Park Avenue, New York, N.Y. In Canada: London, Ontario.

Only this label can assure you of AIR EXPRESS priority service

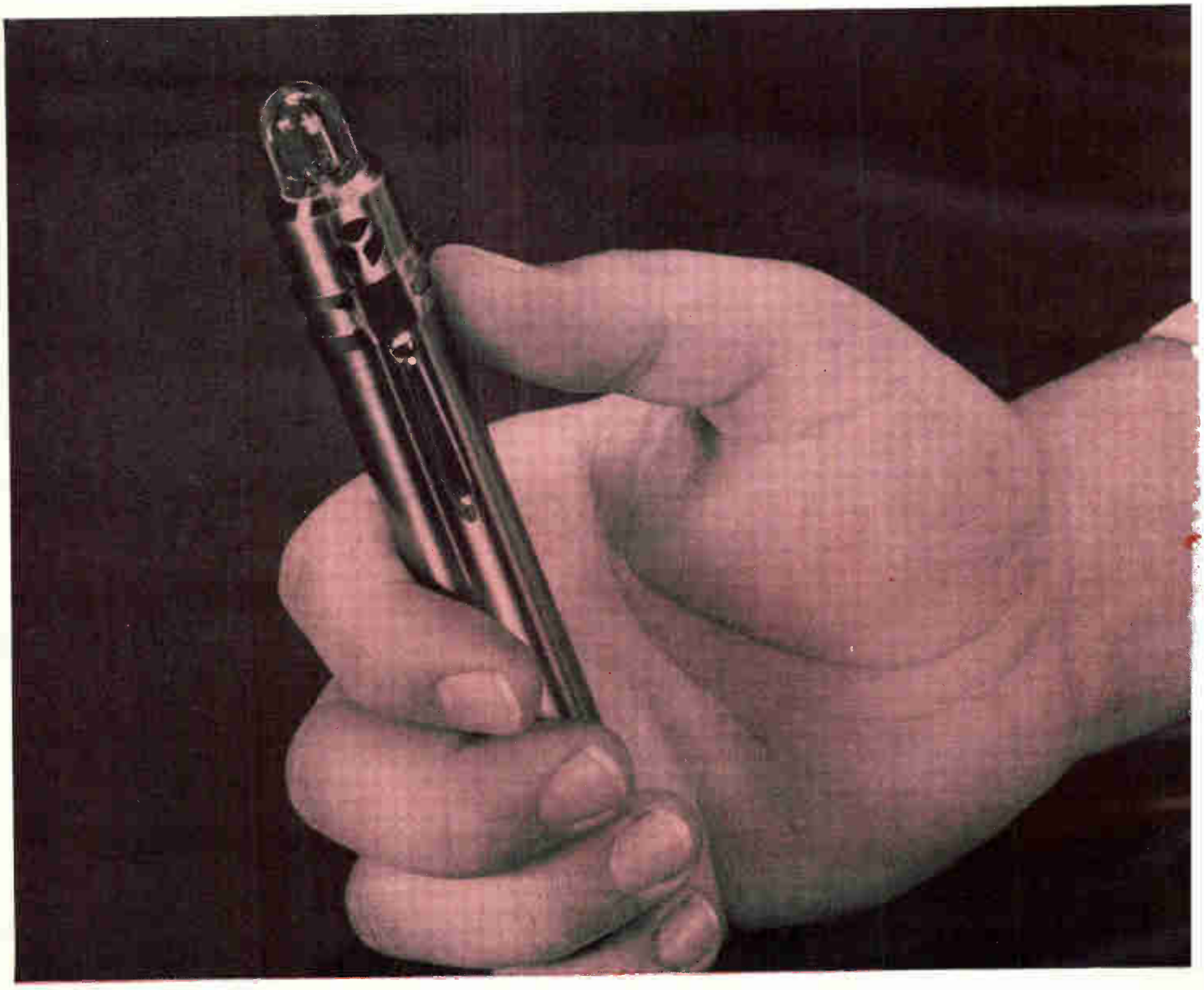
Let's clear up a frequent misunderstanding: AIR EXPRESS is not a general term for all air freight. It's a specific air-ground shipping service: AIR EXPRESS Division of R E A Express. Many businessmen learn this the hard way. They assume that the famous AIR EXPRESS advantages of jet speed and door-to-door service apply to all air shipping companies. It just isn't so. There's only one way to be sure your shipment is first on, first off, first there—via all 35 scheduled U. S. airlines. Or gets kid-glove handling throughout the U. S. and Canada. And that's to be sure it gets this label. If it doesn't . . . it's not AIR EXPRESS.

AIR EXPRESS

CALL YOUR LOCAL R E A EXPRESS OFFICE FOR AIR EXPRESS SERVICE

CIRCLE 55 ON READER SERVICE CARD

Design with
MALLORY MERCURY BATTERIES
for new sales appeal
in your products

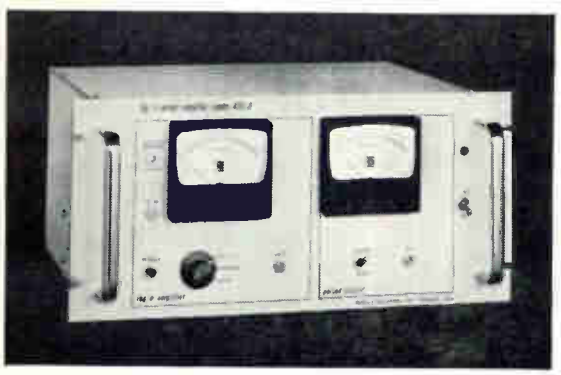


PERSONAL RADIATION MONITOR, developed at Oak Ridge National Laboratory, warns of radiation levels by flashing a neon lamp and sounding a tone in a hearing aid earphone. The transistorized circuit operates 24 hours a day for 30 days at a time, from power by a single Mallory TR-133R mercury battery.

Photo courtesy Oak Ridge National Laboratory
Operated by Union Carbide Corporation
For the U. S. Atomic Energy Commission

PORTABLE TRANSISTOR TEST SET is made by Metronix, Inc., a subsidiary of Assembly Products, Inc. Used as the DC power source, Mallory Mercury Batteries assure stable voltage over long periods of time, are undamaged by momentary short circuits, and provide long shelf life.

MICROMINIATURE TRANSMITTER, used for monitoring tooth wear and pressures and for other biomedical applications, is made by Varo, Inc. Small enough to be fitted into a dental bridge, it transmits information over short distances to a pickup/preamp, utilizing an RM-312 Mallory Mercury Battery smaller than an aspirin tablet.



A DUAL INSTRUMENT FOR REACTOR MONITORING, the log n Period Amplifier made by Keithley Instruments, Inc. gives extremely accurate low-level DC measurements. The constant voltage source used for calibrating this sensitive instrument is a Mallory Mercury Battery . . . chosen for its steady voltage and an accuracy within $\pm \frac{1}{2}\%$. Stable, long-lived Mallory Mercury Batteries are used as the power supply for several other Keithley instruments.

Miniaturize your new product . . . make it more portable . . . give it extra long service between battery changes . . . with Mallory Mercury Batteries. Pioneered by Mallory, these unusual batteries last 3 to 7 times longer than conventional batteries, depending on drain. They provide the highest watt-hours per pound of any commercially available primary battery. Sizes smaller than an aspirin tablet deliver ample energy for many miniature circuits.

Mallory Mercury Batteries have the unique characteristic of staying at constant voltage throughout their long life. This property is ideal for transistor circuitry . . . also proves useful in applying these cells as a highly stable source of voltage for reference or calibration. Voltage of cells coming from production varies no more than a few millivolts.

As for shelf life, we've tested mercury batteries held in storage for over six years: capacity loss was minimum. Steel case construction with molded grommet seal makes them free from leakage.

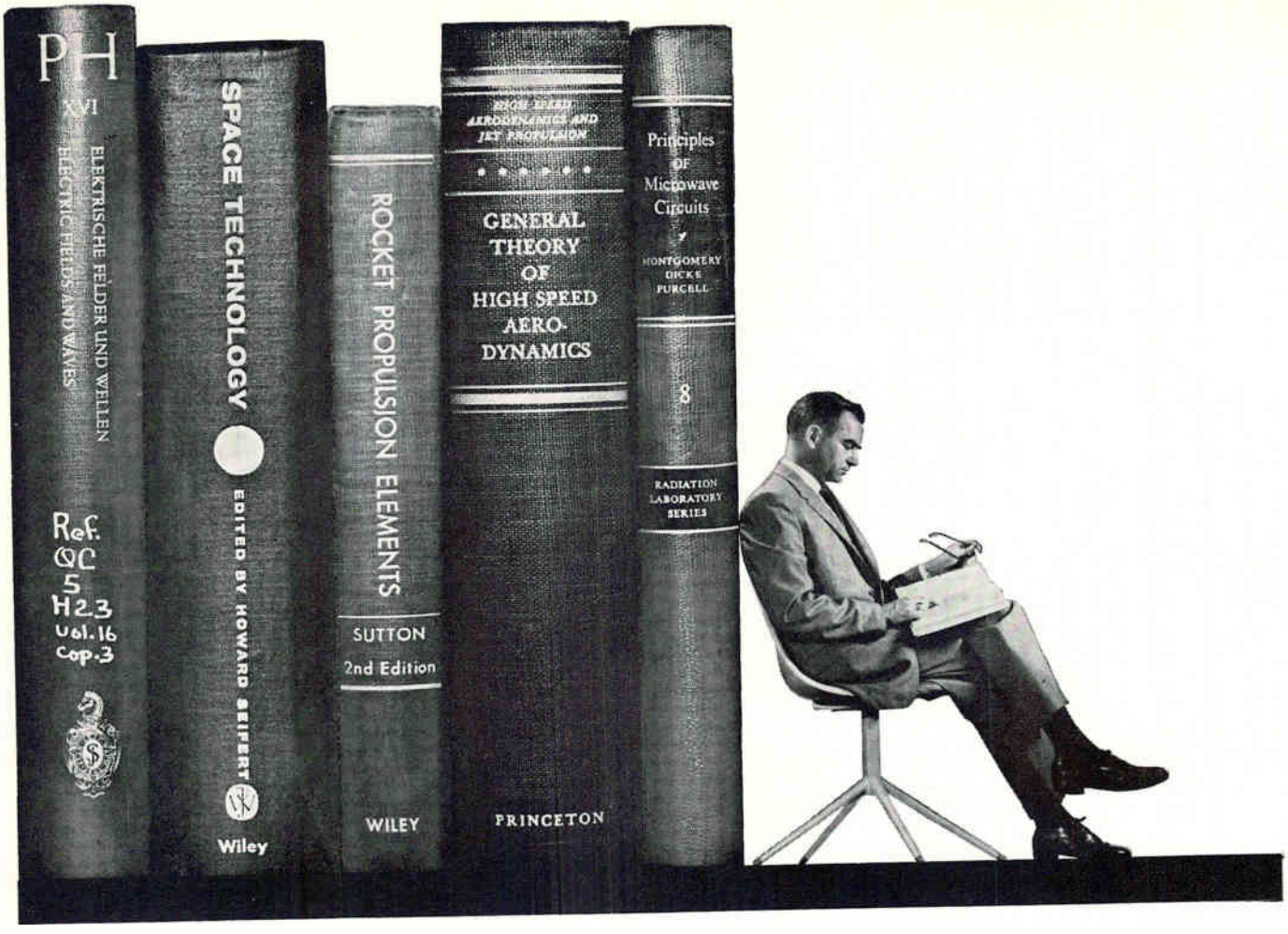
Choose from a broad line of standard single or multiple voltage cells . . . or let us develop a custom power pack for you. Write us for consultation and engineering data.

Mallory Battery Co., North Tarrytown, N. Y.
a division of P. R. Mallory & Co. Inc.

P. R. MALLORY & CO. Inc.
MALLORY

In Canada: Mallory Battery Company of Canada Limited, Toronto 4, Ontario
In Europe: Mallory Batteries, Ltd., Crawley, Sussex, England

CIRCLE 57 ON READER SERVICE CARD



scientists and engineers in a unique role

The frontiers of space science and technology are being expanded at Aerospace Corporation. The scientists and engineers of this organization are the critical civilian link uniting government and the scientific-industrial team developing space systems and advanced ballistic missiles. In this mission Aerospace Corporation provides advanced systems analysis and planning, theoretical and experimental research, initial systems engineering, initial technical direction and general technical supervision. Included in the latter are integration and review of the engineering, development and test operations of industry to the extent necessary to assure achievement of system concept and objectives in an economical and timely manner. These people are privileged to view both the state-of-the-art and system development in their totality. Immediate assignments exist for those individuals highly skilled in these specialties and who are knowledgeable in inter-disciplinary problem solving. Men with advanced degrees are urged to contact Aerospace Corporation, Room 110, P.O. Box 95081, Los Angeles 45, California.

Organized in the public interest and dedicated to providing objective leadership in the advancement and application of space science and technology for the United States Government.

AEROSPACE CORPORATION

All qualified applicants will receive consideration for employment without regard to race, creed, color or national origin.

Special Pliers for the Highly Specialized Electronics Field

When the early transmission lines were strung in this country a century ago, it was Klein Pliers in the hands of linemen that helped do the job.

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

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

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

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

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

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

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

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

D229-4C — Springs between jows hold clipped end af wire.

D052-C—Specially designed for wiring printed circuits.

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

SEE US AT THE NEREM MEETING, BOOTH 1712

SEE YOUR DISTRIBUTOR

Mathias Klein & Sons
Established 1857 — Chicago, Ill., U.S.A.
INCORPORATED
7200 McCORMICK ROAD, CHICAGO 45, ILL.

Mathias Klein & Sons, Inc. 7200 McCormick Road, Chicago 45, Ill.
Please send me the Klein Plier Catalog and information.

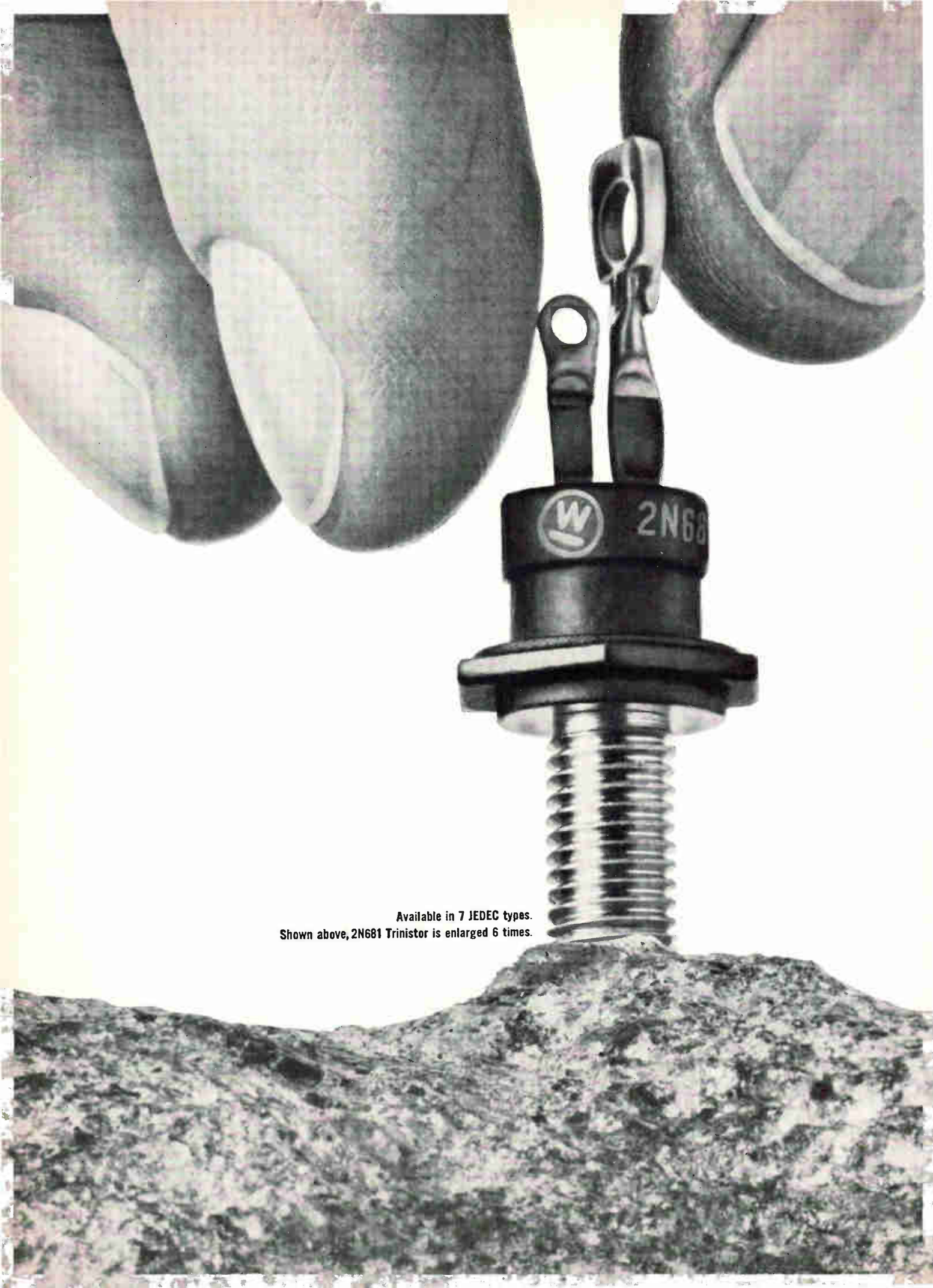
Name_____

Title_____

Company_____

Address_____

City_____ State_____



Available in 7 JEDEC types.
Shown above, 2N681 Trinistor is enlarged 6 times.

Westinghouse announces new 16-amp "Rock-Top" Trinistor® controlled rectifier

Proven "Rock-Top" quality is now available in JEDEC 2N681 Trinistor Controlled Rectifier series! These latest additions to the Westinghouse power semiconductor family incorporate the field-proven design features of the broadest line of medium and high-power switching devices. Such features as hard-soldered junctions and hermetically welded cases provide an extra assurance of reliability at no extra cost. Additionally, each device is 100% tested to maximum ratings. These new devices from Westinghouse, world leader in silicon technology, are backed by production experience with high-power semiconductors for military and industrial applications.

Westinghouse 2N681 series Trinistors are ideal for such applications as: motor speed control ▪ temperature control ▪ inverters ▪ static switching. For more information, or technical assistance, call or write: Westinghouse Electric Corporation, Semiconductor Dept., Youngwood, Penna. *You can be sure... if it's Westinghouse.* SC-1049

For prompt delivery, order from these Westinghouse distributors:

EASTERN

ACK SEMICONDUCTOR INC.	Birmingham 5, Ala./FA 2-0588
CAMERADIO	Pittsburgh, Pa./EX 1-4000
CRAMER ELECTRONICS, INC.	Boston, Mass./CO 7-4700
ELECTRONIC WHOLESALERS, INC.	Melbourne, Florida/PA 3-1441
GENERAL RADIO SUPPLY CO., INC.	Camden, N. J./WO 4-8560
GENESEE RADIO PARTS CO.	Buffalo, N. Y./TR 3-9661
KANN-ELLERT ELECTRONICS, INC.	Baltimore, Md./TU 9-4242
MILGRAY ELECTRONICS	New York, N. Y./RE 2-4400
RADIO & ELECTRONIC PARTS CORP.	Cleveland, Ohio/UT 1-6060
SCHWEBER ELECTRONICS	Long Island, N. Y./PI 6-6520
	Silver Spring, Md./JU 5-7023

MIDWESTERN

E.C.I. SEMICONDUCTORS, INC.	Kansas City, Mo./WE 1-0829
ELECTRONIC COMPONENTS FOR INDUSTRY CO.	St. Louis, Mo./WO 2-9916
HALLMARK INSTRUMENTS CORP.	Dallas, Texas/RI 7-8933
INTER-STATE RADIO & SUPPLY CO.	Denver 4, Colo./TA 5-8257
LENERT CO.	Houston, Texas/CA 4-2663
MIDLAND SPECIALTY CO.	El Paso, Texas/KE 3-9555
	Phoenix, Ariz./AL 8-8254
	Albuquerque, N. M./CH 7-0236
RADIO DISTRIB. CO.	Indianapolis, Ind./ME 7-5571
SEMICONDUCTOR SPEC., INC.	Chicago, Ill./NA 2-8860
S. STERLING CO.	Detroit, Mich./BR 3-2900
UNITED RADIO, INC.	Cincinnati, Ohio/MA 1-6530

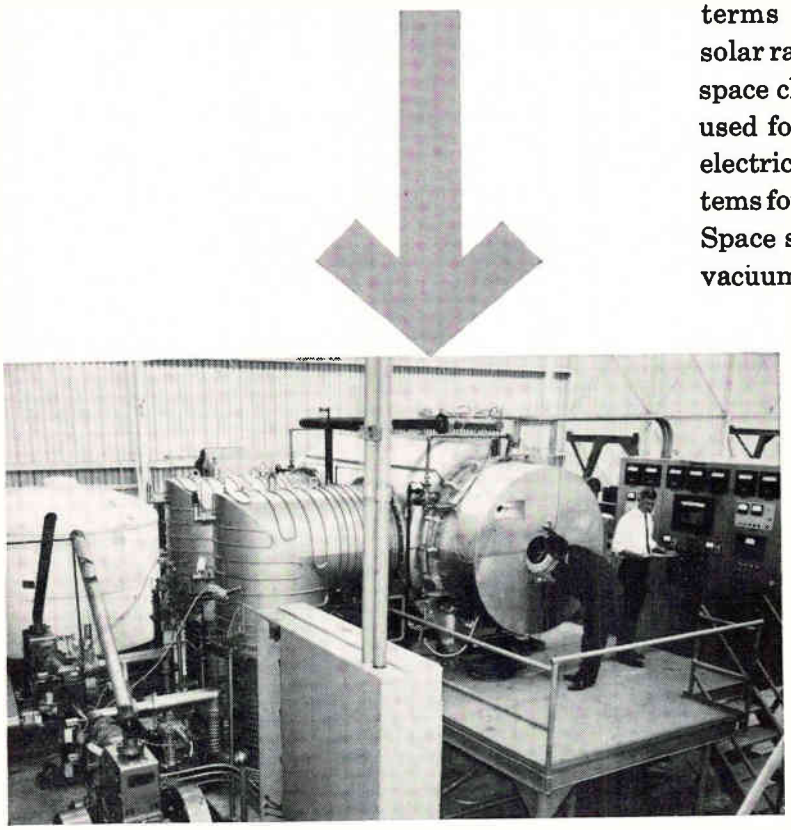
WESTERN

ALMAC ELECTRONICS CORP.	Seattle, Wash./PA 3-7310
ELMAR ELECTRONICS	Oakland, Cal./TE 4-3311
HAMILTON ELECTRO SLS.	Los Angeles, Cal./BR 2-9154
	Palo Alto, Cal./DA 1-7541
NEWARK ELECTRONICS CO.	Inglewood, Cal./OR 4-8440

Westinghouse

NRC provides OUTER SPACE TESTING

in your facility... Now, you can simulate outer space in terms of vacuum, thermal conditions and solar radiation in your own plant... with NRC space chambers. These altitude chambers are used for space environmental testing of both electrical and mechanical components or systems for satellites, missiles, and space vehicles. Space simulation testing can be conducted at vacuums to 10^{-10} torr range.



NRC's ultra-high vacuum R/D programs provide a long and unique background of information on the performance of materials and components in space-vacuum. These programs supplement NRC's actual specialty... the design and manufacture of space test equipment. NRC chambers are in daily use in R/D labs and industry throughout the country.

NRC Equipment has the engineering knowledge, existing designs, and facilities to produce the space chamber and/or vacuum pumping systems you need. On very large chambers, NRC combines with major metal fabricators in an arrangement whereby you still benefit from NRC's vacuum design experience and equipment... where NRC takes responsibility for the complete vacuum technology. Write for details, or phone today: DEcatur 2-5800.

NRC
EQUIPMENT CORPORATION

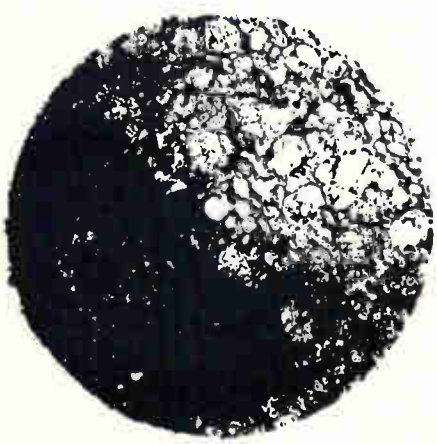
A Subsidiary of National Research Corp.

160 Charlemont Street, Dept. 4K
Newton 61, Massachusetts

MANUFACTURING PLANTS AT NEWTON, MASSACHUSETTS AND PALO ALTO, CALIFORNIA

←CIRCLE 61 ON READER SERVICE CARD

CIRCLE 62 ON READER SERVICE CARD



TOTAL PERFORMANCE

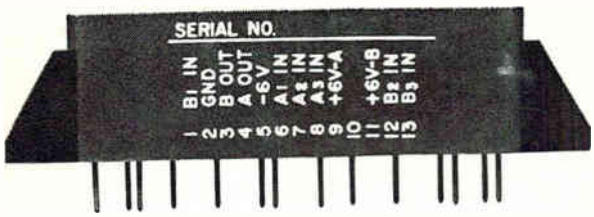
Total performance of your Giannini Controls airborne instrument or system has many phases. Designed-in function-effectiveness and long mean-time-between-failures. Production under a matured quality control system. Delivery on schedule in spite of last-minute changes. Flight readiness when received. Follow-up to integrate the product smoothly into your system. Ask the people on Titan, Atlas, F8U, Talos, Nike Zeus, Skybolt, Polaris, Discoverer, Mercury. You'll hear: **When it's from Giannini Controls you get it on time, it works when you get it, and it keeps on working.**

Giannini Controls Corporation 1600 South Mountain Avenue, Duarte, California

A NAME TO PLAN WITH

SERVO COMPONENTS & SYSTEMS • AIR DATA INSTRUMENTS & SYSTEMS • INERTIAL INSTRUMENTS & SYSTEMS

Plant locations: Duarte, Pasadena, Glendora & Glendale, California • Caldwell, N. J. • Centerbrook, Conn. • Berwyn, Pa. CCC 1-38



In less time than it takes light to cross this room, a new product, **DELCO'S NEW** high speed **10 MC** silicon modules, could: (1) correct the course of a missile in flight; (2) make it possible for sonar pickups to track and compute the position of targets with microsecond accuracy; and (3) handle any number of other airborne guidance and control functions that previous modules—due to low speed or environmental or performance limitations—could not handle. Delco Radio's 10mc modules, with a maximum gate-switch speed of 40 nanoseconds, convert data 100 times faster—even under the most extreme environmental conditions.

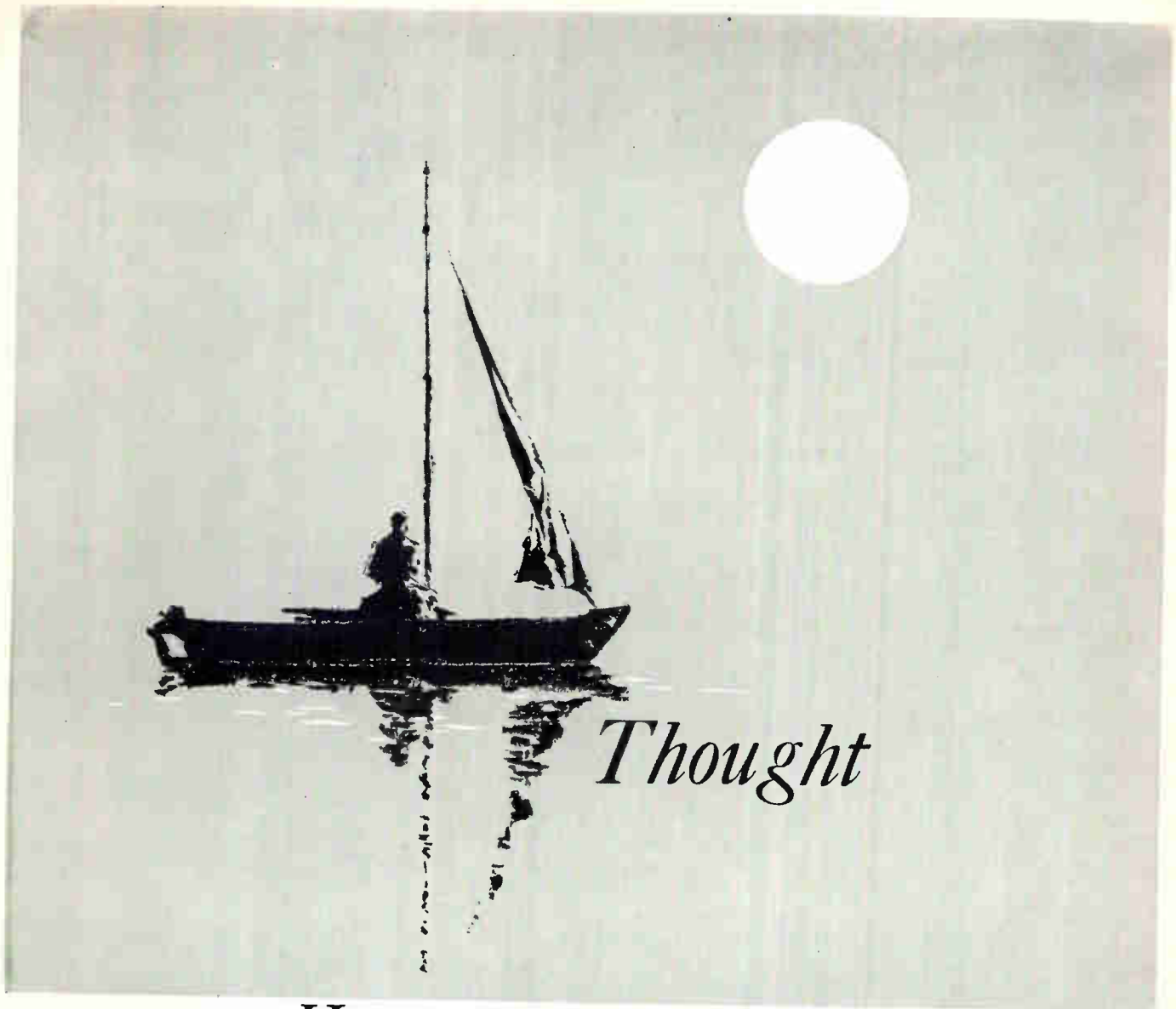
These **SILICON** modules come epoxy encapsulated, and operate over a temperature range of −55°C to +100°C. And these same reliable **DIGITAL** circuits are available packaged on plug-in circuit cards. These Delco **MODULES** are environmentally proved to: **SHOCK**, 1,000G's in all planes. **VIBRATION**, 15G's at 10 to 2,000 cps. **HUMIDITY**, 95% at max. temp. **STORAGE AND STERILIZATION TEMP.** −65°C to +125°C. **ACCELERATION**, 20G's. Designed for systems using from one module to 100,000, and the module's rated performance considers the problems of interconnection. Data sheets are available. Just write or call our Military Sales Department.

Physicists and electronics engineers: Join Delco Radio's search for new and better products through Solid State Physics.

PIONEERING ELECTRONIC PRODUCTS THROUGH SOLID STATE PHYSICS

Division of General Motors • Kokomo, Indiana

DELCO RADIO
DEPENDABILITY
RELIABILITY



How many never think . . . Taylor

An atmosphere of creativity is as much a part of the facilities of Guided Missiles Range Division as the funds and equipment necessary to carry out the programs assigned.

Now with emphasis on new explorations, the need is for technically respected people with leadership ability.

New career positions are available on the technical staffs of the Planning, Engineering and Operations Departments. Requirements are for physicists, engineers and mathematicians with B.S., M.S., and Ph.D. degrees.

A career with GMRD may well provide the career opportunity for you. Address your inquiry in confidence to: Professional Employment Manager, Guided Missiles Range Division, PAN AMERICAN WORLD AIRWAYS, INC., Dept. W-44, P. O. Box 4336, MU 113, Patrick Air Force Base, Florida. Inquiries will receive prompt replies and all qualified applicants will be considered for employment without regard to race, creed, color or national origin.

PAN AM

GUIDED MISSILES RANGE DIVISION

PATRICK AIR FORCE BASE, FLORIDA

FROM MOTOROLA....

POWER

NEW PNP GERMANIUM SERIES RATED AT

170 W. P_d

OPERATES UP TO

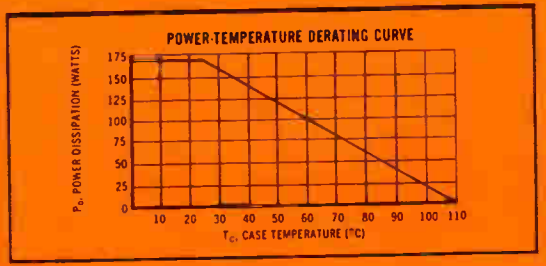
110° C. T_J

AVAILABLE WITH CERTIFIED RELIABILITY

"MEG-A-LIFE"

NEW 2N2075-82 SERIES OFFERS:

- **170 WATTS—93% greater power dissipation capability than conventional TO-36 power transistors.**
- **110° C. T_J — Maximum junction temperature rating (15° higher than conventional TO-36 units) provides added operating temperature safeguard and also increases allowable power dissipation at any given case temperature. In over 3,000,000 device hours of storage life testing at temperatures up to 150°C. the failure rate was only 0.030%/1000 hrs.**
- **"MEG-A-LIFE"—a program offering industrial users certified reliability based upon complete electrical, mechanical, and environmental tests to military type specs. Lot acceptance data and test results available to purchasers of "MEG-A-LIFE" versions of these devices.**



2N2075 SERIES, 15 AMP				
h_{FE}@ 5A	BV_{CES}			
	40V	50V	70V	80V
20–40	2N2078	2N2077	2N2076	2N2075
35–70	2N2082	2N2081	2N2080	2N2079

CIRCLE 68 ON READER SERVICE CARD

THE LEADER IN TRANSISTORS

Plus this most complete line of other TO-36 and TO-3 devices

TO-3

TO-36

3 AMP* P_D = 90 watts, T_j max = 100°C

h_{FE} @ 1.5 A	BV_{CES}				
	30V	45V	60V	75V	90V
30–60	2N2137	2N2138	2N2139	2N2140	2N2141
50–100	2N2142	2N2143	2N2144	2N2145	2N2146

3 AMP P_D = 90 watts, T_j max = 100°C

h_{FE} @ 1 A	BV_{CES}			
	40V	60V	75V	100V
60–140	2N1360	2N618	2N1363	2N1365
35–90	2N1359	2N375	2N1362	2N1364

5 AMP* P_D = 90 watts, T_j max = 100°C

h_{FE} @ 3 A	BV_{CES}				
	30V	45V	60V	75V	90V
75–150	2N1544	2N1545	2N1546	2N1547	2N1548
50–100	2N1539	2N1540	2N1541	2N1542	2N1543
35–70	2N1534	2N1535	2N1536	2N1537	2N1538
20–40	2N1529	2N1530	2N1531	2N1532	2N1533

10 AMP P_D = 90 watts, T_j max = 100°C

h_{FE} @ 10 A	BV_{CES}			
	30V	45V	60V	75V
10–30	2N627	2N628	2N629	2N630

15 AMP P_D = 150 watts, T_j max = 100°C

h_{FE} @ 5 A	BV_{CES}				
	40V	45V	50V	70V	80V
20–40	2N441	2N442	2N443	h_{FE} 25–50 2N174	h_{FE} 25–50 2N1100
35–70	2N277	2N278	2N173	2N1099	

15 AMP* P_D = 90 watts, T_j max = 100°C

h_{FE} @ 10 A	BV_{CES}			
	30V	45V	60V	75V
50–100	2N1557	2N1558	2N1559	2N1560
30–60	2N1553	2N1554	2N1555	2N1556
10–30	2N1549	2N1550	2N1551	2N1552

25 AMP* P_D = 90 watts, T_j max = 100°C

h_{FE} @ 25 A	BV_{CES}		
	35V	60V	75V
15–65	2N1162 2N1163	2N1164 2N1165	2N1166 2N1167

MILITARY TYPES

		BV_{CBO}	BV_{CES}	h_{FE} / I_C
○	JAN 2N174	80V	70V	40–80/1.2A
○	2N297A (Sig C)	80V	50V	20 min/2A
○	2N297A	80V	50V	20 min/2A
○	2N1011 (Sig C)	80V	80V	30–75/3A
○	2N1011	80V	80V	30–75/3A
○	2N1120 (Sig C)	80V	70V	20–50/10A
○	2N1120	80V	70V	20–50/10A
□	2N1358 (Sig C)	80V	70V	25–50/5A
□	2N1358	80V	70V	25–50/5A
□	2N1412 (USN)	100V	80V	25–50/5A
□	2N1412	100V	80V	25–50/5A

*Available in "Meg-A-Life" types

POWER TRANSISTOR HANDBOOK
If you have not yet purchased this valuable reference book covering power transistor design considerations and applications, you may still obtain a copy from your Motorola distributor. Price is $2.

IMMEDIATE LOCAL AVAILABILITY—You may obtain sample or volume quantities of any of these devices by contacting your nearest Motorola distributor. Also be sure to ask for the complete Motorola Power Transistor Selection Chart, listing Motorola's new low prices.

DISTRIBUTORS:

PACIFIC
LOS ANGELES — Hamilton Electro Sales, K-Tronics
OAKLAND — Elmar Electronics
PALO ALTO — Hamilton Electro Sales - North
SAN DIEGO — San Delcor, Inc.
SEATTLE — Almac Electronics Corp.

MOUNTAIN STATES
DENVER — Inter-State Radio & Supply Co.

MIDWESTERN
CEDAR RAPIDS — Deeco, Inc.
CHICAGO — Allied Radio Corp., Newark Electronics Corp., Semiconductor Distributor Specialists, Inc.
CLEVELAND — Pioneer Electronic Supply Co.
DETROIT — Radio Specialties Co., Inc.
MINNEAPOLIS — Allied Electronic Corp.

SOUTHERN
BIRMINGHAM — Ack Semiconductors, Inc
MELBOURNE — Electronic Wholesalers, Inc.
MIAMI — Gulf Semiconductors, Inc

SOUTHWESTERN
DALLAS — Tekko, Inc
HOUSTON — Lenert Co
PHOENIX — Electronic Specialties Co

NEW ENGLAND
BOSTON — Cramer Electronics, Inc

EASTERN
BUFFALO — Summit Distributors, Inc.
CAMDEN — General Radio Supply Co., Inc
MINEOLA, L. I. — Schweber Electronics
NEW YORK — Milgray Electronics, Inc.
WASHINGTON — Electronic Wholesalers, Inc

OUTSIDE U. S. A.
CHICAGO — Motorola Overseas Corp

MOTOROLA
Semiconductor Products Inc.

A SUBSIDIARY OF MOTOROLA, INC

5005 EAST McDOWELL ROAD • PHOENIX 8, ARIZONA

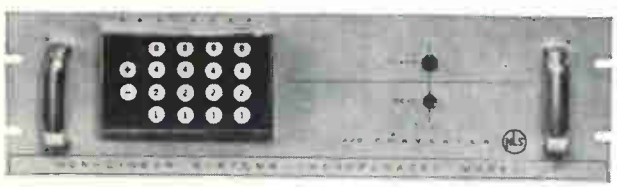
MOTOROLA DISTRICT OFFICES:
Belmont, Mass. / Burlingame, Calif. / Chicago / Clifton, N. J. / Dallas / Dayton / Detroit / Glenside, Pa. / Hollywood / Minneapolis / Orlando, Fla. / Phoenix / Silver Spring, Md. / Syracuse / Toronto, Canada.

CIRCLE 69 ON READER SERVICE CARD

NEW!

4 MAJOR DIGITAL VOLTMETER ADVANCEMENTS FROM NLS

Now Make 15,000 Highly Accurate DC Measurements/Sec... Measure VDC-Ratio-Ohms to Full 5 Digits ...Buy a Quality DVM or Ohmmeter for $1,460... Use Digital Voltmeters in Go/No-Go Testing



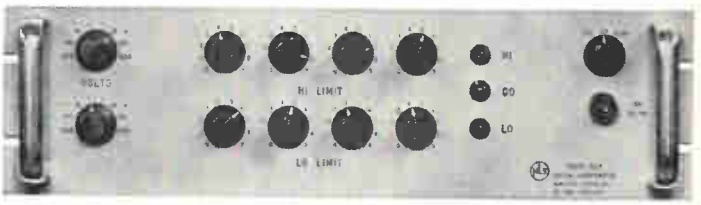
MODEL 15 A/D CONVERTER

M25 VOLT-RATIO-OHMMETER

484A VOLTMETER-RATIOMETER

Tax Line: The blue tag indicates that these new models are NLS "off-the-shelf" instruments. Call your nearest NLS office to see demonstrators in action today or take delivery on your own instrument within 10-30 days. Prices are F.O.B. destination in U.S.A.

784 DIGITAL OHMMETER



MODEL 54A DIGITAL COMPARATOR

MODEL 15 A/D CONVERTER — 4-digit instrument bringing high accuracy to high-speed measuring and data logging . . . 15,000 measurements/sec . . . accuracy: ±0.01% ± 1 digit from 0 to full scale from 0 to 40°C . . . any range from ±1 to ±100 v. full scale . . . true bipolar digital output, high output current, uses internal or external clock . . . constant input impedance. Price: $6,985.

M25 5-DIGIT VOLT-RATIO-OHMMETER — ultra-reliable instrument measuring DC volts, DC ratio and ohms with full 5-digit resolution of 0.001% and accuracy of ±0.01% of reading ± 1 digit over entire range of ±0.0001 to ±999.99 v. and .1 ohm to 1 meg . . . 10 to 1000 meg input z . . . twice speed of fastest stepping switch DVMs . . . advanced transistor circuitry with ultra-reliable mercury relays with 171 years life expectancy . . . input filter . . . remotely programmable . . . fully automatic . . . data logging output . . . AC or low-level DC with accessories. Price: $5,685

484A DIGITAL VOLTMETER-RATIOMETER — most versatile and highest quality instrument at low cost . . . measures ±0.001 to ±999.9 VDC and DC ratio up to ±99.99% . . . ±0.01% accuracy . . . 10 meg input . . . auto range and polarity . . . input filter . . . built-in auto print control . . only a few dollars more than cheapest DVMs without such quality features as plug-in stepping switches that can be replaced in seconds for troubleshooting, snap-out readout, wire-wound resistors, epoxy fiberglass circuit boards . . . measures AC or low-level DC with accessories. Price: $1,460.

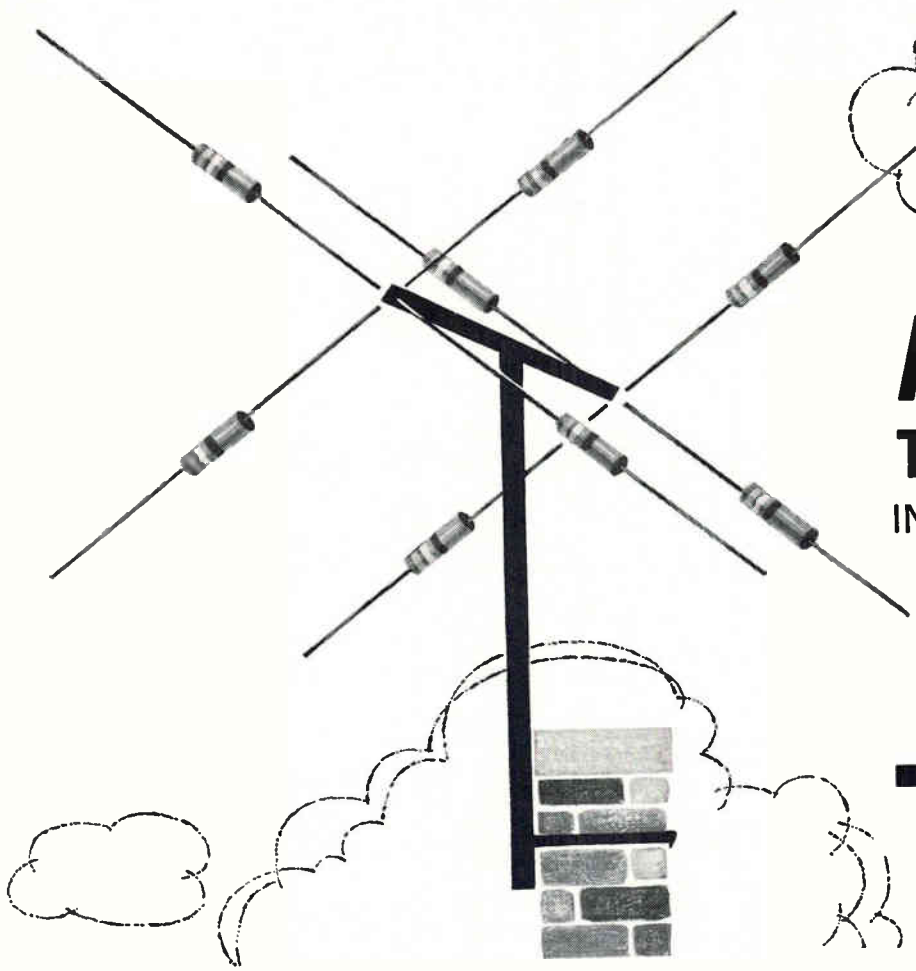
784 DIGITAL OHMMETER — for precise measuring and logging at low cost . . . same high quality features as 484A . . . measures 0.1 ohm to 10 megs with accuracy of ±0.05% ± 1 digit (±0.1% of reading above 5 megs) . . . auto ranging and auto control for data logging. Price: $1,460.

MODELS 54, 54A, 55, 55A DIGITAL COMPARATORS — for go/no-go testing, plug these into any NLS instrument having printer connection . . . limits set by BCD coded voltages, contact closures, or front panel knobs . . . each limit can be on any range and of either + or − polarity . . . signals TOO HIGH, TOO LOW, or OK to recording and control devices. Price $2,035 to $2,935.

Originator of the Digital Voltmeter

non-linear systems, inc.

DEL MAR, CALIFORNIA



ATTUNED TO YOUR NEEDS

INDUCTANCE INCREASED TENFOLD IN NEWEST

JEFFERS

MINI-STAB INDUCTORS

MINIature-**STAB**le

NEW TYPES EXTEND MINI-STAB INDUCTANCE RANGE TO 10,000 MICROHENRIES!

Now, from Jeffers Electronics, pioneers in MINIature, STABle inductors, come the most recent additions to the line—MINI-STAB Inductors Types 2 and 3. Supplementing the Jeffers Type 101 and MINI-STAB Type 1 line, the two new miniatures increase the inductance values available from Jeffers to a range of 0.15 to 10,000 uh.

Miniaturization PLUS Stability

In Jeffers MINI-STAB inductors, *miniaturization* is achieved through more efficient use of coil winding space. *Stability* is made possible through the use of an open magnetic circuit as obtained with a conventional powdered iron coil form.

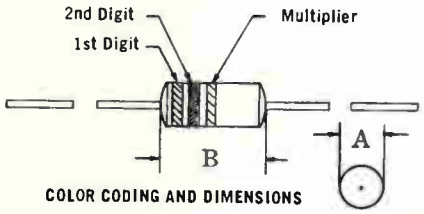
TYPICAL CHARACTERISTICS OF INDUCTOR DESIGNS BASED ON 1000 UH VALUE

INDUCTOR CHARACTERISTICS	JEFFERS MINI-STAB DESIGN	CONVENTIONAL DESIGNS	
		MINIATURIZED*	NON-MINIATURIZED
Miniaturization (wt. in grams)	1.0	0.5 to 2	2 to 10
Stability of Inductance with temp. −55 to +125°C	±2%	±10%	±2%
with applied current (zero to 90 MA)	−1%	−30%	NIL
with applied voltage (test or signal)	GOOD	POOR	GOOD

*Utilizing closed magnetic circuits such as toroids, cup-cores, etc.

A comparison of typical MINI-STAB performance with that of conventional miniaturized and non-miniaturized inductors appears above. Inductor designs of the closed magnetic circuit type such as toroids, cup cores, etc. tend to be inherently unstable.

THIS IS THE EXPANDED MINI-STAB LINE



COLOR CODING AND DIMENSIONS

TYPE	A±.015	B±.015	LEADS
1	.190	.440	AWG. #22 1 5/16 Min. Length
2	.220	.600	AWG. #21 1 5/16 Min. Length
3	.240	.740	AWG. #20 1 5/16 Min. Length

MINI-STAB TYPE 1

PART NUMBER	TYPE	INDUCTANCE (Microhenries)	MEAS. FREQ. (MC)	Q MIN.	SRF MIN. (MC)	D.C. RES. MAX. at 25°C (OHMS)	CURRENT* RATING (MA)	COLOR-CODING		
								1st	2nd	3rd
1311-1	1	18 ± 10%	2.5	50	25	1.8	315	BRN	GRY	BLK
1311-2	1	22 ± 10%	2.5	50	24	2.0	300	RED	RED	BLK
1311-3	1	27 ± 10%	2.5	50	20	2.8	255	RED	VLT	BLK
1321-1	1	33 ± 10%	2.5	50	19	2.5	270	ORG	ORG	BLK
1321-2	1	39 ± 10%	2.5	50	18	3.0	245	ORG	WHT	BLK
1321-3	1	47 ± 10%	2.5	50	17	3.5	225	YEL	VLT	BLK
1321-4	1	56 ± 10%	2.5	50	15	4.2	205	GRN	BLU	BLK
1321-5	1	68 ± 10%	2.5	50	14	5.0	190	BLU	GRY	BLK
1321-6	1	82 ± 10%	2.5	50	12	5.5	180	GRY	RED	BLK
1321-7	1	100 ± 10%	2.5	50	11	6.0	170	BRN	BLK	BRN
1321-8	1	120 ± 10%	0.79	50	9.0	7.0	160	BRN	RED	BRN
1321-9	1	150 ± 10%	0.79	50	8.6	8.0	150	BRN	GRN	BRN
1321-10	1	180 ± 10%	0.79	50	8.0	9.0	140	BRN	GRY	BRN
1321-11	1	220 ± 10%	0.79	50	6.6	10.0	130	RED	RED	BRN
1331-1	1	270 ± 10%	0.79	45	4.0	6.8	165	RED	VLT	BRN
1331-2	1	330 ± 10%	0.79	45	3.6	7.4	155	ORG	ORG	BRN
1331-3	1	390 ± 10%	0.79	45	3.4	10.6	130	ORG	WHT	BRN
1331-4	1	470 ± 10%	0.79	45	3.1	11.5	125	YEL	VLT	BRN
1331-5	1	560 ± 10%	0.79	55	2.9	15.2	110	GRN	BLU	BRN
1331-6	1	680 ± 10%	0.79	50	2.6	17.0	105	BLU	GRY	BRN
1331-7	1	820 ± 10%	0.79	50	2.4	19.0	100	GRY	RED	BRN
1331-8	1	1000 ± 10%	0.79	45	2.2	21.3	90	BRN	BLK	RED

NEWEST MINI-STAB TYPES 2 AND 3

1312-1	2	1200 ± 10%	.25	60	2.2	21.0	110	BRN	RED	RED
1312-2	2	1500 ± 10%	.25	60	2.1	24.0	105	BRN	GRN	RED
1312-3	2	1800 ± 10%	.25	65	1.9	27.0	100	BRN	GRY	RED
1312-4	2	2200 ± 10%	.25	70	1.7	30.0	95	RED	RED	RED
1312-5	2	2700 ± 10%	.25	70	1.6	33.0	90	RED	VLT	RED
1312-6	2	3300 ± 10%	.25	70	1.4	37.0	85	ORG	ORG	RED
1313-1	3	3900 ± 10%	.25	75	1.5	44.0	90	ORG	WHT	RED
1313-2	3	4700 ± 10%	.25	80	1.4	49.0	85	YEL	VLT	RED
1313-3	3	5600 ± 10%	.25	80	1.2	54.0	80	GRN	BLU	RED
1313-4	3	6800 ± 10%	.25	80	1.1	60.0	75	BLU	GRY	RED
1313-5	3	8200 ± 10%	.25	80	1.0	67.0	70	GRY	RED	RED
1313-6	3	10000 ± 10%	.25	80	0.9	75.0	70	BRN	BLK	ORG

*Based on a 25° C Maximum Temperature Rise.

MINI-STAB inductors are capable of meeting the requirements of MIL-C-15305, Grade 1, Class B, as outlined in Jeffers Product Specification SK-393. Details are available on request.

JEFFERS ELECTRONICS DIVISION

SPEER CARBON COMPANY INC.

DU BOIS, PENNSYLVANIA

Other Electronics Divisions of Speer Carbon Company—

Onondaga Electronics, Syracuse, N.Y. · Speer Resistor, Bradford, Pa.

TOLERANCE BE DAMNED

You won't see this statement framed and hung on the walls. You won't find it tacked to a designer's board, or spoken aloud in the die shops. "Tolerance be damned" is not a slogan.

It's an attitude.

In precision machining, tolerance is an allowance for error. Someone stakes out a fence; within it you have permission to go wrong.

At Republic, the Special Products division—designers, tool makers, engineers—have a frank disrespect for what's merely allowable. They worship the absolute. They stay up nights shooting for it.

Take the SPG-51, employing a plastic radar reflector. Raytheon's specifications: that the reflector be operable in winds up to 120 knots, that it operate immediately after a total shock load of 80 tons, that its weight not exceed 400 pounds, that its front surface be within ±.026 of a true parabola, that it not take more than 8 weeks to produce.

Two weeks before deadline Raytheon was invited to inspect the finished reflector. Their findings: for a start, it would operate in hurricane force winds, would recover instantly from 80 ton shocks.

Then came the dividends.

Republic's reflector weighed 51 pounds less than the limit. The entire mold surface trued to .018 of an absolute parabola. This was eight one-thousandths of an inch more accurate than tolerance requirements.

The SPG-51 reflector went into production—three a month. As an extra fillip, the Special Products group lopped another 25 pounds off weight, without reducing structural integrity. Nobody asked them to, they simply didn't give a damn for tolerance.

Special Products and Services will research, design, test and produce radar reflectors, antennas, and radomes from undersea to outer space. They do the same for mechanical and electrical assemblies of any nature. They're a part of Republic, where everyone shoots for the absolute.

That's an edge which cuts both ways. One edge is yours.

REPUBLIC
AVIATION CORPORATION
FARMINGDALE, LONG ISLAND, N.Y.

HOOK UP

Hook up with Cain & Company's specialized capabilities in the microwave field. Cain & Company provides a unique nationwide network of applications specialists... full-range microwave systems and component coverage. The result: faster, better assistance in your microwave system design problems. Through its nationwide representation of **SPERRY ELECTRONIC TUBE DIVISION**, **REMANCO**, **TRAK ELECTRONICS** and **TRAK MICROWAVE**, Cain & Company offers the most advanced klystrons, traveling wave tubes, backward wave oscillators, miniature microwave signal sources, harmonic multipliers, radar simulators, beacon test sets, radar performance monitors and specialized receivers. Your nearby Cain & Company application specialist will be glad to help you. Give him a call.

CAIN & COMPANY 2615 WEST MAGNOLIA BOULEVARD, BURBANK, CALIFORNIA

Offices in: **NEW YORK** (Great Neck), **CHICAGO, ST. PETERSBURG, BOSTON** (Lexington), **PHILADELPHIA, WASHINGTON, D.C., DAYTON** (Yellow Springs), **DALLAS** (Irving), **ALBUQUERQUE, SAN FRANCISCO** (Los Altos), **SAN DIEGO, SEATTLE**

CIRCLE 75 ON READER SERVICE CARD

AFFORDS CONTINUOUS HIGH-TEMPERATURE OPERATION UP TO 250 C—

HERE'S NEWS ABOUT ANACONDA ML

The exceptional heat stability of Anaconda ML Magnet Wire makes it ideal for electrical equipment operating at continuous high temperatures up to 250 C — such as high-temperature motors, relays and dry-type transformers. This same heat-resistant characteristic also makes ML Magnet Wire a valuable tool in miniaturization and in reducing the size of larger equip ment.

Tremendous overload resistance (as demonstrated by thermo-plastic flow above 500 C and heat shock resistance over 400 C) makes ML Magnet Wire particularly suitable for portable tool armatures and other applications where "stall" conditions or unusual overloads may be experienced.

Essentially zero weight loss to 200 C makes it possible to use ML Magnet Wire for relays that will operate at temperatures up to 250 C with low space factor and comparatively low cost. Using ML Magnet Wire in sealed relays practically eliminates contact contamination due to "outgassing" of wire insulation.

Other ML Magnet Wire advantages: high burn-out resistance and cut-through level; dry dielectric strength over 3,000 V/Mil; excellent flexibility; good windability and scrape resistance.

ML Magnet Wire is coated with a solution of ML Polymer, a new chemical development by duPont that represents a tremendous improvement in heat resistance over organic coatings. ML

RESISTS HEAT SHOCK UP TO 425 C

FILM-COATED MAGNET WIRE FOR 220 C

Magnet Wire can be used as a replacement for most film-coated magnet wires, except solderable types, and many glass and glass Dacron wires. Where the positive inorganic spacing of glass is required, the combination of ML film and glass serving offers outstanding properties. ML Magnet Wire's combination of high temperature rating, excellent winding characteristics and space factor permits its use in many applications which formerly required the use of much more expensive combinations of ceramics and fluorocarbons.

ML Magnet Wire is available in all sizes of round, square and rectangular. Film additions are single, heavy, triple or quadruple thicknesses, all conforming with NEMA specifications. ML also meets all requirements of Spec. MIL-W-583B for Class 180 Types H, H2, H3, and H4, and Class 200 Types K, K2, K3, and K4. For prices, technical data and applications engineering information, contact Department EFL, Anaconda Wire and Cable Company, 25 Broadway, New York 4, New York.

61269R

ASK THE MAN FROM

ANACONDA®

FOR ML MAGNET WIRE

CIRCLE 77 ON READER SERVICE CARD

Now! High Power Level from your present signal generator—

10 Volts/50 Ohms
10 to 500 Mc

—with the new BRC Type 230-A Signal Generator Power Amplifier

RF RANGE
10 to 500 MC

RF OUTPUT
RANGE:
0.1 to 15 volts*
*Across external 50 ohm load
IMPEDANCE:
50 ohms

RF INPUT
RANGE:
0.2 volts*, 10 to 250 MC
0.32 volts*, 250 to 400 MC
0.4 volts*, 400 to 500 MC
*For 10 volt output
IMPEDANCE
50 ohms

AM RANGE
Reproduces modulation of driving signal generator 0 to 100% up to 5 volt max. carrier output

AM DISTORTION
<10% added to modulation of driving signal generator

AM FIDELITY
Equivalent base-band bandwidth>350 KC

FM RANGE
Reproduces modulation of driving signal generator to adequately serve all presently established FM services

FM OISTORTION
Negligible distortion added to modulation of driving signal generator

INCIDENTAL AM
<10%* added to modulation of driving signal generator
*At 150 KC FM deviation

PM RISE TIME
<1 μsec

POWER REQUIREMENTS
105-125/210-250 volts, 50-60 cps

The new Signal Generator Power Amplifier Type 230-A is the ideal solution to your high RF power requirements including receiver testing, wattmeter calibration, antenna testing, filter and component testing, and attenuation measurements. The amplifier may be conveniently driven with any conventional signal generator and is designed to reproduce AM, FM, and pulse modulation characteristics of the driving generator with minimum distortion.

The new Signal Generator Power Amplifier Type 230-A employs three tuned, cascaded stages of grounded-grid amplification fed from a regulated power supply. An RF output voltmeter is also included and the unit is designed for either standard 19" rack or cabinet mounting.

Price: **$875.00**
F.O.B. Boonton, New Jersey

BOONTON RADIO CORPORATION
A Subsidiary of Hewlett-Packard Company

P.O. BOX 390
BOONTON, NEW JERSEY
Precision Electronic Instruments since 1934

TELEPHONE: OAKWOOD 7-6400 • TWX: BOONTON, NEW JERSEY 866 • CABLE ADDRESS: BOONRACO

CIRCLE 79 ON READER SERVICE CARD→

Component Testing Systems... products of TI experience

TACT — Transistor And Component Tester. A universally applicable component tester . . . sequentially controlled . . . 24 test parameters . . . punch-card programming.

SMART — Sequential Mechanism for Automatic Recording and Testing. For fast, accurate volume testing of semiconductor devices and other electronic components.

DART — Diode Automatic Reliability Tester. High to very low current range through scanner. Defines leakage to 1 nanoamp.

Providing the sophisticated equipment for fast, accurate, and low unit cost component testing is a natural extension of Texas Instruments semiconductor technology. From the earliest days of transistors, TI has developed test equipment to satisfy the ever-increasing demand for greater reliability assurance and quality control. Equipment has ranged from simple, single-test devices to completely automated, high-speed production testing and sorting systems. Today, numerous government agencies, military and civilian facilities, plus the world's largest semiconductor test center in TI's own plant rely on test systems designed and manufactured by Texas Instruments.

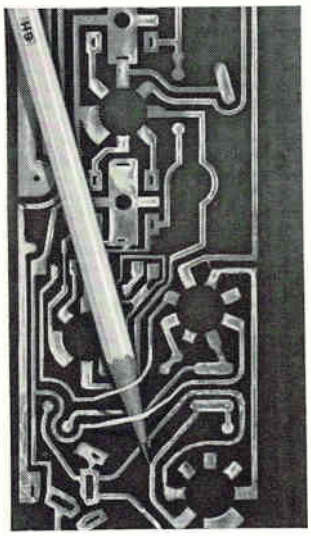
However simple or complex your testing-recording requirements, TI can engineer and produce a system for maximum efficiency and economy in your specific application.

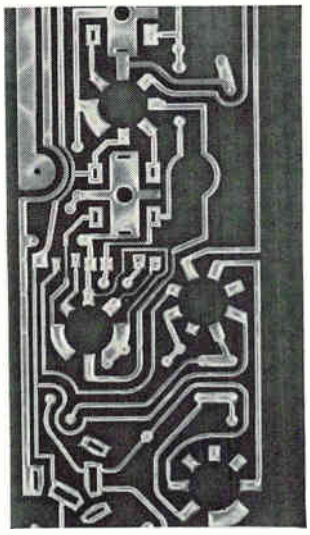
Write for complete information.

APPARATUS DIVISION
PLANTS IN HOUSTON
AND DALLAS, TEXAS

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

NEW
HOT PEEL STRENGTH COPPER-CLAD LAMINATE
at no increase in price!





NOT THIS . . . **BUT THIS**

Many wire failures are occurring in the soldering operation—at temperatures of 500°F—not at room temperatures. Printed circuit users therefore realize a real need for copper-clad laminates with HOT Peel Strength.

Synthane has developed a new grade of copper-clad laminate, G-10R, which meets or exceeds NEMA and MIL room temperature peel strength (9 lbs. per inch of width) and, in addition, has a hot peel strength, using 2-oz. copper, of 2 to 4 lbs. per inch of width (instead of the usual 0.1 to 0.2 lbs. per inch of width) measured on 1/16" and 1/8" widths.

G-10R uses no structural adhesive, meets all G-10 specifications, and doesn't cost a penny more.

AVAILABLE IMMEDIATELY

in sheets 36" x 36" and 36" x 48" with the usual copper foil thicknesses.

SYNTHANE
CORPORATION OAKS, PENNA.

Synthane Corporation, 44 River Rd., Oaks, Pa.
Gentlemen:
Please send me your latest brochure on Synthane G-10R and other Synthane copper-clad laminates.

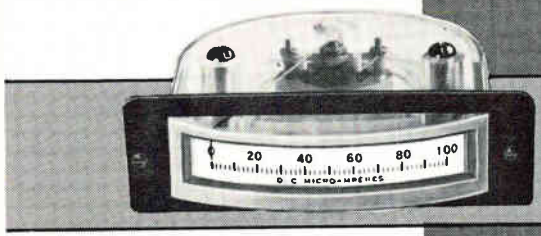
Name_____

Address_____

City_____ Zone____ State_____

80 CIRCLE 80 ON READER SERVICE CARD

BEEDE E-25



EDGEWISE METER

. . . can be used in either Horizontal or Vertical position—may be paired for comparative reading

Conserves space where panel area is limited

BEEDE ELECTRICAL INSTRUMENT CO., INC.
PENACOOK, N. H.

CIRCLE 230 ON READER SERVICE CARD

L & R ULTRASONIC CLEANING SOLUTIONS

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

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

L & R Hydro-Sonic
Cleaning Solution Concentrate

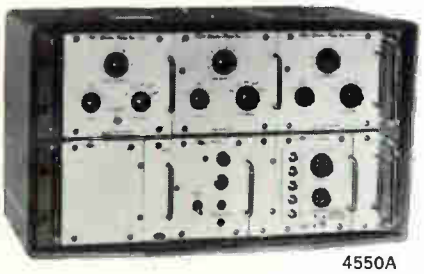
are *specific!*

We'll prove it! Send us small parts you find difficult to clean for test cleaning in our laboratory. We will do the job and return the cleaned parts to you, together with a recommendation for the right L & R cleaning solution which you can use in your ultrasonic cleaning equipment. For over 30 years L & R has been a world leader in precision cleaning for the watch and instrument fields. This experience is at your disposal. Or write for a copy of our latest catalog describing L & R's ultrasonic cleaning and rinsing solutions and ultrasonic cleaning equipment.

WATCHWORD OF THE WATCHMAKER
L & R MANUFACTURING COMPANY
577 Elm Street, Kearny, N. J. · Chicago 2, Ill. · Los Angeles 13, Calif.

CIRCLE 231 ON READER SERVICE CAR

Electro-Pulse 10 mc pulse generator called 'workhorse of engineering lab'



4550A

Computer makers eye high rep rate and 10 nanosec rise time

Workhorse of the engineering lab... with a wide range of rep rates, delay times, and pulse widths...the modular *Electro-Pulse* 4550A pulse generator is designed to fulfill the demand for ultra-reliable generation of variable parameter test pulses at very high rep rates.

Featuring fast rise time of 10 nanoseconds, rep rate going out to 10 mc, and variable delay and width, this flexible pulse instrument finds wide application in the development and test of components, logic circuitry, and high clock rate digital systems.

Typical applications of the compact, transistorized 10 mc pulse generator include:

- High-speed flip-flop design
- Multi-megacycle range clock pulse generation and regeneration
- Shift register drive
- Pulse timing for thin-film magnetic material switching
- High-speed code conversion circuit design
- Digital computer arithmetic and input-output development
- High rep rate resolving time studies

Solid state techniques are emphasized throughout the design. This provides maximum instrument reliability... together with minimum power drain, heat generation, size, and weight.

Unique circuit techniques provide unusual time base stability and low-jitter performance.

Modular plug-in construction gives the instrument extreme versatility. It is quickly and easily adapted to provide a broad number of optional performance capabilities. Maintenance is likewise simplified.

A variety of functional modules are designed to accomplish particular instrument functions. Front panel and controls are integrated for both electrical and mechanical standardization.

Exclusive repeatable digital dial settings, coupled with modular plug-in (front and rear) construction, make it unusually simple to program the instrument.

Through interchange of standard output amplifier modules, a wide choice of output characteristics may be obtained. Other options provide for peak current (300 ma), maximum voltage (20 volts), mixing of multiple channel outputs, and addition of complementary outputs from a single channel.

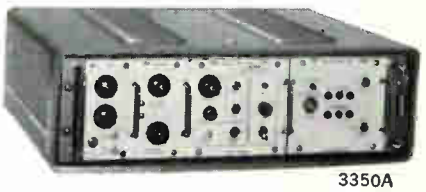
Extended performance capabilities (in addition to standard modifications) include: pulse train generation to 10 mc, coherent double pulse rate generation, multiple-channel pulse generation, and DC biased pulse generation.

One of 33 cataloged instruments in Servo's broad *Electro-Pulse* product line (which includes as many as 200 standard pulse and digital circuit modules—both tube and transistor types), the E-P 10 mc pulse generator couples advanced pulse techniques and circuitry with traditional Servo Corporation instrument quality and reliability.

For further details fill in coupon.

A wide choice of output characteristics is available by simply interchanging standard modular plug-in output amplifiers.

For all-purpose dependability, see the compact 3350A



3350A

Adaptable to console mounting in variety of test systems.

Rep rate: 0.5-500 KC

Output: ±35 V into 93 ohms

Pulse delay: continuously variable 0-10,000 μsec in 5-decade range

Pulse width: continuously variable 0.05-10,000 μsec

Wide-range performance covers a multitude of general-purpose applications in radar, navigational systems, digital computer, control system, and other pulse circuit test and design.

Servo Corporation of America
111 New South Road
Hicksville, L. I., N. Y.

Gentlemen:

☐ Please send detailed catalog.
☐ Please contact me for demonstration.
☐ Please send me a free SERVO slide rule.

(name)

(title)

(organization)

(address)

(city, zone, state)

Electro-Pulse Products

SERVO CORPORATION OF AMERICA

111 New South Road • Hicksville, L. I., N. Y. • WEIls 8-9700

Sales & service offices coast-to-coast • Representatives in major cities

single pulse generators · double pulse generators · word generators · pulse train and pulse code generators · time delay and gate generators · current generators and core testers · modules

Painting in background: "The Piping Shepherd," by Sir Joshua Reynolds, P. R. A. (1723–1792)

New cost savings for users of dielectric materials

. . . a progress report on the MYCALEX METHOD
from Jerome Taishoff, President, Mycalex Corporation of America

"I don't have to tell you about the profit squeeze. It's a hard fact-of-life throughout our industry today. That's why we feel the *MYCALEX METHOD*—the unique molding and finishing technique we recently developed—offers so much promise.

Sample quotations point to cost savings up to 84%

"The many months spent in the developing of this new process enable us to turn out better-performing products for less: savings we, in line with our policy, will pass along directly to our customers. And those savings promise to be substantial! Note the typical parts shown in the photograph below, as well as the two mechanical diagrams. As you can see, this new production technique reveals cost reductions of 78% and 84%, respectively, when compared to previous cost quotations." Just as important, the savings are in *addition to* the high reliability SUPRAMICA® ceramoplastics and MYCALEX® glass-bonded micas are noted for.

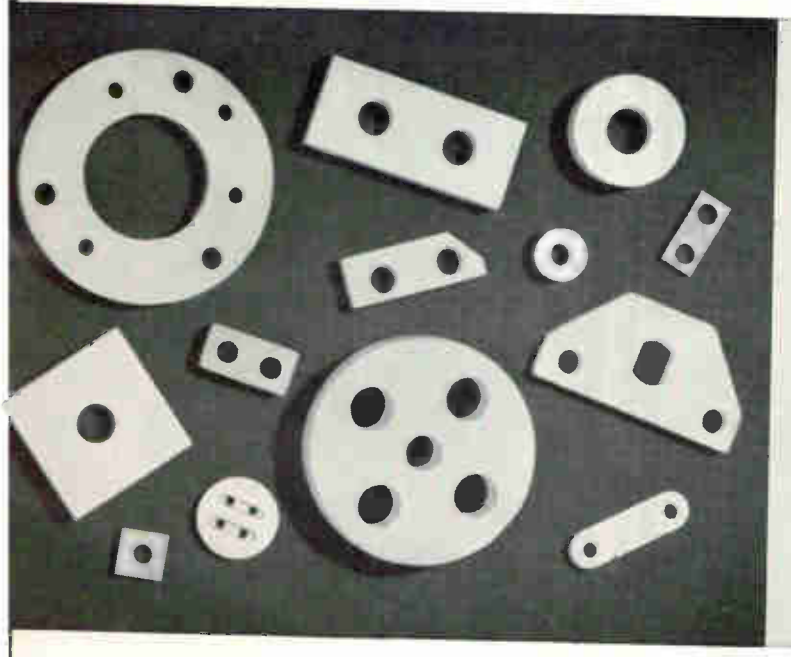
Savings plus quality with the MYCALEX METHOD

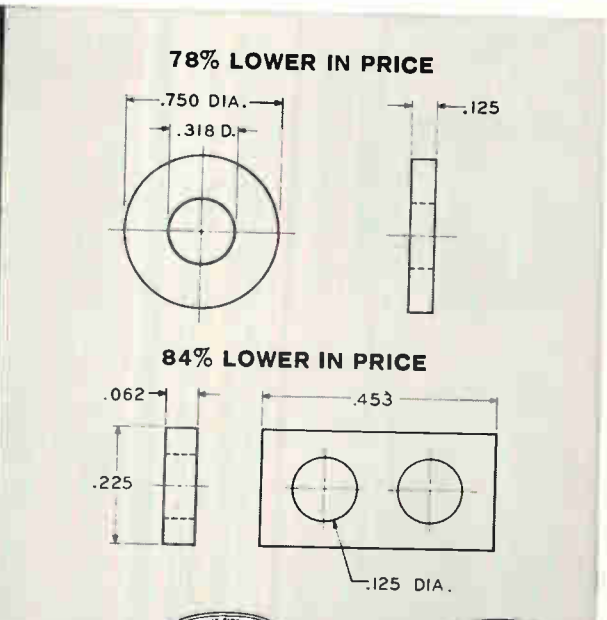
Though these intricate parts now cost much less to make—they offer the temperature endurance, total dimensional stability, high dielectric strength and low loss that SUPRAMICA and MYCALEX formulations have been delivering for years.

Choose from any of these famous materials

SUPRAMICA 620 "BB", 560 and 555 ceramoplastics and MYCALEX 410 glass-bonded mica. *Maximum Temperature Endurance* (unstressed): 1200, 930, 650 and 650°F; *Loss Factor* (10^6 cycles/sec.): 0.020, 0.010, 0.013, 0.010; *Compressive Strength* (psi): 30,000, 25,000, 40,000 and 40,000, respectively.

So for electronic insulation materials with the high-performance properties you must have—at a profit-protecting price — look into the new *MYCALEX METHOD*. Send your blueprints and drawings for specific quotations and information.





General Offices and Plant: 120 Clifton Boulevard, Clifton, N. J.
Executive Offices: 30 Rockefeller Plaza, New York 20, N. Y.

World's largest manufacturer of ceramoplastics, glass-bonded mica and synthetic mica products

SYNTHAMICA® SUPRAMICA® MYCALEX®

MYCALEX
CORPORATION OF AMERICA

CIRCLE 83 ON READER SERVICE CARD

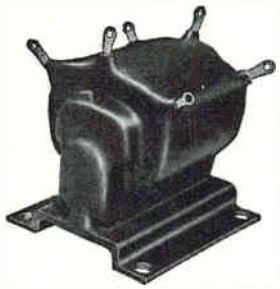
ONE CUSTOMER REPORTS ACME ELECTRIC TRANSFORMERS HAVE A RELIABILITY FACTOR OF

99.4%*

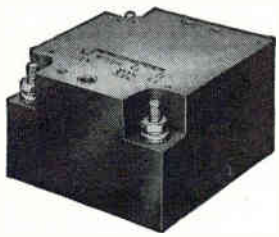
* The six-tenths of one-percent failure rate includes secondary failures caused by initial failures of one or more other components or external arcing.

Engineering "know-how" and manufacturing facilities are available at Acme Electric to produce high reliability transformers in prototype or production runs for applications with operating temperatures up to 350°C.

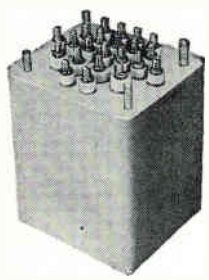
We invite your inquiry for transformers to be supplied



✓ ENCAPSULATED



✓ MOLDED



✓ HERMETICALLY SEALED

SAA3502/1958

ACME ELECTRIC CORPORATION
3111 Water Street Cuba, N. Y.
In Canada: Acme Electric Corp. Ltd., 50 Northline Rd., Toronto, Ontario

Acme ACME Electric

ARNOLD/TOROIDAL COIL WINDER

sets up quickly...easy to operate... takes wide range of wire sizes

SPECIFICATIONS:
- Min. finished hole size: .18 in.
- Max. finished toroid O.D.: 4.0 in.
- Winding speed: 1500 turns/min.
- Wire range: AWG 44 to AWG 26
- Dual, self-checking turns counting system
- Loading (wire length) counter
- Core range: ¼" I.D. to 4" O.D. to 1½" high

LABORATORY USE
- Change wire and core size in 45 sec.

PRODUCTION USE
- 1500 turns per minute
- Insert core and load in 20 sec.

$1200.00 *includes all rings, counters and accessories*
immediate delivery. literature on request

ARNOLD MAGNETICS CORP.
6050 W. Jefferson Blvd., Los Angeles 16, Calif.
VErmont 7-5313

CIRCLE 232 ON READER SERVICE CARD

BY-BUK

PRINTED CIRCUIT DRAFTING AIDS

Time Saving Shapes and Narrow Tape for Making Printed Circuit Master Drawings

"KWIKY-DOT" overlapping Donuts and solid Discs for quick and easy application.

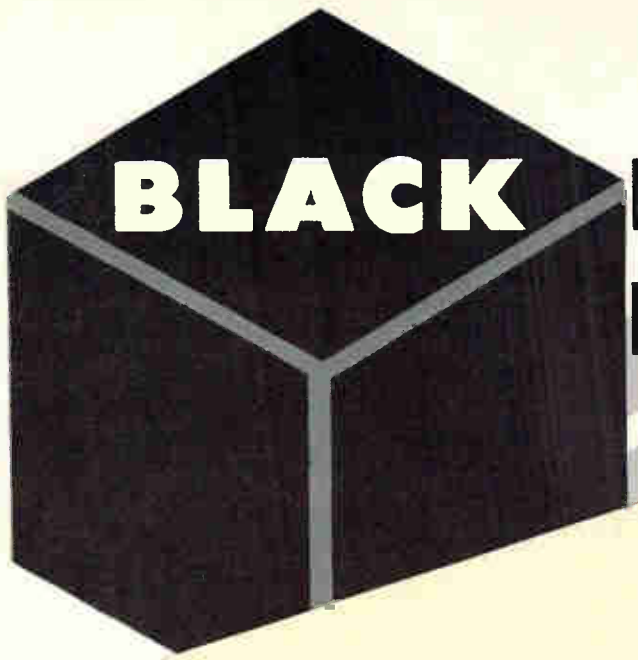
Pressure-sensitive Teardrops, Twin Pads, T's, and Corners.

Black non-stain, non-smudge narrow tape in 15 or 60 yd. rolls from 1/32" wide. Also red translucent and black on white.

WRITE FOR HANDY CROSS REFERENCE CHART, PRICE LIST AND FREE SAMPLES.

BY-BUK COMPANY
4314 WEST PICO BLVD. • LOS ANGELES 19, CALIF.
Same Day Shipment is Our Usual Service

CIRCLE 233 ON READER SERVICE CARD



BLACK BOX RF POWE

Missile and Space

PERHAPS THE BIG STEP forward on some other planet in another galaxy is to crawl out of the sea and explore the possibility of land existence. The goal on another may be to shorten the flight time of the scheduled vacation run to a moon or nearby planet.

We achieved the former some 350 million years ago. The latter is still some years away.

While information for comparing our accomplishment with those of other worlds is not yet [illegible], look at our progress in terms of an age-old dream [illegible] our goals and [illegible] made "arrows of flying fire" through the [illegible]'s progress under. In 1686, Sir Isaac Newton [illegible] satellite is placed in orbit. In [illegible] experiments with sky-

The world's [illegible] 2,000 years [illegible] come true by sending [illegible] air with black gunpowder. In 1903, Robert H. Goddard began experiments described how an earth satellite is placed in orbit. In 1906, Robert H. Goddard began experiments with rockets; in 1922 he tested his first one.

Only a little more than four years ago (Aug. 26, 1957), the Soviet Union announced the first successful flight of an ICBM; on Oct. 4, 1957, the first earth satellite. To date, the Russians have put 13 satellites into earth orbit (Lunik III went once around the moon and then into earth orbit; one on April 12, 1961 carried Yuri Gagarin; Vostok II, on Aug. 6, 1961 carried Gherman Titov), two in solar orbit (one was sent toward Venus from a parking orbit), and one crashed on the surface of the moon.

The U. S. has put 55 satellites in earth orbit, two around the sun; and sent two astronauts into space and down the Atlantic Missile range in Mercury capsules.

Today, the U. S. has 32 satellites in earth orbit and two in solar orbit; 13 of these are transmitting. The USSR has one satellite in earth orbit and two in solar orbit; none are transmitting.

Although the U. S. and Russia are the main participants in the missile and space effort, other nations are building missiles and are engaged in scientific space programs. NASA is stimulating the development of space research in more than two dozen foreign countries. Next year, both Canada and the United Kingdom will cooperate with the U. S. in joint satellite launchings. NASA is already active in joint sounding rocket experiments with Italy, Sweden, Norway and Australia.

Foreign countries are participating in our meteorological and communications satellite programs with their own ground stations and in our manned space flight program in stations we have set up on their territory.

U. S. GOALS AND ORGANIZATION—U. S. goals are divided by two distinct objectives: exploration and application. The most part by two g[illegible] on the environment of our The National [illegible] (NASA) is [illegible] system and galaxy by sounding rockets, interplanetary probes, and scientific satellites; studying practical applications of earth satellites for weather research and forecasting, long distance communication and navigation; and exploring the problems of man in space.

To defend the nation, the DOD is developing a striking force of missiles launched from the ground, air and space; manned and unmanned spacecraft; ground-based and space-based systems to detect and intercept enemy missiles, hostile satellites and other spacecraft; and satellite support systems for reconnaissance, communications, weather, navigation and geodesy.

Until recently the divergence in objectives of NASA and the DOD had little practical significance to industry. They have used essentially the same facilities and hardware to launch satellites and probes. Both have been experimenting. They have used existing rockets, experimental satellites and probes.

From now on, the different demands on industry. Although create different demands on industry. Although will continue to experiment, the DOD will "mass produce" (in the sense of the term) its satellite systems to perfecting operational systems. Key to sense of the term) its satellite systems to fulfill continuous operational requirement. The DOD will be long-tinuous operational requirement to the DOD will be long-tional equipment to the DOD will be long-existing and/or new techniques that outmode existing and/or new techniques that outmode existi

NASA's appropriations for fiscal year 1[illegible] $1,784,300,000. The DOD appropriation for fiscal year 1[illegible] development, test and evaluation for [illegible] to $1.398 billion; for missile procurement, [illegible] for space work, $757 million. The Atomic [illegible] mission has $79.2 million for Snap (Nuclear [illegible] ered rocket engine, and for Snap (Nuclear [illegible] auxiliary power) for spacecraft. (NASA works with AEC on Rover and Snap con[illegible]

The Weather Bureau's 1962 mo[illegible] satellite work is $52.97 million.

NASA's PLANS—NASA will [illegible]

MISSILE and SPACE ELECTRONICS

By JOHN F. MASON
Associate Editor

MICHAEL F. WOLFF
Senior Associate Editor

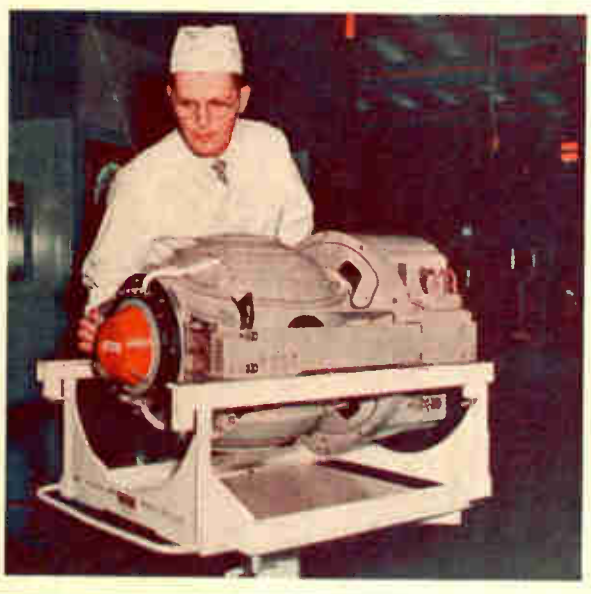
Missile and Space Plans

Guidance and Control

Data Acquisition and Transmission

Propulsion and Power Generation

Earth-Based Electronics



Mark 1 inertial guidance is used in first two versions of Navy's Polaris sublaunched ballistic missile

Missile and Space

PERHAPS THE BIG STEP forward on some other planet in another galaxy is to crawl out of the sea and explore the possibility of land existence. The goal on another may be to shorten the flight time of the scheduled vacation run to a moon or nearby planet.

We achieved the former some 350 million years ago. The latter is still some years away.

While information for comparing our accomplishments with those of other worlds is not yet available, we can look at our progress in terms of time. And we can examine our goals and what we must do to achieve them.

The world's progress has been recent and swift. Only 2,000 years ago, the Chinese made an age-old dream come true by sending "arrows of flying fire" through the air with black gunpowder. In 1686, Sir Isaac Newton described how an earth satellite is placed in orbit. In 1906, Robert H. Goddard began experiments with skyrockets; in 1922 he tested his first one.

Only a little more than four years ago (Aug. 26, 1957), tht Soviet Union announced the first successful flight of an ICBM; on Oct. 4, 1957, the first earth satellite. To date, the Russians have put 13 satellites into earth orbit (Lunik III went once around the moon and then into earth orbit; one on April 12, 1961 carried Yuri Gagarin; Vostok II, on Aug. 6, 1961 carried Gherman Titov), two in solar orbit (one was sent toward Venus from a parking orbit), and one crashed on the surface of the moon.

The U. S. has put 55 satellites in earth orbit, two around the sun; and sent two astronauts into space and down the Atlantic Missile range in Mercury capsules.

Today, the U. S. has 32 satellites in earth orbit and two in solar orbit; 13 of these are transmitting. The USSR has one satellite in earth orbit and two in solar orbit; none are transmitting.

Although the U. S. and Russia are the main participants in the missile and space effort, other nations are building missiles and are engaged in scientific space programs.

NASA is stimulating the development of space research in more than two dozen foreign countries. Next year, both Canada and the United Kingdom will cooperate with the U. S. in joint satellite launchings. NASA is already active in joint sounding rocket experiments with Italy, Sweden, Norway and Australia.

Foreign countries are participating in our meteorological and communications satellite programs with their own ground stations and in our manned space flight program in stations we have set up on their territory.

U. S. GOALS AND ORGANIZATION—U. S. goals are divided by two distinct objectives and administered for the most part by two government agencies.

The National Aeronautics and Space Administration (NASA) is charged with developing a comprehensive program for the study and peaceful utilization of space. The Department of Defense (DOD) is responsible for defending the nation against, as well as competing in, missile and aerospace warfare. Between the two agencies there is a free interchange of technical information.

NASA is gathering data on the environment of our solar system and galaxy by sounding rockets, interplanetary probes, and scientific satellites; studying practical applications of earth satellites for weather research and forecasting, long distance communication and navigation; and exploring the problems of man in space.

To defend the nation, the DOD is developing a striking force of missiles launched from the ground, air and space; manned and unmanned spacecraft; ground-based and space-based systems to detect and intercept enemy missiles, hostile satellites and other spacecraft; and satellite support systems for reconnaissance, communications, weather, navigation and geodesy.

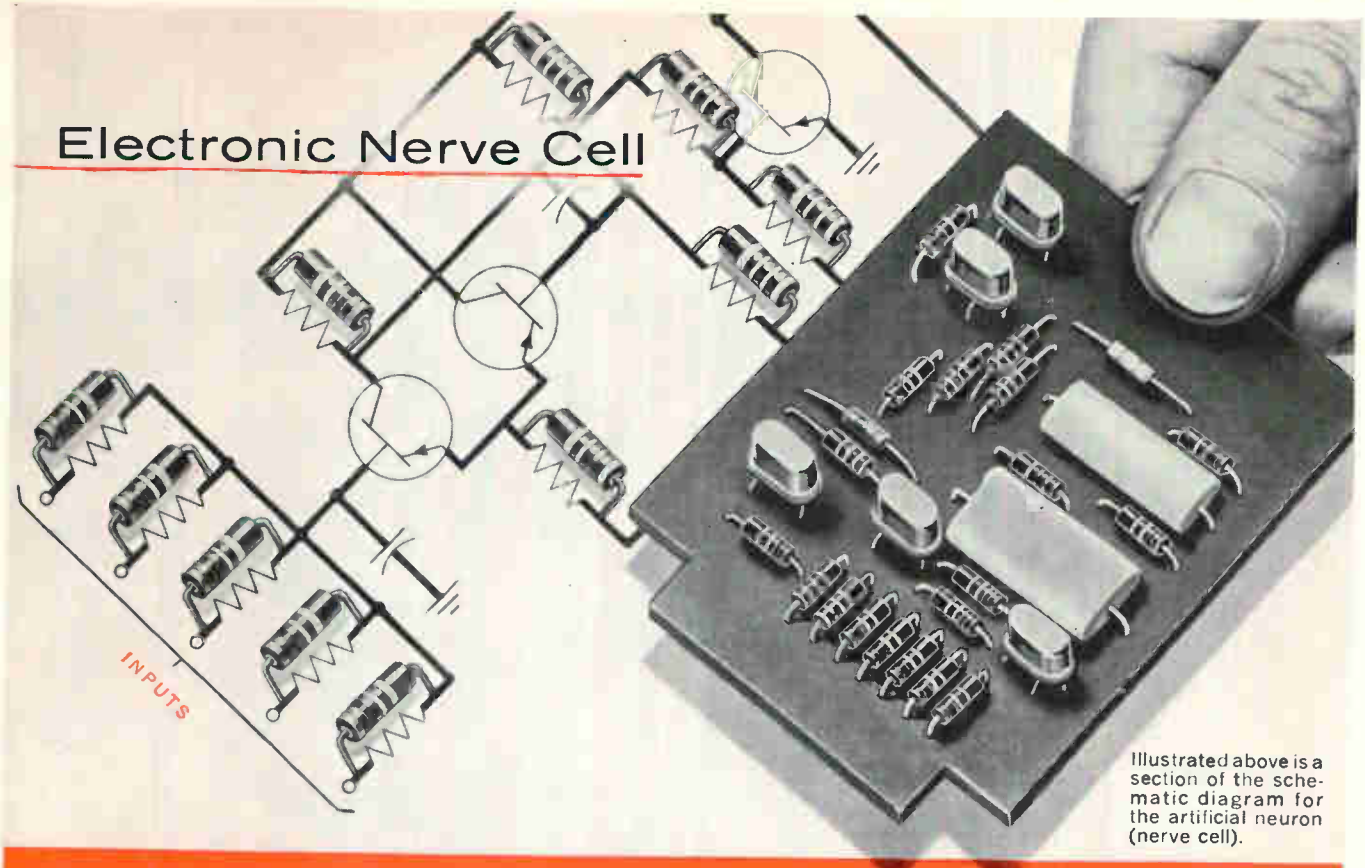
Until recently the divergence in objectives of NASA and the DOD had little practical significance to industry. Both have been experimenting. They have used essentially the same facilities and hardware to launch sounding rockets, experimental satellites and probes.

From now on, the different objectives will begin to create different demands on industry. Although both will continue to experiment, the DOD will work toward perfecting operational systems.

The DOD will "mass produce" (in the new restricted sense of the term) its satellite systems to fulfill a continuous operational requirement. Key to selling operational equipment to the DOD will be long-life reliability and/or new techniques that outmode existing gear.

NASA's appropriations for fiscal year 1962 amount to $1,784,300,000. The DOD appropriations for research, development, test and evaluation for missiles amount to $1.398 billion; for missile procurement, $4.196 billion; for space work, $757 million. The Atomic Energy Commission has $79.2 million for Rover, the nuclear-powered rocket engine, and for Snap (systems for nuclear auxiliary power) for spacecraft. (NASA will work jointly with AEC on Rover and Snap contributing $36 million.) The Weather Bureau's 1962 money for meteorological satellite work is $52.97 million.

NASA's PLANS—NASA will fire more than 300 sound-



Illustrated above is a section of the schematic diagram for the artificial neuron (nerve cell).

Goal of New Research Project: MORE EFFICIENT COMMUNICATION SYSTEMS

A-B QUALITY

Research to explore the information processing in nervous systems is now underway at Bell Telephone Laboratories. Here, scientists are experimenting with newly developed electronic elements which are designed to imitate the actions of a living nerve cell. Too little is yet known about living cells to permit exact electronic duplication. However, experiments with groups of artificial neurons have roughly duplicated some of the eye's basic reaction to light. This new approach to studying basic nerve network functions can provide clues for stimulating further exploration into the fundamentals of the transmission of intelligence.

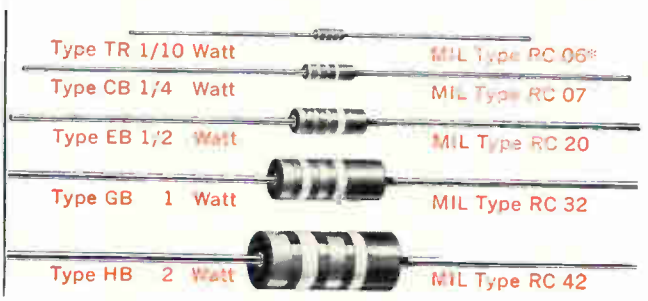
Allen-Bradley is very happy that the quality of their hot molded resistors caused them to be selected for these exacting experiments. With their uniform properties and conservative ratings—A-B resistors will provide the same superior performance in your electronic circuits. Be certain you specify A-B hot molded resistors—especially for your critical jobs. Send for Publication 6024.

A-B Hot Molded Composition Resistors

SHOWN ACTUAL SIZE

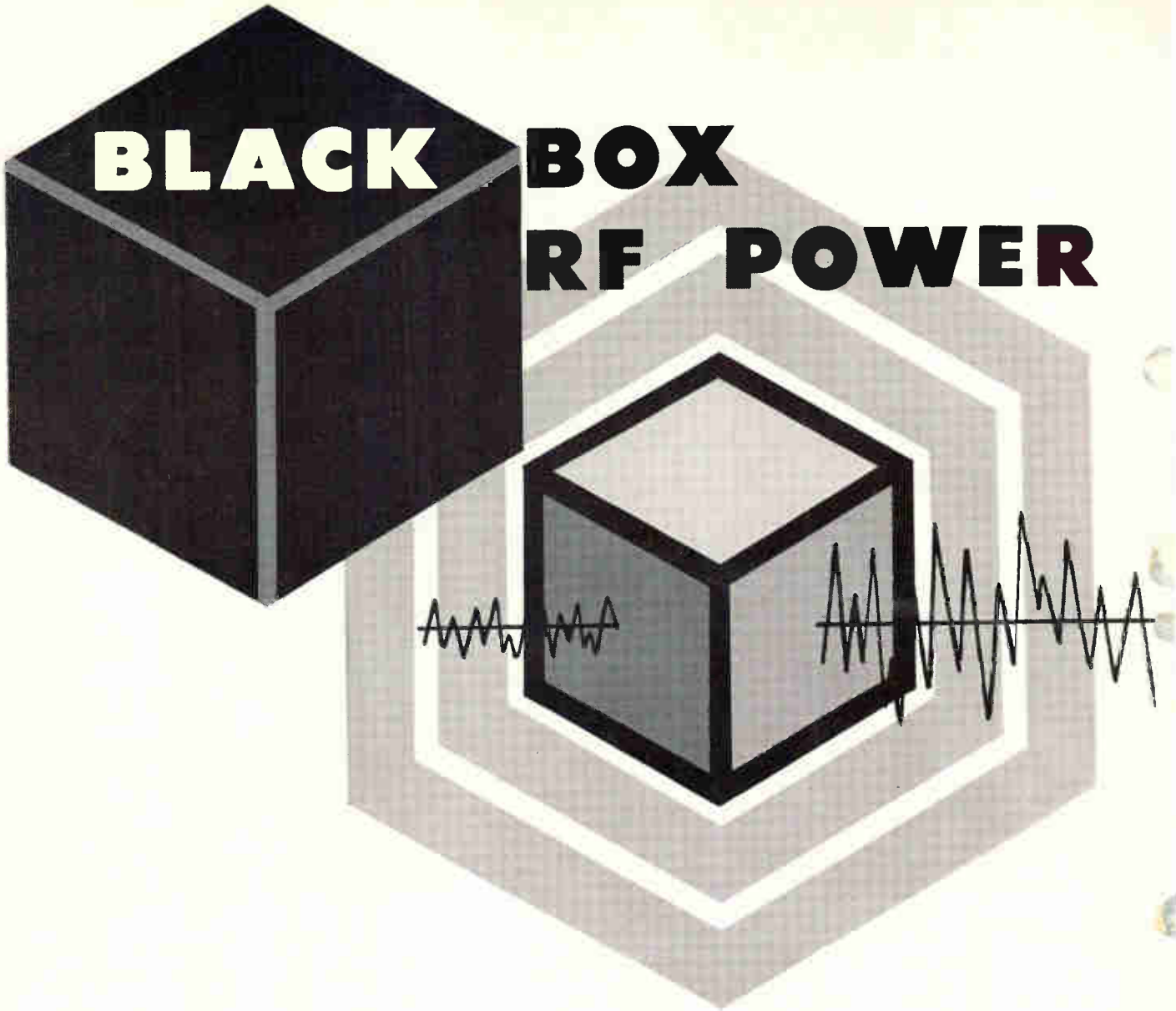
Hot molded composition resistors are available in all standard EIA and MIL-R-11 resistance values and tolerances.

*Pending MIL Spec Assignment



Allen-Bradley Co., 110 W. Greenfield Ave., Milwaukee 4, Wis. • In Canada: Allen-Bradley Canada Ltd., Galt, Ontario

ALLEN-BRADLEY Quality Electronic Components



RF Generators by ITA for every power level . . . every frequency!

ITA Electronics Corporation specializes in manufacturing black box RF power generating equipment for industry and research. One of the nation's leading producers of broadcasting and communications equipment, ITA has the experience with RF equipment to supply *any* power requirement . . . design units that will meet *any* need. ITA products—30 kc to 2000 mc with power levels from a few watts to megawatts—may be modified to perform many specialized functions. Custom equipment, for highly technical applications, can be purchased at very low cost with prompt delivery assured.

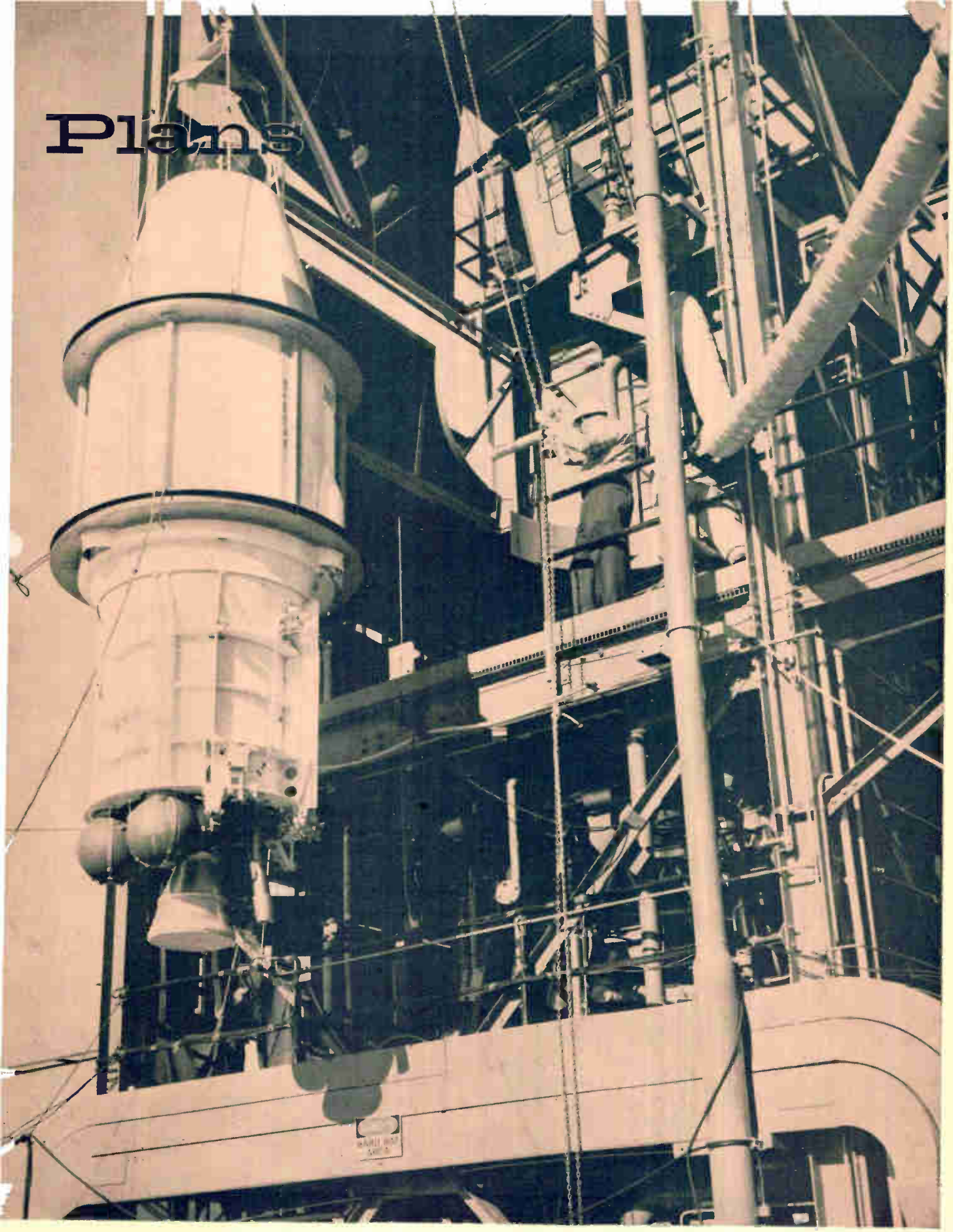
For the finest in RF power generators choose ITA. It's the *best* equipment made!

ITA ELECTRONICS CORPORATION

GOVERNMENT and INDUSTRIAL DIVISION • LANSDOWNE, PENNSYLVANIA

ITA SALES OFFICES:
Chicago, Ill. AN 3-3797
Cincinnati, Ohio. CH 1-6386
Dallas, Texas. FL 7-9607
Jacksonville, Fla. EL 6-0121
Kansas City, Mo. GR 1-2838
Lansdowne, Pa. CL 9-8200
Los Angeles, Cal. MA 2-8552
New York City, N.Y. CH 2-1999
Portland, Ore. CA 2-2651
Washington, D.C. 337-2884

ITA



Agena satellite vehicle is an off-the-shelf powered craft. Boosted by a Thor or an Atlas, it serves as the craft for USAF's Discoverer, Midas and Samos satellite programs, for NASA's satellite observatories, and will send Ranger 3 on its way to the moon (Lockheed Missiles and Space div.)

Schedule For Future NASA Spacecraft

	CALENDAR YEARS									
	61	62	63	64	65	66	67	68	69	70
SCIENTIFIC SATELLITES										
Orbiting Solar Observatory (OSO)		2	(number of follow-ons not decided)							
Orbiting Astronomical Observatory (OAO)			1	1	1	1	1	1	1	1
Eccentric Geophysical Observatory (EGO)			1	1	1	1	1	1	1	1
Polar Orbiting Geophysical Observatory (POGO)				1	1	1	1	1	1	1
Atmospheric Structures Satellite		1	1							
BIOS (Biological Investigations of Space)	1									
Electron Density Profile Probe (night)		1								
Swept-Frequencies Topside Sounder (Canada)		1								
Fixed-Frequency Topside Sounder		1								
International Ionosphere Satellite (UK-1)		1								
International Program Satellite (UK-2)			1							
METEOROLOGICAL SATELLITES										
Tiros	1	3								
Phase I: 1 Nimbus in orbit most of the time		2 Nim 1 b*	3 Nim 1 b							
Phase II: 1 Nim in orbit continuously, a 2nd in orbit most of the time, initiate use of data from R&D Aeros				3 Nim 1 b 1 A+	3 Nim 1 b 2 A					
Phase III: 2 Nim in orbit continuously, 1 Aeros (R&D) in orbit part of the time						3 Nim 1 b 2 A	} steady rate of Nimbus launches } continue R&D until operationally ready			
COMMUNICATIONS SATELLITES										
Echo (rigidized)		1								
Rebound (3 rigid spheres)			2							
Relay Phase I		2								
Relay Phase II		(not yet decided)								
Syncom		1	2							
AT&T's Telstar		2								
LUNAR EXPLORATION, UNMANNED										
Ranger	1	3	(schedule for Rangers 6-9 not announced)							
Surveyor			1st of series of 10 begins in 1963							
Prospector				(schedule not decided)						
PLANETARY AND INTERPLANETARY										
Planetary Launch Opportunities for Venus (V), Mars (M)		VM		VM	V		MV		VM	V
Mariner Interplanetary		(not yet decided)								
Mariner Fly-by (Venus)		1		1						
Mariner Fly-by (Mars)		(not yet decided)								
Voyager Orbit and Land (Venus)							1 (possibly)			
Voyager Orbit and Land (Mars)							1 (possibly)			
MANNED SPACE FLIGHT										
Mercury: Manned, 3-orbit	1									
Animals, 14 days		(Progressive steps needed to achieve goal for 1969 are too interrelated to forecast)								
Apollo: Long-duration, earth orbit; circumlunar flight; lunar landing & return									1	

*b — backup +A — Aeros

WHAT NASA NEEDS FROM OUR INDUSTRY

The major demand which will be placed on the electronics industry by the national space program during the next ten years can be described in one word—reliability.

There may be a need for new instruments, new systems and new techniques not yet defined, but without reliability of electronic components and systems a successful space program cannot be assured.

Since considerable cost is involved in placing a payload into space the requirements for components and systems that can operate unattended for years in the space environment are great.

Many scientific satellites, such as the Orbiting Astronomical Observatory, will have very complex electronic equipment and at least a one-year life requirement. For communications satellites, it is estimated that a lifetime of several years will be required before the system will become economically feasible.

There is a need for better methods for simulating the launch and space environment in order to test out more thoroughly components and systems. There is also the need for preparation of improved specifications, standards, quality assurance procedures as well as improved testing methods which will lead to reliability of space vehicle systems.

Another demand which the space program will place on industry is in the area of power supply—lower consumption and increased output.

Electronic systems using fewer watts of electrical power without sacrificing performance and reliability are, and will continue to be, needed. At the same time, NASA badly needs power supplies that can give from a few hundred to a few thousand watts for long periods of time.

There will be a continuing need for light-weight and compact instruments even when more powerful boosters become available. As the allowable payload weight grows, the more complex the mission will become, and this in turn will increase the need for even more sophistication!

HUGH L. DRYDEN
Deputy Administrator
National Aeronautics and Space Administration

ing rockets—which reach altitudes of from 150 to 4,000 mi—during the next 12 months to study aeronomy, energetic particles and fields, galactic astronomy, solar physics, ionospheric physics and meterorites. From Wallops Island, Va., NASA will soon begin firing Trailblazer II, fourth stage payload capsules that will powerdive toward earth from 190-mi altitudes as part of reentry physics studies for the Advanced Research Projects Agency's ballistic missile defense project, Defender.

NASA's scientific satellites are divided into geophysics projects concerned with the atmospheric and spatial environment in the vicinity of the earth, and the astronomy projects which are directed towards the sun, the solar system, and the universe around us.

Scientific satellities are undergoing a transition. The one-experiment satellite is giving way to heavy multiexperiment observatories. The 1,000-lb geophysical observatory (EGO and POGO) will be one of NASA's first standard satellites. It will accommodate 50 geophysical experiments. The largest being worked on now is the 3,300-lb astronomical observatory (OAO).

The push to land a man on the moon and get him safely back to earth before 1970—and, it is hoped, before the Soviets do—has accelerated and expanded the unmanned exploration of the moon, the planetary and interplanetary programs, changed the objectives of Mercury, compressed the timetable of Apollo, and speeded up the large booster projects—Centaur, Saturn, and Nova.

Current plans call for three spacecraft models for unmanned lunar missions—Ranger, Surveyor and Prospector. Contact will range from ellipitical-orbit flybys to landing, digging holes and crawling around on the moon's surface and returning to earth with the findings.

Concurrently, Mercury will soon make a manned 3-orbit flight, several manned 18-orbit flights over the next two years, then 14-day orbital flights carrying animals; Apollo, carrying three men, will make long-duration flights in earth orbit, circumlunar flights, and finally lunar landing, exploration and return.

Planetary and interplanetary missions will begin next year. Using two craft, Mariner and Voyager, the goal by 1970 is to land on Venus and Mars, and make initial efforts toward probing Mercury and Jupiter.

There is vital interdependence in these programs. Alterations in the planned chain of events that will culminate in landing a man on the moon are inevitable. It is impossible to schedule technological breakthroughs in a desired sequence and timetable.

An example is the number of projects dependent on timely development of Centaur, the first rocket vehicle to utilize liquid-hydrogen and liquid-oxygen propellants. The Centaur second-stage engine will be used to power the S-IV and S-V stages of Saturn—the booster vehicle that carries the highest national priority and has the highest 1962 appropriation, almost $¼ billion. The Rover nuclear rocket engine as well as all the upper stages of Saturn will utilize liquid-hydrogen as fuel. These vehicles therefore depend on the early solution of hydrogen problems encountered in Centaur. The lunar and planetary exploration and Army's Advent 24-hr communication satellite cannot proceed effectively until a vehicle of Centaur's capability is available.

Two other programs President Kennedy assigned high priority are meteorological and communication satellites.

DEFENSE PLANS—While NASA's principle obstacles are the sequence of technological problems that stand between inception of a project and its successful completion, the DOD is confronted by these as well as by the ingenious efforts of a hostile scientific community.

The DOD must detect and destroy incoming weapons and retaliate with offensive weapons of our own.

DETECTION OF MISSILES AND SPACECRAFT—With the exception of the ground beneath our feet, all possible angles of attack by enemy missle or spacecraft

are by now active frontiers that must be monitored. We must watch the entire half sphere around and above us.

ICBMs can be launched over the northern polar region to any point in the U. S.; they can—if an enemy wanted to take the trouble—come in the back door, arriving from the southwest Pacific to California; they can be launched from submarines; satellites carrying nuclear warheads may be programmed to reenter over the U. S. as easily as Yuri Gagarin came down in the U.S.S.R.; missiles may be launched from orbiting satellites toward an earth target as easily as the Soviet's Venus probe was fired from a parking orbit into space.

Our two major threats for the time being, however, if simplicity and cost are weighted factors in the strategy of an attacker, are the ICBM from the north and the submarine-launched ballistic missile. The other possibilities, however, are not being ignored.

DOD work in detection will continue on several levels. The partially operational Ballistic Missile Early Warning System (BMEWS) will be completed in 1962 while R&D work moves ahead on improved ground-based detection radar. The Midas satellite (Missile Defense Alarm System) for detecting enemy ICBMs shortly after launch by ir sensors is being pushed toward operational status while more advanced systems—such as Lofter which will use ir plus uv detectors—are being developed.

The North American Air Defense Command will soon ask industry for proposals for a phased array radar to detect and track satellites as they cross the equator.

INTERCEPTION—At the moment, effective interception of a salvo of ballistic missiles is only an aspiration. It is, however, one of our most urgent aspirations and one that will not be realized without some new concepts and a great deal of money.

ARPA's Project Defender, investigating techniques beyond the Nike Zeus concept, has abandoned most of the far-out approaches the group was considering a year ago. Solutions will follow fairly classic lines of physics and mathematics, ARPA says.

"At present the possibility of developing a death ray using electromagnetic energy seems remote," ARPA's director, J. P. Ruina, told Congress. Several techniques are, however, being studied.

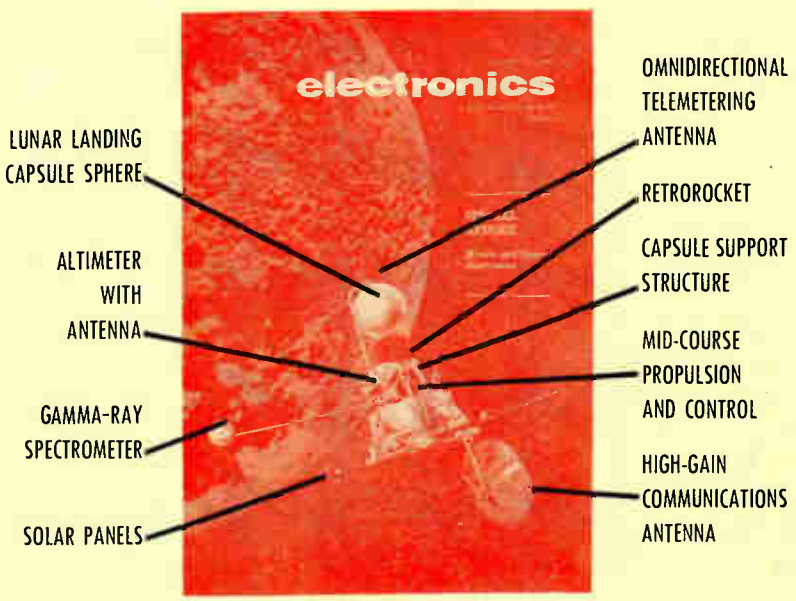
ARPA is studying kill techniques for the three phases in a ballistic missile's trajectory: launch, midcourse, and terminal. Bambi, a system for intercepting a missile at launch by space interceptors, is "the most forward looking concept and has the greatest potential if it works," Ruina says. Navy has some paper concepts for interception during midcourse. And the most recently announced technique for terminal interception is Arpat.

ARPA spends most of its money on missile phenomenology, the study of the environment through which a missile will pass during the various phases of its trajectory and the missile's behavior in these environments. Project DAMP (Downrange Antimissile Measurement Program) and PRESS (Pacific Range Electromagnetic Signature Studies) study the missile's characteristics and behavior so that they may reveal its Achilles heel.

Needed, Ruina says, is the perfection of sensory techniques and learning to interpret the received information. ARPA is also working on super power radar and high power tubes and components.

HIGH PRIORITY—Other pressing military needs in space are: satellite rendezvous techniques, maneuverable manned spacecraft, and controllable reentry vehicles.

Rendezvous is needed for inspection and interception of hostile spacecraft, maintenance and commuter service for manned orbital observatories. The Satellite Inspector (formerly called Saint) and Bambi are forerunners in this area. Closest to a maneuverable spacecraft is USAF's Dyna-Soar, a glider boosted into orbit by an ICBM. First piloted ground launch is scheduled for 1965. A number of DOD-sponsored and industry-financed studies are projecting this concept into future bomb-carrying and reconnaissance weapon systems—



ABOUT THE COVER . . .

This is a model of Ranger 3 carrying America's first outpost to the moon. The lunar and planetary program is being carried out for the National Aeronautics and Space Administration by the Jet Propulsion Laboratory of the California Institute of Technology. The vehicle is called unglamorously 'the bus' because the same hexagonal configuration with the wing-like solar panels can carry a number of different instrument passengers. Follow-on craft will make more expeditions to the moon as well as to the planets. The outpost is the 325-lb 25-in diameter sphere on top, built by the Aeronutronic div., Ford Motor Co. It is scheduled for delivery to the moon early next year. Inside its protective balsa wood shell is a 12-in survival sphere containing a seismometer, temperature-recording devices, radio transmitter and battery.

The Frontispiece—This inertial guidance system, used in the A-1 and A-2 versions of the Polaris missile, is produced by General Electric's Ordnance Dept., was designed by MIT's Instrumentation Lab

both manned and unmanned. Aerospace plane, a USAF study, is the ultimate in a plane that takes off, goes into orbit and lands, all with self-contained propulsion. Controllable reentry vehicles are needed for setting up a system of orbiting nuclear warheads that can be brought down at a precise location on command.

Samos is being developed for reconnaissance, Transit for navigation, Advent for communication, Vela Hotel for nuclear detection, Anna for geodesy.

MISSILES—In the field of missiles, each service is attempting to increase the range and effectiveness of its striking arm and to defend itself better against attack.

USAF will continue to extend the range of its bomber force by air-to-surface missiles such as the operational Hound Dog ($519,000 each) and the air-launched ballistic missile Skybolt. Navy is developing Shrike to home on and destroy enemy radar.

Polaris missile development and test work will be funded at about the same level for the next two years ($443 million for 1962) for the 2,500-mi A-3 version.

Interest is currently high for Slam, USAF's nuclear ramjet-powered supersonic low-altitude missile project. To date, only the powerplant, Pluto, is under development.

Half of Army's R&D funds are going into four missile or space programs: By far the biggest is Nike-Zeus, $171.8 million through Sept. 30, 1962. Next is Advent. communications satellite. Third is the surface-to-surface Pershing, part of Army's new family of solid-fuel missiles. (Pershing get $87.1 million in 1962 making a total of $459.7 since its inception.) Fourth is Mauler, a highly mobile antimissile and antiaircraft defense system.

Navy will continue work on the new Typhon system to be operational after 1965. Typhon, with the biggest funding for missiles after Polaris, will use phased array radar, can handle multiairborne targets.

EARTH BASED—Earth-based facilities for missile and space work are multiplying in number and expanding in size and complexity. They may eventually become one integrated world-wide launching, tracking, data acquisition, detection, and astronomy net.

To date, however, these activities are, with a few exceptions, thought of as separate functions.

Nowhere in the missile and space program is it more obvious than in our missile ranges that our efforts were until recently directed toward countering immediate threats rather than toward long-range goals of our own.

The nation's missile ranges are crowded; they were not built for continued growth or for launching space probes—NASA's base for lunar missions was only selected in August; and most of our ranges are in geographical locations that impose operational limitations.

A look at any of our missile ranges reveals three noticeable trends: (1) a mushroom like growth of new launch sites; (2) acquisition of new, improved range gear while still hanging on to the old because of the increasing workload; and (3) the physical extension as well as widening of the tracking and telemetry range. One means of extension is by conversion of ships into floating "island" stations.

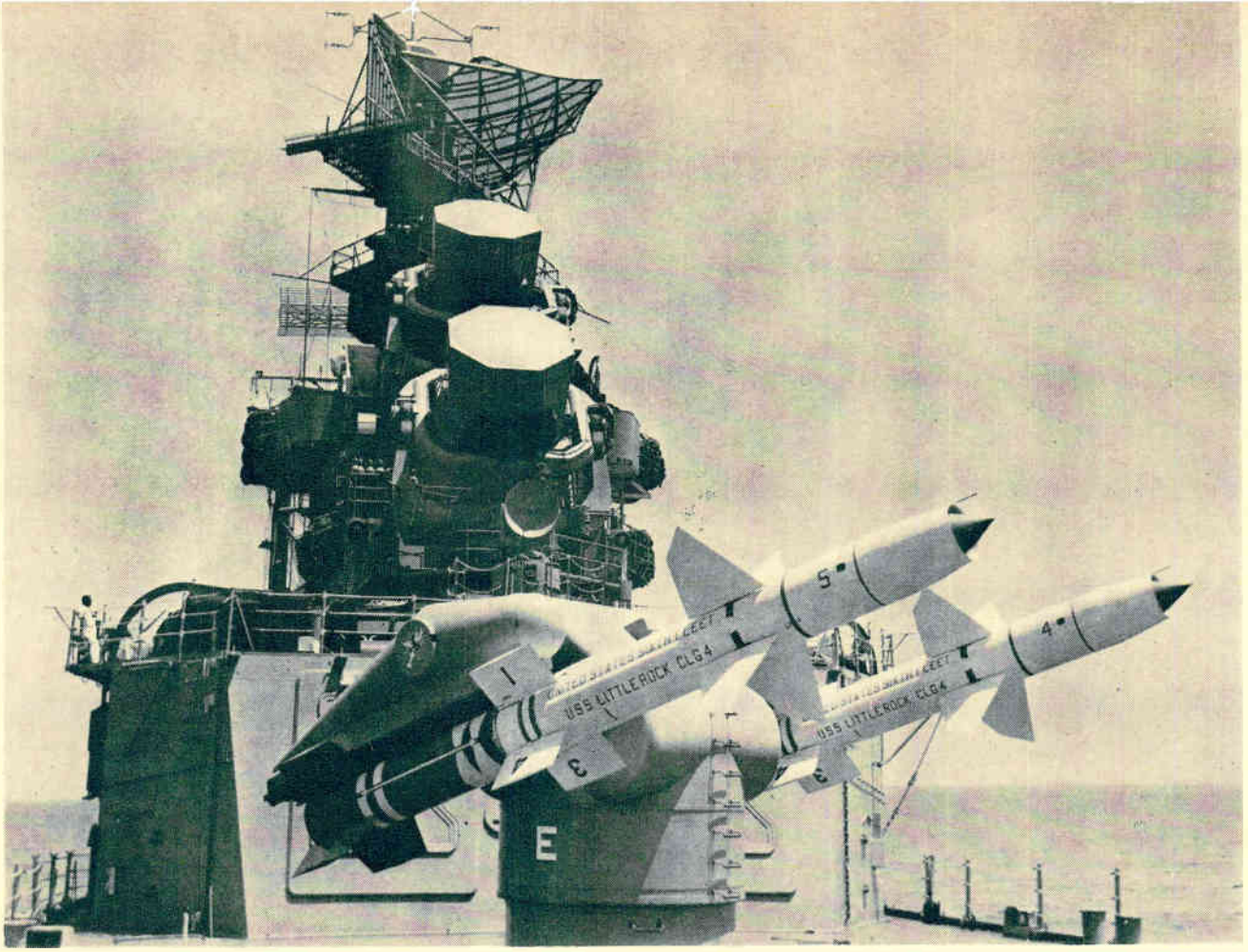
Systems for tracking and communicating with spacecraft are being updated; new ones are being built.

NASA R&D Programs for Fiscal Year 1962

	(in thousands)
Support of NASA plant	$89,110.
Research grants and contracts	7,600.
Life sciences	20,620.
Sounding Rockets	9,000.
Scientific satellites	72,700.
Lunar and planetary exploration	159,899.
Meteorological satellites	50,200.
Communications satellites	94,600.
Mercury	74,245.
Appolo	160,000.
Launch vehicle technology	27,000.
Launch operations development	1,500.
Spacecraft technology	10,360.
Solid propulsion	3,100.
Liquid propulsion	93,020.
Electric propulsion	6,800.
Nuclear systems technology	36,000.
Space power technology	5,500.
Scout	3,675.
Delta	2,900.
Centaur	56,400.
Saturn	224,160.
Tracking and data acquisition	38,650.
Nova	48,500.
Total	1,295,539.

DOD Missile, Space and Related Programs
Fiscal year 1962 appropriations in millions

	(in millions)
Samos	$276.0
Midas	201.0
Discoverer	54.9
Transit	17.5
Advent	72.0
Nike-Zeus	171.8
Vela	37.0
Dyna-Soar	185.8
X-15	7.0
Satellite Inspector (Saint)	26.0
Spadats	30.0
Spasur	8.3
Blue Scout	15.0
West Ford	4.3
Large solid booster	50.0
New upper stage vehicle	15.0
Atlantic Missile Range	163.9
Pacific Missile Range	96.0
White Sands Missile Range	76.7
Project Defender	104.0
BMEWS	34.5
Pluto	7.0
Missile peneration aids	35.0
USAF missile procurement	2,744.8
USAF missile RDT&E	256.3
Army missile procurement	572.9
Army missile RDT&E	460.7
Navy missile procurement	878.2
Navy missile RDT&E	680.7



Talos, Navy's longest range surface-to-air weapon, is shown poised for launch from guided missile cruiser USS Little Rock during recent sea maneuvers. Designed and produced by Sperry Gyroscope Co., the radars and weapon direction equipment detect and track enemy aircraft, assign targets to the Talos missiles, and guide them to the targets. As missiles approach the aircraft, direction is automatically switched to the warheads' homing systems

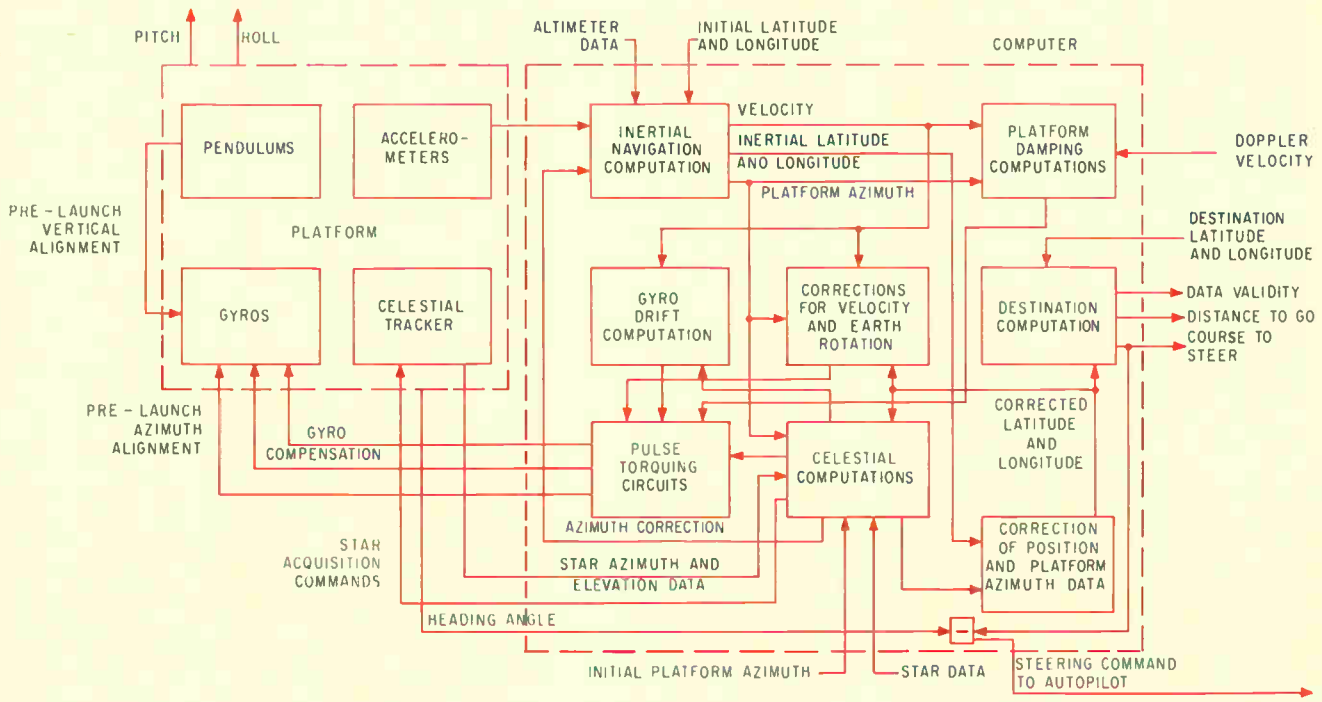


FIG. 1—Aided-inertial system developed at Arma for cruise missile applications employs a stable platform torqued to the local vertical so that gyros are fixed with respect to direction of gravity. System could be used in space vehicles, in which case the doppler input and platform damping circuits would probably be eliminated.

Guidance and Control

MISSILES AND SPACE VEHICLES are guided by measuring the deviation from the desired course and supplying steering commands to a stabilization and control system. This system then establishes and maintains the attitude, including heading, required to navigate to the destination. Major types of guidance are inertial, aided-inertial, command, homing, beam-rider, and celestial.

INERTIAL GUIDANCE—These systems will see increasing use during the next decade in manned spacecraft, ballistic missiles, space-launch vehicles, and deep space probes. They continuously compute vehicle velocity and position relative to an external reference frame by integrating acceleration sensed by three mutually perpendicular accelerometers carried on a gyro-stabilized platform. The platform is usually space-stabilized in that the gyros are fixed in inertial space and tumble relative to the direction of gravity, although for some applications (see Fig. 1) the platform may be torqued to a local vertical.

Major advantages claimed for inertial guidance stem from its being completely self-contained. An inertial system is not restricted to line-of-sight tracking and, for military applications, is attractive because it is passive, nonjammable and has salvo capability.

Inertial systems will be used in Dyna-soar and Apollo. Automatic guidance during Dyna-soar boost is accomplished with a three-axis attitude reference to which programmed booster turning rates are compared. During second-stage boost, pitch rate steering commands from the inertial subsystem are compared to the reference; in third-stage boost the inertial system provides its own reference. Radio command guidance provides backup.

For suborbital and reentry flight the inertial subsystem calculates steering commands by comparing present velocity and altitude rate to a programmed velocity and altitude rate. The programmed rates are calculated to ensure that the glider will arrive at a landing phase initiation point with zero heading error, maximum remaining maneuvering capability, and a specified nominal velocity, altitude and range-to-go. Resulting error signals are fed to an adaptive flight control system. Flight is guided by the pilot after sighting the landing field.

In the event the inertial system fails, attitude and steering information is supplied to the pilot by a secondary attitude reference system. This consists of a gimbaled, all-attitude platform whose gyros are precessed to keep it locally level. This is in contrast to the main platform which is space-stabilized and carries three single-degree-of-freedom, floated rate integrating gyros and three pendulous pulse rebalance accelerometers. Both platforms are modifications of Minneapolis-Honeywell's Centaur system.

A space-stabilized inertial platform and associated sensors will be used in Apollo for complete on-board control capability. Ground control, possibly including radio command guidance, will be for backup only. On a lunar mission where much of the trajectory is ballistic the inertial system will provide short-term indications of instantaneous velocity and direction change that must be continually updated with position fixes. Sensors for position-fixing will include an automatic star and planet optical tracker and an ir earth's horizon scanner. Present ballistic missile inertial components are seen accurate enough for Apollo; however, weight and power will be lowered.

Inertial systems are used in strategic missiles (such as Air Force's Atlas, Minuteman and Titan II, and Navy's Polaris and Regulus) and tactical missiles such as Army's Pershing and Sergeant. These missiles use the accelerometers during the powered phase of flight to measure thrust acceleration. The computed steering commands go to an autopilot to correct the missile's velocity so that at engine cutoff it will be directed at the target.

A ballistic missile guidance system must function in a high-g and high-vibration environment where, at ICBM range, a one-mile miss will occur if the error in measured velocity is 1 ft per sec, if the azimuth misalignment is one min of arc, or if hourly fixed drift exceeds 0.3 deg. Space-stabilized platforms are frequently used because they eliminate the need for high-speed gyro torquing and correction of coriolis and centripetal accelerations.

Future vehicles for injecting space vehicles into an escape trajectory or an earth orbit will probably have all-inertial guidance. Such systems, already planned for Centaur and Saturn C-1, might allow larger payloads since there would be more flexibility in choosing trajectories not limited to line-of-sight.

CELESTIAL-INERTIAL GUIDANCE. Although inertial systems can be used alone in ballistic missiles and space-launch vehicles, the fact that position errors diverge as the cube of time makes it likely that celestial—inertial will be used for long-range navigation such as midcourse guidance of planetary and interplanetary probes.

A celestial guidance system can measure the relative angular position of the moon, planets or stars and by triangulation compute vehicle position. By its nature it provides good steady-state, low-frequency measurements of velocity and position.[2] An inertial system, on the other hand, can instantaneously sense changes in vehicle motion and is therefore a good source of high-frequency data. By mixing the celestial and inertial data in a filtering servo loop that rejects high-frequency celestial data and low-frequency inertial data, smoothed celestial-derived position data is obtained. This provides the best current data from which the autopilot can generate steering and cutoff commands. Because of progress in celestial position fixing techniques, it is estimated that, with appropriate data processing, accuracies comparable to those of position fixes at the best observatories are possible.

An idea advanced as a possible replacement for present celestial-inertial systems is mosaic guidance. A mosaic detector under study by General Dynamics/Astronautics would consist of multi-celled arrays of thousands of photoconductive or photovoltaic cells, each able to respond to visual and/or ir stimuli originating or

reflected from stars or planets. Detectors would be used with a computer for position fixing.

PASSIVE SYSTEMS—In a self-contained midcourse guidance system, velocity is basically inferred or calculated from position measurements separated by known time intervals. Attempts to measure velocity directly have prompted work on passive velocity sensors including one based on the doppler shift of sunlight and another based on aberration of light.

Both template spectroscopy and optical heterodyning, possibly with optical masers, are being investigated as potential optical doppler systems at the Franklin Institute.[3] Optical doppler is subject to a velocity noise magnitude of 200 ft per sec. However, by analyzing the time constant of the noise component, researchers hope to find a less noisy region and apply radiometer techniques to modulate the signal and achieve sensitivities and detectabilities below this average noise level.

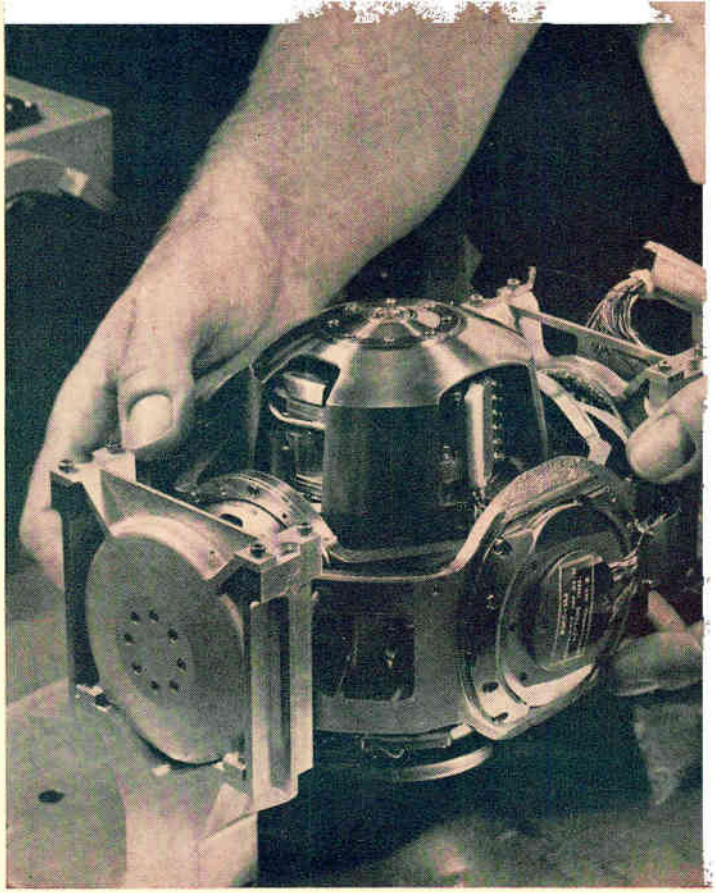
COMMAND GUIDANCE—Antithesis of self-contained guidance is ground-directed electromagnetic guidance such as radio command or beam-rider. It will continue to be important for missile and space applications where the bulk of the guidance must be on the ground.

Radio command guidance involves tracking the missile (or the missile and target missile) and supplying position data to a ground-based computer that calculates the steering and engine cutoff commands to be transmitted to the missile control system. Pulse radar with a single antenna may be used as in Bell Labs' command guidance for Titan I, or multiple antennas and doppler techniques as in GE's Atlas I system.

Proponents of radio command guidance claim that (1) by keeping most of the weight on the ground, reliability is improved and payload capability increased, (2) radio command is more accurate than inertial at present, and (3) by keeping the missile under ground control the operator can follow its course and recall it or send additional missiles, depending upon strategic considerations. Moreover, jamming may not be as serious a problem as has been thought. For example, it is believed that lightweight decoys carried by an ICBM would not be too effective against Army's Nike-Zeus. Zeus, which utilizes acquisition, discrimination, and missile and target track radars, is designed to intercept ballistic missiles outside the atmosphere.

Difficulty of hardening antennas has been cited as an objection to military command guidance. For its Titan system, Bell Labs is presently studying antenna and feed construction techniques in an attempt to get equivalent collimation from simpler and smaller antennas. For instance, by using polarization techniques to make a transparent sub-dish, it has been possible to put the feed in the center of the antenna, thus avoiding the thermal expansion problems that come from mounting at a distance as with a conventional paraboloid feed.

In space vehicles, command guidance has been used with Thor-Delta and Able-Star launches, and is planned for later Rangers. Ranger guidance will use the NASA Deep Space Instrumentation Facility to supply commands for midcourse maneuver periods when a rocket is fired to correct trajectory. The command, which is stored on board, contains (1) the magnitudes and directions of the pitch and roll angles through which the spacecraft must turn to point the rocket thrust motor in the desired direction, (2) the time the motor must be started, and (3) the velocity increment that must be imparted.[4]

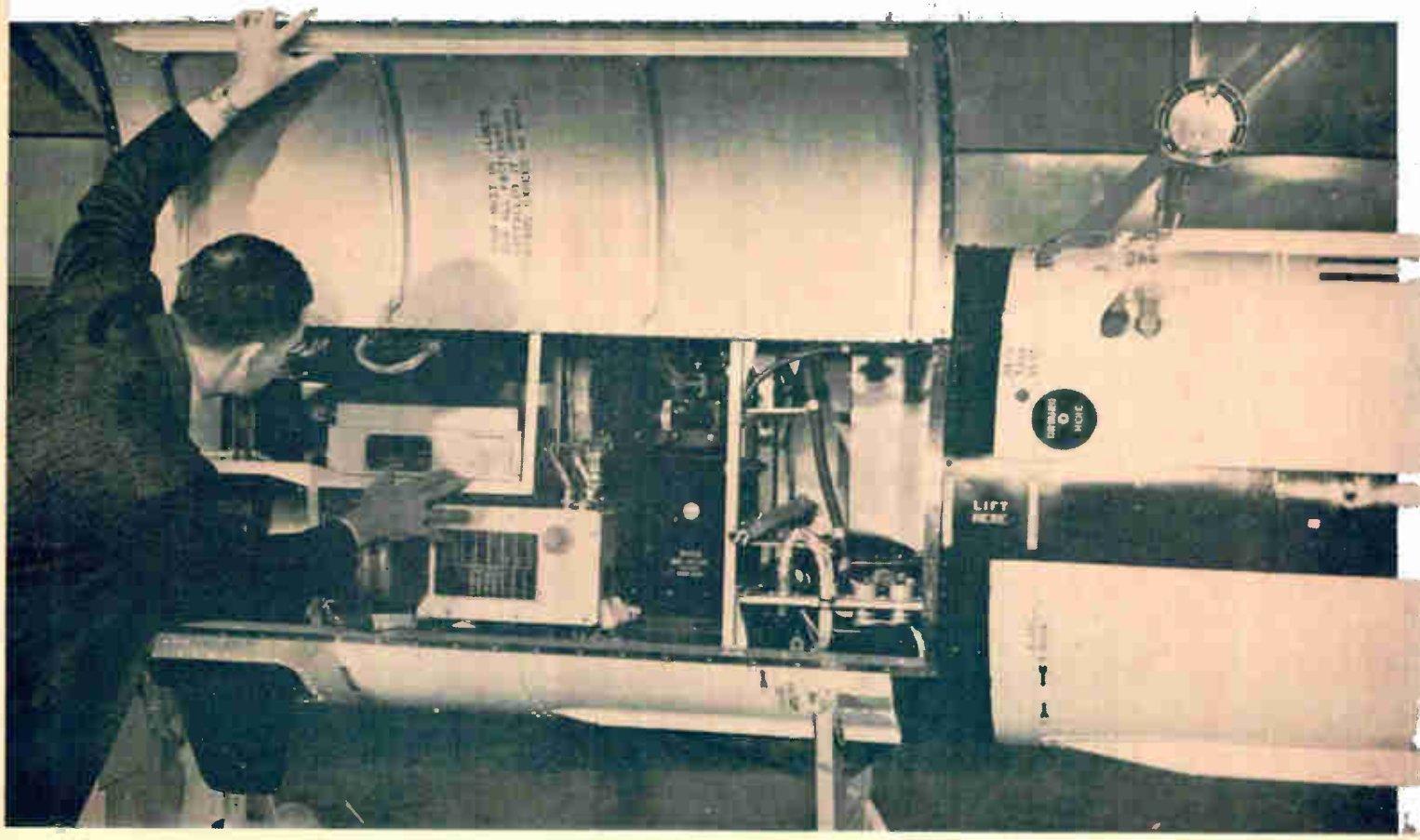


Inertial platform developed for USAF by Litton Systems has two two-degree-of-freedom gyros and three torque-balance accelerometers supported by gimbals permitting vehicle angular freedom in azimuth, pitch and roll. Platform is for an advanced flight data system for orbital and suborbital vehicles

BEAM-RIDER GUIDANCE—A beam-riding missile contains only the radar receiver; it seeks and travels along the center of a conically-scanned or lobe-switched radio or optical beam transmitted by an auxiliary radar.[5] The missile may travel along a beam that is always pointed at the target (line-of-sight beam-rider) or it may be launched into a separate beam that guides the missile along a controlled trajectory to interception (a controlled beam-rider). The former has the advantage of simplicity and is generally used at ranges below approximately 30 miles. Controlled beam-riders are useful for long-range, high-speed applications where trajectories may be modified for tactical reasons; they require an accurate guidance computer and radar in addition to a tracking radar and launch computer whereas line-of-sight beam-riders require only one radar and a launch computer.

Emphasis in beam-rider work is now more toward short-range applications such as antitank missiles. Sperry Gyroscope Co. is investigating an optical beam-rider for forward-area use against tanks. The line-of-sight system uses a conventional light source; however, range could be extended by using a laser.

Beam-rider guidance for navigation on the moon is also being studied. Idea is to shine a laser beam from earth that would cover the moon's diameter and contain reference and error signals so that a vehicle on the moon could determine its location. Frequency-modulation tech-



Programmed flight control functions for NASA's Delta launch vehicle are generated by a Texas Instruments Incorporated programmer, shown here being checked at the plant of the Delta prime contractor, Douglas Aircraft Co. Programmer generates flight control signals and sums them with guidance corrections from the ground. It also programs the sequence of stage separations and provides synchronizing signals for power supply frequency control. Located in the compartment with Bell Labs' command guidance equipment, programmer has a full timing capacity of 2,047.5 sec

niques would be used to generate the signals.

HOMING GUIDANCE—A homing missile senses the target by a radar, ir, visible light or electromagnetic sensor; the missile navigates to the target by continuously computing the rate of turning in space of a line between the missile and target.[6] Proportional navigation, pure or deviated pursuit may be used.

Homing guidance may be active, semiactive, or passive.[7] Active homing is the antithesis of command guidance in that the track radar and computer are carried in the missile. Technique is generally for terminal guidance, and is used in Air Force's Bomarc antiaircraft missile.

When a ground radar can reach the target, semiactive homing is advantageous. The target is continuously illuminated by the radar during missile flight and the reflected energy picked up by a tracking receiver in the missile nose. A control system attempts to drive the sightline space rate to zero to maintain a course where target bearing is constant. This type of guidance tends to be more accurate than beam-rider because it is not dependent upon the accuracy of the target tracking radar, and the signal-to-noise ratio increases as the target is approached. Even greater accuracy might be achieved in semiactive homing by using a laser radar because of the finer resolution. Army's Hawk antiaircraft missile uses semiactive homing.

Passive homing missiles utilize ir, optical or electromagnetic sensors to home on naturally emitted radiation. Most common technique is ir homing, used in the Navy-Air Force Sidewinder and the Air Force Falcon air-to-air missiles. and Army's Redeye antiaircraft missile.

Improvement of present homing missiles is largely directed toward developing counter-countermeasures. The error signals received by a homing system can be masked or fooled in the command link range from low-frequency to optical. Counter-countermeasures work is aimed at processing the received signal to reject or partially reject the jamming components by new signal modulation, processing or correlation techniques.

Probability of destroying the target depends on system accuracy and warhead effectiveness. System accuracy depends in part on the fuzing system characteristics. A fuzing device in the missile can contribute from 5 to 10 ft to the miss distance, while fuzing by ground command can contribute a larger error.[8] Most present arming and fuzing devices contain mechanical subassemblies which, unless heated, tend to run slow as ambient temperature drops below —40 F.[8] Thus, attention has been given to developing solid-state programmer-timers.

RENDEZVOUS—Homing techniques will aid rendezvous between space vehicles and terminal guidance of lunar and planetary probes. For rendezvous with an unmanned vehicle, active radar homing would be useful when range information is required. Transmitter power could be saved with a radar beacon system, which might be useful for rendezvous with manned vehicles where the beacon could be maintained. Where vehicle position is known, it might be advantageous to use optical masers because of their narrow beamwidth. It has been estimated that by using with two-ft-diameter mirrors the

transmitter and receiver masers expected in the next few years, about 66 w of average beam power will allow measurement over 160,000 Km with an accuracy of 1 part in 100,000.[12]

The high resolution and relative optical gain that can be realized with reflected sunlight and ir systems make these passive detection and tracking techniques attractive for applications where accurate target range can be obtained with another sensor. Weight and primary power of an image orthicon reflected sunlight system has been estimated at about 28 lb and 50 w, that of a thermal radiation system to be roughly 55 lb and 100 w (including the cryogenic refrigerator).[13]

Techniques under study for lunar and planetary terminal guidance include ir and optical horizon seekers for the approach phase and radar altimeters and doppler velocity sensors for landing. Ranger 3 will carry a radar altimeter built by Wiley Electronics, Surveyor an altimeter and velocity sensor developed by Ryan Electronics. Optical masers might also be useful for terminal guidance.

Radar-inertial mixing may be used for lunar and planetary landings. Such a system filters and combines low-frequency radar altimeter data with high-frequency inertial altitude data to produce a dynamically and statically accurate measure of altitude.[14]

An interrupted c-w doppler system has been developed by Laboratory For Electronics as the input to a space vehicle inertial system. The 1 cu ft radar provides three components of surface velocity with single-beam scanning, weighs approximately 55 lb. Altitude, vertical velocity and horizontal velocity could be measured up to 100 nautical miles above the moon's surface for lunar landing. Range, bearing and their rates could be measured at the same range for space rendezvous.

ATTITUDE CONTROL—Three-axis attitude control systems are being developed to meet the increasing requirements for midcourse guidance, satellite orbit correction, directional scientific experiments, directional antennas, and for orienting solar cells and controlling temperature. Basically, an attitude control system consists of sensors which establish reference directions and provide signals proportional to variations in vehicle attitude to actuators which apply torques to correct for any deviations between actual and desired attitude.

Typical sensors are[4]: silicon solar cells or cadmium selenide detectors to determine angular deviation from the sun line, multiplier phototubes to determine angular deviation from the direction to a star or the earth's radiation center, gyros to measure angular turn rates, and horizon seekers to find the angular deviation from the true center of a planet.

Optical telescopes can be used as horizon seekers, but most often a thermistor bolometer is used to discriminate the thermal horizon. Pre-image scanning is mostly used at present. It is estimated than an ir horizon scanner in an earth satellite or sounding rocket could detect a deviation from the local vertical of as low as 0.1 deg. A scanner now being built by Barnes Engineering Co. is expected to yield this accuracy at distances of 5,000 to 100,000 miles from Venus and Mars.[15] Scan pattern will allow obtaining error signals about two

IMPROVING SPACECRAFT GUIDANCE SYSTEMS

With spacecraft lifetimes of 1 *to* 3 *years envisioned, extensive effort is underway to improve the guidance components. Key equipments under study include inertial platforms and sensors, computers and astrotrackers.*

Objective of present platform work is to reduce complexity, size and power requirements while improving reliability. One approach is to replace the conventional gimbal rings with a sphere having complete angular freedom. By floating the platform inside the sphere, a system useful for high spin rate and high-g applications might be obtained, provided such problems as power and data transmission between the platform and sphere can be overcome.

Conceptually more radical approach is to eliminate the gimbals and body-mount the gyros and accelerometers. This so-called strap-down system is being actively developed but faces several problems. First, the required computing rate is increased because the coordinate transformation process has been shifted from the platform to the computer. Also, it is necessary to minimize the transmission of vibration from the airframe to the inertial components. These components offer the greatest problem, however. The accelerometers need high-frequency response characteristics, and rate gyros are required that have greater sensitivity and linearity than those presently available.

Whether for strap-down or conventional inertial systems, gyros and accelerometers are under intensive study.[9] Gyros need to have low drift, long life, high reliability and low power. While tactical missiles can use gyros with drift rates of 10 *deg per hr, high-accuracy gyros using gas bearing and fluid suspension give drift rates of* 0.001 *deg per hr in present applications.[10]*

For space applications, however, improved performance may be obtained by such friction-eliminating schemes as electrostatic and electromagnetic suspension. Electrically suspended gyros will most likely be in operation first but the cryogenic gyro also looks promising. Both might yield hourly drift rates of 0.0001 *deg; cryogenic gyros would have negligible power consumption. Main problem in optimizing these gyros is to make a perfectly spherical ball and to develop digital readout systems.*

Theoretically the best gyro would be one based on aligning the spin moments of atomic nuclei. This so-called nuclear gyro is probably several years from being operational and still requires an experimentally proven method of detecting the output signal.

Electrostatic, cryogenic and solid-state accelerometers are also under development for space missions. They need to be low-g sensitive and therefore have a problem measuring the signal in the noise level. Analog version of a cryogenic accelerometer is being tested at GE's Ordnance dept. under a NASA contract. The mass is supported by superconducting bearings and nulled by superconducting force-drive coils. Testing of a digital version is scheduled for 1962.

Trend in guidance computers is toward digital for speed, reliability and the fact that signal-to-noise ratio can

mutually orthogonal axes sufficient to define the local vertical with a single immersed thermistor detector.

Where detectors will be used for guidance and control in subsystems independent of exact vehicle orientation, it has been estimated that the following accuracies will be required within the next five years: star sensors (including sun)—0.001 deg, planet sensors—0.03 deg, gyros—0.001 deg per hr, and horizon seekers—0.001 deg.[4]

There are two types of actuators for attitude control: those utilizing external torquing techniques such as mass expulsion, solar pressure or ambient magnetic or gravity gradient fields, and internal momentum transfer techniques such as inertia wheels and powered gyros.[16]

Example of precision attitude control is provided by the OAO, for which Grumman Aircraft Engineering Corp. is prime contractor and systems manager. Allowable margin for telescope pointing error will be 0.1 sec of arc.[17] After injection into orbit, pitch, roll and yaw rate gyros supply control signals to gas reaction jets to reduce satellite angular velocity to approximately 0.02 deg per sec. Satellite is then oriented to the sun by silicon solar cell sun sensors and rotated about the sun line until two or more of six star trackers lock onto preselected stars. The system is now ready to accept commands for specific observations. These commands produce rotation of coarse pitch, roll and yaw inertia wheels to change the satellite orientation. When the approximate position is reached the star trackers are commanded to the proper gimbal angle relative to the OAO to lock on the star. Any difference between actual and desired gimbal angle produces an error signal that is fed to fine inertia wheels to position the OAO to 1 min of arc. In later OAO's the experimenter will be able to refine this to 0.1 min.

For certain satellite experiments it is advantageous to align the satellite axis along the direction of either the earth's magnetic field (as on Transit satellites) or the gradient of the earth's gravitational field[18] (Midas).

BIONICS—For unmanned planetary exploration the ideal guidance and control system would be one that could appreciate its environment and change its mode of operation to meet changing conditions. Present work in adaptive control systems for spacecraft such as Dyna-soar is a step in this direction. Adaptive systems can adjust the amount of corrective moment per given control area in terms of preestablished criteria. By building in a learning capability, however, it might be possible to devise systems that could adapt to unplanned conditions by learning and making decisions on the basis of what they learn. It is conceivable that this may come about by creating electronic systems that perform in a manner analogous to the more sophisticated functions of living systems.

There are several approaches to this goal. One, which is being investigated by the Air Force, is Melpar's Artron[19] and other devices where present performance is influenced in a statistical sense by past history and where, also, the goals can be non-specific; that is, they can be applied to a number of situations. Artron, a Boolean function generator that is nonthresholded, can store partial successes and has predicted a binary series.

---

be maintained at a higher level than with analog. A digital computer will be used in Centaur and probably other large launch vehicles; several are on ballistic missiles. While the simpler missions can be accomplished with computers of nominal capacity and speed, greater complexity will be required for vehicle maneuvering, compensating for failure of one of several engines (a possibility after Centaur) and where launch vehicle requirements are integrated with those of the spacecraft.

While whole number computers may be adequate for possibly 70 percent of space vehicle problems, one that could switch in a faster incremental computer for jobs such as engine control will be desirable. Storage capacity of several million bits will be required. Pneumatic digital computers may also find application because of small size and low power requirements.

Requirement for digital systems is spurring work in digital inertial components and pickoffs. Smaller digitized pickoffs having an accuracy of 10-20 sec of arc over 360 deg are required in the next few years. Example of an inertial component with an inherent digital output is Arma's vibrating string accelerometer.[11] Three of these are used on the space-stabilized Atlas platform. They utilize a pair of magnets to laterally vibrate a matched pair of metallic tapes at their natural frequencies. One end of the pair is fixed and the other ends are clamped to a pair of equally balanced masses joined by a spring. Acceleration along the common sensitive axis of the tapes produces a force on the masses, thus increasing the tension and frequency in one tape and decreasing them in the other. Difference frequency is a measure of input acceleration; total accumulated count measures velocity change.

Present astrotrackers are basically gimbaled telescopes; mechanical scanning is used prior to forming the star image on a multiplier phototube. They are roughly 10-lb, 10-w, 10-sec-of-arc devices (when on an inertial platform, weight is nearer 5-6 lb). Trend is to try to reach accuracies of 1 sec of arc with less weight and power.

Some tracker needs are presently being filled by pressure-sealing the moving parts, but because of the problems associated with rotating mechanical-optical systems in the vacuum of space for thousands of hours, considerable effort is aimed at developing nonrotating systems using post imaging, as typified by the vidicon. The more-sensitive image orthicon is also under study, as are solid-state arrays. An array sensor might be an electroluminescent-photoconductive panel that would be interrogated electronically to find the conducting square. For simple targets (points and lines) a sensor of one or at most a few silicon or gallium arsenide photodiodes might be useful.

Moving parts such as vibrating reeds and apertures that do not involve coulomb friction are also being studied. Another technique is to control sensitivity of the different modulator areas with solid-state elements to improve discrimination of target signal from noise.

Trackers are also being developed to identify stars by their peculiar color and brightness. Such a device is under development at Kollsman Instrument Corp. to pick out Canopus, a star useful for attitude orientation in space because it is nearly 90 deg from the plane of the ecliptic

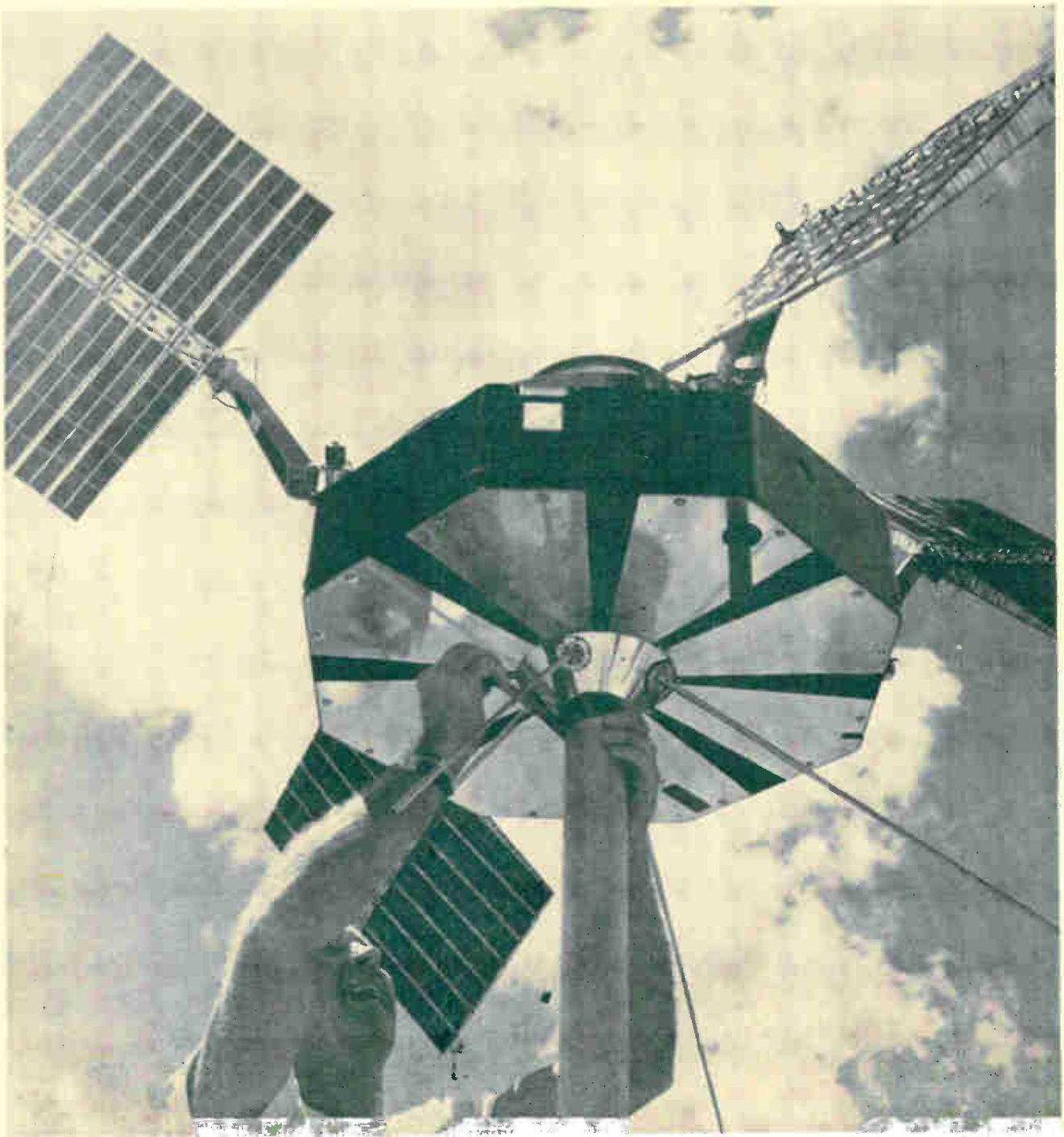
Data Acquisition

SENSING THE PARAMETERS of our space environment, and processing and transmitting the information to earth, are major functions of space probes, satellites and sounding rockets. Future instrumentation for these purposes will include adaptations of present equipment as well as completely new devices and systems.

SCIENTIFIC EXPERIMENTS—The wide scope of scientific experimentation is indicated by the instrumentation planned for upcoming lunar and planetary probes. Rangers 3, 4 and 5 will carry a tv vidicon camera, gamma-ray spectrometer and seismometer capsule. The seismometer is a single-axis suspended magnetic type with an output sensitivity at 1 cps of 0.75 μv per millimicron of ground amplitude (peak-to-peak deflection).

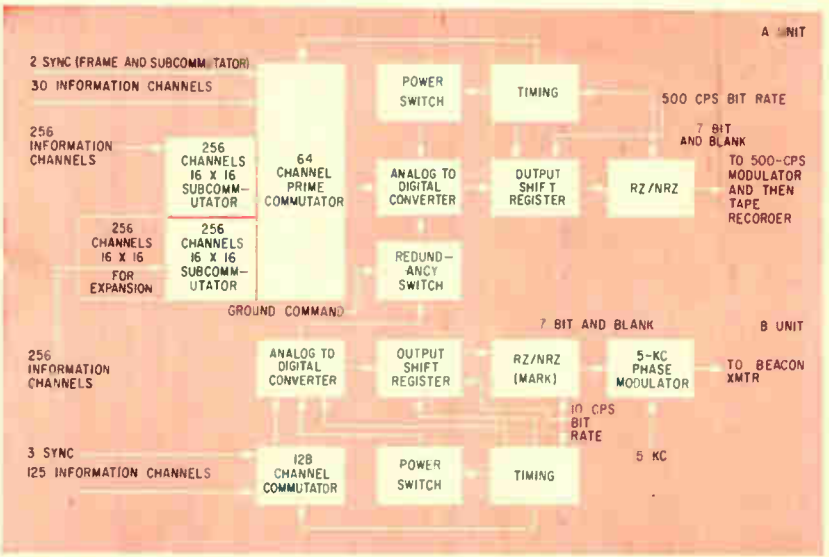
The vidicon camera will take a series of pictures of the capsule landing area in the 30 minutes before impact as the spacecraft descends from 4,000 Km to 24 Km.

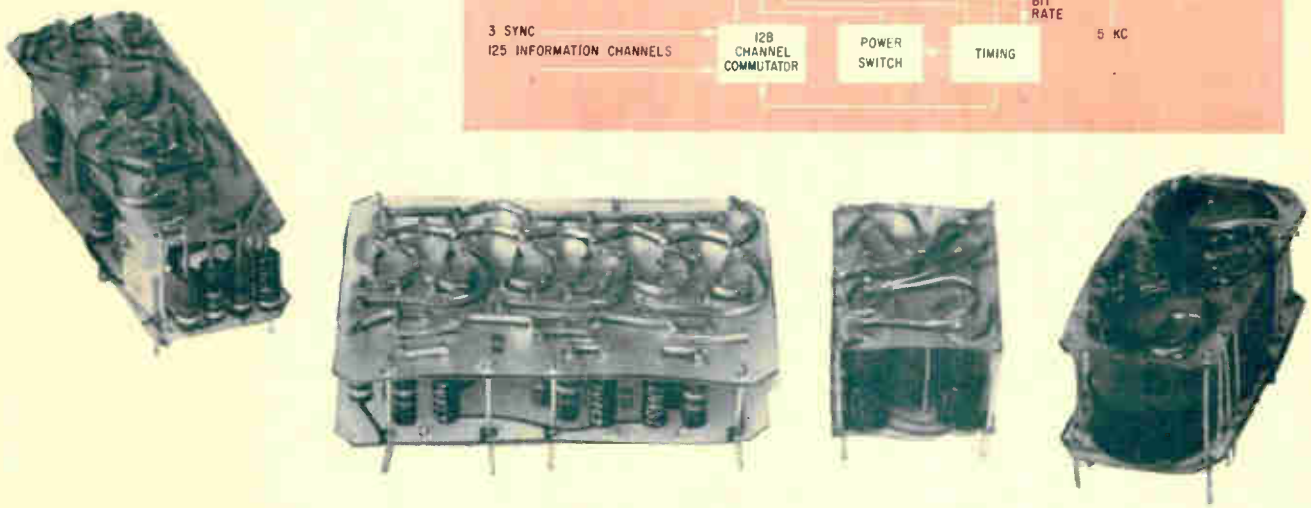
Explorer XII launched Aug. 15 is the first of four satellites designed specifically to make repeated observations of the solar wind, interplanetary magnetic fields, distant regions of the earth's magnetic field, and the particle population of interplanetary space and the Van Allen belts. Developed and managed by NASA's Goddard Space Flight Center, the satellite has provided data for more than 1,400 miles of tape so far



and Transmission

Pulse-code-modulation circuit elements shown below before encapsulation will be used in the telemetry systems (right) being developed by Radiation Incorporated for Nimbus. Each satellite will have two electrically independent pcm systems weighing less than 30 lb and designed to consume 1.4 w. Pulse-code modulation, which has been used in Minuteman and Titan, is slated for other large satellites because it lends itself to automated data handling and processing





At 24 Km, 350 sq meters on the moon will be recorded with a surface resolution of approximately two meters.

The gamma-ray spectrometer consists of a double scintillator for coincidence rejection of charged particles and a multichannel pulse-height analyzer. During flight it will measure background gamma radiation and after a terminal maneuver near the moon will point toward the lunar surface to detect relative distribution of uranium, thorium and potassium-40.

On Rangers 6 through 9 it is presently planned that the capsules will contain high-resolution vidicon tv in place of the seismometer.

Present Surveyor plans call for 360-deg coverage of the lunar surface from the immediate point of observation to the horizon by three tv cameras, each having a 120-deg azimuth field of view. A fourth camera with interchangable lenses may be used for closeup observation and to assist in observing the remote handling of the borehole samples of materials collected by a drill system for subsequent analysis by a variety of experiments.

Experiments being considered include an x-ray fluorescent spectrometer, x-ray diffractometer, gas chromatograph to detect organic compounds, sensitive ionization gage to measure atmospheric pressure, cosmic-ray counters to measure particle energies from the Kev to Mev range, plasma probes to measure flux and energy spectrum of low-energy protons and electrons, gamma-ray spectrometer, and three mutually perpendicular magnetometers for fields up to 10,000 gammas.

Mariner R, an attempt at the first Venus fly-by in 1962, will carry six experiments according to present plan. They are: geiger tubes similar to those on Pioneers III and IV and an ionization chamber similar to the one on Ranger 1; a solar corpuscular radiation experiment, probably consisting of a curved-plate analyzer to sample proton and electron flux; an experiment to determine flux, directionality, mass and velocity distribution of cosmic dust in the interplanetary space between earth and Venus; three-component magnetometers for the ranges 0 to 200 and 0 to 2,000 gammas; and radiometers operating at 13.5 and 19 mm. The magnetometers will measure the interplanetary field between the orbits of earth and Venus, as well as the Cytherean magnetic field itself. The radiometers will be used with a parabolic antenna to determine Venus surface temperature and the temperature of the Cytherean atmosphere.

Next Mariner (B) will be for Venus and Mars fly-bys. Experiments presently under consideration include multi-grid Faraday cup plasma probes which would be placed at the end of a boom beyond the spacecraft plasma sheath to measure proton and electron flux; and uv and ir spectrophotometers. The uv spectrophotometer could

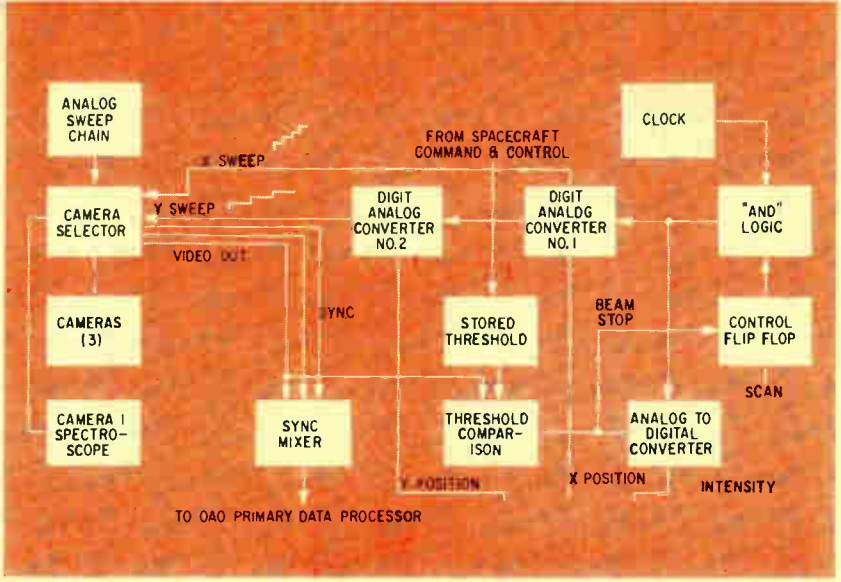


FIG. 2—The OAO-borne payload for Smithsonian Astrophysical Observatory's Project Celescope has tv pickup tubes with analog or digital scanning. In the digital scanning every picture element contains a signal above threshold that is described by a word of 25 bits (plus 3 bits for parity check). Of these, 9 are X-position, 9 for Y and 7 for intensity. Thus, 128 discernible levels are available, while with the analog scanning a gray scale of about 30 is expected

record the spectral energy distribution of the illuminated and dark sides of Venus in the region of 1,100 to 4,000 angstroms. The ir spectrophotometer could be used to study organic molecules on Mars.

Next step after a Venus fly-by might be to analyze the lower atmosphere of Venus by landing a small payload from a probe on a near-miss trajectory. Studies indicate that a 1-lb payload of presently developed sensors could supply enough data to support a nearly complete analysis of the physical and chemical structure of the atmosphere below the cloud layer.[20] Possible transducers include a linear accelerometer, phototransistors to measure light intensity, temperature-sensitive resistance elements, and strain-gage type devices to measure static atmospheric pressure. During descent of approximately 15 to 20 minutes, each sensor could be sampled every 13 seconds by a ppm/p-m telemetry system.[21] Data would be sent from a 450-mw solid-state transmitter at 100 Mc to a phase-locked receiver in the fly-by vehicle.

SATELLITES AND SOUNDING ROCKETS—While space probes directly explore the moon, planets and interplanetary space, sounding rockets and satellites acquire data in the earth's atmosphere and near space.

Sounding rockets determine characteristics of a vertical slice of the atmosphere that cannot be obtained with satellites—for example the variation of electron density with altitude; they will continue to be a proving ground for satellite instrumentation and, like satellites, probably use more stabilized scientific experiments.

Second generation of satellites is typified by the OSO, OGO, and OAO observatory satellites. Each family will have essentially the same telemetry, guidance and control, and power supply—but different experiments.

The OSO is being built by Ball Brothers to provide a stabilized platform for solar-oriented experiments. Principal experiments on the first OSO will be pointed at the center of the sun to within a long-term accuracy of two minutes of arc. Pointed experiments and those not requiring fixed orientation relative to the sun include a Lyman-alpha profile spectrophotometer, a soft x-ray spectrograph (10-100 angstroms), and sensors for neutron, proton and electron flux, gamma-rays above 100 Mev and below 5 Mev, and relative intensity and angular distribution of x-ray and gamma-rays from 0.1 to 5 Mev.

Second OSO will have a raster scan of the solar disk so that the pointed instruments can either lock on the center of the sun or, upon command, scan the disk.

The OGO is being built by Space Technology Labs to provide a stabilized platform for earth-oriented experiments. These satellites will be launched into two basic orbits—a highly eccentric, low-inclination orbit (EGO) and a polar orbit of low eccentricity (POGO). The OGO's will carry up to 50 experiments and are expected to play an important role in the World Magnetic Survey now underway and to be heightened during 1964 and 1965 in connection with the International Year of the Quiet Sun.[22] First launch will be an EGO in 1963. The largest number of experiments will probe the magnetosphere (roughly 14 to 20 earth's radii) as part of the energetic particles and magnetic fields program. Most of the remainder will deal with ionospheric propagation, radio astronomy and direct measurements of ionospheric structure. Magnetic field measurements may be made with optically pumped rubidium vapor magnetometers.

The OAO will provide an inertially stabilized platform for stellar-oriented experiments. (See Guidance and Control section.) Principal experiments presently slated for the first OAO are a broadband photometry study by the U. of Wisconsin of individual stars and nebulas, and Project Celescope—a tv-equipped uv telescope for mapping the celestial sphere.

Project Celescope will utilize three uv-sensitive broadband tv photometers and a uv-sensitive spectrograph. (See Fig. 2.) The tv pickup tubes are expected to be ebicons sensitive over different portions of the 1,150 to 3,000-angstrom range. Each pickup tube can be scanned by digital or analog methods. The digital scan is a variable rate staircase scan with 500 lines of resolution and a frame scanning time of approximately 2 sec. Data rate is 12,000 bits a sec. Digital tv is considered attractive for space use in general because it allows lower S/N ratios in the radio link and favors bandwidth reduction.[23]

In addition to the observatories, there will be during the 1960's special-purpose scientific satellites such as the ionospheric topside sounder, and satellites for such purposes as meteorology, communications, navigation, reconnaissance and missile detection.

Reconnaissance satellites could use electro-optical, photographic, ir, radar, passive microwave, and ferret reconnaissance to observe the earth or other planets. Some predicted capabilities are as follows.[24]

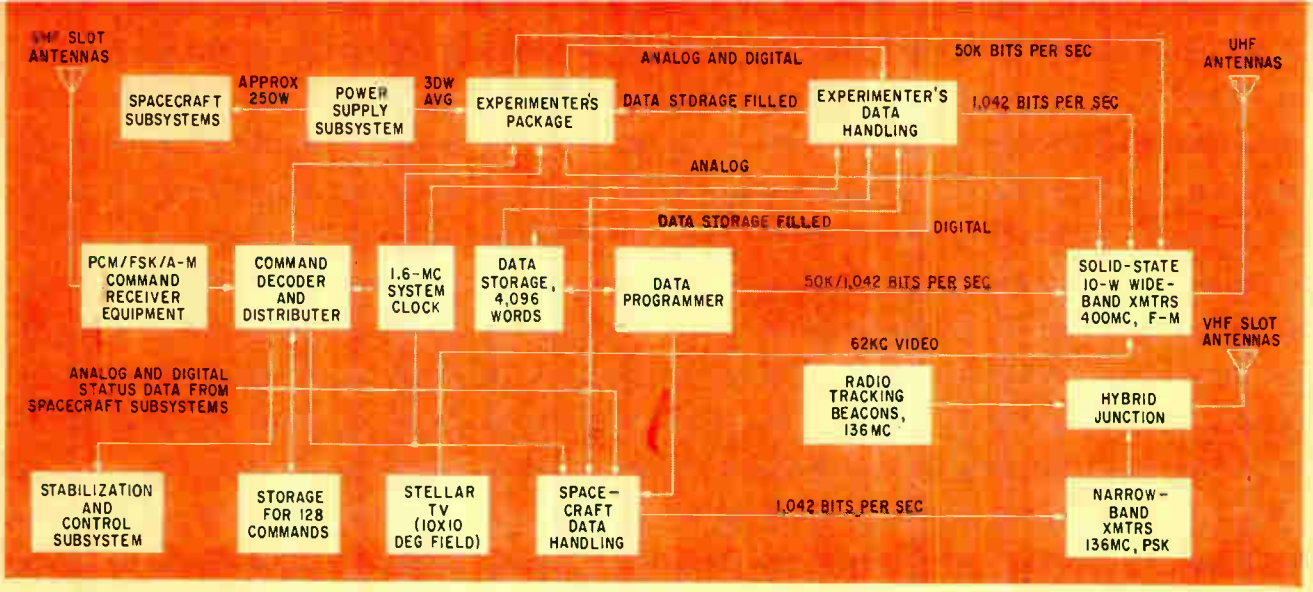


FIG. 3—OAO data handling system measures performance of the satellite systems and the on-board experiments. Developed by Grumman Aircraft Engineering Corp., the system allows for both on-board and ground verification of commands. Extra transmitters and receivers are carried for equipment redundancy

(1) Electro-optical systems will be improved by such techniques as multistaging the light amplifiers with fiber-optic couplers; by 1970 they are expected to be sensitive enough to provide useful returns under starlight.

(2) Photographic systems may employ electrostatic or thermoplastic tape that requires no chemical processing.

(3) Infrared reconnaissance devices will probably be capable of providing 90-ft resolution from 300 nautical miles, assuming 40-in. optics and a detector sensitivity of 10^{-14} w per sq cm in the 8 to 14 micron range. Detector trend is toward ir imaging tubes. Radiation storage capability of ir vidicons gives simultaneously a high sensitivity and data rate.[25]

(4) Radar systems are expected to have the capability of 25-ft resolution from 300 miles and map interval capability of 10 miles by 1970.

(5) For passive microwave reconnaissance, by 1970 a 3.5-mm radiometer may provide resolution of about 0.005 deg with a 20-ft linear array.

MAPPING—There is considerable interest in lunar orbiters for mapping. Possible mapping methods include photographic, vidicon tv, radar and ir.

To avoid chemical processing and physical recovery of film, various systems that go directly from ground imaging to video storage and transmission are being investigated. One state-of-the-art system studied by the Defense Products div. of Fairchild Camera and Instrument Corp. uses two diverging line scans to look forward and aft and cover a strip which from 100 Km altitude would be 45 Km wide. (This includes a sidelap corridor to insure against alignment errors due to attitude and unknown oblateness of the moon.) System, which has 1-Mc bandwidth, and 10-meter resolution and stereo coverage, uses fiber optics to transform from line scan to a format making optimum use of the geometric characteristics of a single vidicon. This increases resolution to 2 mils with 4,000 elements. Accuracy required for 1:50,000-scale maps is 25 meters, an accuracy which can be met by the system despite the relatively poor metrics of the data link.

DATA HANDLING—As space experiments and missions become more sophisticated, so too will on-board data storage and pretransmission processing techniques. Magnetic tape recorders are needed that will store up to 10^8 bits and operate reliably for 6 months to a year. Ratio of storage to readout time is of the order of 50 to 1.

Some satellites, such as OAO, will be so precisely stabilized that they would be affected by spinning tape reels. Similarly, although magnetic drums are a cheap way to store data, their gyroscopic effects are encouraging development of cores and thin-film devices.

The OAO will use a random-access multiaperture ferrite core memory having nondestructive readout. Developed by IBM's Federal Systems div. for their data processor, the memory will be able to store 102,400 bits with redundancy. To meet OAO's requirement for one year of reliable operation, the data processor will employ quadruple component redundancy and triple modular redundancy. Overall OAO data handling system is shown in Fig. 3

Projected characteristics for nonmechanical digital storage systems that appear attainable in 2 to 4 years according to researchers at IBM's Space Guidance Center are: capacity equal to or less than 10^6 bits (typically 250,000), cycle times equal to or greater than 2 μsec, watts and pounds per bit of 5×10^{-5} (including instrumentation). Environmental tolerances are temperature from −25 to 100 C, vibration of 15 g to 3,000 cps, shock of 50 g for 12 msec, vacuum of 10^{-6} mm of mercury and radiation resistance equal to or greater than 10^{14} nvt.

Quantity of information will present problems, especially on meteorological satellites. To meet the storage requirements for Nimbus, which will transmit 25 million bits per orbit, an electrostatic tape system is being developed by RCA's Astro-Electronics div. System will use scan techniques to obtain pictorial information of selected 1,500-mile-square areas of the sun-lit earth. Resolution will approach 0.1 mile and it is hoped that an information density of 15,000 bits per sq inch can be obtained on the tape. (It will not be on the first Nimbus.)

Direct electrical readout of GE's thermoplastic recordings with an electron beam has been demonstrated in the laboratory and is expected to be available for satellites

in 1962-1963. A 68-lb demonstration model has been constructed with optical readout at GE's Missile and Space Vehicle dept. Storage density is 4×10^6 bits per sq in., power drain is 180 w at 28 v d-c, and writing gun filament life is 30 hours. Resolution of 100 lines per mm and 9 to 10 shades of gray have been demonstrated.

A flyable thermoplastic static digital memory with a capacity of 10^8 bits is considered feasible. Device could have a maximum bit rate of 1 megabit per sec, would weigh 10 lb and occupy 0.3 cu ft; power dissipation might be 40 w at 28 v d-c.

For deep space probes it is hoped that storage capacity of 10^9 to 10^{10} bits will be available by 1964. Current thinking is to use magnetostrictive lines for buffer memories and magnetic tape for long-term storage.

A storage system of this type has been designed for a Mariner data automation system to store approximately 1,300,000 bits of information during any 24-hour period. It would be interrogated only once a day from earth, as compared to Ranger which stores around 270 bits and is interrogated 24 hours a day.

The Mariner system is designed to maximize the amount of scientific information which can be obtained and transmitted during the mission.[28] In addition to storage, it acts as a programmer to sample experiments according to a predetermined routine, provides a control program for planetary scanning at encounter, and accepts program changes received over the command link.

TRANSMISSION—Satellites for mapping and reconnaissance have to transmit in each pass vast quantities of pictorial data. Requirement for data rates of 10^8 bits per sec and bandwidths of 200 Mc is envisioned.

Efforts to design for high data rates are directed toward removing redundancy as well as going to higher frequencies. A graphic compression technique developed by Philco for Aeronautical Systems div. of Air Force Systems Command (ASD) is aimed at reducing the time-bandwidth product required for transmitting pictorial data ranging from simple line drawings to detailed aerial photographs. At the transmitter a scanner converts the input hard copy into video to be processed by an encoder. The encoder reduces the redundancy of the video scanned from the input picture by combining a variable-recognition technique that recognizes and encodes straight-line transitions and ramps. When brightness of all elements in a 5×5 element block is essentially constant, that brightness is transmitted in one data-link Nyquist interval, yielding a 25:1 time-bandwidth saving. When a transition between two brightness levels occurs, the characteristics of the straight line or ramp with which it can be approximated are transmitted in a six-pulse code, producing a 4:1 time-bandwidth saving.

Efforts are also underway to eliminate the redundancy in human speech. For example, a speech compression system delivered to ASD by Melpar provides digitized communication of speech at 1,000 bits per sec, compared with the 24,000 bits per sec normally required. Sentence intelligibility is approximately 95 percent.[27]

ADAPTIVE SYSTEMS—Feedback is being studied for improving accuracy of data transmission from space vehicles. Where much error reduction is required, feedback could be cheaper than unidirectional systems employing coding for error correction. Also, feedback is particularly effective in channels with widely varying characteristics, such as are caused by signal fading.

Feedback can be used in two ways. First is in the command sense to control the transmitter mode of operation. The desirability of such a change in mode might be indicated, for example, by estimation of the parameters of the incoming signal, or of the signal content itself. Thus, the transmitter power level could be changed upon command by a receiver capable of sensing signal-to-noise ratio.

Second way is to establish the transmitter mode and use feedback to correct errors. One such technique is a combination of decision feedback with long codes. This is presently being investigated at NYU as a means of insuring reliable reception under all channel conditions. In this system, error probability can be kept arbitrarily low (10^{-10} for instance) when signal-to-noise ratio drops to zero.[29] The information rate adjusts to channel conditions without sacrificing reliability—when channel conditions are unfavorable the transmitter keeps repeating, while under good conditions most messages are accepted immediately. Reliability is achieved by obviating the effect of errors due to fading and burst-type noise. The use of long codes with only a small amount of error correction accomplishes this in the forward channel. "Accept" to "reject" errors in the feedback channel which may occur are neutralized by a labeling of code words in the forward channel, while the transmitter uses a decision mechanism to avoid "reject" to "accept" errors.

This system may eventually find application in those satellites where large amounts of data must be handled with extremely high reliability, as, for example, when transmitting computational data. Deep space probes that might not need the same order or reliability could use simpler feedback systems, possibly of the command type.

Space communications reliability is also being studied at the component level. For example, Sylvania is developing a 35-cu in. S-band receiver for ASD with a predicted operating life of 38,000 hr. Receiver has an extra i-f stage so that if one fails it is automatically by-passed. Other circuits are duplicated for fail-safe operation.

EXOTIC COMMUNICATIONS—Possibility of long-range secure communication by transmitting at optical frequencies has prompted study of wavelengths from ir through visible light to uv, x-rays, gamma-rays and particle beams[29]. At these frequencies range may be limited only by the ability of the transmitter and receiver to locate and track each other—admittedly a problem requiring orders of magnitude improvement over present acquisition and tracking capability. Most work is presently devoted to masers in the ir and visual regions[30], may lead to uv masers. Low power required by these potentially narrow-beamwidth systems would be particularly valuable for space-to-space communications. Deflected sunlight is also being studied as a potentially simple communication system. Such a system developed for ASD by Electro-Optical Systems might handle transmission rates at earth-to-moon distances.

Experiments in uv communication at Westinghouse have indicated the feasibility of transmitting with a 10-cps bandwidth over 50 million miles with 1 w radiated power. Generator is a crt arranged such that the excited spot sweeps over the phosphor area but is stationary with respect to the environment.

Propulsion and Power Generation

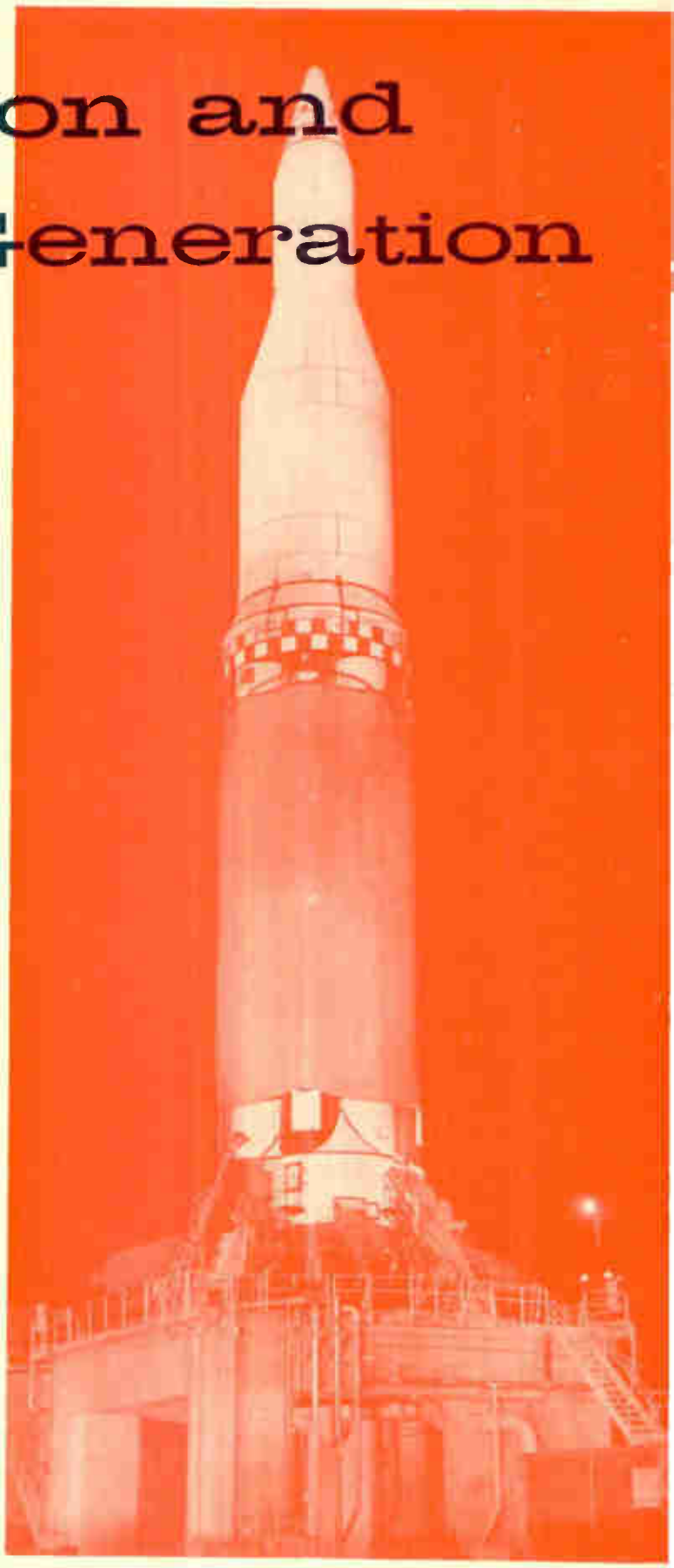
NEITHER ADVANCED GUIDANCE nor sophisticated payloads are of much use without the ability to boost a vehicle into its proper trajectory and to provide power to operate on-board equipment. Although progress is being made in both areas, there is still much to be done.

PROPULSION—All present propulsion as well as that planned for delivering payloads into space in the near future utilizes the energy developed from combustion of chemical fuels with an oxidant. For missions involving multiton payloads to the moon and beyond, however, it is important to increase the specific impulse of the propulsion system far beyond that which can be achieved with chemical combustion. For this reason, nuclear and electrical propulsion are under active development.

Aim of the joint AEC-NASA Rover program is to use a nuclear reactor to heat liquid hydrogen to a hot gas which would be accelerated through a nozzle, producing thrust. Such a system may produce specific impulses around 800—some two to three times the value possible with chemical propulsion. This increase in thrust per pound of propellant flow permits reducing propellant weight, thereby increasing payload. For example, while an all-chemical vehicle in earth orbit might weigh 9,100,000 lb for a 1-yr Mars mission, the same trip could be made with a 935,000-lb nuclear rocket with reactor powers of approximately 10,000 Mw in the first stage, 6,000 Mw in the second, and 1,800 Mw in the third.[81] First experimental flight of a nuclear engine may be made as a Saturn upper stage in 1966-67.

Interest in electrical propulsion derives from the ability of such systems to produce specific impulses in the range of 1,000 to 10,000 sec. This feature, together with their low thrust-to-weight ratios (10^{-8} to 10^{-5}), makes electrical propulsion systems of use for satellite attitude control and orbit changes, and for primary propulsion of deep space probes that have been boosted into orbit by other means. A typical mission might be to spiral from an earth orbit at an initial acceleration of 10^{-4}g into a Mars orbit and return to an earth orbit after one year of continuous propulsion. In this case the electrical propulsion system could return a payload 50 percent greater than a nuclear rocket and with possibly fewer stages.[82]

There are three basic types of electrical propulsion: electrothermal, electrostatic, and electromagnetic. Electrothermal systems, reported furthest along, are essentially ordinary rockets employing an arc or resist-



Saturn, largest U. S. vehicle developed to date, successfully completed first NASA R&D launch Oct. 27. Tests are expected to lead to a C-1 vehicle capable of placing 19,000 lb into a 300-mile orbit

ance heater as the source of thermal energy for a propellant which is then ejected through an expansion nozzle. The latter are useful for specific impulses below 1,100 sec, while arc jets provide specific impulses between 1,000 and 2,000 sec. These devices are limited at higher specific impulses by electrode erosion and frozen-flow losses where energy is lost as the gas cools during expansion through the nozzle.[33] Thus, electrothermal propulsion systems are seen as particularly applicable to satellite attitude control and orbital transfer.

Plasmadyne is developing an electric arc plasma thrustor system to stabilize in orbit, make periodic orbit adjustments and orient a satellite in any desired direction. This system will be self-contained except for the power source. A 1-Kw flight model of an arc jet engine is scheduled for a short flight test in 1962; arc jets under development at Avco may lead to 30-Kw flight tests on a satellite in 1965.

Electrostatic propulsion is accomplished by ionizing the propellant and accelerating the resulting positive ions by electrostatic fields. Electrons are then fed into the ion beam to neutralize it and prevent space-charge buildup. These systems may be most useful in the specific impulse range above 5,000 sec. Two most commonly considered electrostatic systems are contact ionization of cesium on tungsten and electron bombardment. The latter uses a magnetic field to confine electrons emitted in a chamber through which the propellant is fed. The electrons move in the magnetic field with sufficient velocity to ionize atoms, and the resulting ions are accelerated electrostatically. Advantage of this method is that no heated surfaces are required and propellant materials other than alkali metals can be used.[33]

Since some of the basic features of ion engines such as beam neutralization and spreading cannot be tested adequately in the laboratory, flight testing is considered essential. Between 1962 and 1965 it is expected that a number of ion engine models, as well as a few other electrical engines, will be flown on Scout vehicles. One technique, which will be used by NASA, is to mount two engines on outrigger arms in such a way that their thrust will decrease or increase the spin of the payload capsule. First test, with a 1 to 2-Kw power source, is scheduled to be a Hughes Aircraft cesium ion engine and a mercury-fueled bombardment-type ion engine developed at NASA's Lewis Research Center.

Other possible methods for electrostatic propulsion include the Von Ardenne source, which uses a magnetically confined arc to ionize the jet, and the oscillating -electron source. The latter produces a space-charge neutralized plasma beam and can operate over a wide range of specific impulse by varying operating voltage. Since it is a bombardment-type source, any material that can be vaporized at reasonable temperatures may be used as a propellant.[34]

Electromagnetic propulsion refers to the acceleration of plasma by a magnetic field. The numerous experimental devices can be divided into continuous and pulsed as well as those with electrodes and those without.[35] For continuous operation there are crossed-field Lorentz-force accelerators, and engines based on accelerating by electric and magnetic field gradients. Pulsed plasma accelerators include T-tubes, button guns, rail guns and electrodeless induction guns. Republic Aviation's pulsed plasma engine is scheduled for flight testing next June. Although electromagnetic propulsion may require higher power than the other types, researchers hope to operate at specific impulses of 3,000 sec, thus enabling electromagnetic engines to complement the others.

POWER GENERATION—Most space vehicles will require electrical power for communications, instrumentation, and stabilization and control; some will need power to actuate chemical or nuclear propulsion systems, or to drive an electrical propulsion system. Figure 4 shows an estimate of the electrical power levels required in various spacecraft during the next few years.[36]

Main sources for power remain solar, nuclear and chemical, with the latter dominant for launch vehicles and missiles.

SOLAR POWER—Principal solar power systems are solar photovoltaic cells and systems where solar energy is converted directly to electrical energy. Solar cells, with chemical batteries for storage, will continue to be of major importance for the next few years. Silicon solar cells permit simple systems and presently offer conversion efficiencies around 12 percent.

An example of one advanced application of solar cells is OGO, which will have 30,000 cells compared with 8,000 on Explorer VI. They will be mounted on two modularized paddles maintained normal to the sunlight. Both automatic and ground control will be used to adapt the system in orbit by switching groups of cells in and out of the circuit in response to battery temperature, voltage, charge current, and possible open or short circuits. System is designed to operate continuously for more than a year.[37]

A major problem with solar cells, especially when applications above 1 Kw are considered, is cost. Thus, flat-plate and curved solar concentrators are being investigated for increasing power output per unit cell area.

Development of new materials such as gallium arsenide may allow significant improvements in solar cell efficiency and radiation resistance. Maximum theoretical efficiency for the gallium arsenide cell is about 25 percent, compared to 20 percent for silicon.[38] Cadmium sulfide cells are being developed to obtain lighter weight, lower cost generating capability. Efficiencies between 2 and 2.5 percent have been obtained with 20-sq-cm thin-film CdS cells.[39]

Researchers at International Rectifier Corp, are considering putting a reflecting barrier within the diffusion length of a silicon solar cell junction so that the hole-electron pairs generated below the junction would be reflected back and collected. Technique will involve combining epitaxial and diffusion techniques; if it works efficiencies of 20 percent may be obtained.

Use of solar energy for power levels above 1 Kw may be feasible with several types of solar-heated systems under development. These are solar-thermionic, solar-thermoelectric and solar-mechanical, which may be competitive in the range from 1 to 10 Kw.

Thermionic converters should reach efficiencies of 20 percent within the next few years. These systems need highly accurate solar concentrators with concentration ratios greater than 2,000 to 1, but are potentially lighter, cheaper and smaller than solar cell systems. Major problem is improving lifetime and reliability, although some feel that until energy storage is successfully incor-

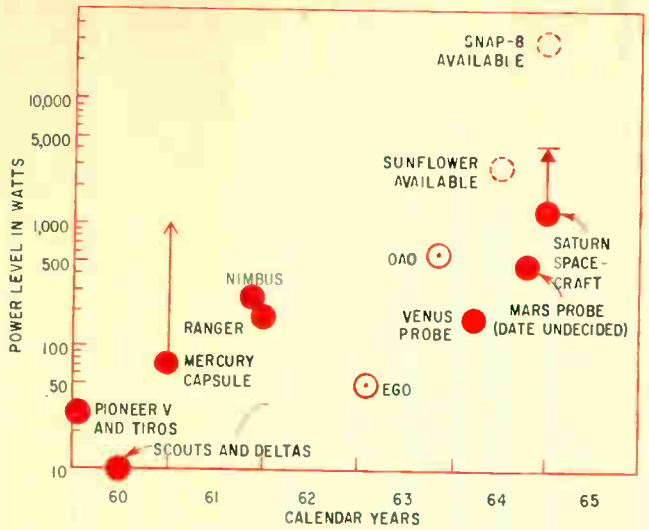
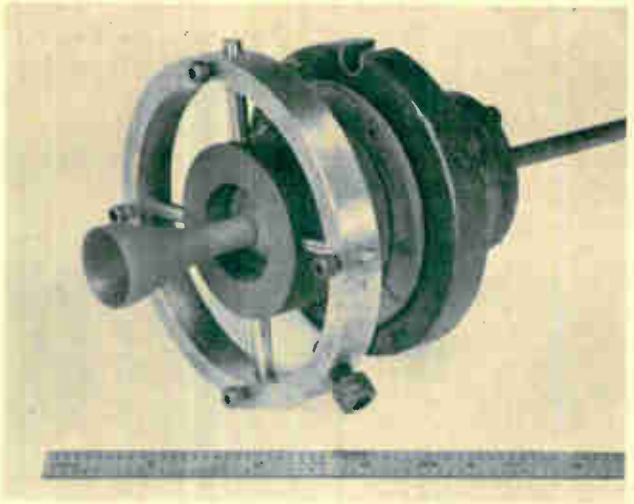


FIG. 4—Estimated electric power requirements for NASA spacecraft through 1965



Plasmadyne electric arc thrustor can produce 1 lb of thrust. Similar unit is programmed by NASA for a 1962 flight test

porated, thermionic converters will find application in planetary probes where they could be in the sun all the time, rather than satellites.

A solar-thermionic system being developed by Electro-Optical Systems may supply 135 w on Mariner probes. It will use a solar collector 5 ft in diameter to focus radiation onto cesium diode converters being built by Thermo-Electron Engineering Corp.

Solar-thermoelectric systems may be used where their disadvantage of large collector area is offset by their light weight. General Atomic is developing a flat-plate generator for ASD where there is no concentrator and the orientation can be varied ± 10 deg without a significant decrease in power output. Device is an aluminum sandwich of lead telluride and (probably) zinc antimonide thermoelectric elements. Although efficiency is only 2 to 2.5 percent, weight is 50 lb per Kw.

Solar-mechanical systems under development include a 3-Kw mercury vapor turbine system (Sunflower I) and a 15-Kw rubidium vapor turbine system. Sunflower I is being developed for NASA by the TAPCO group of Thompson Ramo Wooldridge to supply the auxiliary power requirements of Centaur and Saturn. The latter is being developed for the Air Force by Sunstrand Aviation.

NUCLEAR POWER—Radioisotope decay and fission reactors will be used as nuclear energy sources for space power. Radioisotope thermal energy can be converted into electrical energy by thermoelectric and thermionic converters, or used to decompose lithium hydride into lithium and hydrogen in a regenerative fuel cell.[40]

A 19-w isotope-thermoelectric Snap generator has been designed at Martin's Nuclear div. for a Surveyor-type mission. Device would weigh 16.6 lb and withstand 100-g lunar landing shock.[41] Radioisotope systems are designed for the range from a few watts to several hundred watts; isotope-thermoelectric systems will probably be competitive with solar cells and solar-thermionic sources in the range between about 100 w and 1 Kw. Above that, radioisotopes become impractical and somewhere between 5 and 30 Kw there is probably an upper limit to the use of solar sources. Thus, the region over 30 Kw will most likely be dominated by nuclear reactors. They have the potential of supplying power well into the megawatt range.

Reactor-turboelectric systems are under development for 3 Kw (Snap 2) and 30 to 60 Kw (Snap 8) by Thompson Products and Aerojet General, respectively, and the Atomics International div of North American Aviation. Atomics International is also developing a reactor-thermoelectric system (Snap 10A) that will be capable of supplying 500 w at a weight of less than 750 lb. Snap 10A will have application for an Air Force satellite system and may be flight tested in 1963; Snap 8 is planned as an electrical propulsion source.

Thermionic conversion is considered promising for electrical propulsion or power for semipermanent lunar bases after 1965. A reactor-thermionic system might produce megawatt power at 7 lb per Kw.

CHEMICAL POWER—Systems using chemical power are electro-chemical types, where batteries or fuel cells directly convert chemical into electrical energy, and combustion types that use the thermal energy of chemical reactions.

Fuel cells have conversion efficiencies of greater than 70 percent and provide the greatest advantage over conventional batteries when loads are moderate over a continuous long period.[42] Most promising spacecraft applications are considered to be the primary hydrogen-oxygen fuel cell with cryogenic storage of the fuel and oxidizer for an output of 500 w to several Kw for several days to 3 weeks, and the regenerative hydrogen-oxygen cell for energy storage with solar power systems. A primary fuel cell is among the power sources being considered for Apollo.

Chemical batteries will continue to be important for spacecraft energy storage and for providing high peak power over short time periods in missile and space applications. Sealed nickel-cadmium batteries can provide about 10 to 12 watt-hours per lb and have been widely used because of their high cycle life. Lower cycle life but higher energy-to-weight ratio is provided by silver-zinc cells, which can give 40 to 50 watt-hours per lb.[43] Silver-cadmium batteries can provide 20 to 30 watt-hours per lb and are reported showing cycle life comparable to that of the nickel-cadmium battery.

Earth-Based

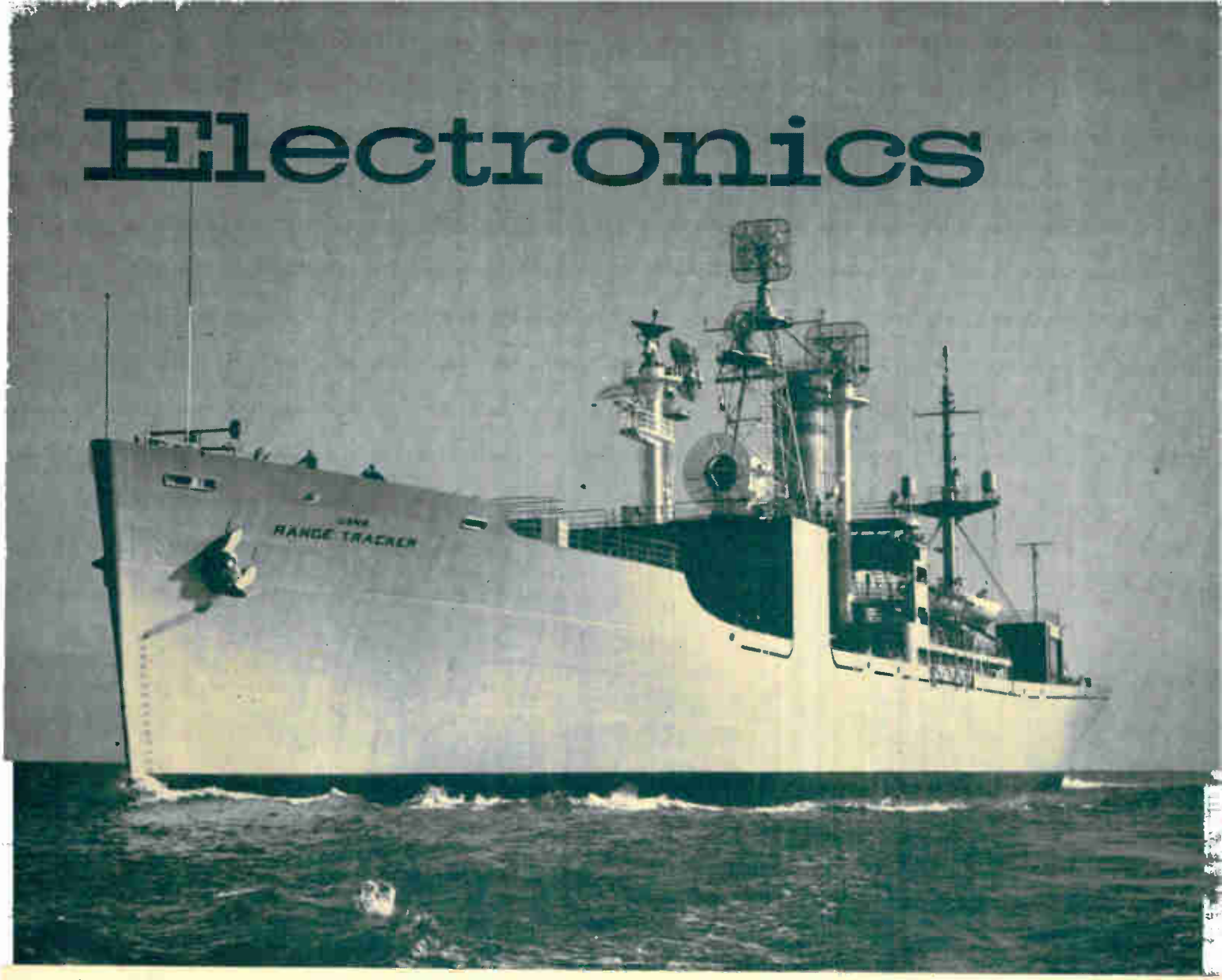
To discover a missile's vulnerable points they are studied on reentry by a floating laboratory, the **USAS American Mariner.** Top center is a uhf L-band antenna and on either side, C-band tracking radars (RCA). Below are optical instruments (Barnes Engineering) that cover the spectral region from the far ir through uv. Downrange Antimissile Measurement Program is sponsored jointly by the Army Rocket and Guided Missile Agency and the Advanced Research Projects Agency

FOR EVERY POUND of man-made object sent into space there are millions of pounds of equipment on the ground needed to put it there, to track it, instruct it, and to receive and reduce its findings to usable data. If the object is a test missile, all this will be done at the missile range. If, however, the vehicle is putting a manned or unmanned satellite into orbit or taking a spacecraft to the moon, the missile range will put the craft into its trajectory and another network will then take over. This second network for cooperating satellites or probes is discussed in this section following missile ranges. Also described are efforts toward the detection of enemy missiles and spacecraft, our operational ballistic missile launching sites, and radio and radar astronomy.

MISSILE RANGES—Our launch facilities were built to test developmental airbreathing missiles; they were successfully updated to accommodate long-range ICBMs. The big push now is to retain these capabilities while creating new installations to launch manned and unmanned craft into space.

All the nation's missile ranges are expanding. USAF's Atlantic Missile Range, Cape Canaveral, is growing rapidly to accommodate the growing military and NASA space programs. Vehicles launched into polar orbit will still be launched from Navy's Pacific Missile Range. Army's White Sands is the test bed for the Nike Zeus. NASA's Wallops Island, Va. is building up to take care of more sounding rocket probes and satellite firings. USAF's Eglin AFB, Fla. is used for strategic short range missiles and the longer-range air defense Bomarc.

New range instrumentation must have greater coverage and more precision. Coverage must be more comprehensive since any spot on the globe might be the right place to initiate a trajectory for the moon from a parking orbit. This might be solved by sending interferometer-



Island stations are giving way to instrumented ships like the **USNS Range Tracker** to provide missile ranges with expanded, mobile tracking and telemetry coverage. Chance Vought installed the electronics, Ingalls Shipbuilding converted the ship

equipped ships to that spot. Three or four ships could establish such a temporary system or one or two in connection with a land mass.

Because of the trajectories taken by longer range missiles some island stations in the Atlantic Missile Range are being closed, more ships added.

While the fact that some scientific satellites "achieve orbit" is enough, vehicles carrying men or payloads that must be placed in precise positions, such as hovering satellites, require improved trajectory position and velocity data acquisition systems.

Mainstay for obtaining this data at Canaveral is still Convair's Azusa Mark I, a c-w cross baseline interferometer operating in the C band, requiring a transponder in the missile. Output data are digitized for use in the IBM 709 computer and measured parameters consist of range, coherent or fine range and two direction cosines.

The Azusa II, intended to replace Azusa I, was installed in the spring but will not be operational until the first of the year. It is nearly identical to the Mark I except that its circuit design was refined and cosine rate was added which provides better direction cosine information. Both Azusas have identical limitations: they will not track cross-polarized signals; missile antenna nulls deeper than 10 db cause noisy data, ambiguities and in severe cases, loss of data.

Next generation system is Mistram," an X-band, c-w radar using interferometer techniques, developed by the Defense Systems dept. of GE. Mistram, now being installed at AMR, will be operational by spring. A second Mistram will go on AMR's downrange station, Eleuthura, next August.

Mistram uses five receiving stations arranged in an L shape. Baselines are 10,000 ft and 100,000 ft. Coverage is said to be 360 deg in azimuth and 20 to 600 mi in range at elevation angles between five and 85 deg. With re-

duced accuracies, this coverage can be increased to a minimum elevation angle of zero deg with ranges in excess of 1,000 mi.

Using all four stations Mistram will achieve the following accuracies: Range error, 0.40 ft; range rate error, 0.02 fps; range difference error, 0.03 ft (10,000 ft baseline) and range difference rate error, 0.002 fps.

Reason for Mistram's accuracy, according to GE, is the long base lines used; and the extensive use of phase lock loops throughout the system to maintain precise phase coherency. Also, refractometers are located at each observation site.

Besides the modified World War II pulse radars at AMR, there are five C-band monopulse tracking radars, FPS-16. They are being modified with digital range systems to increase range tracking capability to 5,000 n mi. Two FPQ-6s now on order will track transponder targets at 32,000 n.mi. Antenna is a 29-ft cassegrain system using 5-horn feed; 3-Mw peak power transmitter is tunable from console (54-5,900 Mc); beam width is 0.4 deg, gain of 51 db. Operational late 1962.

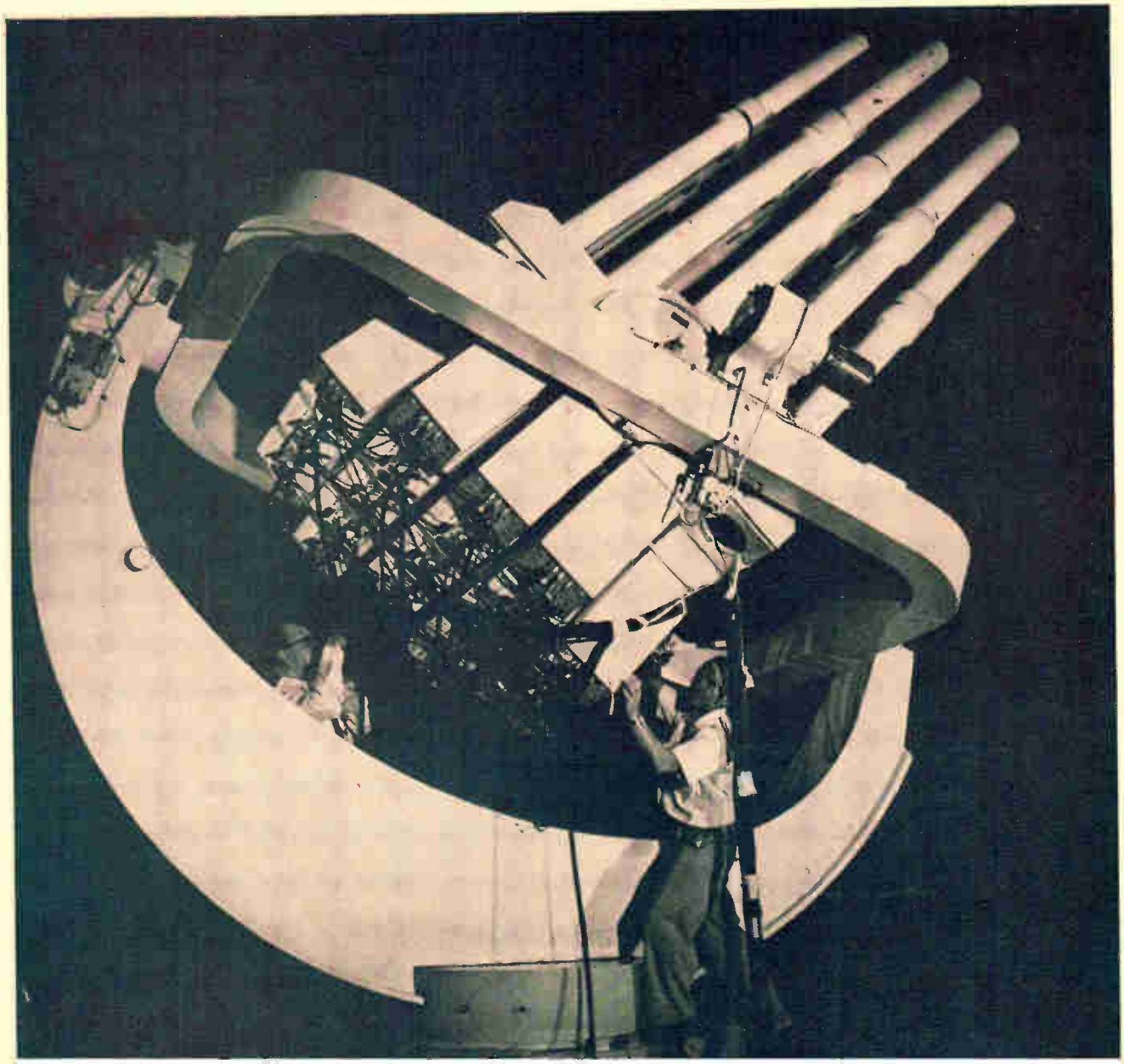
Two ship stations now being equipped by Sperry Rand will use C, X and L-band radar systems.[45] Future radar equipment is not limited to these frequencies. It is highly important to measure characteristics of missiles in flight at as many frequencies as possible. A range measuring technique with good potential is the laser, although many problems must be solved between the present state of the art and an operational system.

Infrared instrumentation is receiving increased emphasis for several reasons: At the launch site it is used with radar to acquire the target—which it does faster than radar—and pass it on to the radar which is better for precision data gathering. Also at the site ir is used in connection with the second function of a missile range: providing data for determining ways to intercept enemy missiles. Radiation measurement systems are used to study the missile plume during the missile's first 100 sec of flight. Identification by a particular missile's signature reveals the probable trajectory of the enemy missile.[46]

At impact point ir acquires the missile prior to impact and studies the ablation of the nose cone.

Problem with ir is atmospheric attenuation. Sperry, among others, is doing in-house work on a system that

Facet-eye camera system tracks earth satellites, planets Jupiter and Venus, day or night. Developed in-house at Air Force Missile Development Center, Holloman AFB, New Mex., it consists of multipatterned telescopic lenses linked to image-orthicon tubes and oscilloscope screens. Image-intensification techniques mark an improvement over ballistic cameras, USAF says



will be affected less by attenuation than the 2 to 9 micron band now being used.

More than a dozen varieties of optical systems are in use at the Cape. The present ballistic camera provides accuracy of one part in 100,000. AMC is buying new 1,000-mm focal length cameras with accuracy of 1 part in 400,000 from Instrument Corp. of Florida. These new instruments can be used to calibrate Mistram. Also on order are 600-mm focal length cameras from Nortronics.

Current attempt to advance the state of the art is Port, a photo-optical recorder tracker system. Purpose is to record events at great distances. Primary sensor will be a 40-in. aperture optical telescope with a 1,000-in. focal length. Target acquisition will be automatic, data will be recorded on 70-mm film. Proposals from industry are now being studied by AFMTC.

Major telemetry systems at AMR are: pdm/f-m; f-m/f-m; and pcm/f-m. The pcm/f-m systems are used in applications where a time division multiplex system can meet the bulk of telemetering requirements. The f-m/f-m systems are of the frequency division multiplex type—an r-f carrier is modulated by a group of subcarriers, each of a different frequency. The pcm/f-m system produces high capacity, digital telemetry; is transmitted as binary coded, time division multiplexed samples. Advantages of a binary coded digital system in addition to large channel capacity, is accuracy, flexibility and the ease of data processing.

The elaborate communication system at AMR must be capable of quick expansion, modification, modernization or replacement. By 1966, AMR hopes to have a communications satellite net. This will provide real-time, broader bandwith communications.

TRACKING AND DATA ACQUISITION—The most sophisticated craft in space is as worthless as its burned-out booster if its findings are not received on the ground.

After the missile range has got the sounding rocket into space, the satellite into orbit, or the lunar probe headed toward the moon, far-flung ground networks take over to track, issue commands and collect data. Even though some of these ground stations are at the missile range itself—particularly in the case of sounding rockets—their function is distinct from that of the range. Most of them are far removed from any range.

The ground instrumentation needed in this rapidly expanding area depends on the spacecraft and mission. NASA breaks these down into four categories: the earth satellite, manned earth satellite, sounding rocket and deep space probe.

In general, the major areas of advanced research and technical development in which NASA is working are: wide-band data links (vital for tv at increased distances); improved data coding (advanced information theory is resulting in improved coding so that more information may be transmitted per watt of spacecraft power); low-noise receivers; large ground antennas; automatic data handling; improved data reduction; longer range tracking.

Specifically, here are the plans for each major net:

Plans to update minitrack, the basic tracking system for earth satellites, include: completion of the 85-ft antenna at Fairbanks, Alaska by 1962 for the Nimbus weather satellites; building a new station, similar to the Fairbanks installation, on the east coast of the U. S. These stations will acquire wider bandwidth data from the complex satellites to come; they will operate on a real-time basis for commanding attitude control and other instructions.

Modernization plans for 1962 call for new, wider bandwidth receivers and recorders at several stations, tracking filters for new receivers, modifications to command transmitters and improved ground communications from South America to the Goddard communication center.

To accommodate the increased volume of data from such satellites as the orbiting astronomical, solar and eccentric geophysical observatories, four small (about 30 ft) data acquisition, self-tracking antennas will be installed. These will be coupled with improved telemetry receivers and wide bandwidth data recording and conversion units. Command transmitters will be replaced and updated in all stations to meet the increased requirement for satellite interrogation and command.

Along with the trend toward wide-band, high-resolution data transmitted from the bigger satellites, ground data-handling capabilities must also improve. Goddard will buy new equipment designed and developed to handle the large variety of incoming data. Rapid conversion of the large amount of processed data collected from the satellite projects to numbers or graphs that the experimenters can use in their final reports can be accomplished only through use of electronic or electromechanical instruments designed for this purpose, NASA says.

NASA also uses a network of 12 Baker-Nunn camera sites that photograph a satellite against a star background. Design of a photoelectric optical tracking system has begun which is more sensitive than existing photographic systems and provides data simultaneously.

USAF's Satellite Test Center, located at Sunnyvale, Calif., is operated jointly by USAF and the Lockheed Missiles and Space div. The satellite control room provides a communication focal point for command surveillance and direction during launch, orbit and recovery.

The net now consists of four main stations—Vandenberg AFB, Calif; Kodiak, Alaska; Kaena Point, Hawaii and New Boston, N. H. By fall of next year, there will be another station in Alaska. Two more are planned for still undisclosed locations.

The center is involved in eight programs consisting of 14 satellite configurations: Discoverer, Midas. Samos, Advent, Satellite Inspector (formerly called Saint), Snapshot, Vela Hotel and Transit. (The additional six configurations are special test versions of the same satellite requiring different satellite control systems. Midas, for example, has several configurations.)

Five antenna systems are used at USAF's stations: (1) Verlort, S-band, capable of radar tracking, angular readout and limited command facility. (2) TLM-18, a 60-ft paraboloid for telemetry and data. (3) 3-axis 60-ft paraboloid for vhf telemetry and data with multipurpose feed capability; operates in the upper uhf band for command transmission, reception of telemetry and data and automatic tracking; in the lower uhf for doppler tracking and also limited command transmission; and in the vhf band for telemetry and data reception (f-m/f-m or pam/f-m). (4) Tri-helix for telemetry, vhf, f-m/f-m. (5) Two 10-ft parabolic uhf antennas, one for angle tracking, the other for command.

Reeves Instrument has developed and will soon make available a new Verlort radar capable of nonambiguous beacon tracking to a range of 5,000 mi. The radar will

use wide-band parametric r-f amplifiers capable of covering the entire operating spectrum without tuning. They will also permit switching from beacon to skin tracking without tuning.

The reflector and scanner will be mounted on a high-precision, two-axis pedestal having a tracking accuracy of 0.1 milliradian. This accuracy is possible by direct-drive permanent-magnet torque motors, combined with tachometer rate feedback. The drive motors and tachometers are mounted directly to the gimbals, thereby eliminating the need for intermediate gearing.

Analog output data are provided by 36-pole synchros, directly coupled to the azimuth and elevation gimbals. Seventeen-bit encoders provide the digital output data.

Needed for the military satellite control net are developments in wideband readout systems, real-time data handling and real-time high-volume command capability. With existing satellites it is already necessary to transmit up to 400 commands, some to be acted on immediately and some to be stored and acted on later. More will be required of later satellite systems.

The existing 18-site Mercury net[47] will be the building block for future manned orbital flights. An additional site will be built for the first phases of Apollo at an existing Minitrack station in the southern hemisphere. The Station will include a precision C-band radar of the FPS-16 class as well as the same equipment used at the other manned flight net stations for telemetry, ground-to-capsule voice, and for command. An Agave will be installed for capsule acquisition. Ground-to-ground communications will be ssb-voice. Dyna-Soar will also begin with Mercury's downrange facilities.[48]

Ground equipment for sounding rockets differs from that required for other classes of missions since coverage required is over a limited area. Facilities at Wallops are being updated to take care of the long-range rockets to be launched there. With the use of longer-range and greater weight-carrying-capacity rockets, there has been an attendant growth in instrumentation problems. A primary problem is that of range safety displays. Trajectory parameters must be accurately determined in real-time for guidance and control and for range safety.

AN/FPS-16 and Mod II radars are being equipped with acquisition computers to enable radar trackers to determine pointing data from information fed in from remote sites to pick up spacecraft and ballistic missiles launched from other ranges. These radars are being modified to increase range capability by increasing receiver sensitivity and installing extended range tracking units. Digitalization and data transmission capability are being provided for the precision trajectory determination system to obtain near real-time position and velocity data. A high-power pulse doppler radar system will operate with the precision trajectory determination system to obtain range rate without vehicle-borne beacons.

Equipment for tracking and communicating with deep space probes has about the same capability as the spacecraft themselves. With plans for more and deeper missions, requiring greater data transmission capacity, the ground gear must improve apace.

The present 3-station, 85-ft antenna Deep Space Instrumentation Facility (DSIF) is being improved ($9½ million for fiscal year 1962); a second phase feasibility study for a 240-ft antenna (expected to improve communications over the 85-ft dish by a factor of ten) is underway; and USAF's 120-ft Haystack system which may influence design of future space communications gear will be operational in late 1962.

Study for a 240-ft antenna will be completed by July. Planning calls for one operational antenna at Goldstone by Jan. 1, 1965. Ultimate goal is to equip both overseas stations with the large dishes.[49]

The 120-ft antenna system, Haystack, is the test bed for development of large ground-based transmitting and receiving equipment to operate high-capacity satellite-relay communication systems. Designed and being constructed by Lincoln Laboratory, the project is managed by USAF's Electronic Systems Division.

The transmitter and receiver are housed in an 8 ft sq and 10 ft long pluggable package, mounted just in back of the center of the antenna. This module concept allows the facility to be used over a wide range of frequencies and for a variety of different experiments without costly and time-consuming modifications. First package will be a 100,000 c-w X-band transmitter, operating at 8 Gc. It will be used with Project West Ford—metallic fibers placed in an orbital belt around the earth as an artificial ionosphere. At an operating frequency of 10 Gc, the beamwidth will be only 3 sec.

A phased-array technique for achieving high antenna gain for deep-space communication systems is under development by Sperry. Called Athesa (Automatic Three-dimensional Electronic Scanned Array), this project will be described below along with other phased array radar.

DETECTION—The main ground-based sensor being pushed to meet the critical need for better areospace surveillance of ballistic missiles and nonradiating satellites continues to be radar.

Long-range distance measuring by ground-based ir and uv sensors is not possible now due to atmospheric dispersion. Research is underway on lasers but the foreseeable goal is space-to-space operation.

Orthicon scanning techniques and more automatic photographic cameras are being studied for high altitude satellites. An illuminated surface of 10 sq m can be seen with optical systems at moon ranges—equivalent to a 17th magnitude star.

The requirements of detectors today and for the future are formidable. The radar cross section of a ballistic missile warhead is about 1/10 that of a small aircraft. High altitude satellites may be even smaller. Progress in penetration-aid techniques is resulting in even smaller nose cones as well as the ability to camouflage radar visibility. Radars must discriminate between warhead-carrying vehicles and decoys. Atmospheric effects surrounding nose cones must be understood.

Parameters being pushed in ground-based radar are: greater power and range, better resolution, discrimination, rapid, automatic tracking, multiple target handling and rapid data processing.

The Advanced Research Projects Agency is spending $104 million this fiscal year on Project Defender to evolve a defense against ballistic missiles. For the most part, ARPA buys data. Development work is farmed out to the military services and to industry.

The Electronic Systems Division (ESD) of the Air Force Systems Command (AFSC), Hanscom Field, Mass., is carrying out a large-scale research program on advanced radar techniques—some of which is for ARPA.

ESD calls on its own Rome Air Development Center, Rome, N. Y., as well as MIT's Lincoln Labs, AF Cambridge Research Laboratories, the Mitre Corporation, universities and industry. Techniques being studied by ESD include phased array radar, multistatic radar, pulse compression, coherent signal correlation and doppler acceleration correlation techniques.

Transmitter power is improving at a good rate—ten times better than it was ten years ago. The problems are building equipment to handle high power, improving low-noise receivers, and determining the point at which high power no longer pays off.

Today, microwave radar with a 2.5-megawatt peak power is considered powerful. A little beyond this, conventional transmission lines and primary feed systems break down.

Cornell Aeronautical Laboratory, under contract to ARPA, has experimentally emitted a 21-Mw peak power radar beam into space on a 10-cm frequency by using a highly evacuated wageguide and a special gaseous-dielectric lens.[50]

This summer CAL transmitted a 48-Mw peak power (48 Kw average) at a frequency close to 10 cm. The output waveguide transmission line is pressurized with a dielectric gas raised to three atmospheres absolute, which CAL says, is sufficient to permit operation of the transmission line at power levels of about 70 Mw.

Power was supplied by eight VA 820 paralleled klystrons in the output amplifier, each operating at 6.25 Mw peak power. Inputs are fed in phase and the outputs are combined by a special output combiner system. The transmitter which will achieve 50 Mw uses a 60-ft parabolic antenna.

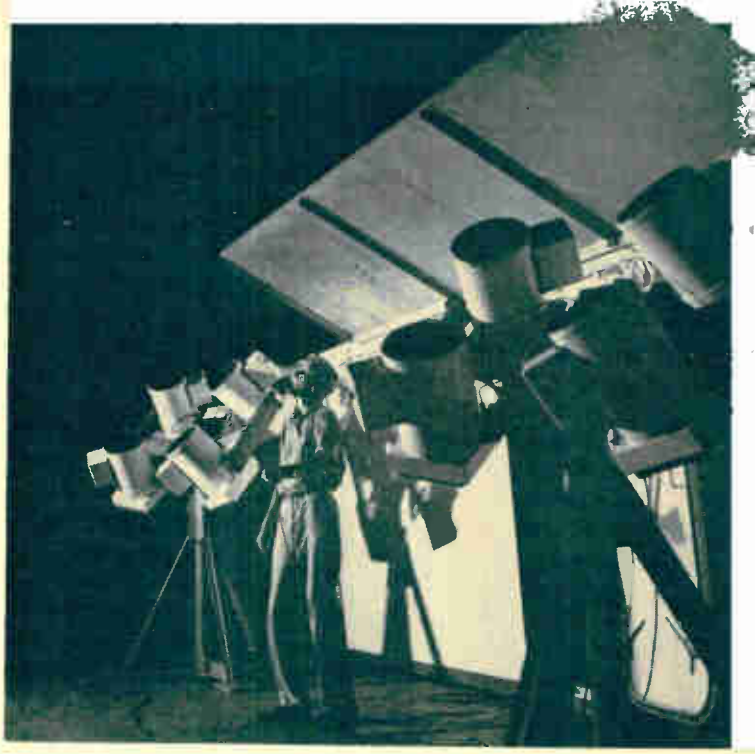
CAL is beginning a program of active experiments to determine at what range a missile nose cone is indistinguishable from its environment, the ionosphere. Beyond this point additional power would be useless.

Another way to increase average power is by pulse stretching and compression—the technique used in the Nike-Zeus radar. In this technique, a narrow pulse is passed through a network which spreads it out in time. The resulting long f-m pulse is amplified, transmitted and when it returns is compressed to its original length. In this way, the long pulse radar gives the equivalent resolution of a short pulse.

Phased array radar, another way to gain power and resolution, is being developed to detect enemy missiles and nonradiating satellites and for deep-space communications. This system utilizes a number of transmitters and receivers spread out over a flat surface. The outputs of the transmitters are added in space resulting in increased power. The individual horns, dipoles or small parabolas can form one beam or a number of beams; they can move quickly from target to target; they are useful in cataloging multiple targets; they scan electronically. The flat surface—possibly a hillside—results in a hard structure that can withstand high blasts.

Phased array radar will open the door to other advances. It will require—and therefore necessitate development of—adaptive signal processors, time-shared acquisition and tracking functions; and investigation of fine grain information content of radar signals.

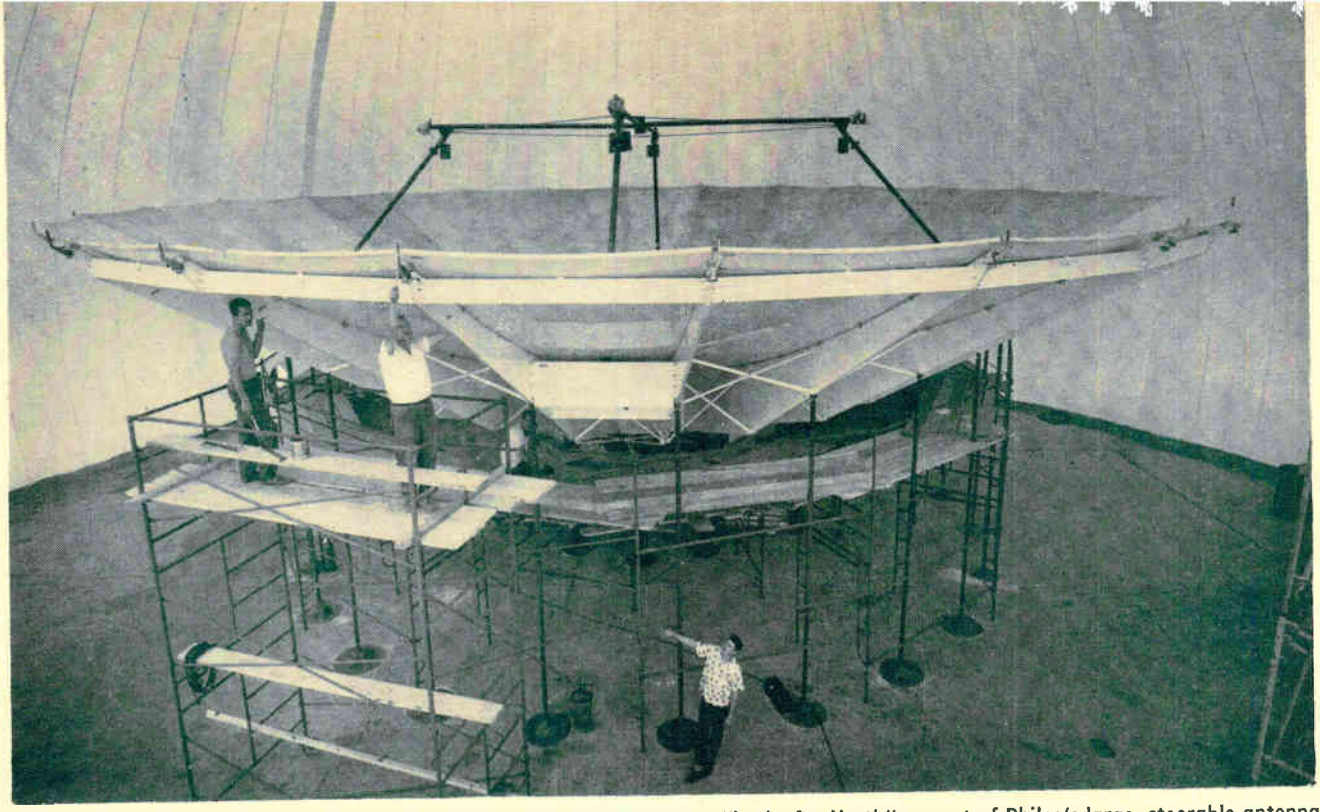
Although cost is high—the system requires many transmitters and receivers and elaborate signal processing—its capabilities are considered worth it. One solution to cutting cost is to come up with standardized modules that can be constructed in quantity at low cost.



Two ballistic camera arrays record missile reentry from the deck of **USAS American Mariner.** Such systems, land-based and ship-based, will continue to play important role in missile range facilities (Barnes Engineering)

Master control console at Air Force Satellite Test Center monitors Discoverer, Midas, Samos and other military polar orbiting satellites, was built by Radiation, Inc. for Lockheed

According to Sylvania, costs have been reduced in its CODIPHASE (coherent digital phased array system) by reducing the number, complexity and expense of components. Sponsored by ARPA as a part of Project Defender, Sylvania-developed signal processing and beamforming techniques make the system capable of simultaneous search and tracking of multiple targets; im-



Sixty-ft antenna reflector is being erected by builder Rohr Aircraft Corp. "in the far North" as part of Philco's large, steerable antenna system to track DOD's polar orbiting satellites (Rohr)

proved range determination; resistant to certain types of ECM signals; less costly and more flexible.

The technique used in Sperry's Athesa for deep-space communications consists essentially of dividing a large aperture into areas wherein the phase errors can be held to a small value.[51] Various configurations are suggested possibilities. One consists of eight paraboloids placed in a circle with the ninth in the center. A more elaborate configuration is needed for wide information channel bandwidths. Sperry believes the Athesa concept is a practical technique for overcoming the cost barrier in achieving antenna gains in excess of 50 db.

The use of pulse compression and phased array simultaneously results in a radar with few theoretical limitations. ESD says the problems in achieving this are big but not insoluble.

Multistatic radars—use of two or more radars in known relation to one another—are being studied to improve the accuracy of determining vector velocity.

An advanced example of multistatic radars is Rome Air Development Center's Active Swept Frequency Interferometer Radar (ASFIR). An L-shaped configuration will consist of one transmitter and three receivers. For the first time in an interferometer system, a linear f-m technique will be used. This was used in the Lobar radar; and prior to this by bats. RADC will have an experimental model toward the end of fiscal year 1963.

Westinghouse reports a study of several methods of target ranging with a pulse doppler radar. Findings: the multiple pulse repetition frequency method is most advantageous for moderate target situations. The linear frequency modulation method, which is less complex, is most advantageous for surveillance and/or simple target situations. But the simultaneous use of both ranging methods and the subsequent correlation of range information, although more complex, possesses the potential to perform well in any target situation.[52]

General Atronics Corp. is working under contract with USAF's Ballistic Systems Div. on a theoretical and experimental program to establish feasibility of an advanced technique for detecting and identifying ballistic objects. Atronics hopes to show feasibility within a year that the technique, called TAM (Tangent Approximating Manifold), will obtain the following information from a normal radar return: rotation, size, acceleration, velocity, range, cross section, multiplicity and distribution. Acquisition of such detailed data is made possible by forming a specific pulse structure and by a set of parallel i-f filters.

Two types of long range 3D radars are: the stacked scanning beam and the overlapping stacked beam. Both categories generate a number of pencil beams stacked in elevation. The stacked scanning beam operates like a nodding-beam height finder. In the overlapping stacked beam, elevation is measured by comparing amplitudes of signals in adjacent channels. This does away with the scanning problem but precision is called for in obtaining accurately shaped beams and controlled overlap. Also, the receivers must have accurately matched input/output characteristics.[53]

An electromechanical scanner called Mubis (Multiple-Beam Interval Scanner) has been designed at Air Force Cambridge Research Laboratories with a number of applications: ballistic missile detection, deep-space-probe telemetry, silent satellite fence and radio astronomy. It is cheaper to build than a BMEWS-type radar; its reflector area is smaller; and it has a wider scan angle (100 degrees). Using a number of beams, it scans rapidly and tracks a number of targets simultaneously.

A number of simultaneous radar beams, spaced in azimuth, are generated and scanned from a single antenna

reflector or array. The beams may be moved either independently of each other or in synchronism. Each beam has its own sector of space to scan and has a separate transmitter, receiver and indicator.

This is done by use of a parallel plate microwave lens that can focus r-f energy from point sources placed along its focal arc into well-collimated beams in the corresponding directions in space (Fig 5A). The lens elements are made of coaxial cables connected to a linear array of radiators through a bank of phase shifters (Fig 5B). These introduce a variable and linearly increasing phase shift along the length of the radiating aperture. This phase delay causes a change of the positions of all the beams simultaneously. The beams of many independent courses can thus be shifted simultaneously, scanning a large region of space, by subdividing it into many sectors.

The line source can be used to illuminate a parabolic cylindrical reflector for collimation of the beam in elevation. Several beams separated in elevation can be obtained by stacking sets of horns in the vertical plane. Alternately, height-finding may be accomplished by instantaneous phase-comparison techniques, developed at AFCRL. In this case the horns comprising the line source are replaced by two-terminal waveguide arrays from which the elevation angle of a target is obtained by phase comparison of the terminal outputs. Two parallel plate lenses and two sets of phase shifters are used. The phase-comparison method of height-finding has advantages over spaced-beam techniques in that the target is tracking continuously rather than in steps.

Alternate modifications of the basic Mubis antenna system replace the bank of variable phase shifters by coaxial organ pipe scanners at the input to the lens to give a monopulse capability and independent beam control. The lens can also be used to feed waveguide or coaxial line sources, in place of the parabolic cylinder, to provide over-head coverage for satellite orbital determination. Still another modification incorporates the "stretch array" developed at AFCRL with the parallel plate lens to provide a three-dimensional steerable beam for deep-space-probe communications or radio astronomy. Sylvania is developing under USAF contract an advanced model using an organ pipe scanner.[54]

For detecting nonradiating satellites, improvements on photographic cameras and orthicon scanners are being made.

An instrument that will record star images and space vehicles in darkness or daylight, near or far, both photo-optically and electronically, for image identification and for digitized information on image coordinates is being built at the Air Force Missile Development Center, Holloman AFB, New Mex.

Called the Facet-eye camera, the system will consist of 25 individual camera chains; each includes a telescope of 75-in. focal length, an image-orthicon camera, a camera control unit, a video amplifier link and a reproducing display unit.

With improved filter techniques and accessory instrumentation, the center expects to obtain real-time readouts of image coordinates in digital form that can be stored or taped on any memory device commonly in use. The latest advances in image tube technology and circuit design for intensifier orthicon tubes may increase sensitivity by as much as five stellar magnitudes. The Center is already successfully operating a 19-chain system.

NORAD's computer for cataloging objects in space is a Philco 2000. Its capacity will be improved as needed. In October it was semiautomated to handle up to 500 objects. In March data processing will be speeded up five times with a two microsecond memory to handle 2,500 targets. Later building blocks will increase target-handling capability to 10,000. Above this number, a new computer will be needed or else a different approach—perhaps on-site computers will send on to the Philco 2000 only new pertinent data.

OPERATIONAL BALLISTIC MISSILE SITES—The site activation program for USAF ballistic missiles has been plagued by a number of problems. Besides community relations, union strikes and other impediments the technological obstacles are numerous.

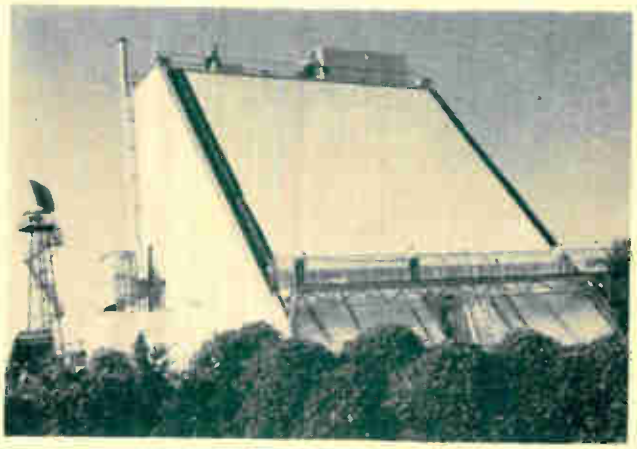
Four different missile systems utilizing five types of launcher configurations are being installed at 24 U.S. locations—eleven sites for Atlas, five for Titan I, three for Titan II and five for Minuteman.

The earliest Atlas missiles are housed in soft gantries. Later models are better protected in the surface coffin type launch pad. Others are in the semihard, buried coffin. Titan I will be stored vertically in inverted silos, fueled in the silo, raised to the surface for topping off and launch. Titan II, powered by a storable liquid propellant, and the solid-fueled Minuteman will be stored, fueled and ready to go, in underground silos constructed for immediate launch from within the silo.

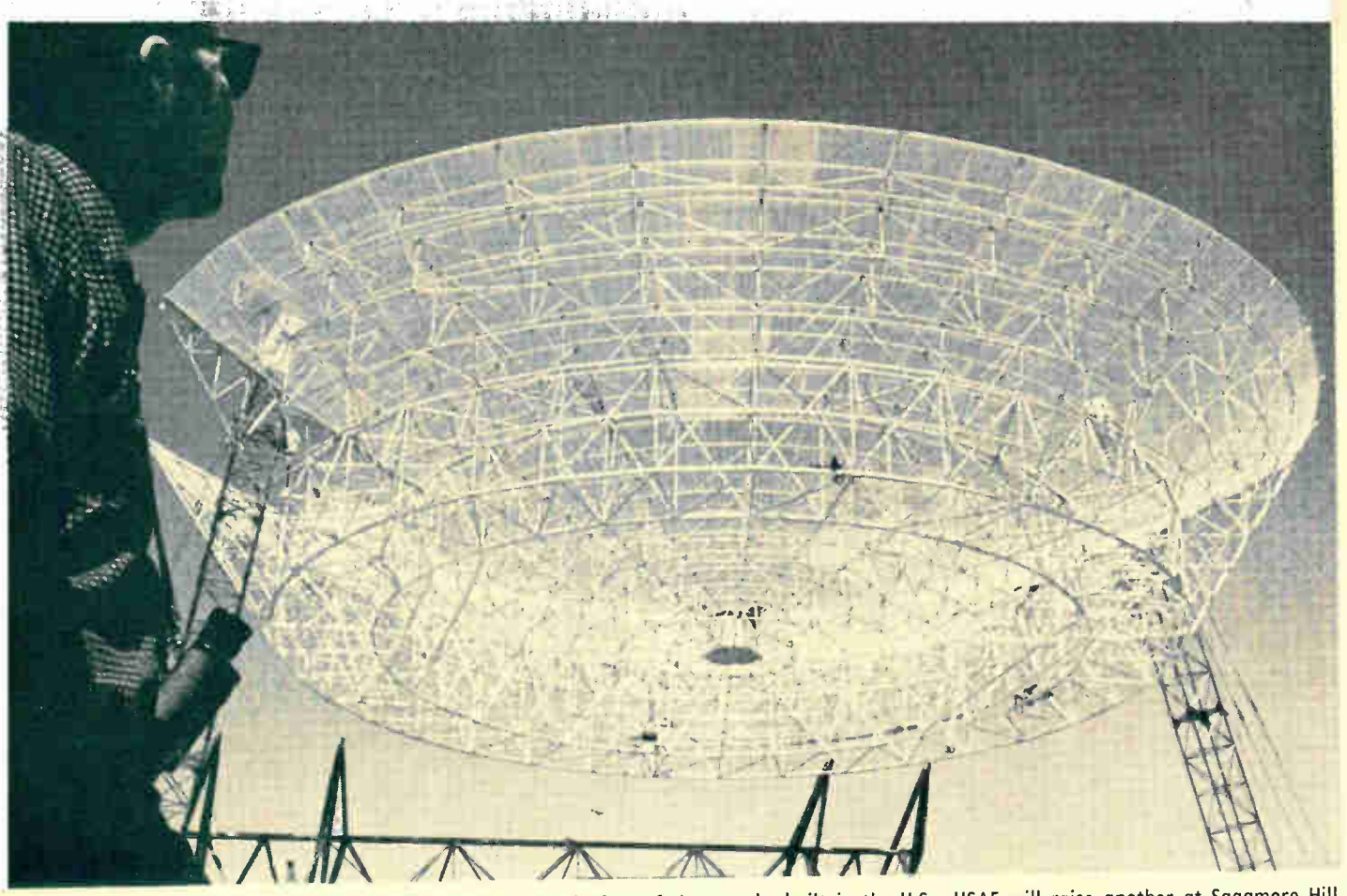
The obvious trend in existing projects is toward hardened, well-dispersed, near-automatic, simplified facilities. Development of the mobile, railroad launch pad is also still underway. There is no reason to believe that Minuteman is the ultimate ICBM. There will be later generation, smaller, solid-fueled, compact missiles, like the proposed Mini-man; larger maneuverable ballistic missiles; nuclear ramjet-powered missiles like Slam. These will require new launch facilities.

The ballistic missile with the greatest immediate potential, however, is Minuteman and its future modified versions. Future launch gear will probably evolve from the equipment now being assembled for it.

Systems requirements for Minuteman are rigid:[55]



ESAR (Electronically steerable array radar) consists of nearly 9,000 radar antennas, can track hundreds of targets at one time and can be used to communicate with deep space probes. It was built by Bendix for USAF's Rome Air Development Center and ARPA



Stanford University's 150-ft radio telescope dish is first of three to be built in the U.S. USAF will raise another at Sagamore Hill, Mass. Navy is building a third on the Virginia coast. All are designed and built by Stanford

fully automatic checkout and launch sequencing functions must be provided within 30 sec total elapsed time; remote operation and readout capability is required from initial turn-on through launch; compatible operation for laboratory, system integration, missile assembly building, sled testing, and launch from either pad or silo is required; complete analog testing to verify operational go or no-go tests is necessary; the complete design philosophy for the operational hardward must be proved in R&D.

A number of design characteristics appear in Minuteman ground equipment that will be repeated or improved in later systems.

Ground gear was reduced by utilizing the airborne computer to a maximum extent during all prelaunch operations and tests. Once the computer is commanded to perform tests it proceeds automatically to the completion of the sequence. This cuts operator training time and permits rapid data gathering. It also ensures that each test is run in an identical manner.

Once the missile has been physically installed on the pad, changes in its state are accomplished over simple communication links, and all subsequent operations are fixed in nature and completely automatic.

At an early stage in the R&D development program it was realized that a potential ground loop problem would exist when signal leads between equipments provided by associate contractors were connected. For this reason, signal transfers are accomplished by relay closure activated at the point of origin, and contact signal source power is provided by the receiver of the signal. In this way, no actual electrical connection exists on signal leads between any two pieces of associate contractor gear.

In the R&D gear electromechanical devices such as relays and stepping switches are backed up by solid state electronics. In the operational guidance and control coupler design no relays or stepping switches are used.

RADIO AND RADAR ASTRONOMY—The radio astronomer, increasingly important in the missile and space effort, is still stuck with the same old law of physics: to get better resolution, you need bigger apertures. He is also facing some new problems such as holding on to enough frequency allocations to allow him to continue mapping the skies; and currently he is worried that Project West Ford—the belt of dipoles the Air Force placed in orbit around the earth—will inspire more obstructions to the distant natural radio emissions from space with which he is concerned.

Built to listen to natural radio-emitting sources, telescopes are now used to listen to man-made emissions from transmitting satellites and space probes traveling within our own solar system.

Basic astrophysical research yields valuable data to designers and operators of long-range radar, solid-state-devices, and communications systems—both ground/space telemetry and point-to-point.

For example, Air Force Cambridge Research Laboratories is cataloging the modulation structure of solar noise bursts to distinguish solar a-m signals from true radar targets and to understand better the mechanism of the solar bursts and their associated radio signals.

Radars with sensitive receivers using parametric amplifiers and masers may receive a-m solar signals in the side lobes even though the main beam of the radar may be

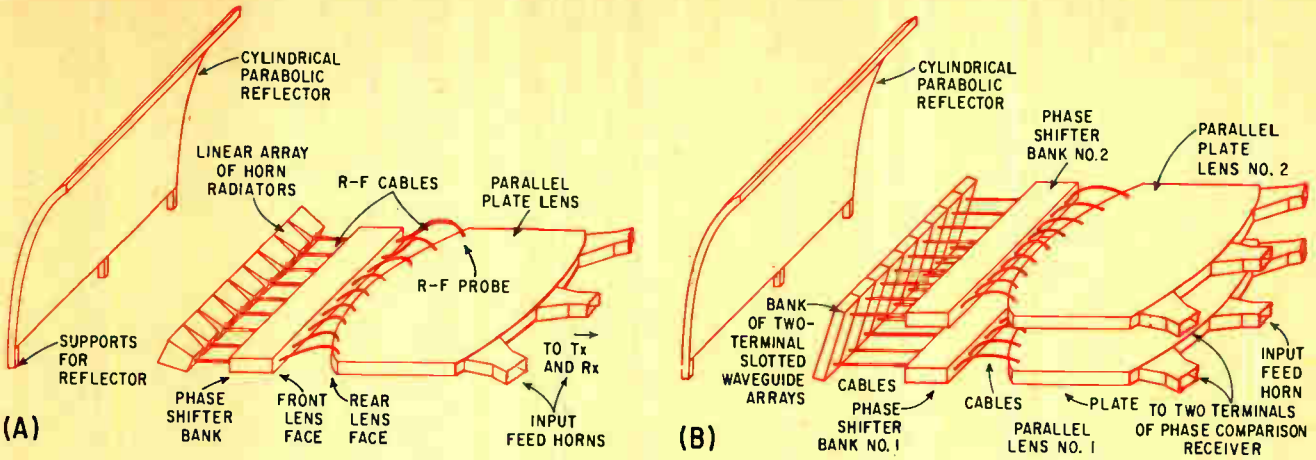


Fig. 5—Mubis antenna system with parallel plate lens (A) accomplishes height-finding by phase comparison (B)

directed at a substantial angle away from the sun. For antimissile radar, precise refraction information is necessary for pinpointing the target in space.

Radar astronomy is used for studying the electron densities and temperatures in the ionosphere; for measuring the density in interplanetary space; refining the astronomical unit; and for mapping the surface of the moon and planets, determining their rotation periods and many other parameters needed for space flight.

The radio astronomer needs—besides sheer size of aperture—narrower beam-width, improved tracking ability, less background and receiver noise, greater receiver stability and better data handling.

The largest steerable parabola operational to date is still the 250-ft Jodrell Bank telescope in England. The Parkes, Australia parabola that went into operation this summer is 210 ft. A 300-ft dish steerable on a north/south line only is going up at Green Bank, W. Va. NASA, as mentioned earlier, wants three 240-ft dishes primarily for communication with spacecraft.

The most ambitious steerable parabola project to date is Navy's 600-ft dish near Sugar Grove, W. Va.

There are obviously physical limits to building the ideal steerable paraboloid. For a one-minute-of-arc beam, operating at 30 Mc, the parabola would have to be 45 Km in diameter. For a frequency of 30 Gc, however, the parabola would be reduced to 45 meters.

A number of techniques have been, and are being, devised to circumvent the job of balancing dishes the size of several football fields on spinning pedestals. This may be done by sacrificing the steerable capability of the dish and building a fixed paraboloid or sphere.

Whether more large fixed spherical antennas will be built in natural earth craters depends on the success of the Arecibo Ionospheric Observatory now being built in Puerto Rico. It is 1,000 ft in diameter, 160-ft deep, is lined with ½ in mesh, and can scan 20 deg from vertical. A correcting line source is used to eliminate spherical aberration.

By using several feeds, it can operate on several frequencies simultaneously. The transmitter operates at a fixed frequency of 430 Mc.

Although the main purpose of the observatory is to study electron densities and temperatures in the ionosphere, it will be capable of looking at 1/10 of the visible disk of the moon; provide a good look at Venus; reveal range of planets and details of their atmospheres, rotations and surface roughness, and the Faraday rotation of the earth. It is hoped that more can be learned about the disturbed regions of our sun as well as those of other suns. A frequency of from 40 Mc to 50 Mc would be better for this work and may be added later.

The spherical antenna was based on early research at AFCRL. The Air Force's Electronic Systems Division and Cornell University are building the observatory under the sponsorship of ARPA.

Another means of avoiding the unwieldy aspect of size is by abandoning the classical optical system entirely and spreading antennas around the landscape in crosses, tees, circles, in rows like venetian blinds or other configurations. The antennas used in such an interferometer array may be dipoles with reflectors, yagis, cylindrical paraboloids, or a group of small steerable paraboloids.

Basically the interferometer uses the combined output of a number of antennas pointed in the same direction. Unlike paraboloids, the multielement system can be expanded after it is built. Remote elements can be installed, permitting the application of special techniques of interferometry and aperature synthesis to particular astronomical problems, and by narrow extensions along the arms of a high cross or tee.

A report prepared by Stanford University for USAF describes one way to build a one-minute-of-arc in one dimension telescope using a frequency of 21-cm.[56]

The system would consist of a multifocus arrangement of tiltable cylinders, stacked like the slats of a venetian blind. Grating responses, however, of such iterated structures would be a problem. These responses could be suppressed by a new tilt-independent technique in which a staggered pair of elements is switched against the remaining elements.

Problems of interconnecting the tiltable elements to counteract the jump in path from one element to the next are serious, the report says, but have already been partly met in achieving a one-minute fan beam.

Distributed preamplification or mixing is essential to overcome attenuation in the transmission lines resulting from the choice of a multifocus arrangement. Automatic phase monitoring capable of controlling phase drifts in amplifiers, as well as in long transmission line

runs, must be developed and demonstrated on a sufficiently large model.

Multibeaming, a technique of halving observing time by doubling the investment in electronic equipment, is justified when the antenna cost is high and the beamwidth extremely narrow. The line feeds, and their built-in preamplification and phase monitoring, must be designed from the beginning for multibeaming.

The report recommends building first a scaled-down model, perhaps a quarter of the instrument, scaled down further by a factor of three in wavelength; for example, ten 400 by 30-ft tiltable cylinders working at 7 cm.

BIBLIOGRAPHY

Jet Propulsion Lab—Industry Conference Report, Oct. 1960.

C. J. Mundo et al, The System Characteristics of Modern Guidance Techniques, *Control Engineering*, p 85, Aug. 1960.

Proc NASA—Industry Program Plans Conference, July 1960.

REFERENCES

(1) H. L. Dryden, NASA, private communication, Oct. 5, 1961.

(2) C. J. Mundo, Optimumization of a Cello-Inertial Filter for Interplanetary Space Travel, *Arma Engineering*, p 10, Dec. 1959-Jan. 1960.

(3) R. G. Franklin and D. L. Birx, Optical Doppler for Space Navigation, paper presented at ARS Guidance, Control and Navigation Conference, Stanford Calif., Aug. 1961.

(4) N. Sirri, Space-Vehicle Attitude Control, paper presented at AGARD Meeting, Istanbul, Turkey, Oct. 1960. (JPL Technical Release 34-121).

(5) C. F. Chubb, Beam-Rider Guidance, *Sperry Engineering Review*, p 33, Oct. 1960.

(6) V. J. McDonough, Control of Surface-to-Air Missiles, *Sperry Engineering Review*, p 2, March 1961.

(7) E. L. Chatterton, Radar Design for Missile Guidance, *Arma Engineering*, p 20, June 1961.

(8) R. S. Reed, Rugged Arming-Fuzing Timer For Atomic Artillery Missile, ELECTRONICS, p 48, Sept. 22, 1961.

(9) M. F. Tomaino and G. J. Flynn, Electromechanical Devices and Systems for Electronics, ELECTRONICS, p 57, Sept. 30, 1960.

(10) B. Lichtenstein, Gyros of All Types Face Change in Design, *Missiles and Rockets*, p 21, Feb. 27, 1961.

(11) B. Litman and A. Riker, Arma Inertial Components—Current State of the Art, *Arma Engineering*, Fall, 1961.

(12) C. B. Ellis and I. A. Greenwood, Optical Masers in Space Navigation, paper presented at 17th Annual Meeting of Inst of Navigation, Williamsburg, Va., June 1961.

(13) W. H. Heiss et al, Space Rendezvous Terminal Sensors, *Proc NAECON*, May 1961.

(14) T. J. Holmes et al, SPIRAL, The Sperry Inertial-Radar Altimeter for Re-entry Vehicles, *Proc NAECON*, May 1961.

(15) E. M. Wormser and M. H. Arck, Infrared Navigation Sensors for Space Vehicles, paper presented at ARS Guidance, Control and Navigation Conference, Stanford, Calif., Aug. 1961.

(16) H. B. Haake and J. D. Welch, Mechanizing a Space Navigation System, *Proc Fifth National Symposium on Space Electronics and Telemetry*, Sept. 1960.

(17) R. R. Ziemer, Orbiting Astronomical Observatories, *Astronautics*, p 36, May 1961.

(18) R. E. Fischell, Magnetic and Gravity Attitude Stabilization of Earth Satellites, Johns Hopkins U. Applied Physics Lab report CM-996, May 1961.

(19) T. Emma and M. Wolff, Future Developments in Engineering, ELECTRONICS, p 159, March 11, 1960.

(20) R. L. Sax, Exploration of the Atmosphere of Venus with a Small Payload, paper presented at 6th Symposium on Ballistic Missile and Aerospace Technology, Los Angeles, Calif., Aug. 1961.

(21) R. W. Clapp, A. T. Owens and R. L. Sax, Planetary Landing and Observation Package, paper presented at 6th Symposium on Ballistic Missile and Aerospace Technology, Los Angeles, Calif., Aug. 1961.

(22) J. P. Heppner, T. L Skillman and J. C. Cain, Contributions of Rockets and Satellites to the World Magnetic Survey, paper presented at 2nd International Space Science Symposium of COSPAR, Florence, Italy, April 1961.

(23) R J. Davis, Smithsonian Astrophysical Observatory, private communication, Sept. 13, 1961.

(24) W. S. Heavner, Reconnaissance Trends, paper presented at NAECON, Dayton, Ohio, May 1961.

(25) M. E. Seymour, Space Applications of Infrared Imaging Devices, paper presented at IRE Winter Convention on Military Electronics, Los Angeles, Calif., Feb. 1961.

(26) B. D. Martin, The Mariner Planetary Communication System Design, paper presented at 2nd International Space Science Symposium of COSPAR, Florence, Italy, April 1961. (JPL Tech Report 32-85, Rev. 1.)

(27) S. J. Campanella, D. C. Coulter and R. Irons, A 1000 Bit Per Second Speech Compression System, *Proc 5th National Symposium on Global Communications*, May 1961.

(28) J. J. Metzner and K. C. Morgan, Coded Feedback Communication Systems, paper presented at NEC, Chicago, Ill., Oct. 1960.

(29) L. R. Bittman, Exotic Methods in Space Communication, *Proc 5th National Symposium on Global Communications*, May 1961.

(30) S. Vogel and L. Dulberger, Lasers: Devices and Systems—Part II, ELECTRONICS, p 40, Nov. 3, 1961.

(31) H. B. Finger, Nuclear Propulsion for Space Vehicles, paper presented at First National Conference on Peaceful Uses of Space, Tulsa, Oklahoma, May 1961.

(32) E. Mitchell, NASA Propulsion Program, paper presented at ARS Propellants, Combustion and Liquid Rockets Conference, Palm Beach, Fla, April 1961.

(33) W. E. Moeckel, Status of Electric Propulsion Systems For Space Missions, paper presented at Cryogenic Engineering Conference, Boulder, Colo., Aug. 1960.

(34) R. G. Meyerand, Jr., The Oscillating-Electron Ion Source, United Aircraft Corp report M-1773-1, Dec. 1960.

(35) M. F. Wolff, Plasma Engineering—Part III: Applications of Plasma, ELECTRONICS, p 29, Sept. 1, 1961.

(36) W. C. Cooley, Spacecraft Power Generation, paper presented to Combustion and Propulsion Panel of Advisory Group for Aeronautical Research and Development, Pasadena, Calif., Aug. 1960.

(37) A. K. Thiel, Recent Growth in Space Technology, paper presented at American Rocket Society Meeting, Las Vegas, Nev., Aug. 1961.

(38) G. E. Mueller, W. E. Hebenstreit and E. R. Spangler, Communications Satellites, Space Technology Labs internal report, April, 1961.

(39) W. C. Cooley, Solar Direct-Conversion Power Systems, paper presented at IAF Congress, Washington, D. C., Oct. 1961.

(40) D. P. Ross, Space Power Trends, paper presented at National IAS-ARS Joint Meeting, Los Angeles, Calif., June 1961.

(41) D. G. Harvey and J. G. Morse, Nuclear Energy in Space—Radionuclide Power for Space Missions, *Nucleonics*, p 69, April 1961.

(42) N. Wheeler, Power Sources for Space Applications, General Electric Advanced Electronics Center internal paper, Sept. 1961.

(43) P. L. Howard, The Sealed Silver-Cadmium Battery, paper presented at International IRE Convention, N.Y.C., N.Y., March 1961.

(44) J. Mason, New System Will Measure Missile Trajectories, ELECTRONICS, p 38, July 29, 1960.

(45) J. Mason, Missile Ranges Expand at Sea, ELECTRONICS, p 22, July 28, 1961.

(46) J. Mason, How Tell-Tale Signs Can Help Kill Missiles, ELECTRONICS, p 46, Dec. 16, 1960.

(47) J. Mason, Mercury Ground Network: Roadmap for Future Space Systems, ELECTRONICS, p 30, Oct. 7, 1960.

(48) J. Mason, Plans for Dyna-Soar's Ground Net Revealed, ELECTRONICS, p 24, July 21, 1961.

(49) J. Mason, Market Growing for Space-Tracking Gear, ELECTRONICS, p 20, Feb. 24, 1961.

(50) R. Beitz, High Power Microwave Radar Research, Cornell Aeronautical Laboratory's *Research Trends*, VIII, No. 3, p 1, Fall 1960.

(51) M. Breese *et al*, Phase-Locked Loops For Electronically Scanned Antenna Arrays, *Proc 5th National Symposium on Global Communications*, Chicago, Ill., May 1961.

(52) G. Hetrich, Linear FM Ranging and its Application to Pulse Doppler Radar, *Proc 8th Annual East Coast Conference on Aerospace and Navigational Engineering*, Oct. 1961.

(53) E. Watters and R. Dax, Improvements in Search Radar Systems, *Westinghouse Engineer*, p 77, May 1961.

(54) W. Rotman, Air Force Cambridge Research Laboratories, private communication, Aug. 17, 1961.

(55) W. Attride and G. Stuart, Jr., Launch and Countdown Equipment for The Minuteman Missile, Design Course in Automatic Electronic Test Equipment, NYU, Sept. 1, 1961.

(56) R. Bracewell, Proposal Leading to Future Large Radio Telescopes, Stanford Radio Astronomy Institute Publication No. 14, May 12, 1961.

The authors thank the National Aeronautics and Space Administration, Department of Defense, other government agencies, companies, and scientific and educational institutions who supplied information for this report.




·coax and waveguide couplers · attenuators · mounts ·



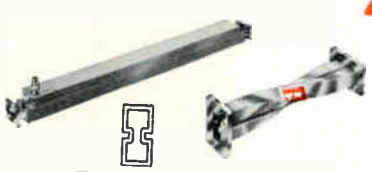

·bolometers · isolators · detectors · frequency meters ·

·r. f. probes ·

·klystron mounts ·

·thermistors ·

·tuneable shorts ·



·ridged waveguides ·

·ferrite circulators ·

waveguide adapters & accessories · stands · horns ·

·hybrid junctions · instruments and modulators ·

UHF to 90 Gc!

NARDA

can supply you with more than 600 PRECISION microwave instruments, components and hardware!

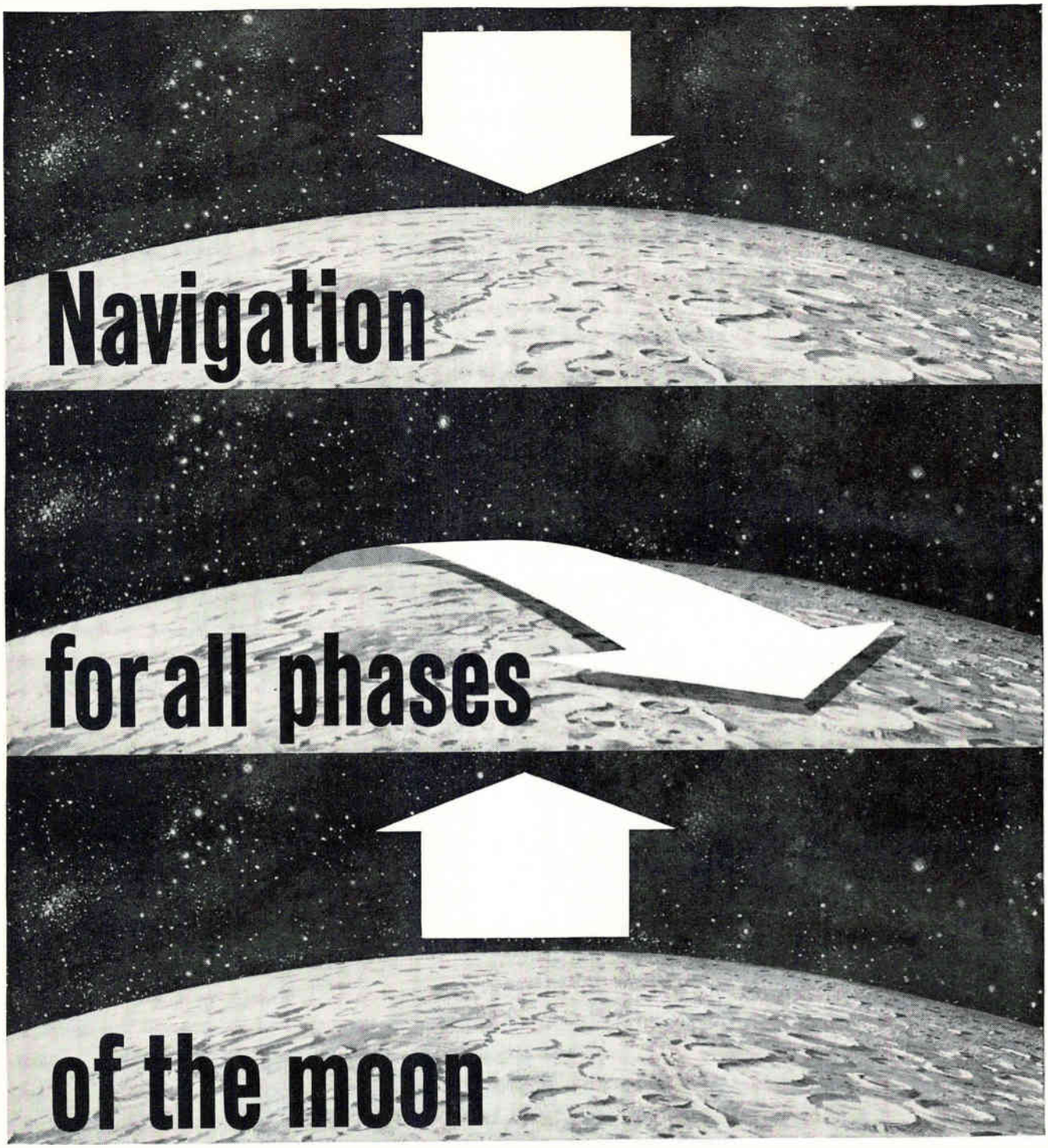
Write for your free catalog!

SEND FOR FREE CATALOG TODAY!

Address: Department E-1-13

the narda microwave corporation

PLAINVIEW, L. I., NEW YORK · AREA CODE 516 GE 3-9000



"Manned lunar probe" means a successful round trip . . . and poses a host of problems. Among others, navigation.

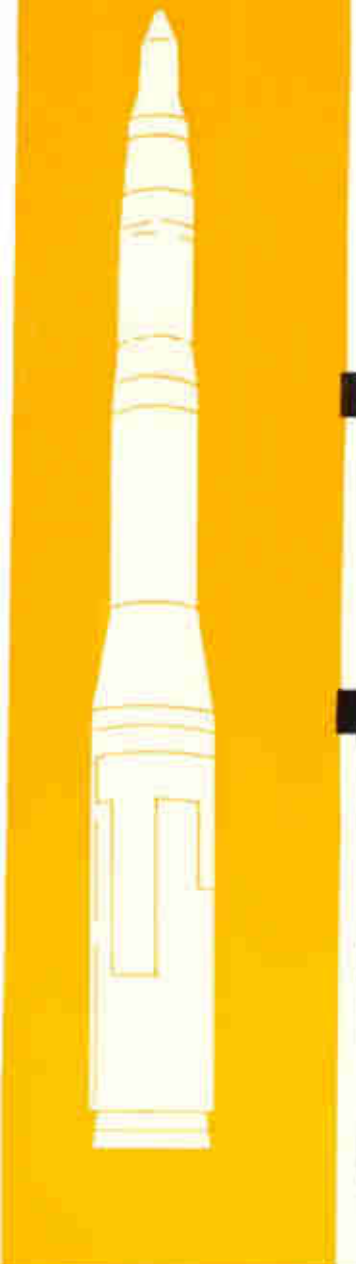
To get to the moon or a planet, move on its surface, and return to earth is a full-scale systems requirement, calling for the highest order of navigation, guidance and control sophistication.

In all phases of space navigation—particularly the tougher ones of rendezvous guidance, mid-space station assembly, movement over the surface of planets, return vehicle remote launch, recovery and landing — the Sperry Rand Systems Group offers a maximum technological and management capability.

This capability includes deep space tracking radars, rendezvous, orbital and mid-course injection nets, space command and control centers, attitude control systems, real time data processing, and sophisticated recovery systems to guide a vehicle through the difficult final approach, controlling its speed and maneuvering it to a precise landing site. Other systems include optical communications and navigation, pilot displays and controls, auxiliary power and automatic checkout. General Offices: Great Neck, New York.

SPERRY RAND SYSTEMS GROUP

NEW Transitron MILITARY TYPE REFERENCES & REGULATORS

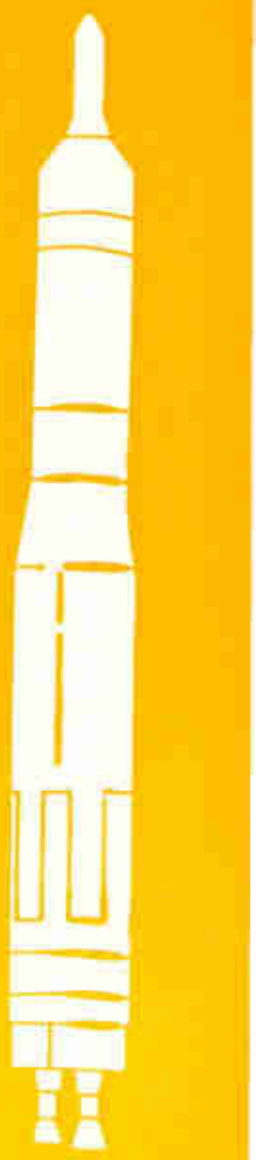


Stemming from over seven years of research-to-production experience, these USN approved families of silicon voltage references and regulators incorporate quality-assurance features derived from Transitron's contributions to the Minuteman and Titan reliability programs.

Designed to meet demanding military requirements, all types are now available to industry in volume quantities. Both series offer long life, with long-term stability a proven feature of the silicon voltage references.

Ask for the Transitron bulletins indicated . . . For still further information relative to specifications, ratings, or specific applications, direct your inquiries to the Transitron field office in your area — or, contact Transitron's main facility in Wakefield, Massachusetts.

For quantities 1 – 999, call your nearest Transitron Industrial Distributor.



MILITARY TYPE SILICON VOLTAGE REFERENCES (MIL-S-19500/159 (NAVY))

TYPE	Reference Voltage @ 7.5 mAdc (Volts @ 25°C) Min.	Max.	Maximum Dynamic Impedance @ 7.5 mA (ohms)	Voltage — Temperature Stability (ΔV in volts*)
USN1N821	5.90	6.50	15	.050
USN1N823	5.90	6.50	15	.025
USN1N827	5.90	6.50	15	.006

*Determined by measuring a change of voltage from −55°C to +25°C and a change of voltage from +25°C to +100°C.

Write for bulletin TE-1352F.

Also available: Transitron's Certified Voltage Stability References. Write for bulletin TE-1352F-1.

CIRCLE 259 ON READER SERVICE CARD

MILITARY TYPE 400 MILLIWATT REGULATORS (MIL-S-19500/127 (NAVY))

TYPE	Breakdown Voltage @ 25°C mAdc (Volts ±5%)	Maximum Dynamic Impedance (ohms) @ 2 mA	@ 20 mA
USN1N746A	3.3	250	28
USN1N747A	3.6	250	24
USN1N748A	3.9	250	23
USN1N749A	4.3	250	22
USN1N750A	4.7	250	19
USN1N751A	5.1	250	17
USN1N752A	5.6	250	11
USN1N753A	6.2	250	7
USN1N754A	6.8	50	5
USN1N755A	7.5	50	6
USN1N756A	8.2	50	8
USN1N757A	9.1	50	10
USN1N758A	10.0	50	17
USN1N759A	12.0	50	30

Write for bulletin TE-1352A-1.

CIRCLE 260 ON READER SERVICE CARD

MEET US AT THE NEREM SHOW, BOOTHS 207-208

Transitron electronic corporation

wakefield, melrose, boston, mass.

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

To thread a needle in unmanned flight...

...required Motorola systems ingenuity

NAVIGATION with "needle's eye" precision is achieved by Motorola RDI. Synergistic combinations of Radio, Doppler, and Inertial sensory data into one integrated system exceed the sum of the capabilities of each. Ranging hundreds of miles from their ground-anchored reference, these R+D, R+I and R+D+I combinations provide targeting accuracy... immunity to interference... resistance to detection. Unique combinations of these techniques have been proven in applications requiring real-time, position-fixing and space vehicle-guidance. These Motorola systems originally were designed for missile guidance and surveillance drone navigation... they now provide reliable solutions to a broad range of problems requiring continuous, current, and extremely accurate control data never before attained in a dynamic environment. Sensory synergism is another demonstration of Motorola's systems ingenuity. Classified details of these programs are available to those with an established need to know.

Military Electronics Division **MOTOROLA**

All qualified applicants will receive consideration for employment without regard for race, creed, color, or national origin

CHICAGO 51, Illinois, 1450 North Cicero Avenue
SCOTTSDALE, Arizona, 8201 East McDowell Road
RIVERSIDE, California, 8330 Indiana Avenue

DALMESA APPLICATION REPORT NUMBER 2

7 TURNS #16 AWG, O.D. = 0.6 inches, length 0.8 inches

N_1 = 1.25 TURNS

N_2 = 0.5 TURNS

N_3 = 5.25 TURNS

T_2 Cambridge Thermionic Coil Form PLS 62C4L/20063-D (or equivalent)

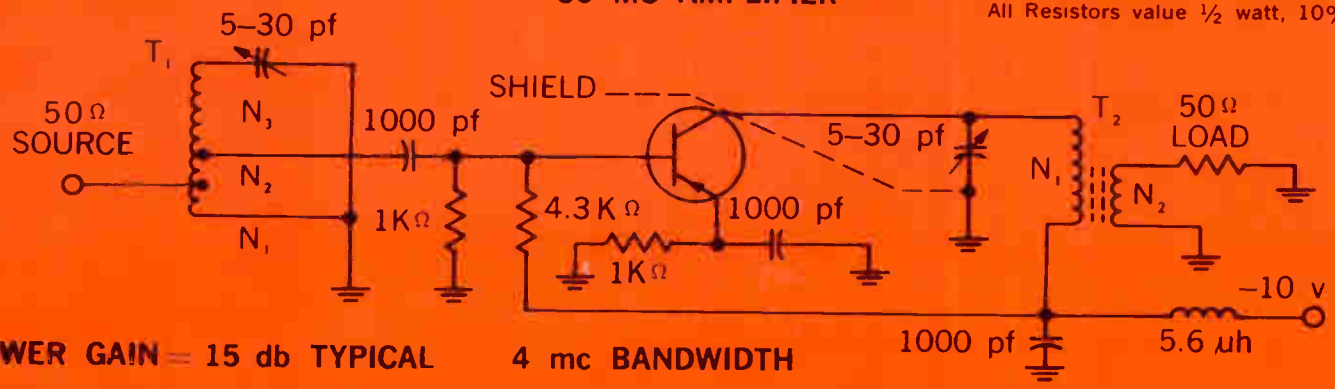
N_1 = 12 TURNS #30 AWG L = 1.2 μh

N_2 = 3 TURNS #30 AWG L = 0.18 μh

Coefficent of Coupling = 0.58

All Resistors value ½ watt, 10%

30 MC AMPLIFIER



POWER GAIN = 15 db TYPICAL **4 mc BANDWIDTH**

Apply Low-Noise, High-Gain DALMESA Transistors to Your Amplifier Designs

■ **Solve your industrial communications design problems today** with TI's new **DALMESA** 2N2188 series. This new germanium alloy diffused mesa transistor family is specifically designed to meet your requirements for high-performance, low-noise, economically-priced transistors for application over the entire communications band from dc to 150 mc. ■ The **extremely low, low-frequency noise corner** and **high alpha cutoff frequency** offered by new **DALMESA** transistors result in **low-noise performance over a very wide bandwidth** — the 2N2188 series gives you a typical mid-frequency noise figure of 1.5 db. ■ These new devices also give you **guaranteed gain/bandwidth products of 60 and 102 mc** to assure excellent performance in your IF, RF and video amplifiers. **Increased high-frequency stability** results from the guaranteed maximum **output capacitance of 2.5 pf at 9 volts.** ■ Apply new **DALMESA** transistors to your communications designs today and take advantage of the increased performance capabilities of this new Texas Instruments series. These new 125-mw transistors are **immediately available** through your nearest TI Sales Office or Authorized TI Distributor.

PARAMETER	TEST CONDITIONS	2N2188	2N2189	2N2190	2N2191
BV_{CBO}† AND BV_{CES}	I_C = −50 μa	40 v min	40 v min	60 v min	60 v min
BV_{EBO}	I_C = 0, I_E = −100 μa	2 v min	2 v min	2 v min	2 v min
h_{FE}	V_{CE} = −6 v I_C = −2 ma	40 min	60 min	40 min	60 min
h_{fe} (at 1 kc)	V_{CE} = −6 v, I_E = −2 ma	40 min	60 min	40 min	60 min
f_T	V_{CE} = −9 v, I_E = −1.5 ma	60 mc min	102 mc min	60 mc min	102 mc min
I_{CBO}	V_{CB} = −12 v, I_E = 0	3 μa max	3 μa max	3 μa max	3 μa max
C_{OB} (at 1 mc)	V_{CB} = −9 v, I_E = 1.5ma	2.5 pf max	2.5 pf max	2.5 pf max	2.5 pf max
Noise Figures§ (at 1 mc)	V_{CE} = −5 v, I_E = 0.5 ma	1.5 db typ	1.5 db typ	1.5 db typ	1.5 db typ
Maximum Power Dissipation	25°C Ambient	125 mw	125 mw	125 mw	125 mw

†I_E = 0 §R_G = 1KΩ

TRANSISTOR PRODUCTS DIVISION

TEXAS INSTRUMENTS
INCORPORATED
13500 N. CENTRAL EXPRESSWAY
P. O. BOX 5012 • DALLAS 22, TEXAS

. . . AMP's tapered terminal, crimped to electronic component leads with precision-engineered, high-speed, automatic application machines.

CIRCUITIP Terminals give you quick, secure mounting of components at lowest installed costs anywhere.

ADDITIONAL FEATURES: • Mechanical retention of components prior to soldering • crimp configuration to aid capillary action of solder • standardization of hole size • bridging and offsetting of components for air circulation • heat sink in tip to help dissipate heat and protect costly components • uniform solder fillets • automatic trimming and bending of component leads • absence of radial wire protection ideal for increased board density. **Send for complete information today.**

*TRADEMARK OF AMP INC.

AMP INCORPORATED

GENERAL OFFICES: HARRISBURG, PENNSYLVANIA

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

Breadboard version of delta analog-to-digital system is checked out with tape-recorded voice. It's simpler than pcm

SINGLE-BIT

Delta Modulating Systems

By A. LENDER
M. KOZUCH,
ITT Federal Laboratories,
Nutley, N. J.

DELTA MODULATION is a method for transmitting analog signals digitally, then recovering the analog information. Invented[1] in 1946 and discussed in recent papers[2, 3], delta modulation is not as widely known as pulse-code modulation (pcm), another form of analog-to-digital conversion. While pcm pulses represent binary values of samples of the modulating signal, delta pulses represent binary decisions determined by the polarity of the difference between the modulating signal and the approximation of this signal.

The delta process is shown in Fig. 1A. The encoder contains a difference circuit that subtracts the output of a pulse integrator from the input or modulating signal. The difference controls the pulse generator, which produces either positive or negative pulses of uniform duration and constant amplitude in that pulse interval. Pulse polarity is determined by the polarity of the signal from the difference circuit. The polarity of the pulse from the generator is such that the feedback loop reduces the difference between input signal and integrator output. Thus the integrated signal is constantly corrected to a close approximation of the input signal.

The bipolar pulse train that feeds the integrator in the encoder is transmitted to the decoder. The decoder consists of an integrator, identical to the one in the encoder,

and a low-pass filter. Thus, the output signal of the decoder is also a close approximation to the original input signal.

In the decoder the filter removes frequency components outside the desired band. These components may not have been filtered by the integrator. A low-pass filter is not used in the encoder since it would introduce excessive delay in the feedback path. Furthermore, such a filter in the encoder would eliminate the clock-frequency component. This component establishes a periodic pulse pattern when there is no input signal.

Suppose the maximum input signal is such that a group of positive pulses is generated with each clock time. The positive pulse train is fed back and integrated and generates a constant rising ramp voltage. The slope of this ramp is the maximum positive slope of the input signal. Similar reasoning holds for a negative pulse train. If, however, the input signal is such that positive and negative pulses are alternately generated, the output of the integrator is a constant d-c voltage. Any other pulse pattern results in an integrator output voltage having a slope somewhere between the maximum (positive or negative) and zero. The average pulse density from the encoder is proportional to the slope of the input signal. When there is no input signal, the idle pattern consists of alternate positive and negative pulses. Figure 1B shows a typical input signal E_1, the pulse train E_2 that feeds the integrator and the output of the integrator, E_3.

A better approximation to the input signal is obtained when the integrator is a double rather than single integrator. The double integrator consists of two cascaded integrators, with the second one presenting a small load to the first. As a result of the additional integration, the approximation to the input signal is smoother and the difference voltage in the encoder can control more accurately the polarity of the pulses from the generator. However, additional delay is introduced in the feedback circuit, causing the system to be somewhat sluggish. This effect is noticeable, as shown in Fig. 1C, when input waveform E_1 changes slope. The integrated waveform does not sense this change of slope soon enough, and the approximation E_3 is not too close. To remedy this, the difference circuit is fed from a point slightly ahead of the output of the double integrator, as shown in Fig. 1D, thus introducing some prediction. Voltage E_3 is a prediction of the value that integrated voltage E_3 will reach if the integration of the next pulse continues in the same direction. The price paid for the prediction is a loss in smoothness in the integrated waveform E_3. A comparison of Fig. 1C and 1D shows that the approximation to the original signal is better with prediction than without. In the decoder, however, no prediction is needed, and the output of the integrators, E_3' in Fig. 1D, is relatively smooth.

Another modification of the delta encoder-decoder is to use single polarity pulses instead of bipolar ones; that is, pulse and no-pulse replacing positive and negative pulses. The advantage is a simplification of pulse generation and detection.

Because of this modification the

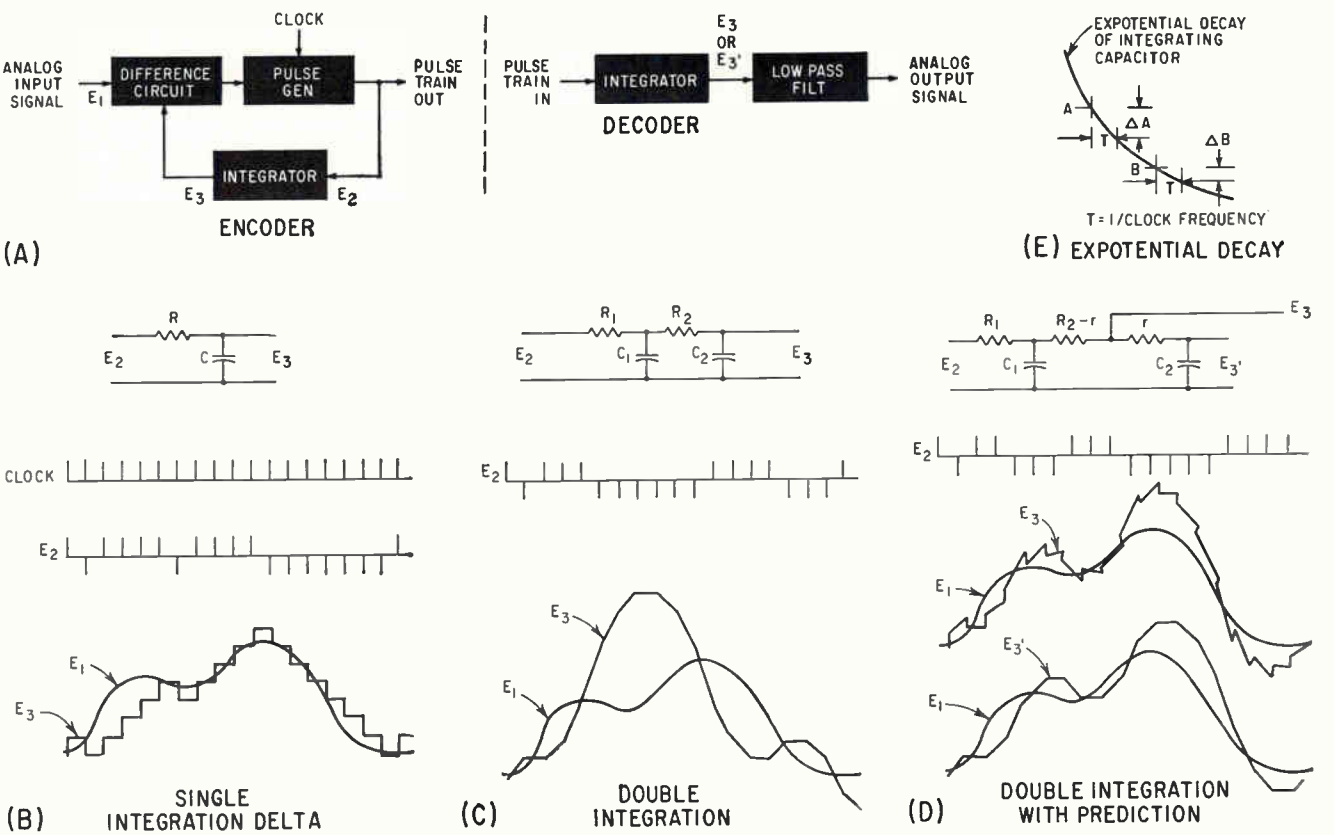


FIG. 1—Delta encoder (A) uses integrator in feedback loop to control polarity of pulses from generator. Decoder has simple integrator and filter. Experimental system used double integration with prediction (D); exponential decay of integrator (E)

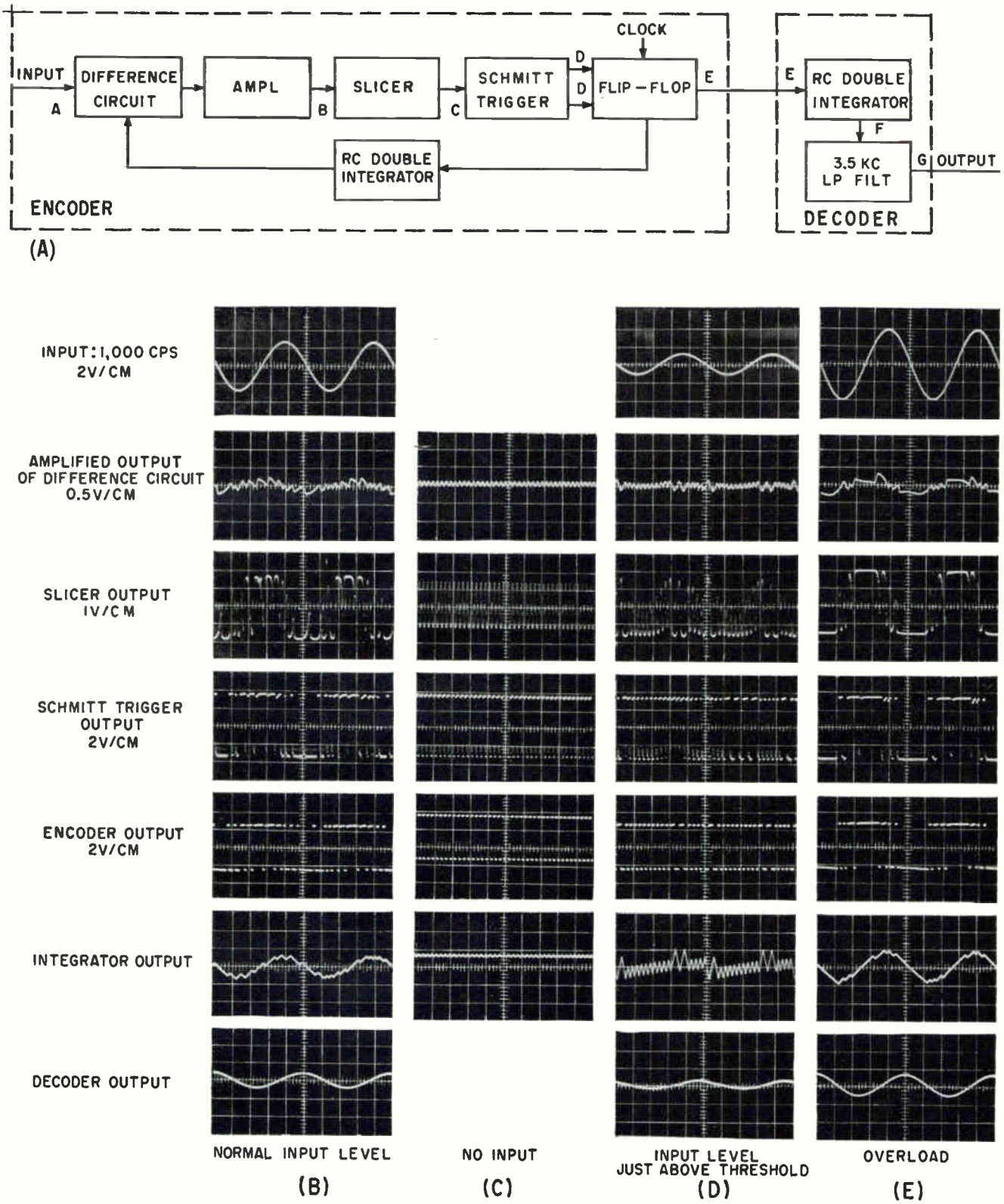


FIG. 2—All waveforms at points in experimental delta system (A) are for a clock rate of 40,000 bits per second. Integrator and decoder output waveforms were photographed at 0.5 v per cm, except for set D, which were at 0.1 v per cm

integrators must be altered, since single polarity pulses can drive the capacitor voltage in one direction only. For the other direction, the function formerly performed by a pulse of the opposite polarity is accomplished by discharge of the integrating capacitors.

A practical method of implementing the capacitor decay with an R-C integrator is to shunt the capacitor with a resistor. Such an R-C network performs time limited integration, as opposed to the integrator of the basic system, which has a large time constant and a long integration period.

Since the voltage from the limited integrator decays continuously, the memory of the integrator is relatively short. Consequently, errors due to noise in transmission have only a short-term effect. On the other hand, for conventional

VARIATION OF PERFORMANCE WITH BIT-RATE

Line Rate in Kilobits/Sec for Delta	Equivalent Number of PCM Digits	Quality of Speech
8	1	Poor but intelligible
16	2	Intelligible
24	3	Acceptable
32	4	Fairly good
40	5	Good
48	6	Little improvement over 10 kilobits

delta with large time constants, such errors may affect the system for a prolonged period.

As pointed out for an integrator with large time constant, the density of the pulse train is proportional to the slope of the input signal. In the limited integration system, the pulse train density is proportional to both the signal and its derivative. This can be seen from the exponential decay of the capacitor voltage (Fig. 1E). When operating at a high voltage level *A*, and with no pulse fed to the integrator during pulse time *T*, integrating capacitor decay is ΔA. When operating at a lower voltage *B*, the equivalent decay is ΔB, where ΔA is greater than ΔB. Therefore, more input pulses are necessary to maintain d-c level *A* than to maintain level B. Each d-c level has a corresponding pulse pattern.

An experimental encoder-decoder diagram is shown in Figure 2A. It uses limited R-C double integration. Typical waveforms are shown for certain points in the diagram for a 1,000-cps sinewave input and a clock rate of 40,000 pps. For Fig. 2B, the input level is adjusted to a value below overload but above threshold; this is defined as the normal input level.

The difference signal is amplified to drive the slicer, which in turn feeds a Schmitt trigger. The slicer followed by Schmitt trigger ensures fast rising and trailing edges, good control of the trigger despite d-c level shift, and direct and complementary signals to set and reset the flip-flop. One flip-flop output is applied to the R-C integrators in the encoder, the other flip-flop output is the delta modulated output. In the decoder, the digital signal is integrated and filtered.

The flip-flop pulses have 100 percent duty cycle to take advantage of the maximum energy available with such pulses. The d-c amplifier can be placed either between the two integrators or after the difference circuit; both methods have their advantages. If the amplifier is between the integrators, the input signal does not drop too low before it is amplified so that some noise immunity is introduced. However, the linearity required from the stage is high because of the distortion and clipping possibilities at high amplitudes. High amplitudes from the integrator result from input patterns consisting of a series of pulses of one polarity.

For the arrangement actually used, Fig. 2A, the signal to be amplified can be as low as 5 mv. Linearity is not a consideration since the difference signal controls only the binary decision: whether to generate a pulse or not. Direct coupling is used around the loop so that the system can recognize its quiescent operating point and return to it after being disturbed by signal or noise.

Initial gain in the feedback loop is controlled by a potentiometer in the amplifier. With no signal input a wide range of pulse patterns result, from no pulse to a maximum of pulses. The correct setting is obtained when a periodic pattern such as 101010, 11001100, or 111000111-000 is obtained. The first pattern usually indicates the highest degree of sensitivity. It is shown in Fig. 2C, which also shows waveforms at other points in the system when no input is present.

Gain of the d-c amplifier is directly related to the integrating time constants. When the feedback network has a large integrating time constant, the gain of the amplifier must be high to control the flip-flop. Empirical results indicate that the feedback-integrating time-constants are not critical. Time constants used (for voice modulation) in the two integrators are 1,000 and 250 μsec and can be varied ± 15 percent without affecting the signal-to-noise ratio.

Threshold effect is present in all analog-to-digital conversion systems, and manifests itself in delta as follows. A low-level input signal is introduced but is poorly sensed: it barely breaks the idle pulse pattern so that decoder output is a poor replica of the signal (Fig. 2D). When the system is overloaded, the integrator cannot follow the input and the pulse pattern is a succession of pulses and blanks (Fig. 2E). Overload is controlled by the R-C time constant of the integrating network. In limited integration delta, the time constants of the double integrators are such that the system overload

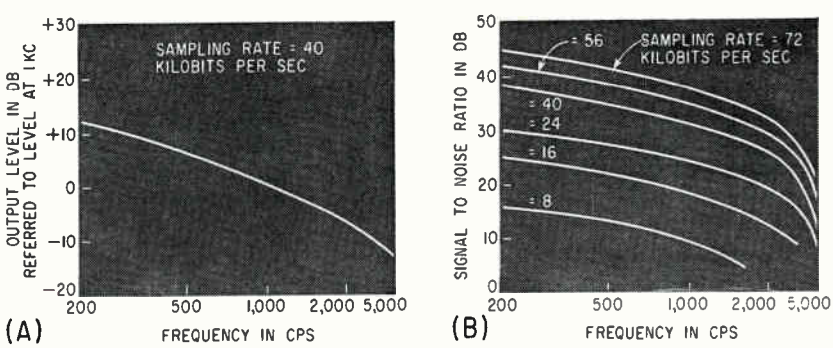


FIG. 3—Overload characteristics (A) and signal-to-noise ratio as a function of frequency (B)

response is approximately 6 db per octave. Figure 3A shows the overload characteristic of the experimental double-integration delta.

In evaluating the experimental delta modulator for voice, two criteria were used: signal-to-noise ratio and subjective voice tests. The two were found to be strongly correlated.

For signal-to-noise measurements, the signal was a 1-kc sinewave just below overload. This choice was dictated by the nonuniform energy distribution of speech, which drops at 8 to 9 db per octave above 1 kc. The noise is essentially the quantizing noise representing the difference between the original signal and its replica. Noise power was measured in the 3.5-kc band, which contains the signficant frequencies of the voice signal.

Measured signal-to-noise ratio versus signal frequency is shown in Fig. 3B. Figure 4 shows theoretical signal to noise ratios for delta and pcm, and experimental data for delta. The values of abscissa represent the sampling rate of delta and are proportional to the transmission bandwidth required for both delta and pcm. Theoretical values for delta are a few db better than actual results. A good signal approximation was obtained at the sampling rate of 40,000 pulses per second.

A comparison of delta with pcm (Fig. 4) on the basis of equal line bit rate shows that the crossover point occurs at about 40,000 or 5-bit pcm. This corresponds to medium quality of speech. Consequently, where channel bandwidth is at a premium, delta can compete with pcm only when medium or lower quality of speech is acceptable. In microwave systems, where bandwidth is often no problem, delta can match pcm even for high quality. For example, to match 7-bit pcm, delta requires approximately 40 percent more bandwidth.

In comparing delta to pcm it is convenient to use a parameter n, referred to as bandwidth expansion factor[3]. In delta n represents the ratio of the sampling rate to the top frequency of input signal multiplied by two. For pcm, n is equivalent to the number of binary digits per pam sample. In either case, n is proportional to the transmission bandwidth. The bandwidth

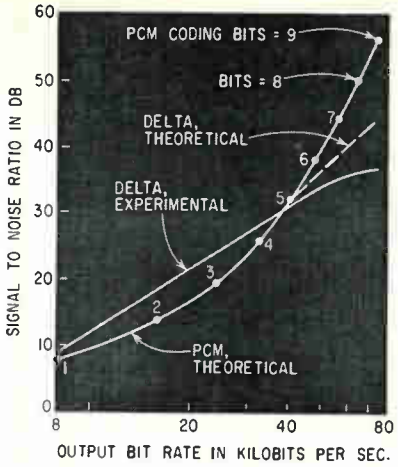


FIG. 4—Signal-to-noise ratio for delta modulation and pcm

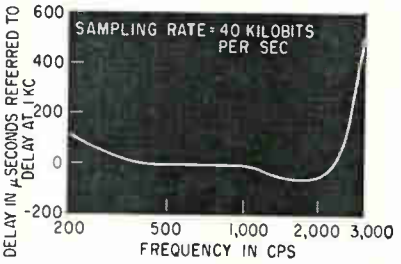


FIG. 5—Envelope delay as a function of frequency

expansion factor n, which corresponds also to the number of digits in pcm, is related in both systems to signal-to-noise ratio. Every time n is increased by one, the signal-to-noise ratio in pcm goes up 6 db. On the other hand in delta this improvement is larger for low values of n and decreases as n goes up. For example, the improvement in signal-to-noise ratio ranges from 9 to 4 db for each digit up to $n = 5$. From there on the improvement is a decreasing function. For example, increasing n from 8 to 9 results only in 2-db improvement in signal-to-noise ratio. Thus, compared to pcm, delta is most efficient for low bit rates up to $n = 5$.

A number of subjective tests were performed with trained and untrained listeners. These listeners were queried on voice recognition, background noise, threshold effect and intelligibility. Results, given in the table, show a definite correlation between signal-to-noise ratio for test tone input and subjective tests.

A comparison was also made between the experimental delta system and a single-channel transistor pcm system. At the line rate of 8,000 pps, which corresponds to 1-digit pcm, delta was intelligible while pcm was not. The quality of 3-bit pcm was considerably below that of delta at the same line rate. At the 40-kilobit rate, the two systems appeared to be equal. The superiority of pcm was demonstrated when the line rate was increased beyond 40 kilobits.

One application of delta is in the conversion of telemetry signals. A number of tests were conducted to determine response to d-c and low frequency. With the top frequency of these signals arbitrarily set at 150 cps, the time constants of the feedback integrators were, since they related to the highest signal frequency, decreased by a factor of 20. A sampling rate of 2,000 pps was found adequate for coding signals up to 150 cps.

Delta modulation is also suitable for signals that require good envelope delay characteristics, such as data transmission over the voice band and facsimile. Shown in Fig. 5 is the differential delay curve of the experimental delta coder at the line rate of 40,000 bits per second. For example, 2,400 bits per second of data, using quaternary phase modulation, cannot tolerate more than 500 microseconds of differential delay up to 2,600 cps. The delta delay characteristics are better than this requirement. An actual facsimile test was also satisfactory.

Based on limited experiments, the delta process is better than pcm for line rates of 40,000 bits per second or less. But delta cannot match pcm for high quality except where bandwidth is not a serious consideration.

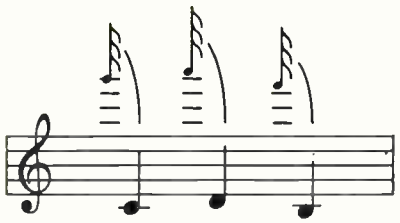
The limited integration delta model is capable also of handling with one percent accuracy d-c and low-frequency telemetry signals. In addition, signals such as data and facsimile can be handled with satisfactory accuracy.

REFERENCES

(1) E. M. Deloraine, S. Van Mierlo, and B. Derjavitch, French patent 932, 140; Aug. 10, 1946.

(2) F. de Jager, Delta Modulation, *Philips Research Report*, 7, p 442, 1952.

(3) F. K. Bowers, What Use is Delta Modulation to the Transmission Engineer, *AIEE Trans Part I Communication and Electr.*, 30, p 142, May 1957.



DEFINITION OF CHIFF

Chiff is an onomatopoetic musical term that describes the combination of wind noise and transient pitch components occurring momentarily during the initial speech period of a note, as produced by organ pipes with certain structural features. The transient pitch components are substantially higher in frequency than the fundamental of the steady-state tone, and are often harmonically related to the fundamental. The figure illustrates the effect of chiff. The top note plays for only a fraction of a second, after which the note settles down to its normal pitch

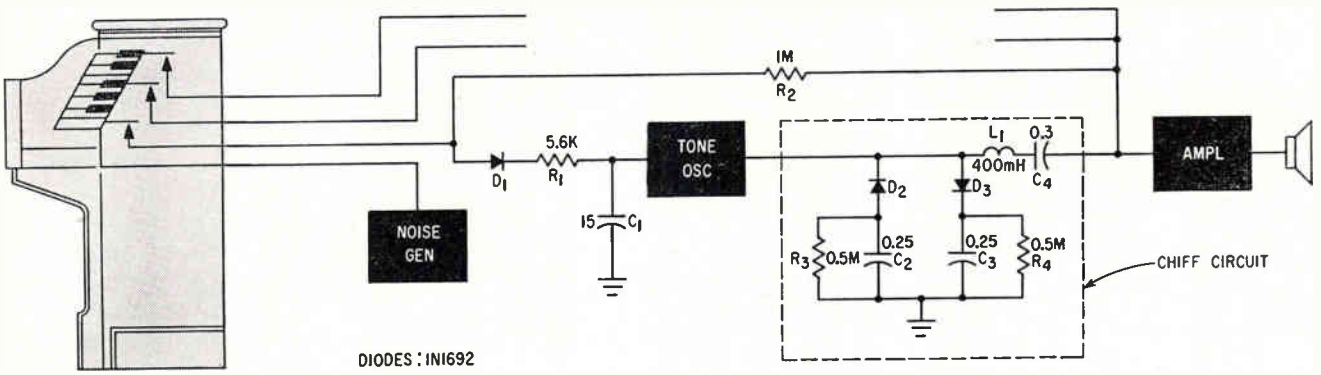


FIG. 1—Circuit for producing classic pipe-organ sound. The component values shown are for a tone with a fundamental frequency of 65.4 cps, which is two octaves below middle C. The chiff circuit can be switched in and out by the organist

Pipe-organ tone is approached by creating initial transient harmonics of the fundamental pitch to simulate "chiff," by varying pitch and intensity with a random noise generator to imitate varying wind pressure, and by adding integrated noise transient to simulate wind noises

Noise Generator Helps Create

By JEROME MARKOWITZ
MILTON F. NELSON
Allen Organ Co., Macungie, Pa.

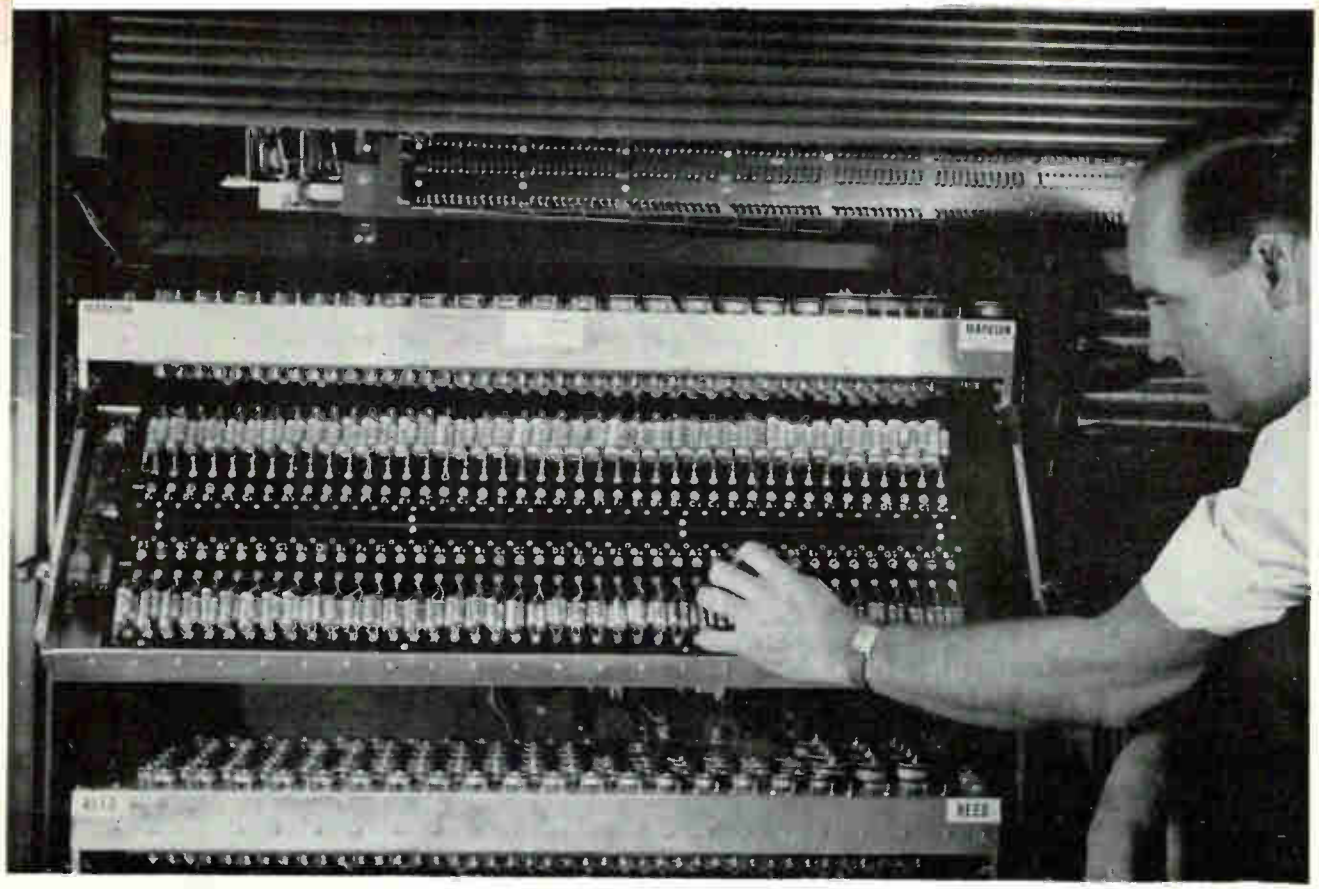
TO SOME listeners, the distinguishing feature of an organ is simply its ability to produce a number of sustained tones simultaneously, and nothing more. Others require only the addition of keyboards and stop controls. They then accept the instrument as an organ. The more keys and stop controls, the better the organ.

Other listeners find the classic, or pipe-organ sound, to be the most appealing. To the organ builder, classic sound identifies, among other things, unnicked flue pipes, bright reed tonalities of mild intensity, and low wind pressures. To the uninitiated, it might suggest a 17th-century musical curiosity with strange tones and excessive wind noises. Whatever one's point of view, classic organ sound constitutes an important influence in the contemporary pipe organ, and this is the type of organ sound that has inspired its proponents to state dogmatically "this type of sound will never be produced except through wind-blown pipes."

The basic elements of musical tones have been known for many years. These include pitch, intensity, duration, wave form and speech. Lesser-known factors include the effect of pitch and noise transients, including those that occur during the initial speech period or onset of tone, and those that occur during the continuous state. These phenomena have previously been omitted in electronic musical sound production and have resulted in negative psycho-acoustic responses on the part of listeners who prefer the tone of a pipe organ with classic voicing.

This problem has been solved by providing a basic tone generation system incorporating circuits for production of transients, together with a power source for the tone generators that is derived from or modulated by a noise generator. Resulting effects are continuous random variations in tone generator output, and integrated noise transients in combination with pitch transients during the initial speech period.

A system using a noise generator as a power source for the tone gen-



Tone-generator chassis is slide-mounted and invertable for tuning and regulating. Chiff circuits are not mounted as a unit but are integrated with the associated tone-generator circuits

Pipe-Organ Sound Electronically

erator, plus a circuit for production of pitch transients during the initial speech period of the tone is shown in Fig. 1. A desirable noise source should produce a noise spectra with Gaussian amplitude distribution and with frequency components in the d-c to 20-cps portion of the spectrum. Noise generators using a 6D4 gas triode as a temperature-limited diode have been successful. Noise output is rectified by diode D_1 and partially filtered before being applied to the tone oscillator. Filter R_1-C_1 attenuates the rectified noise component frequencies above 20 cps. The tone oscillators are conventional LC types, (Hartley or Colpitts) and are operated so that the output amplitude follows the infrasonic frequency modulation of the rectified and filtered noise power source. Transistor oscillators are especially desirable because of their low power requirements. The resulting random frequency modulation of oscillator amplitude produces equivalent variations of amplitude similar to those caused by air turbulence resulting from irregularities in the air path between the blower and the speaking pipe, and by pressure irregularities resulting from the effects of the varying air load that is produced when performing music.

Resistor R_2 allows a specific quantity of the unrectified and unfiltered noise signal to be fed directly to the amplifier and speaker system, producing, with the oscillator signal, a measured amount of hiss, which simulates the noise produced by the escaping air at the embouchure of the organ pipe.

In this organ system, each oscillator of a given rank would be keyed and an independent set of components for the generation of waveform, pitch and noise transients would be provided for each note. Figure 2A is a waveform of a typical organ tone as produced by an LC oscillator plus harmonic generation circuit and powered by well-filtered direct current. Figure 2B illustrates the same waveform with added noise such as would be produced by the addition of resistor R_2 in Fig. 1. A longer time base showing several successive cycles would be required to illustrate the infrasonic amplitude modulation produced by the rectified and filtered noise power source.

The chiff circuit provides the

transient components of the classic organ tone which occur at the start of the tone just before the continuous state condition is reached. The flue types of classic organ pipes were so constructed and operated that they would speak at a pitch that was a fifth or seventh harmonic of the fundamental during the initial speech period of the tone. Odd harmonics are produced with the parallel opposite-polarity diodes D_2 and D_3 which function as a symmetrical clipper. Capacitors C_2 and C_3 will block the diode currents when they become charged, but during the charging period the series-tuned circuit L_1-C_4 will function as a bandpass filter, passing the desired odd harmonic to the amplifier.

It requires a minimum of about 13 milliseconds for the ear to identify a sound as having a definite pitch. Thus the time constant of the RC combination of C_2-C_3 and the diode and source resistance are adjusted to meet this requirement. Resistors R_3 and R_1 allow capacitors C_2 and C_3 to discharge at a rate that permits repetitive keying of the oscillator with the production of the transient chiff effect.

Relative amplitude of the frequency components of a typical 440-cps (fundamental) note during the transient or attack period is shown in Fig. 2C. Figure 2D is the same note after the steady-state condition has been reached.

The first eight cycles of an electronically produced organ tone with chiff, with a fundamental frequency of 65.4 cps, is shown in Fig. 2E. During the first five cycles the transient chiff frequency of the seventh harmonic of the fundamental occurs as the fundamental component gradually builds up. At the sixth cycle of the fundamental, the seventh harmonic has disappeared and the steady state tone prevails. The chiff interval is about 76.5 milliseconds.

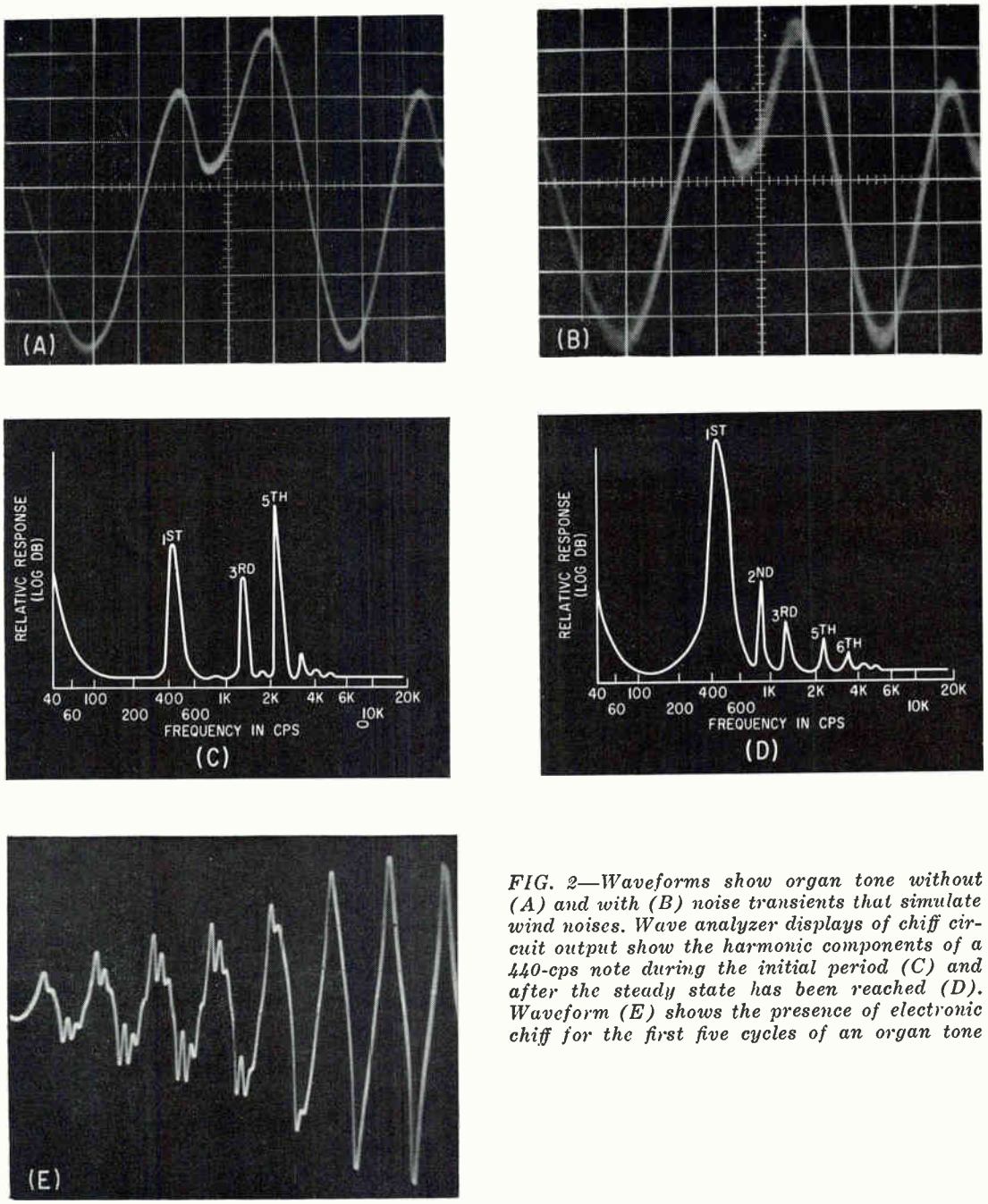
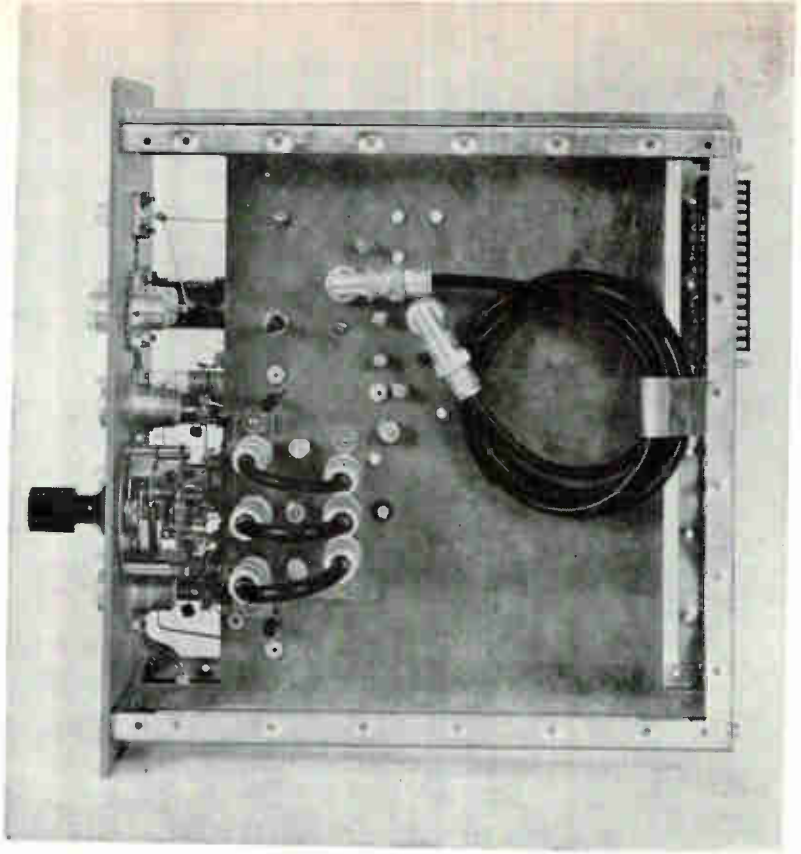


FIG. 2—Waveforms show organ tone without (A) and with (B) noise transients that simulate wind noises. Wave analyzer displays of chiff circuit output show the harmonic components of a 440-cps note during the initial period (C) and after the steady state has been reached (D). Waveform (E) shows the presence of electronic chiff for the first five cycles of an organ tone

Characteristics of tunnel diodes enable circuit to determine pulse coincidence within nanosecond limits. Circuit design combined with other properties of the diodes result in good temperature stability and limited sensitivity to transistor parameters



Component layout is shown in bottom view of chassis for nanosecond coincidence circuit

TUNNEL DIODES

Stabilize Coincidence Circuit

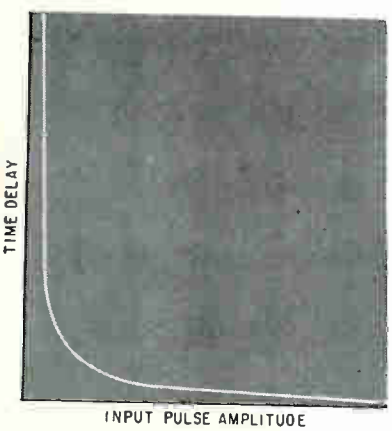


FIG. 1—Variations in delay of a regenerative circuit are a function of input amplitude

By C. INFANTE*
F. PANDARESE
Laboratori Nazionali Di Frascati
Rome, Italy

PERFORMANCE requirements for a coincidence circuit to be used in high-energy physics experiments were obtained using tunnel diodes. The high ratio of loop gain-bandwidth to loop delay obtainable with these inherently regenerative devices permitted design of a circuit in which timing jitter is limited to a few nanoseconds.

Coincidence circuits in some high-energy physics experiments function like the AND gate, but specifications are usually different. A coincidence circuit must handle high peak input rates, accept coincident pulses that vary widely in amplitude and shape, and reject pulses that do not coincide in time within a few nanoseconds.

Since the coincidence circuit is usually fed by a scintillation counter, input pulse amplitudes vary statistically and limiting circuits are incorporated before the AND circuit to establish the range of pulse amplitudes accepted. Trigger circuits or discriminators are also used preceding the AND circuit to

*Now with Tektronix, Beaverton, Oregon

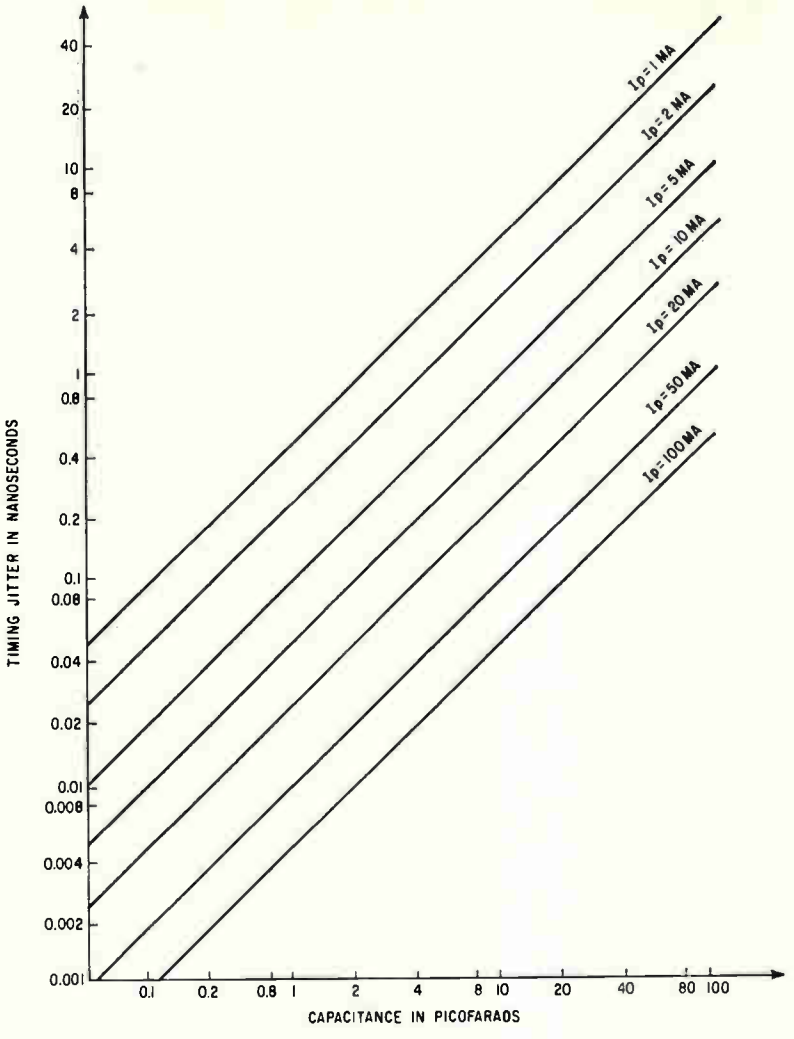


FIG. 2—Timing jitter for a current pulse 10 percent above threshold is a function of peak current and capacitance of a germanium tunnel diode

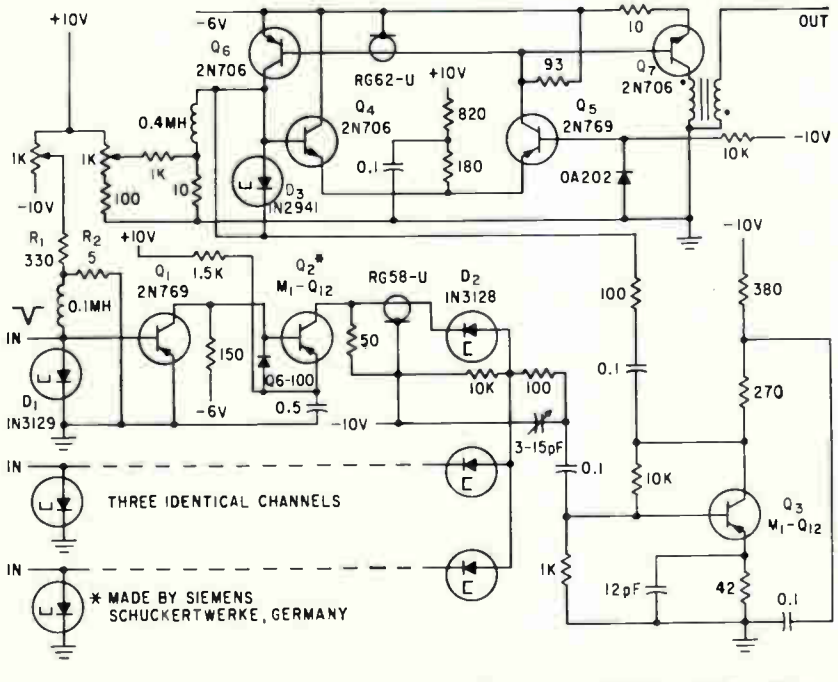


FIG. 3—Coincidence circuit using tunnel diodes has limited timing jitter, good temperature stability and is insensitive to transistor parameters

establish the shape of pulses that will be accepted, although these circuits have rarely been used in the past because timing jitter is encountered in regenerative circuits operating with pulses near the threshold level.[1]

Circuit delay is plotted as a function of input pulse amplitude in the curve in Fig. 1, which shows that some deterioration in timing results. In a regenerative circuit, it can be demonstrated that timing jitter is dependent on loop gain-bandwidth and on loop delay.[1] The tunnel diode, which is inherently a regenerative device, behaves similarly, but loop gain-bandwidth is so large and loop delay so small that timing jitter can be limited to a few nanoseconds.

The plot in Fig. 2 is based on an analytical approximation of the voltage-current characteristics of the tunnel diode.[2] From measurements of peak current and capacitance of a germanium tunnel diode, timing jitter can be found from the plot. The resulting number is the variation in delay between an input current pulse 10 percent above the threshold and an infinitely large input pulse. For example, a tunnel diode with 20 ma peak current and 10 pf capacitance has timing jitter of 0.2 nsec. In contrast, timing jitter of vacuum-tube circuits is one or two orders of magnitude greater.

The coincidence circuit is shown schematically in Fig. 3. In operation input tunnel diode D_1 is biased by resistors R_1 and R_2 so that it operates close to maximum sensitivity. Since the scintillation counter is connected to the coincidence circut through 125-ohm coaxial cable, the circuit acts as a voltage generator with 125 ohms impedance. To properly terminate the cable, it must be matched at the multiplier phototube end

When magnitude of an input current pulse exceeds the difference between peak diode current and bias current, the diode switches on transistor Q_1. Emitter current in Q_2, which is normally 10 ma, is switched off, producing a pulse of standard amplitude at the collector. The pulse is clipped by the 50-ohm shorting stub so that electrical length of the shorting stub deter-

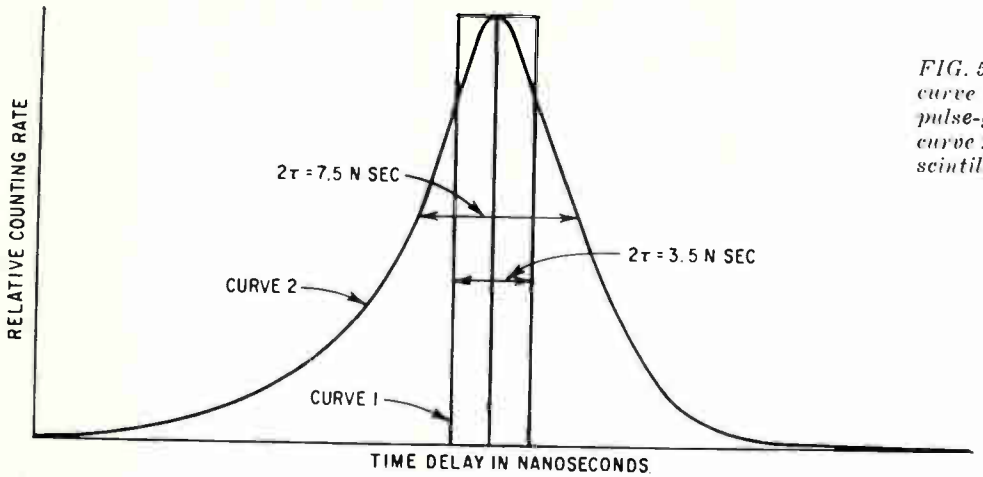


FIG. 5—Resolution-time curve 1 was taken using pulse-generator and curve 2 using scintillation counters

mines resolving time of the coincidence circuit. Shape of the output pulse for different cable lengths is shown in Fig. 4. By using voltage to bias the tunnel diode, linearity and independence from diode characteristics is greater than that obtainable using current-biasing techniques.

Selection of transistor Q_2 was based primarily on cost. Any transistor with a minimum gain-bandwidth product of 300 Mc and a dissipation rating of 100 mw can be used (2N1143 and 2N1385 have been used successfully).

Output of each discriminator is fed to the input of a tunnel diode coincidence circuit.[3] The ratio of coincident to noncoincident pulse amplitudes can be increased by integrating output from the circuit with a time constant equal to the diode switching time. Output of the AND circuit is inverted and amplified by transistor Q_3 with a large amount of negative feedback.

The amplified output is then fed to a final discriminator and shaper.[4] In the shaper circuit, tunnel diode D_3 is operated in the bistable mode. The diode is reset to the low-voltage state through transistors Q_4, Q_5 and Q_6 after a time determined by the RG 62-U coaxial cable. Transistor Q_7 is saturated by the signal, furnishing a 4-volt pulse at the output. Either a positive or negative pulse can be provided depending on how the transformer is connected.

Because of the small temperature coefficients of tunnel diodes and the large amount of negative feedback in the circuit, the coincidence circuit has proved to be temperature stable and to be insensitive to transistor parameters. Each input discriminator and the combination amplifier-output discriminator were stable within less than 1 percent over an 8-hour period under laboratory conditions. At their most sensitive settings, the input discriminators are triggered by a 2-ma current pulse at a 20-Mc maximum input rate. Because of the relatively small number of a-c couplings, no shift in d-c base potential was experienced.

Typical curves of resolving time using standard pulses from a pulse generator are shown in Fig. 5. The curves were plotted under actual operating conditions. The increased width of the second curve resulted from both timing jitter in the input circuits and from statistical variatons in multiplier phototube output. The second curve was plotted using carbon 60 with detection by two plastic scintillators.

The authors gratefully acknowledge the assistance of R. Rizzi, who designed and tested the apparatus, and M. Tanzini, who assembled most of the test circuits and the final coincidence circuit.

REFERENCES

(1) J. May, L'onde electrique, 38, p 622, 1958.
(2) C. Infante and F. Pandarese, The Tunnel Diode As A Threshold Device: Theory and Application, Proc 1961 Belgrade Conference on Nuclear Electronics (to be published).
(3) R. C. Sims, E. R. Beck, Jr., and V. C. Kamm, A Survey of Tunnel Diode Digital Techniques, *Proc IRE*, 49, 136, 1961.
(4) R. M. Sugarman, Proc 1960 Conference on High-Energy Physics Instrumentation at Berkeley.

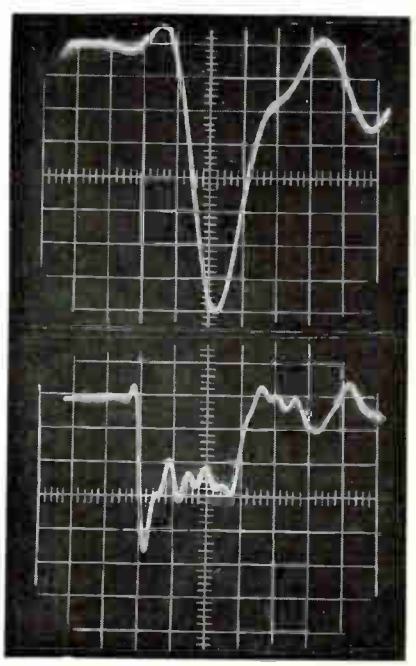


FIG. 4—Upper and lower discriminator pulses were photographed using 0.5 and 5 nsec shorting stubs, 0.06 and 0.1 volt per cm vertical sensitivities, and 1 and 4 nsec per cm horizontal sweep rates, respectively

FORMING SEMI-PERMANENT MEMORIES

Presence or absence of a metal shield between two closely spaced coils has a large effect on their mutual inductance. The principle is used to build a read-only memory whose content is determined by thin metal cards

By JUNJI YAMATO
YASUNOBU SUZUKI,
Electrical Communication Lab., Nippon Telegraph and Telephone Corp., Tokyo, Japan

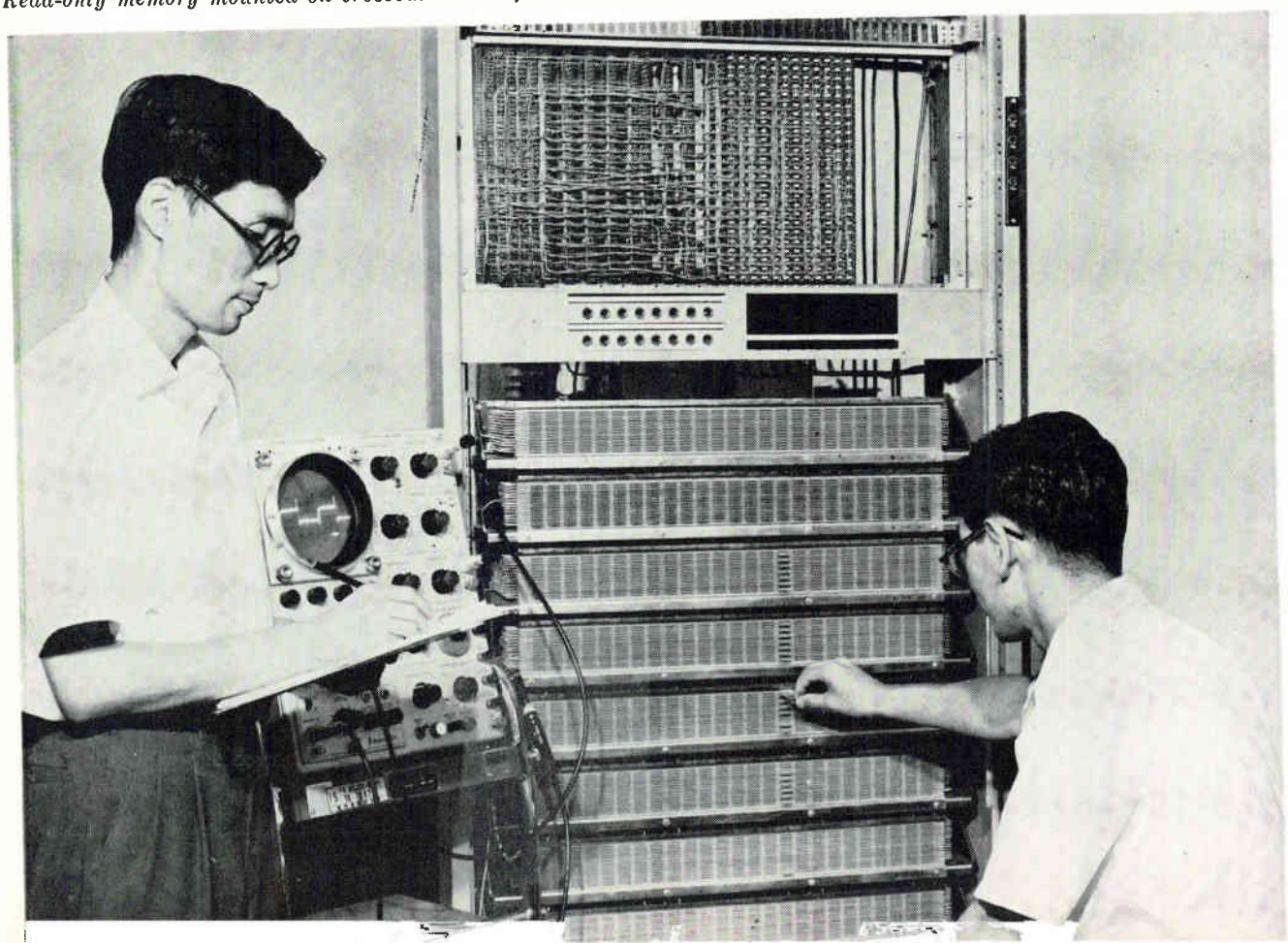
SEMIPERMANENT MEMORY is composed of metal cards for storage and stacks of printed-circuit coil boards for reading. The memory allows electrical read-out but not electrical read-in. Memory content is contained on punched metal cards and no ferromagnetic materials of any kind are used. Read-only memories of large capacity are necessary to develop the functional capability and to increase the flexibility of information processing machines such as electronic computers and common control telephone exchanges.

The random access memory consists of metal cards for storage and stacks of printed-circuit coil boards for reading. Information storage is accomplished by punching or not punching a hole in a strip of metal for each bit, depending on the information to be stored. The fact that the electromagnetic coupling between two coils is considerably reduced if they are shielded by a metal plate is used in reading out stored data. Advantages include ease of fabrication, small size, high reliability, high-speed operation, long life and low cost.

Good results were first obtained with a demonstration metal card memory with a capacity of about 20,000 bits. Development has been started of an improved miniature memory that will have an ultimate capacity of about 500,000 bits. Performance of initial modules of the improved memory is excellent.

The principle of operation of the metal card memory is extremely simple. Suppose the mutual inductance of two identical one-turn coils

Read-only memory mounted on crossbar-switch frame. Content of memory is determined by punched metal cards



WITH METAL CARD STORAGE

L_1 and L_2 is M_o. Then a high frequency current I in one of the coils, L_1, induces an electromotive force (emf) of $\omega M_o I$ in coil L_2 (Fig. 1A). However, if a metal plate is inserted between the two coils (Fig. 1B), the induced emf decreases because of the reduction of M_o.

The magnitude of the effect is shown in the table for two 6.5 mm diameter circular coils in free space separated by 0.8 mm. A 1-Mc current was sent through one coil; metal plates of various thicknesses were inserted between the coils and the reduction in the induced emf was measured in db.

As shown in Fig. 1C, if the metal plate has a circular hole (with hole diameter slightly larger than that of the coils) between the coils, with the plate parallel to the coils and the centers of the hole and the coils aligned, the magnitude of the emf induced in L_2 is nearly half that induced when there is no metal plate between the coils. It then becomes possible to sense electrically whether or not a hole exists in a metal plate between coils L_1 and L_2. Information stored on the metal plate, as the presence or absence of a hole, can be read out electrically.

Generally, a memory capacity of several tens of thousands to several hundreds of thousands or more bits is required in a semipermanent memory. Therefore, one of the main problems is that of arranging a large number of storage elements, each of which is composed of a pair of coils and a metal plate, in a manner convenient for memory operation.

For the metal card memory proposed, circular coils were not convenient and instead of the mutual inductance between two circular coils, that between two parallel lines is used.

One of the photographs shows an excitation coil board with one metal card shown in position. (Each coil L_1 shown in Fig. 1 is an excitation coil.) Each excitation coil board contains coils connected in series in 25 rows, with each row

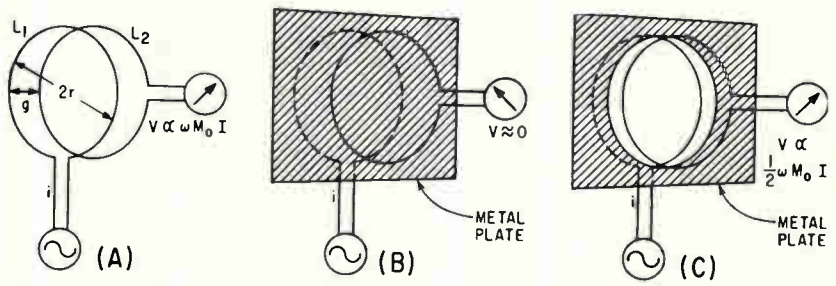


FIG. 1—Voltage induced in a nearby coil is greatly affected by thin sheet of metal shielding. Metal card memory is based on presence or absence of shielding between pickup and excitation coils

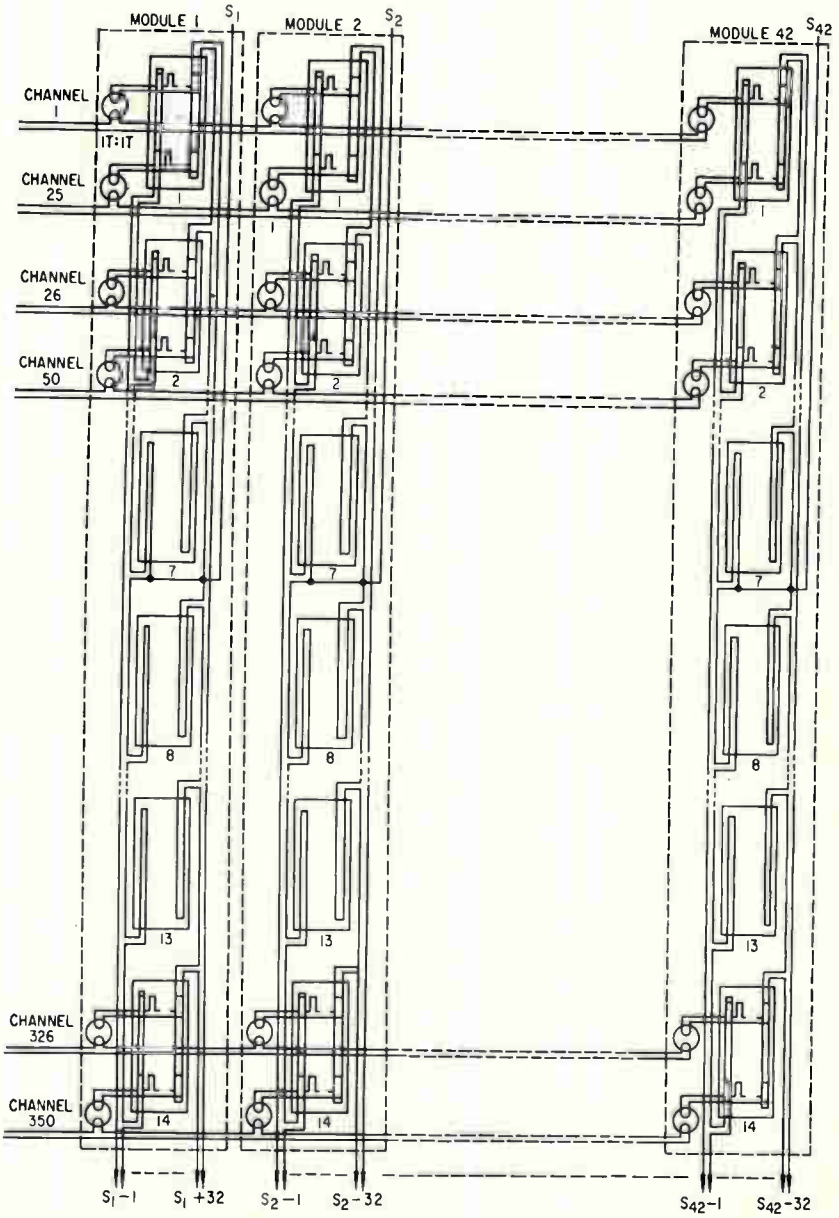
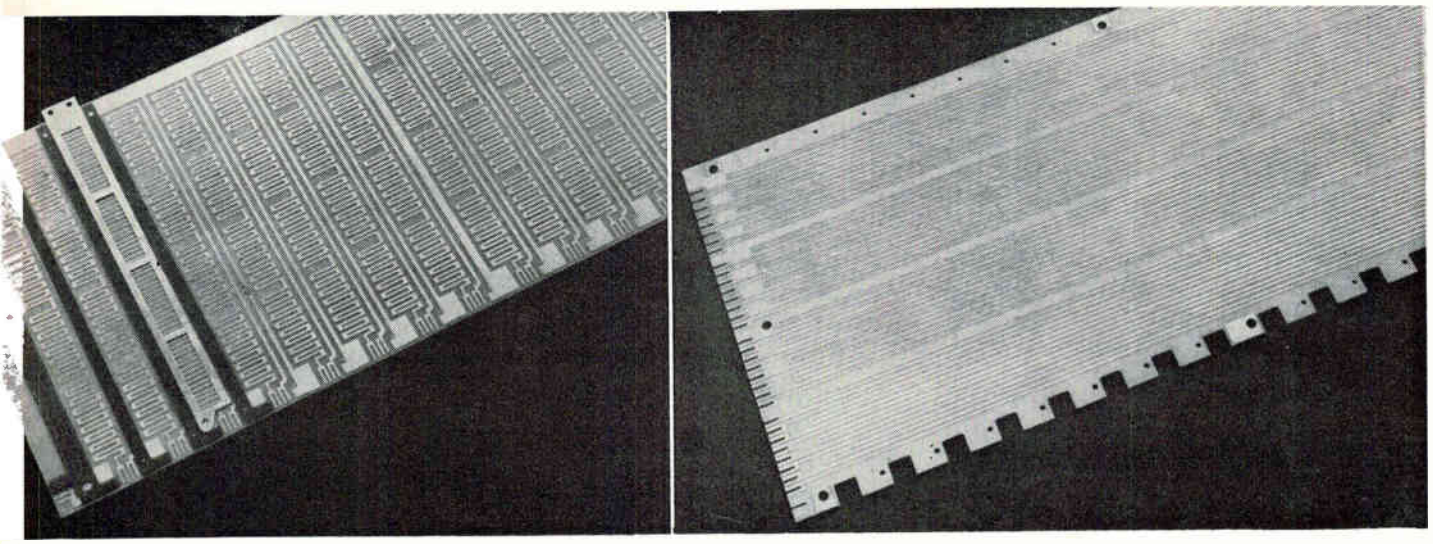


FIG. 2—Module connections for building up the complete memory



Excitation coil board with one metal card placed in guide-spacer and aligned by spacer hook at bottom

Sensing coil board. Dimensions are 64 × 18 × 0.16 cm, about 2 cm longer than companion board

corresponding to one 32-bit word; each row is called an excitation coil group.

A sensing coil board is shown in the photograph next to that of the excitation coil board. (Each coil L_2 of Fig. 1 is a sensing coil.) Each board contains sensing coils connected in series in 32 columns, each of which corresponds to a bit common to all 25 words; each column is called a sensing coil group.

One excitation coil board and one sensing coil board, which have received a 0.1-mm thick coating of insulating material, are clamped together with 0.7-mm thick spacers between them. The excitation coil groups and the sensing coil groups are orthogonal, and the center of each excitation coil and the corresponding sensing coil coincide. An X-ray photograph of a board pair shows the coincidence of both types of coils.

Next, 0.3-mm thick Duralumin cards, measuring 17 by 170 mm, are inserted in the board pair, using spacers as guide rails, as can be seen in the picture of the excitation board. The centers of the holes must coincide exactly with those of the corresponding coils. The hooks at the bottoms of the spacers fix the exact position of the metal cards.

A rectangular hole measuring 4.5 × 10 mm stores a ONE. If ONE occurs n times in succession on the card, a hole whose length is $n \times$ 4.5 mm is punched.

The sizes and positions of the holes in the cards must be held within precise limits. To make the holes, a punch controlled electronically by programmed tape has been developed. Parametrons are the logical elements of the punch.

If one of the excitation coil groups is chosen and high-frequency excitation current sent through it, the information stored on the card corresponding to the group is sensed electrically by the sensing coil groups. If a large number of such board pairs are stacked and the corresponding coil groups are connected in a network, a memory having a large capacity is obtained.

The board pairs must, when stacked, be shielded from each other. Solid sheets of copper are printed on the outside of the pairs to prevent linkage between the coils of

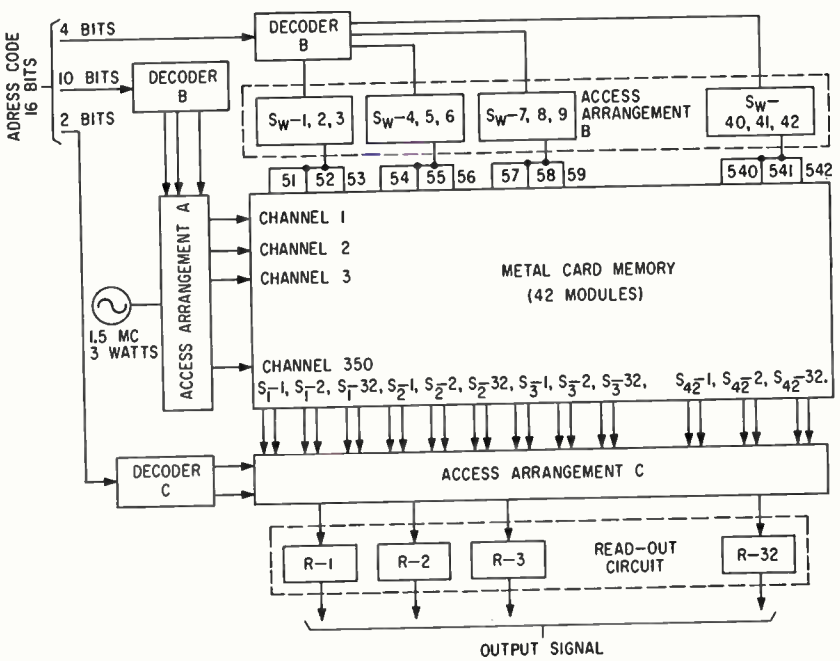
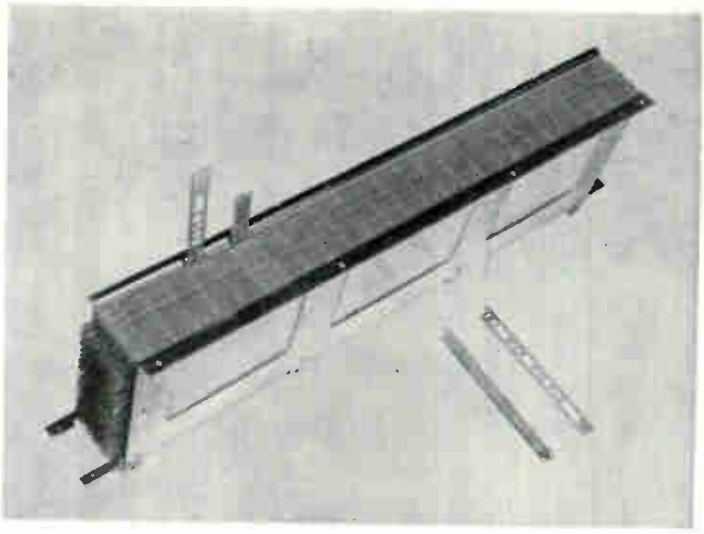


FIG. 3—Peripheral circuits are required for read-out. Three access arrangements provide channel and coil group selection



Memory module. Punched metal cards determine content. Capacity of module is 350 32-bit words; size is 64 × 18 × 6 cm

different pairs. Each coil pair in the structure is thus separated from neighboring coils by two thicknesses of copper foil, whose total thickness is 80 microns. They give a shielding effect of more than 50 db at 1.6 Mc. This is more than sufficient.

One of the photographs shows a stack of 14 board pairs, which is called a module. Figure 2 indicates connections within modules and from one module to another. Each module can accept 350 metal cards, each of which has spaces for 32 bits; thus the total capacity of a module is 11,200 bits. A memory having a larger capacity can be formed by connection of the modules as shown in Fig. 2. Note that the individual coil groups on the boards have been connected in cascade coil groups; for example, cascade coil group S_1-1. Thirty-two cascade coil groups comprise one word coil group. A one-turn to one-turn transformer prevents a potential rise of the exciting coils, which would result in deterioriation of the s/n ratio of the sensing signal because of capacitive coupling between excitation coil groups and sensing coil groups. The transformer is also useful in making the excitation current along the excitation coil groups uniform.

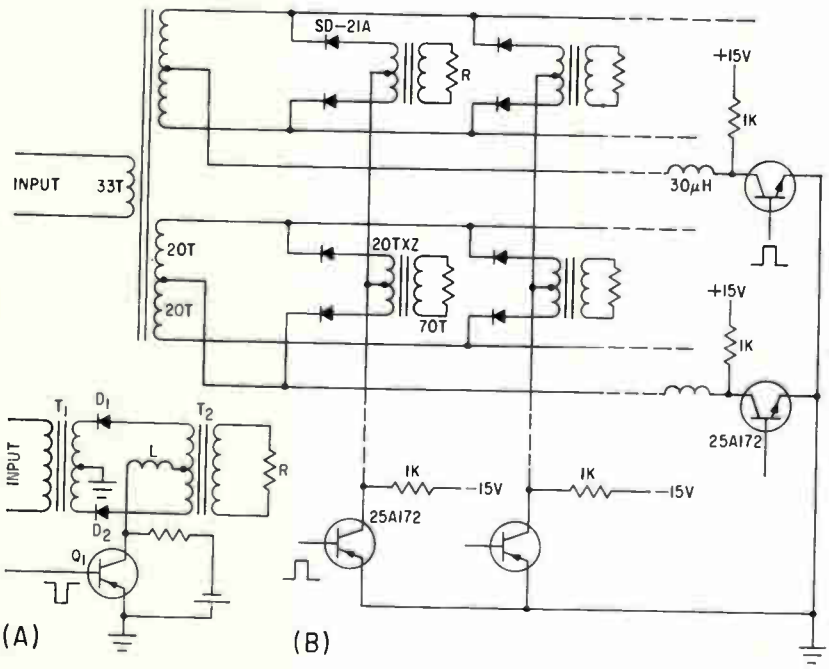


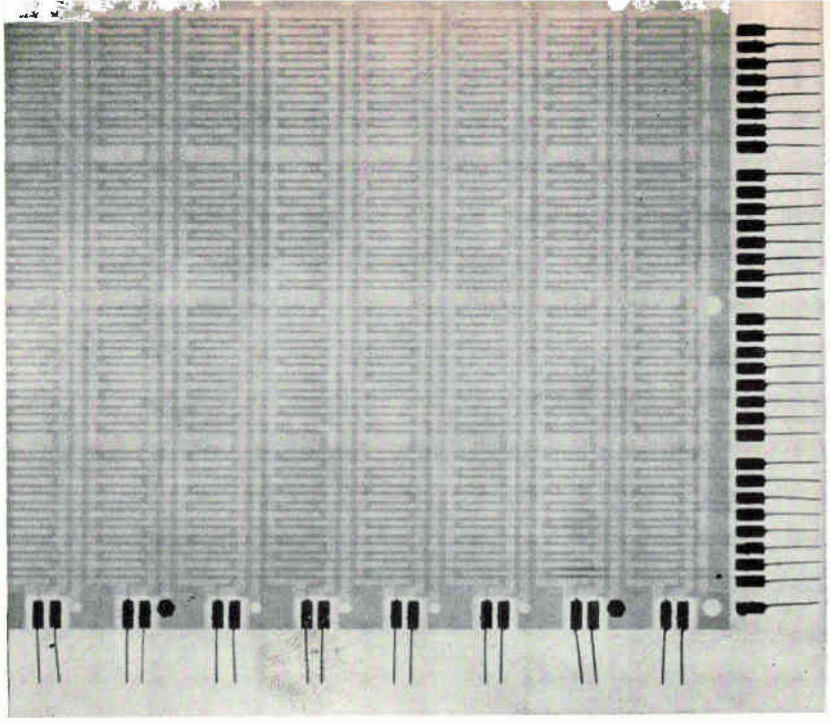
FIG. 4—Diode switching circuit (A), and diode switch network (B), for access arrangement A

Peripheral circuits are necessary for operation of the memory. The address selection circuit shown in Fig. 3 and the read-out circuits of the metal card memory consist of three kinds of access arrangements, read-out circuits for each word (32 bits), and a transistor high-frequency power supply.

Access arrangement *A* is for channel selection. It selects one of the 350 channels according to its control signal, which is composed of 10 bits, and sends a high-frequency current through the selected channel.

Access arrangements *B* and *C* are for selecting word coil groups. They are controlled by 4 bits and 2 bits, respectively, of the address signal. Access arrangements *B* and *C* select the word—from among the 42 words simultaneously excited by access arrangement *A*—and send the information to the read-out amplifiers.

Figure 4 shows the circuit details of access arrangement *A*. The circuit, whose input is a continuous



X-ray of memory sandwich shows precise alignment of circuits

sine wave, is shown in Fig. 4A. When switch S, (transistor Q_1) is ON, the half-wave rectified currents flowing through diodes D_1 and D_2 are combined in T_2, and an output voltage appears across load R. If a choke coil L is inserted in the circuit as shown, the rectified current flowing through the coil and the switch—whose fundamental frequency component is the second harmonic of the supply frequency—is smoothed and its peak value decreases. Therefore, the specifications required of the transistor used in the switch become less severe.

The choke also provides a certain amount of d-c bias on the diodes. If junction diodes are used for D_1 and D_2, hole storage enables them to provide adequate output with small switching loss, even if the bias current is insufficient. When S is in the OFF state, a reverse bias voltage is applied to the diodes by the battery and resistor r; therefore no power is transmitted to load R.

Figure 4B shows a selection matrix composed of the basic circuits. Assume that one switch in the row switch group and one switch in the column switch group are ON, and that all of the other switches are OFF; then a load connected to the circuit at the cross-point will be provided with h-f power. For example, in an experiment performed on a rectangular matrix with 6 rows and 8 columns using a 1.6-Mc power supply with an output power of 3 w, the power transfer efficiency was 85 percent and the switching ratio was 50 db.

Using the circuit shown in Fig. 4B, a selection can be made of one out of $m \times n$ circuits with only $m + n$ switch circuits. By connecting two matrices ($m \times n$, $p \times q$) in cascade to form a selection circuit, a selection can be made of one out of $m \times n \times p \times q$ circuits with $m + n + p + q$ transistors, and this allows economy of transistor switches. Connection leakage in the nonselected channels is greatly reduced with this circuit. Therefore, an improvement in the switching ratio results. For example, switching ratios as high as 71 db have been obtained.

In the experimental memory shown in the photographs, the bit address is broken into units of 1 bit, 3 bits, 3 bits and 3 bits each; and each unit is decoded to drive the transistor switches of the two-stage matrix-type access arrangement. Thus any channel out of 350 ($= 2\times 5 \times 5 \times 7$) can be selected.

Figure 5 shows the transistor switching circuit in access arrangement B. The output terminal is connected to three words coil groups, and when a pulse appears at the input, the output terminal is grounded. These large-current transistor switches are driven after the input information is decoded, and one of the 14 three-word groups —[S_1, S_2, S_3] (three-word group 1), [S_4, S_5, S_6] (three-word group 2), . . . [S_{40}, S_{41}, S_{42}] (three-word group 14)—is grounded.

Figure 6 shows the circuit of the part of access arrangement C used for reading the first digits of words and its portion of the read-out circuit. Access arrangement C consists of diode switch circuits, and for control uses large-current transistor switches $S_{w\text{-}x}$, $S_{w\text{-}y}$, and $S_{w\text{-}z}$, similar to those used in access arrangement B.

When one of the transistor switches in access arrangement B and one in access arrangement C are selected and turned ON, one word out of the 42 words read simultaneously by access arrangement A is selected and fed to the read-out circuits. The circuit is efficient in that it uses only a small number of transistor switches.

The read-out circuit is composed of transistor read-out amplifiers and rectifiers.

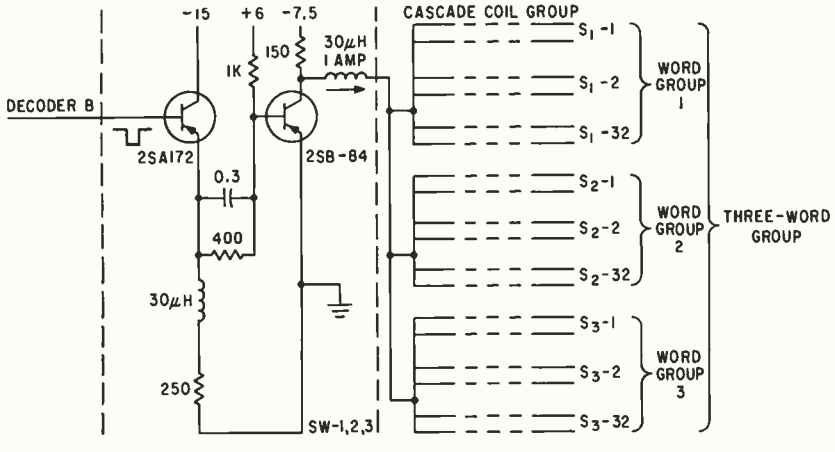


FIG. 5—Transistor switching circuit used in access arrangement B

To prevent a decrease in s/n caused by electromagnetic disturbances, the amplifier must have a narrow bandwidth whose center is the excitation frequency. The bandwidth is determined by the width of the address pulse, which is a function of reading speed. As the width of the address pulse in the experimental memory is 30 μsec—this pulse width was determined by the modulation frequency (15 Kc) of the parametrons in the logic circuits-the amplifiers have a 3-db-down bandwidth of $\pm$100 Kc and an average s/n of 30 db. Even in the worst case, the s/n at the output terminals of the amplifier was 20 db.

There are a number of possibilities for improvement in the system. If the number of bits in one word is too large for a single line of one card, it can be divided into several lines. Reading can be accomplished by time-sharing. If all bits of the word must be read simultaneously, this may be accomplished by different excitation frequencies for the different lines into which the word is divided, and then using filters to separate the outputs from the read-out amplifiers. The number of access arrangement *A* circuits must be equal to the number of lines into which the word is divided. To each of these access arrangement *A* circuits a h-f power supply of different frequency must be connected. However, the transistor switches can be common to all of the access arrangement *A* circuits.

The specifications of the improved metal card memory are as follows:

Capacity: 2,800 words of 32 bits each (final capacity will be 14,700 words).

Number of modules: 8 (final number will be 42).

Mutual inductance M_o: 2.0×10^{-9} H with no card and 1.9×10^{-9} H for ONE bit location.

Excitation: 200 ma at 1.6 Mc, pulsed sinusoidal current of 33 μsec duration. Output power of the sinusoidal supply is about 3 watts.

Sensing voltage: 2 mv for ONE The one to one turn transformers cause approximately a 6 db exciting current loss. Transformer core outside dimension is 8.7 mm, single turn inductance is 0.35 microhenry.

Sensing signal-to-noise ratio is approximately 30 decibels.

Cycle time: 67 microsecond.

Volume: 0.6 cubic centimeters for each bit.

The metal card memory is a static device. The only phenomenon used in the memory is the change in the mutual inductance between two coils caused by the insertion of a metal card between them. No electromechanical contact of any kind is used, therefore the memory is electrically stable. If the coil boards are printed and insulated with care, their life is almost infinite.

Fabrication is simple and inexpensive. The boards, which are made by printed-circuit techniques, and the metal cards can be mass produced.

Physical dimensions are small. A crossbar switch frame (85 $\times$ 26 $\times$ 350 cm) can hold about 300,000 bits. The miniaturization of this memory is limited by the 1-mm minimum guaranteed width of the printed coils. Further improvements in printed-circuit techniques are expected to enable further miniaturization.

Time for reading is small. In a preliminary experiment reading was accomplished in less than one microsecond a word using an h-f power supply operating at a higher frequency than that described in this article.

The authors thank Z. Kiyasu, associate director of the Electrical Communication Laboratory, for permission to publish this paper. They are also indebted to H. Kawasaki, I. Endo and K. Fukui, who gave them effective guidance.

The systems were designed in our laboratory and constructed with the cooperation of Hitachi, Ltd.

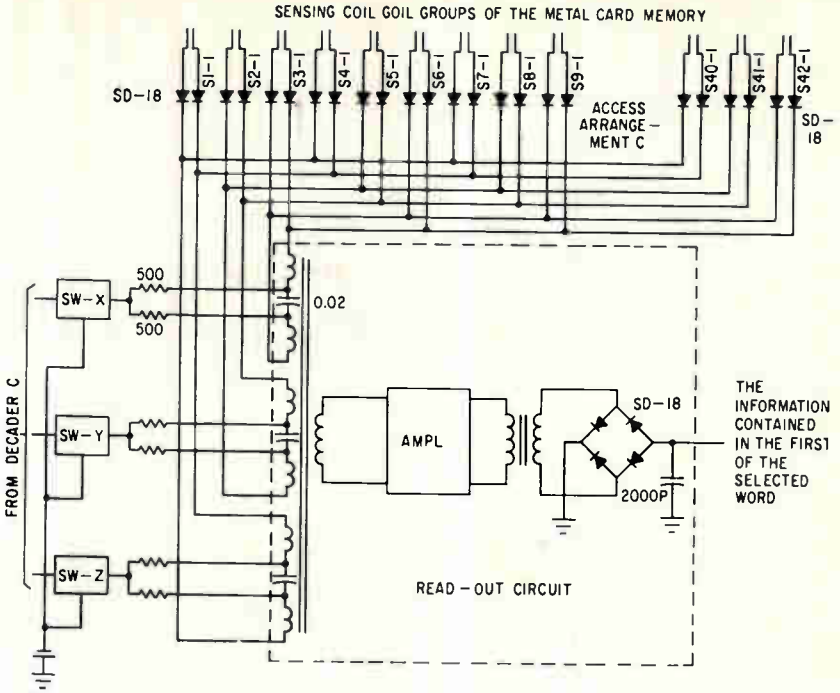


FIG. 6—Access arrangement C and read-out circuits

SHIELDING EFFECT OF METAL PLATE FOR SINGLE TURN COILS 0.8 MM APART

Shielding material		Copper		Duralumin	Brass
Thickness in mm	0.3	0.04	0.04×2	0.3	0.3
Reduction of induced emf, in db	>54	21	38	>54	43

The T.S.S. Oriana, on which the power meter is used. The 42,000-ton liner develops 40,000 horsepower per shaft at 157 rpm. Meter measures torque of about 600 tons-feet on 96 feet of a 25-inch diameter shaft. Ship's top speed is 31 knots

Digital Technique Measures Ship's Horsepower

Power meter continuously multiplies torque and speed, integrates product to indicate horsepower hours used up

By JOHN BELL
Muirhead & Company Ltd.,
Beckenham, Kent, England

A POWER METER has been devised for measuring the power output of marine engines. The meter continuously multiplies torque and speed, and integrates the product in a digital counter so that horsepower hours are registered and displayed as the vessel proceeds. The meter will replace cumbersome methods in which an operator had to keep track of torque over periods of time and then obtain an average product.

Figure 1 illustrates the plan of operation applied to a ship's propeller shaft. An appropriate distance apart on this shaft are two identical armature rings, each carrying a number of soft iron armatures equally spaced around the circumference. Each armature is $\frac{1}{8}$ inch in diameter and about one inch wide.

Next to each armature ring is a magnetic pickup consisting of a small permanent magnet with a soft-iron pole tip. The pole tips are so shaped that as each armature passes the pickup, a pulse in the magnetic field induces a voltage pulse in the pickup coil.

The armatures are initially aligned with the propeller shaft unstressed. When the shaft is then loaded and twist occurs, the time difference between pickup voltages at the two pickups is a measure of the transmitted torque. A twist of about 2 degrees is desirable for convenient measurement.

An alternator driven by the ship's engine produces a frequency of about 10 Kc at the normal operating speed. The actual frequency at any moment is a measure of the shaft speed.

Successive signals from a pair of armatures (one on each ring) open and close an electronic gate. The horsepower hours are registered on the meter by integrating the number of alternator output voltage waves that pass through the electronic gate.

Processing of the signals is shown in Fig. 2. The rise and fall of the flux as the armature and pickup pole tip pass through coincidence is seen in Fig. 2A. Figure 2B is the differential of the flux, or the voltage produced. This is amplified and applied to a wave-shaping circuit that produces a gating pulse of constant amplitude and

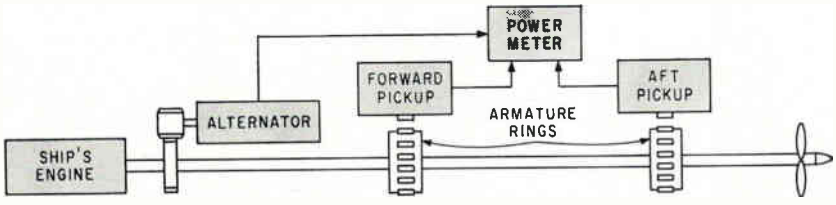


FIG. 1—By a system of armatures and pickups, the power meter measures shaft torque as indicated by shaft twist. Alternator driven by engine indicates speed

THIS IS THE VANGUARD RELAY...

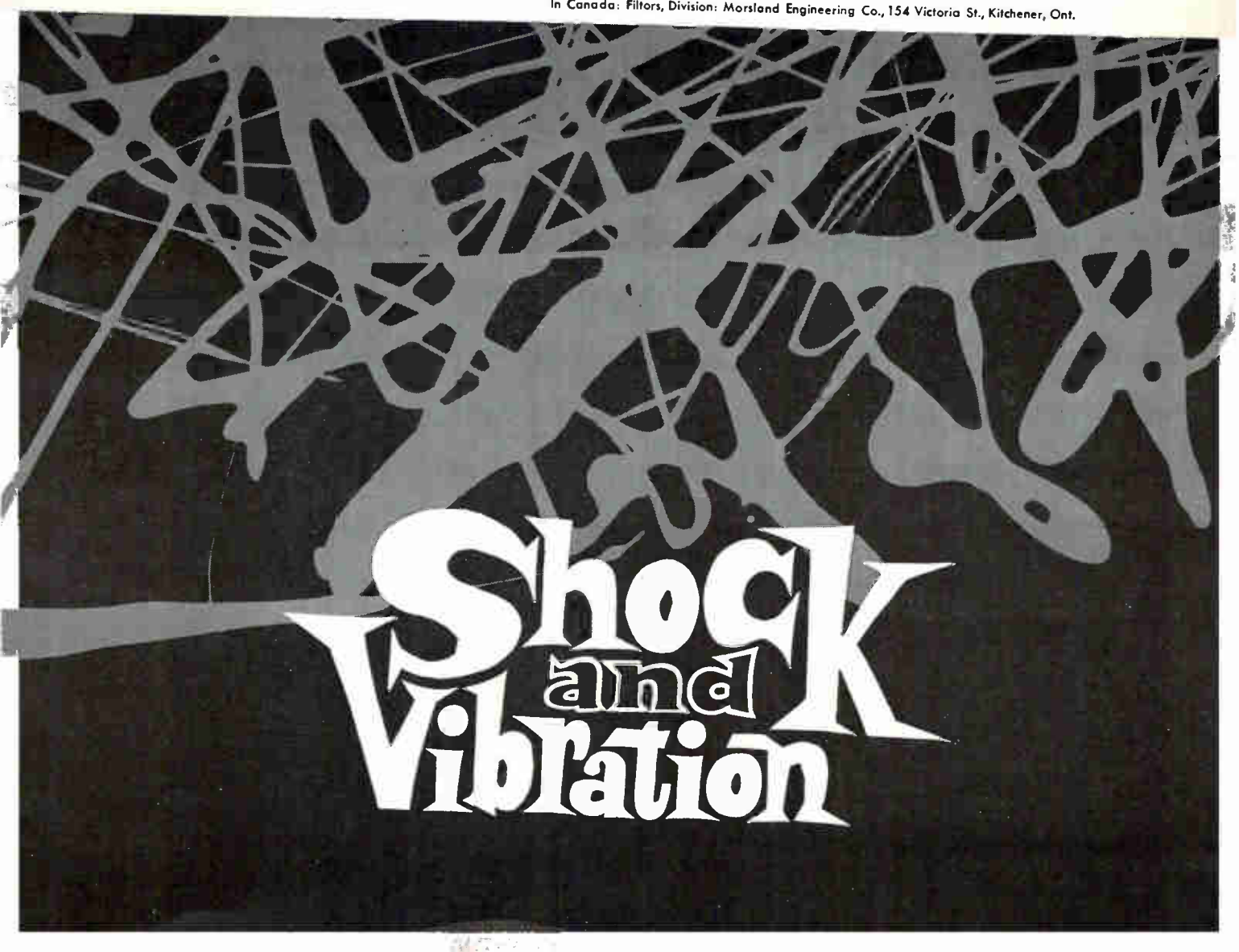
the rugged new offspring of Filtors' famous H-Series subminiature relay. Its rotary relay motor incorporates Filtors' patented coil-enclosed armature design, the most efficient motor in the industry, and the new header design has established the Vanguard firmly in the symbol-3 relay category set forth by MIL-R-5757D; this means the Vanguard can be used in any known missile application. Though there is great emphasis on microminiaturization, don't overlook the advantages of subminiature relays, namely, in circuits where six-pole switching is required; one six-pole relay occupies less area and volume than three two-pole crystal-case relays, costs less, cuts production or assembly time, and improves the circuit reliability figure. The reputation for reliability earned by over two million H-series relays is part of the Vanguard heritage; its performance, however, is both unique and superior to other relays of this style.

MILITARY STANDARD PART NUMBER	MS 24115-6
AMBIENT TEMPERATURE RANGE	−65°C to 125°C
INSULATION RESISTANCE	100 megohms min. at 25°C at 500 VDC
DIELECTRIC STRENGTH	1000 volts rms (sea level)
CONTACT ARRANGEMENTS	4 or 6-pole double throw
CONTACT RATING (26 VDC or 115 VAC to 400 cps)	2 amps resistance (available with low-level and/or 5-amp contacts)
SHOCK	75 G's, 11 milliseconds
VIBRATION	20 G's to 3000 cps (30 G's available)
OPERATE TIME	10 milliseconds max. at nominal coil voltage at 25°C
RELEASE TIME	6 milliseconds max. at nominal coil voltage at 25°C.

FILTORS, INC./RELAYS

PORT WASHINGTON, NEW YORK
POrt Washington 7-8220, area code 516

In Canada: Filtors, Division: Morsland Engineering Co., 154 Victoria St., Kitchener, Ont.



duration. The leading edge of this pulse occurs at the instant when the pickup voltage goes negative (at the coincidence point of armature and pickup). At the gate, the pulses from the forward pickup (3C) are positive-going and those from the aft pickup (3D) are negative-going.

Illustrating the processing for the alternator output, Fig. 2E is the voltage wave, approximately sinusoidal. It is amplified and cut off to product a square wave (2F). This is differentiated to give voltage spikes (2G) which are rectified (2H). After passing through the gate they are expanded in time (2I) to provide power to operate the counters.

Block diagram of the power meter is shown in Fig. 3.

Signals from the alternator (2H) are waiting at the gate, and as the shaft rotates under load, the gate is opened for a small fraction of a revolution each time a pair of armatures pass their respective pickups. During the open period, a number of alternator pulses pass through to a 4-stage binary divider and thence to a train of four dekatrons. The last of these on completion of each decade operates a relay, recording one count on a mechanical six-digit counter. Each revolution of the shaft when operating on a given load will register the same number of counts. For example, with two degrees of twist and ten armatures and an alternator geared to give 5,000 pulses per revolution, the number of counts would be $2 \times 10 \times 5{,}000/360 = 277.77$. There would be 27 or 28 counts at each gate opening and the number might average out to be 277 or 278 per revolution giving a probable

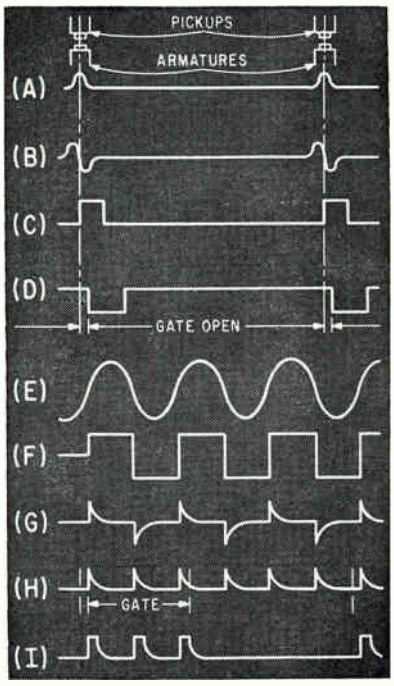


Fig. 2—Waveforms processed by the meter, from flux rise (A) to final series of pulses (I) that operate counters

error of about $\pm\frac{1}{3}$ percent. To obtain a better average, the alternator is geared to the main shaft so that the pulses are generated in successive revolutions in progressively changing phase position with relation to the shaft (and armature) angle.

If the torque is not steady, the opening of each of the ten gates as the shaft rotates will vary correspondingly. Ten samples give a good representation of the mean torque. As the speed varies, the rate of doing work also varies and is registered by the counter as more or less counts in a given time.

An additional feature seen in Fig. 3 is a remote display that registers the horsepower transmitted and also the shaft speed. Such information is particularly useful for sea trials and in multi-shaft equipments to obtain equality of load between shafts. The remote display incorporates a crystal-controlled timing circuit, which allows the power pulses taken from an intermediate dividing point in the main counter to operate a second counter system for a predetermined time interval. A second counter, using the pulses generated by one armature ring, gives shaft revolutions for a specified time. A zero-torque setting facility is provided by selecting an internal oscillation to replace the alternator.

The power meter has been applied with success to steam-turbine, gas-turbine, and diesel ships including oil tankers and the passenger liner *T.S.S. Oriana*. The integrated power, recorded and related to the ship's passages between various ports and to the weather encountered, can give information not hitherto available for planning economical operation.

The accuracy depends upon the calibration of the elastic member, and also upon the time over which readings are taken. One quarter percent can be expected under normal conditions.

The voltage of the measuring frequency and of the timing pulses is dependent on shaft speed; under practical conditions a range of speed of about 10 to 1 can be catered for.

The research station concerned with this development is the Parsons and Marine Engineering Turbine Research and Development Association, Wallsend, Northumberland. Muirhead & Co. Limited in Beckenham, Kent, are manufacturing the meters.

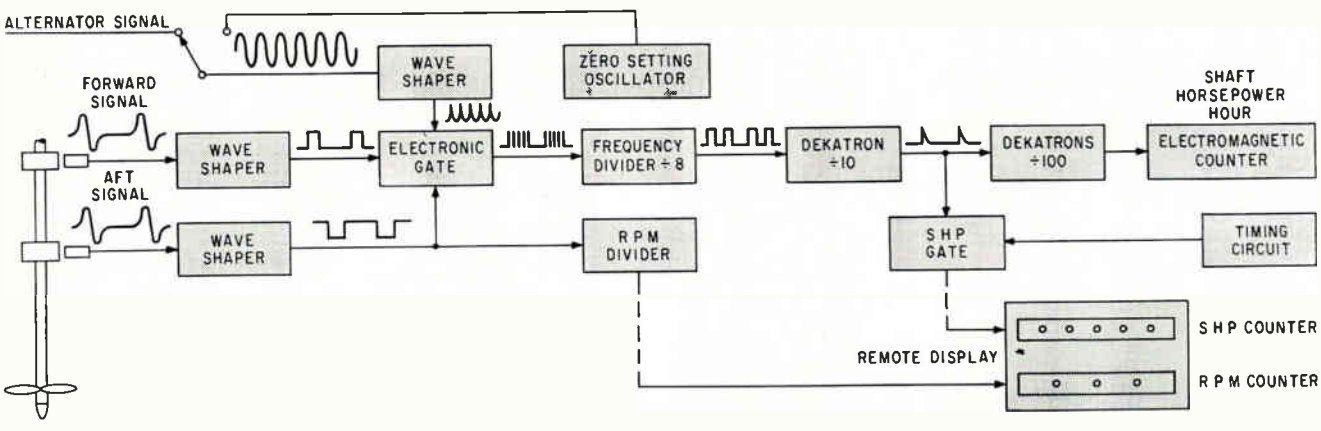
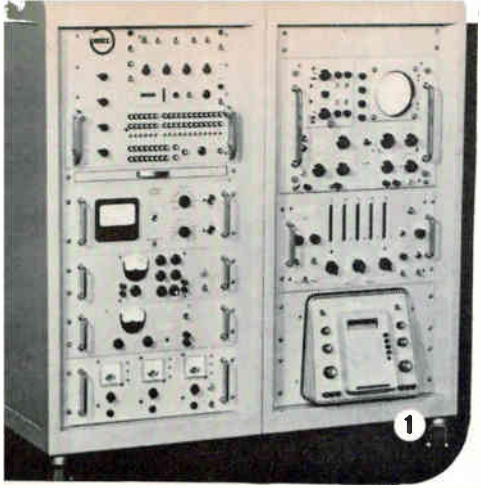
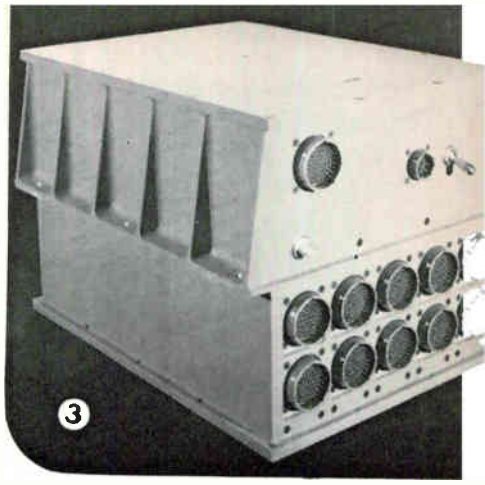
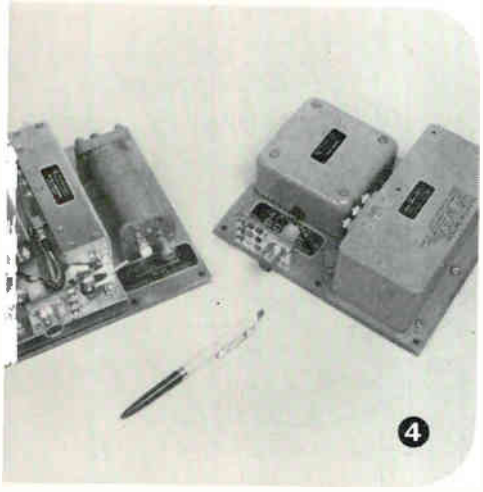


FIG. 3—Block diagram shows zero-setting oscillator for calibrating meter and remote display unit



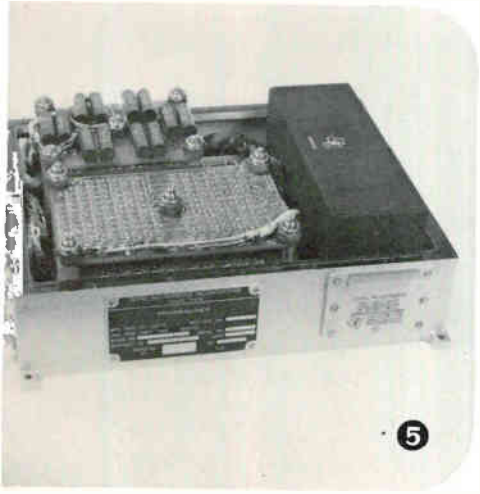


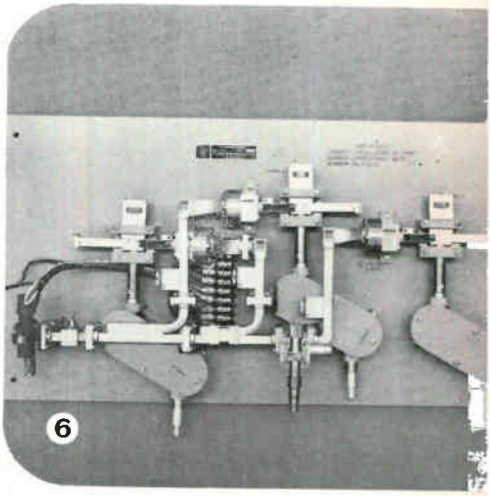
HERE'S HOW TI SOLVES SPACE COMMAND/GUIDANCE PROBLEMS

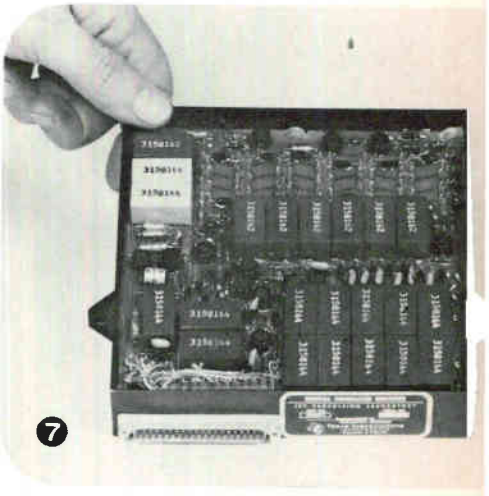


With **experienced** systems engineering staff–**complete** manufacturing capability–**product-proved** research and development laboratories–plus **time-tested** equipments now operational, some of which are:

1. Command System Ground Checkout Equipment for Jet Propulsion Laboratory, California Institute of Technology, to test Ranger 3-5, NASA lunar probe.
2. Solid-State FM/FM Telemetry Transmitters operated in Mercury spacecraft flights.
3. Flight Data Encoder uses high/low-level PCM telemetry system . . . with ±0.5% accuracy, nulled-out drift. A similar 70-channel system has been supplied to Jet Propulsion Laboratory for Mariner A.
4. Solid-State UHF Beacon Transponder made possible missile tracking by MIT Lincoln Laboratories Millstone radar.
5. Digital flight controller/programmer in Douglas Aircraft's Delta Launch vehicle helped orbit NASA weather satellites Tiros II and III, communication satellite Echo I, space probes Explorer X and XII.
6. 3-Channel Parametric Amplifier—Low-noise operation for C-Band monopulse satellite tracker for Bell Telephone Laboratories.
7. Digital Command Decoder for Ranger 3-5 lunar probes.







For information on your specific command/guidance requirements, contact **MARKETING DEPARTMENT.**

APPARATUS DIVISION
PLANTS IN DALLAS
AND HOUSTON, TEXAS

TEXAS INSTRUMENTS
INCORPORATED
6000 LEMMON AVENUE
P. O. BOX 6015 • DALLAS 22, TEXAS

CIRCLE 145 ON READER SERVICE CARD

Microwave Switch Uses Multipactor Discharge

HIGH-POWER microwave switch has been developed using a multipactor discharge. The voltage-controlled device provides nanosecond rise, recover and switching times. It produces no leakage spike, and life is expected to exceed 5,000 hours.

The multipactor switch was described at a recent Electron Devices Meeting of IRE PGED by C. Milazzo of General Electric Power Tube Dept., Palo Alto, Calif. The work was sponsored by Rome Air Development Center and Air Research and Development Command.

Multipactor discharge current is derived from secondary emission. It is produced by a thin electron cloud driven back and forth by an r-f electric field between two parallel plane surfaces in a vacuum. An electron leaving one surface is accelerated toward the opposite surface by the field. With correct spacing and r-f voltage, it arrives just as the field is reversing. Secondary electrons generated on impact are then accelerated back to the original surface during the next half cycle, where the process is repeated.

Transit time in the simplest case is one-half r-f cycle but can also take place in odd multiples of a half cycle. The electron cloud is reformed by secondary emission, and secondary emission coefficient must exceed unity for the impact energies involved.

Characteristics of Discharge

High secondary emission yield provides a rapidly rising exponential discharge. Starting with N_o electrons, there are $N_o\delta$ electrons after the first discharge, where δ is secondary emission yield. After m half cycles, $N_o\delta^m$ electrons participate in the discharge. If δ is 5, the electrons increase ten orders of magnitude in seven r-f cycles. Thus there is no spike leakage with this discharge. When electron losses from space-charge debunching effects balance gain from high secondary yield, current is constant.

In a switch, the discharge is placed across a high impedance, like the gap region of a resonant cavity, where the heavy current loads and detunes the cavity and reflects most of the power. Theoretically discharge current drops to zero in about one-half r-f cycle because there is no deionizing time. In practice, the time may be determined by ringing time of the circuit across which the discharge occurs.

Controlling the Discharge

Applying d-c voltage to the multipactor quenches discharge by destroying transit-time synchronism. Thus d-c voltage can make the multipactor cavity transmit or reflect power, with switching time measured in r-f cycles.

In the design in Fig. 1, the break in the re-entrant cavity wall is for d-c isolation of one electrode. Since it is on the electrode diameter, it becomes the input plane of a coaxial filter. The high-attenuation reactive filter prevents serious power loss through the break. The choke filter presents a well-defined equivalent short-circuit plane that does not move relative to the filter input over a wide frequency range. A second choke section forms the ceramic holder. The hollow filter center carries water for cooling.

With no control voltage, discharge starts at about 50 w, as shown in Fig. 2. At the upper limit of more than 2.5 Mw, isolation is 20 db and most power is reflected.

Cavity isolation as a function of control voltage from zero to quenching level is plotted in Fig. 3A for interpulse switching (control voltage maintained during r-f pulse). Above about 100 Kw peak power, control voltage changes operating state abruptly and switching voltage varies among pulses in a seem-

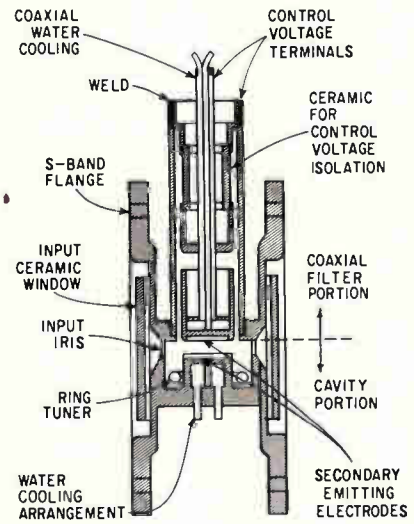


FIG. 1—Multipactor switch is incorporated into resonant cavity

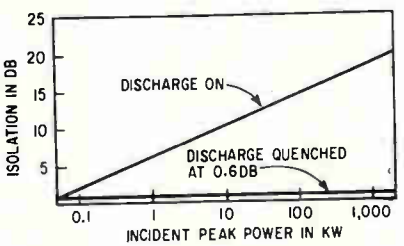


FIG. 2—Transmission characteristics for multipactor discharge in a single cavity

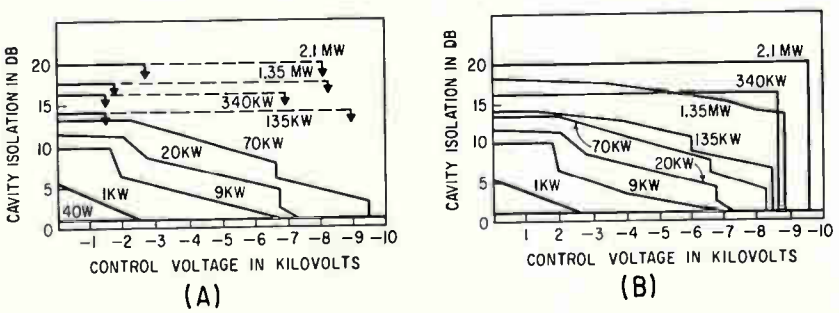
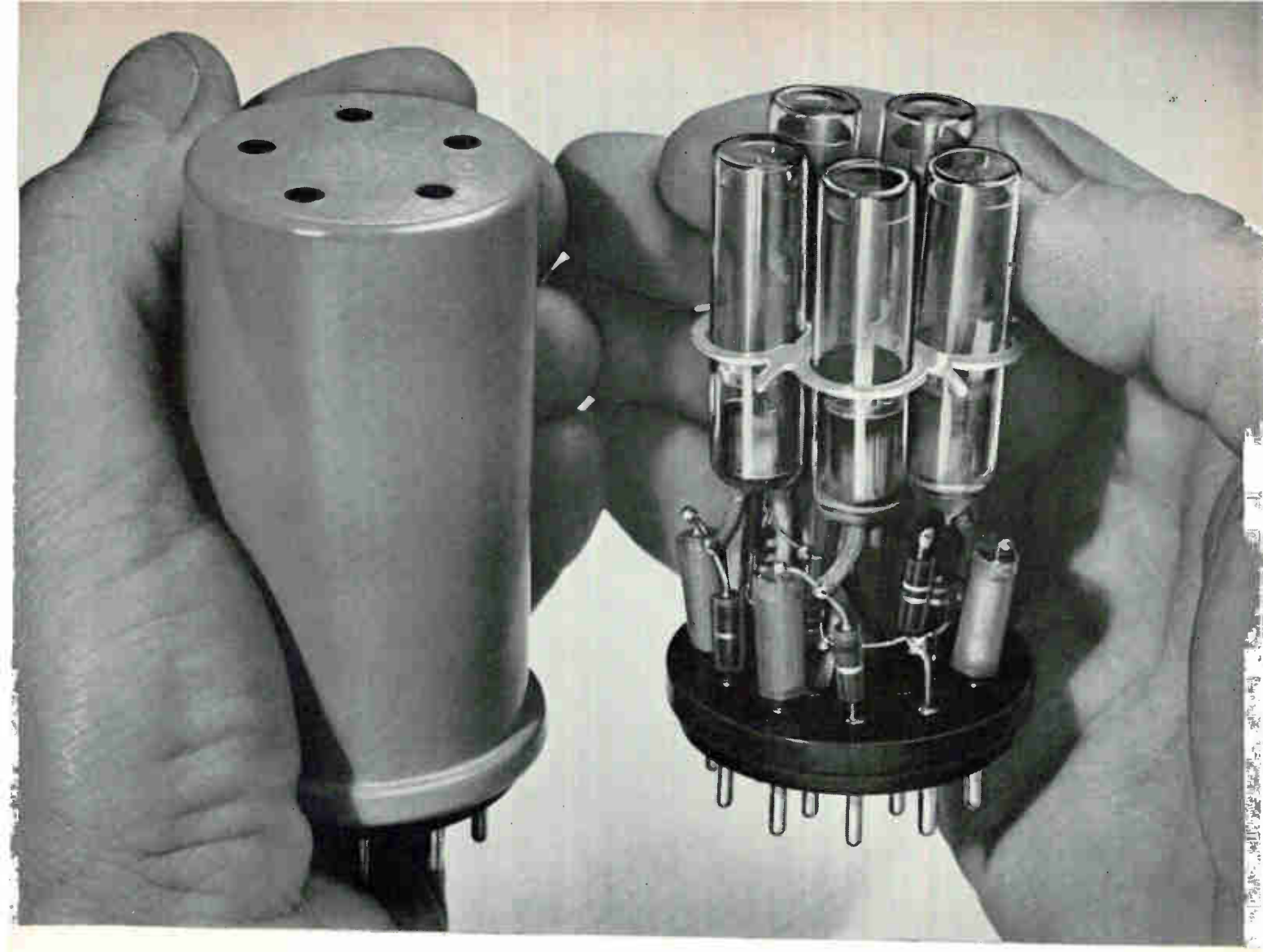


FIG. 3—Control voltage for interpulse (A) and intrapulse (B) switching



Tung-Sol indicator thyratrons serve Friden, Inc. with life expectancy of 100,000,000 firings

An extremely high standard of reliability has been set for the five-tube plug-in units that perform information storage and programming functions in a converter that Friden, Inc. manufactures for the U. S. Government.

After being potted and sealed along with the other components, a life expectancy of 100,000,000 operations (firings) of each tube must be maintained. In order to observe which tubes are firing during operation, a small window has been provided directly over each tube.

Friden is another top-flight manufacturer who has called upon Tung-Sol to provide components of utmost reliability. Like all Tung-Sol tubes, indicator thyratrons are produced to rigid standards of quality control. The heavy-duty reliability of Tung-Sol tubes is built in. Tough tests assure that each production unit will provide uniformly rugged long life and minimum short-life failure rate under the most severe environmental stresses.

You can enjoy the same premium tube performance as Friden. Specify Tung-Sol power tubes for any military or industrial socket you must fill. For complete information on the Tung-Sol line of industrial and special purpose tubes, germanium transistors and silicon rectifiers, or to consult on your applications problems, contact: Tung-Sol Electric Inc., Newark 4, New Jersey. TWX: NK193

Technical assistance is available through the following sales offices: Atlanta, Ga.; Columbus, Ohio; Culver City, Calif.; Dallas, Texas; Denver, Colo.; Detroit, Mich.; Irvington, N. J.; Melrose Park, Ill.; Newark, N. J.; Seattle, Wash. In Canada: Abbey Electronics, Toronto, Ontario

TUNG-SOL®

RELIABLE ELECTRONIC COMPONENTS

CIRCLE 147 ON READER SERVICE CARD

ingly random manner. At about 1 Kw, cavity transmission is a linear function of control voltage. At intermmediate powers, abrupt changes occur only at some voltages.

Intrapulse switching (control voltage changes during r-f pulse) is identical at low power, as shown in Fig. 3B. Abrupt switching again occurs above 700 Kw, but required quenching voltage is well defined. Increasing voltage has little effect until a critical value is reached that completely quenches discharge. Intrapulse switching at high power took less than 10 nsec in the final developmental model, while control-pulse rise time is about 40 nsec.

Simple kinematic theory predicts discrete voltages for synchronous electron motion with no space charge (very small currents). More detailed analysis shows that a space charge decreases electric field in the gap. As current increases,

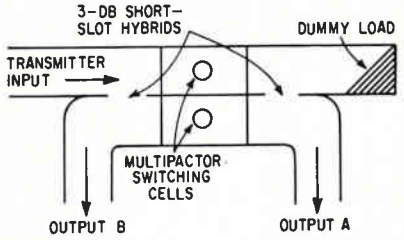


FIG. 4—Output is transferred between terminals by multipactor discharge

higher voltage is required to provide synchronism. At the lowest power for which discharge occurs in this cavity, operation is in a long transit-time mode, such as the five half-cycle mode. As incident power increases, discharge occurs in the three and the one half-cycle modes. Abrupt changes at 2 to 7 Kv are probably from mode changes.

The dual cavity in Fig. 4 provides a waveguide switch with two output terminals for use between two 3-db short-slot hybrid junctions. Transmitter power appears at B unless control voltage prevents discharge, transferring it to A.

Performance Measurements

Electrical characteristics were measured at 2,800 Mc, 5 Mw peak power and 0.001 duty. With no discharge, input vswr is 1.1, insertion loss 0.5 db and isolation to the unused output terminal 36 db. With discharge, vswr is 1.14, insertion loss 0.6 db and isolation 20 db.

This model was tested with a 0.5-μsec control voltage pulse of -7 Kv applied during the r-f pulse. Input power was about 140 Kw. Transmitter power was switched from B to A and back to B within the 2-μsec transmitter pulse. At 2.2 Mw peak power, power was switched from B to A but remained at A for the rest of the r-f pulse. At high power, after quenching the discharge, gap voltage is too high to initiate it again during the r-f pulse.

The power limit for intrapulse switching in one direction only is a function of cavity parameters. Two-way switching in this cavity was achieved only below about 200 Kw. Switching time measurement could not be resolved to more than about 10 nsec, and it did not change noticeably at powers of about 300 Kw, 1 Mw and 3 Mw. The switching time measured was the decay for the r-f pulse at output terminal B with the application of the control pulse. It is probably a few r-f cycles, which are 0.33 nsec at 3,000 Mc.

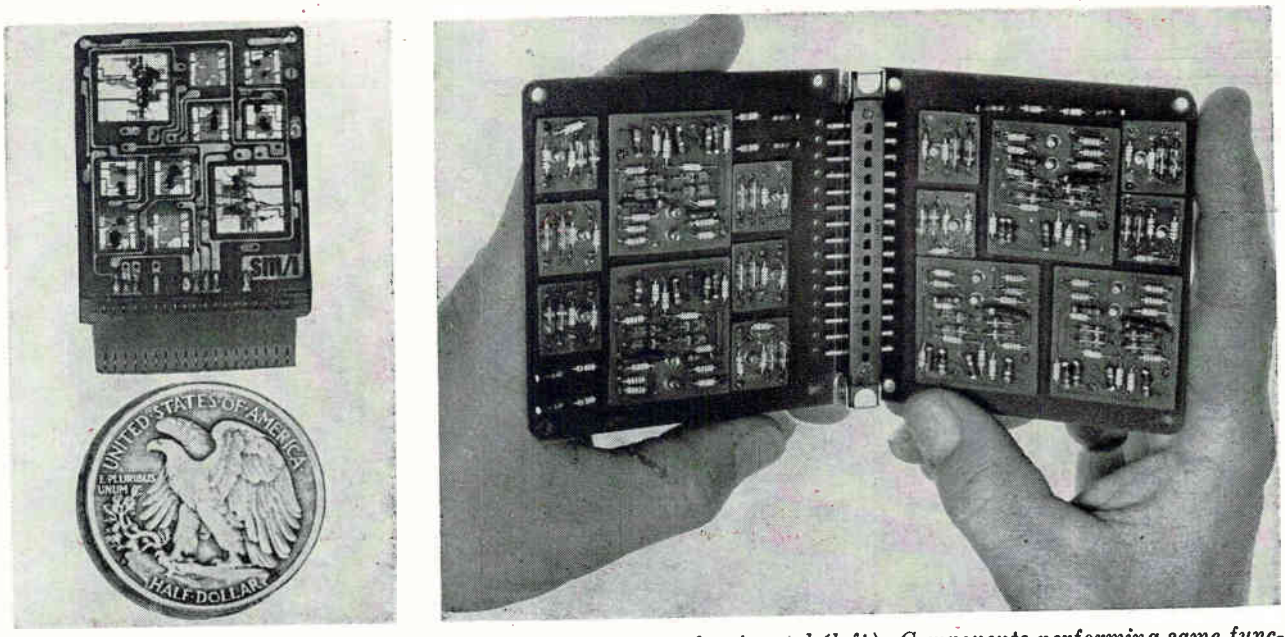
Tropo-Scatter Antenna Cuts Installation Costs

TROPOSPHERIC scatter antenna could make economically feasible world-wide transmission of voice, television and computer data. It can operate over distances up to 500 miles without signal boosters.

The antenna was developed by The Boeing Company Antenna Department. It is assembled at the site from only one quarter as many parts as conventional tropospheric antennas. Simplicity was achieved by using preformed and predrilled girder construction. It will be available with reflector widths of 30, 60 and 120 feet.

Principle advantage claimed for this approach to tropospheric antenna design is ease of assembly. The parts can be color-coded so that unskilled workers who may not even speak English can erect the antenna. Eight men can erect a 60-foot antenna in 50 hours.

Because a powered crane may not be available, the wooden antenna packing crates are drilled so that a gin pole can be assembled from them. This upright post with a cable and pulley can be used with a truck winch or crew of men to hoist the antenna structures into place.



Microelements of reversible binary counter are set flush on plug-in card (left). Components performing same function are shown in larger system (right) that uses miniature building blocks

Bonding Microelements to Phenolic Board

By H. J. WEBER,

Chief Development Engineer,
Servomechanisms, Inc., Research Div.,
Santa Barbara Airport, Goleta, Calif.

THE PLANAR INLAID method of packaging vacuum-deposited microcircuits consists of inlaying the microcircuits flush upon a phenolic plug-in card. This allows each microcircuit to be prepositioned and indexed. Microcircuits on each card are interconnected through photoetched connectors using thermocompression bonding of the microcircuit to the etched circuit board[1].

The planar inlaid technique permits the replacements of individual modules in a subassembly and utilizes the reliable card-to-connector method of interconnection.

A four stage reversible binary counter[2] was selected to demonstrate this method of packaging. And this approach was compared in volume, weight and power to an equivalent circuit that uses miniature digital building blocks.

One side of the microcircuit counter consists of two flip-flops and eight gates. The other side contains the remaining flip-flops and gates and is interconnected by plated through holes in the plug-in card.

TWO TYPES OF BINARY COUNTER PACKAGES

	Microminiature Building Block Counter	Vacuum Deposited Microcircuit Counter
Volume		
Flip-Flop	0.391 in³	0.0037 in³
Logic Gate	0.091 in³	0.0009 in³
Counter	9.26 in³	0.55 in³
Weight		
Flip-Flop	3.6 gr	0.16 gr
Logic Gates	0.65 gr	0.03 gr
Counter	112.0 gr	4.41 gr
Power		
Flip-Flop	42 mw	18 mw
Logic Gate	20 mw	8 mw
Counter	410 mw	170 mw

REFERENCES

(1) H. J. Weber, Development of Thin Film Astable Multivibrators, *Space/Aeronautics*, Aug. 1961.
(2) H. J. Weber, Binary Circuits Count Backwards and Forwards, ELECTRONICS, Sept. 25, 1959.

Coating Semiconductors With Silicon-Carbide Skin

FILMS of silicon-carbide, less than one micron thick, can be deposited on all types of semiconductor devices with a surface passivation technique developed by Nuclear Research Associates Inc. of Long Island City, New York, the company says.

Thin enough for coating thin-film

When should you use Mercury-Wetted Contact Relays?

IF YOUR RELAYS MUST

SWITCH UP TO 100 TIMES PER SECOND

HAVE A LIFE IN EXCESS OF A BILLION CYCLES

BE COMPLETELY RELIABLE AND FREE FROM CONTACT BOUNCE

THEN SPECIFY P&B MERCURY WETTED CONTACT RELAYS

An unusual combination of advantages found only in mercury-wetted relays has led many design engineers to specify them for tough switching jobs. Here are but 3 typical characteristics of our JM series:

RELIABILITY. Sealed-in-glass mercury contacts are renewed with every operation. Won't pit or weld. Make or break is positive . . . every time. No bounce, no chatter. Signals ranging from a few micro amps to 5 amps are switched with singular consistency.

LONG LIFE. Think in terms of *billions* of operations when considering JM series relays. Proper application, of course, is a requisite.

SPEED. Operate time is just less than 3 milliseconds using 2 watts of power. Release time is about 3.2 milliseconds. Thus, relays can be driven 100 times per second.

If your project calls for exceptional relay performance, perhaps the answer lies in our JM Mercury-Wetted contact relay.

JM SERIES ENGINEERING DATA

Contact Rating:
5 amperes maximum
500 volt maximum
250 volt-amp max. with required contact protection.

Contact Configuration:
Each capsule SPDT. Combination of capsules in one enclosure can form DPDT, 3PDT, 4PDT. (All Form D.)

Terminals:
Plug-in or hook solder; 8, 11, 14, or 20-pin headers.

Coil Resistance:
2 to 58,000 ohms.

More information?
Write today for free catalogue.

P&B STANDARD RELAYS ARE AVAILABLE AT YOUR LOCAL ELECTRONIC PARTS DISTRIBUTOR

POTTER & BRUMFIELD

DIVISION OF AMERICAN MACHINE & FOUNDRY COMPANY • PRINCETON, INDIANA
IN CANADA: POTTER & BRUMFIELD, DIVISION OF AMF CANADA LIMITED, GUELPH, ONTARIO

circuits, the silicon-carbide layer can be applied to completed semiconductor devices or at intermediate steps in the manufacturing process. This flexibility of application contrasts to the silicon-oxide passivation technique, where the oxide layer is formed first and the device is then built up.

Accelerated life tests using concentrated acids, temperatures up to 300 C and metallic salt baths have shown that the film is stable and impervious to moisture and other usual contaminants. Changes in transistors protected by the film are negligible; transistors with a back leakage current approaching 10^{-11} amp, for example, are unaffected by the film. The basic silicon-carbide film is itself transparent but controlled impurities can be introduced to make it black and opaque, thus blocking semiconductor photosensitivity.

Varying the Composition

Film formation occurs at room temperature, when various chemically active gases are mixed in the presence of the device being passivated. The gases react to form the film, which is basically a silicon compound with controlled amounts of other substances. Film composition can be varied to produce different types of coatings for different applications. Masking protects any surfaces that are not to be coated. Equipment needed for the process is inexpensive, consisting of a vacuum bell jar, gas storage and piping equipment, and pressure instrumentation. Processing time is approximately ten minutes. Although the technique has so far been tested only with silicon transistors and diodes, germanium devices can also be treated.

Melvin P. Ehrlich, President of NRA, states that the company is prepared to coat sample semiconductor devices for manufacturers so the process can be evaluated. It is known that several manufacturers, including RCA and General Transistor, have already done so.

Magnetrons Open New Field For Frequency Agile Radars

RAPID TUNING of magnetron oscillators has high military importance in view of the extensive use of these

tubes in military radar systems. A paper by R. E. Edwards and R. Y. Clark of Raytheon, delivered at the recent Aerospace Fluid Power Conference in Detroit, outlined an unusual application of the hydraulic servo to several existing magnetrons. And the Raytheon engineers pointed out how the accomplishment of rapid tuning of magnetrons opens up new fields of radar design. The frequency agility, previously obtained only in a large chain of radar transmitting tubes can now be offered in a single compact unit.

Prolonged Life Promised

Because of the relative ease of converting a radar system to employ the rapid-tuning technique, many radar systems, already in the field, are promised prolonged life. New frequency agile radars can be developed in a smaller size and weight configuration.

Servo tuning of magnetrons has been applied to large high-power tubes and to smaller tubes of medium power. The servo for the highpower magnetron was developed by Vickers, Inc. Moog Servocontrols, Inc., developed the servo for the low-medium power tube. Speed, versatility and degree of control of the servo tuner drive have been outstanding.

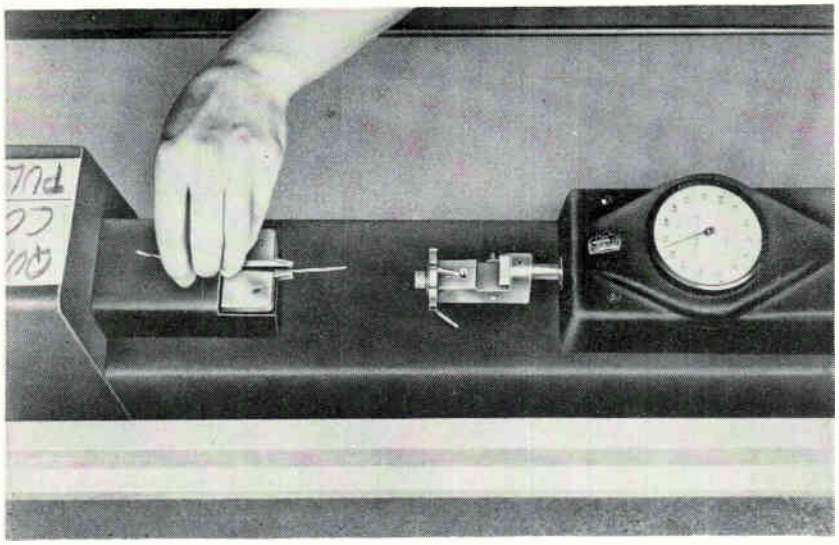
A number of low power hydraulically-tuned tubes have been used in the field with no serious problems with either tube or the hydraulics.

A major problem in actuator design was in perfecting hydraulic seals effective for a minimum of 500 hours of tube life. To date there has been no trouble with either tube or the hydraulics.

The large high-power pulse magnetron required a relatively low tuning speed (10 cps) but the tuner mass and stroke length are both rather large. The medium-power type was designed for operation at a higher oscillating frequency. Here the tuner stroke and mass are small enough so that a high tuning speed of 60 cps is achieved without imposing excessively severe design requirements upon the hydraulic servo system.

Raytheon has applied the hydraulic servo to several existing tunable magnetrons, and currently concentrates efforts upon two tubes which have broad potential field usage.

Tests Keep Solderless Connections Reliable



Three sample connections from each production crimping tool are tested daily. Air motor pulls wire steadily until connection fails, gage records maximum force

TO INSURE the tensile strength, and hence low electrical resistance, of solderless electrical connections in the Bmews data processing equipment built by the Data Systems Operations of Sylvania Electronic Systems, Needham, Mass., all crimping tools are checked daily with a test instrument especially designed for the purpose. The tester, manufactured by Hunter Spring Co., Lansdale, Pa., consists of a precision force gage and an air motor, both mounted in-line on a common base.

As shown in the photograph, the crimped terminal is inserted in the holding fixture and the wire lead is placed the jaws extending from the air motor. When the air motor is started, the jaws close and the wire is pulled at a predetermined, controlled rate of speed. The gage pointer holds the maximum force reading, which occurs when the connection breaks. Since the test is destructive it cannot be used on actual connections in the computer. Therefore a statistical quality control procedure was set up to check sample connections made with all production line crimping tools.

At first, since no strength data was available, absolute minimum tensile strengths were set 10 percent greater than those permitted by MIL-T-7928. Tensile readings falling below these values caused rejection of the tools used to make the connections. Three crimped leads from each tool were tested daily. After about 20 days of inspection, a lower control limit for the daily average tensile value and an upper control limit for the range were established by conventional statistical methods. These tensile averages were higher than the absolute minimum values because any sample having a lower value had been rejected.

Testing on Statistical Basis

These limits were then used as a new basis for comparing the daily test values from each tool. Tests were continued in the same fashion, with three samples from each tool. If the average for a tool fell below the established lower control limit, or if one correction was below the absolute minimum set in MIL-T-7928, the tool was rejected and its work that day inspected electrically. If average values were satisfactory, but the range exceeded its upper control limit, the tool was allowed to remain in production but was watched closely because the excessive range indicated a possibility of malfunction.

Rejected crimping tools were readjusted or returned to the manufacturer for repair. Availability of a mechanically operated tester specifically designed for the job not only sped inspection, but, by insuring testing accuracy, saved many times its own value in rework and scrap material costs. In addition, since forces over 60 lb were involved, manual testing would have been time consuming and incompatible with production rates.

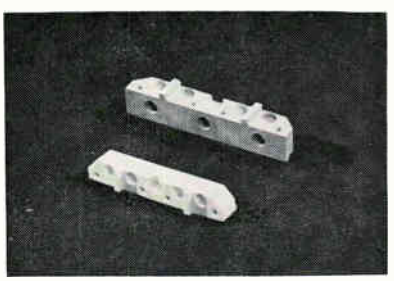
Semi-automatic Process Molds Ceramic Parts

HIGH-SPEED, semi-automatic production of intricate ceramic shapes is now possible using an injection molding process developed by American Lava Corp., Chattanooga, Tenn.

Insulators, appliance parts, electronic components, radomes, nose cones, dielectrics, refractories and leachable ceramic designs are some of the parts being fabricated in high-speed production.

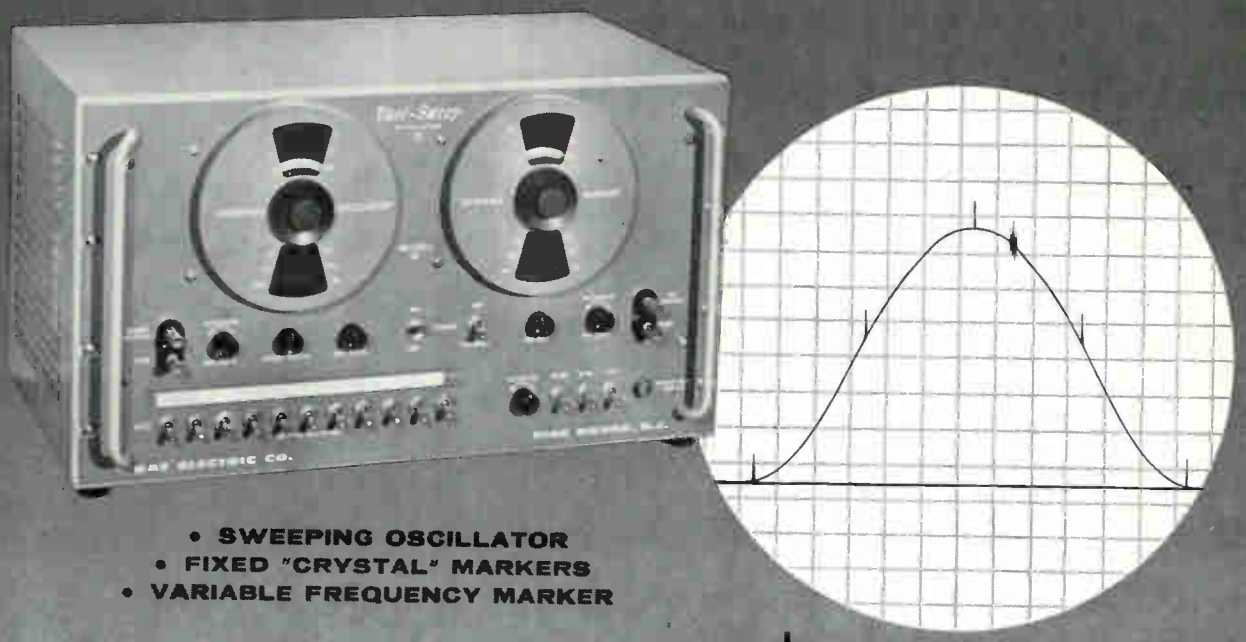
The injection molding process helps reduce costs by faster production and it also allows making more complicated shapes from ceramic materials than was previously possible.

Many common ceramic shapes previously pressed or extruded are



Electrical insulator in background after leaving the mold. Finished part in foreground shrinks to size and turns white during firing

Complete Sweeping Oscillator and Frequency Marker Systems



- SWEEPING OSCILLATOR
- FIXED "CRYSTAL" MARKERS
- VARIABLE FREQUENCY MARKER

KAY *Vari-Sweeps*®

- Fundamental Frequency — No Spurious Beats
- Built-in Attenuators • Direct Reading Frequency Dials
- Stable Wide Sweeps • Stable Narrow Sweeps
- 1.0 V into 70 ohms, AGC'd

MODEL IF and MODEL RADAR

4-120 MC VARI-SWEEP MODEL IF

Frequency Range: 4 to 120 mc in six overlapping bands.

Sweep Width: Continuously variable to maximum of at least 30 mc (above 50 mc) or 60% of center frequency below 50 mc.

Sweep Rate: Variable around 60 cps. Locks to line frequency.

RF Output: 1.0 V rms into nominal 70 ohms (50 ohms upon request). AGC'd to ±0.5 db over widest sweep and over tuning range.

Zero Reference: True zero line during retrace.

Attenuators: Switched 20, 10 and 3 db: variable 6 db.

Fixed Markers: Up to eleven, pulse-type, crystal-controlled markers at customer specified frequencies. Accurate to ±0.05%.

Variable Marker: "Birdie pip" marker continuously variable from 2 to 135 mc in 6 overlapping bands. Direct-reading frequency dial accurate to within ±1.0%.

Marker Output: Approx. 5 V peak. **Sweep Output:** Approx. 7 V peak.

10-145 MC VARI-SWEEP MODEL RADAR

Same as Model IF in a different frequency range.

Price: $950.00 f.o.b. factory, including cabinet. $1045.00 f.a.s. New York. Crystal markers $20.00 ea.

TWO UNIT SYSTEM 2-220 mc

KAY *Vari-Sweep*

Frequency Range (CW or Sweeping Operation): 2-220 mc, 10 bands. Direct-reading dial.

Sweep Width: Continuously variable to maximum of at least 30 mc (above 50 mc) or 60% of center frequency (below 50 mc).

Sweep Rate: Variable, 10 to 40 cps; line lock.

RF Output: 1.0 V rms (metered) into nom. 70 ohms (50 ohms upon request). AGC'd to ±0.5 db over widest sweep and tuning range.

Attenuators: Switched 20, 20, 10, 6 and 3 db, plus continuously variable 6 db.

Price: $795.00 f.o.b. factory. $875.00 f.a.s. N.Y.

KAY *Vari-Marker* MODEL H

VARIABLE MARKER: (CW or "Birdie pip").

Frequency Range: 1.7 to 230 mc in ten overlapping bands.

RF Level: 1.0 V rms into 70 or 50 ohms, metered.

Flatness: ±0.5 db, AGC'd.

Attenuators: Switched 20, 10, 6, 3 db, continuous 6 db.

Frequency Dial: Direct reading, accurate to ±1%.

Marker Amplitude: Variable to 5.0 volts peak.

HARMONIC MARKER: (Picket-fence pip or CW).

Intervals: Switched 250 kc, 500 kc, 2.5 mc, 5.0 mc, other frequencies can be specified.

Accuracy: ±0.01%.

Price: $845.00 f.o.b. factory. $930.00 f.a.s. N.Y.

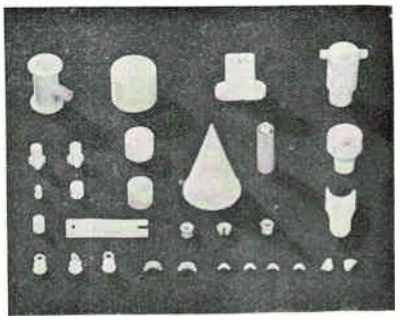
Other Vari-Marker Models — Fixed and Variable Markers.

WRITE FOR CATALOG INFORMATION.

KAY ELECTRIC COMPANY

Dept E-11 MAPLE AVE., PINE BROOK, NEW JERSEY, CAPITAL 6-4000

now molded, eliminating costly hand and machine operations. A thread guide for the textile industry, once made by machining one at a time, is now made 14 at a time. After forming, one machining operation and a drum finisher com-



Large variety of materials can be used in semi-automatic process

plete the process, eliminating the multiple machining and hand polishing previously necessary.

Parts that at one time were considered impossible to shape from ceramic materials in economic quantities can now be molded in one automatic operation. Since all parts fabricated in this manner come from the same mold, they are identical in shape and size, reaching a matched condition not possible with machining.

More than a dozen ceramic compositions, or bodies, can be used in the injection molding process. The bodies are commercially available as materials that have been molded with consistent success. On the list are many of the AlSiMag brand compositions: aluminas, titanium dioxide, forsterite, zircon, spinel, barium titanates, alkali leachable ceramics and others. These materials cover the wide range of uses for which ceramics are commonly designed, including those requiring specific electrical properties, mechanical strength or chemical and abrasion resistance.

Shock Test Standard Developed by ASA

A NEW American Standard has been developed and taken out by federal agencies and electronic equipment suppliers in an effort to assure product performance under conditions of stress and strain.

A 26-member sectional committee

has developed a standard specifying the design, construction and operation of a shock-testing machine that duplicates on the ground what aircraft take-offs, landings and rough air do to precision made electronic equipment.

Approved and published by the American Standards Association, "American Standard Specification for Design, Construction and Operation of Variable-Duration, Medium-Impact Shock-Testing Machine for Lightweight Equipment, S2.1-1961" is the result of more than three years of research by the Association.

Historically, the importance of shock came to light in the early stages of World War II when failures occurred in electronic equipment used in aircraft. Subsequently, the Air Force designed the shock-testing machine and used it to test precision equipment.

Testing Procedure

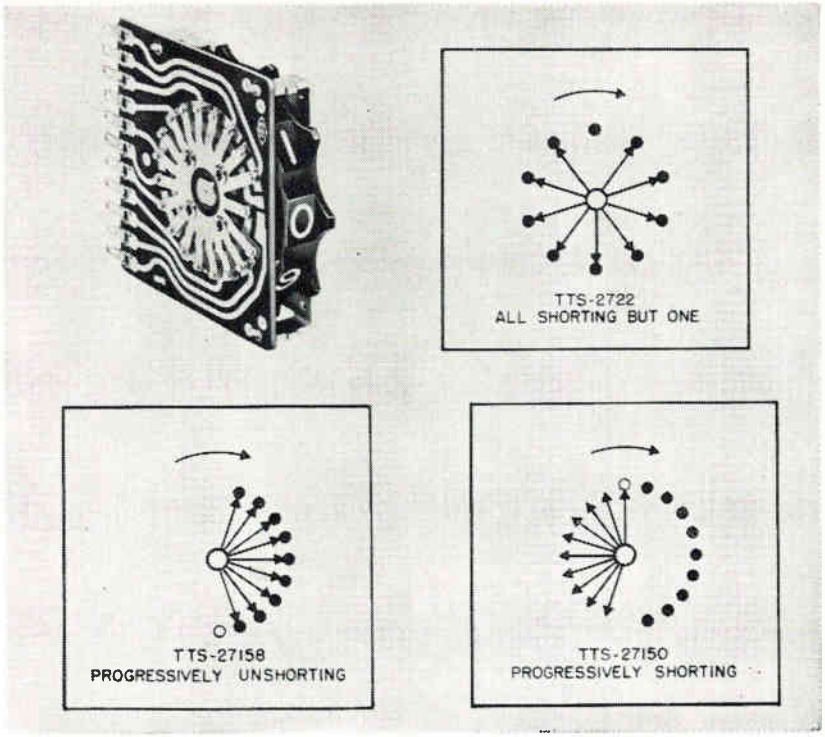
According to the Standard, only test loads ranging from 150 to 400 pounds are to be used on the device, which is of the drop-table type. Shock pulses are produced by allowing the loaded drop-table to fall freely into a sandbox at the base of the machine. In the testing procedure, the equipment must be rotated in six directions (bottom side down, right side down, top down, left side down, back down and front down) for the drop, anywhere from four to 13 inches.

Prescribed in the standard are the principles of operation (velocity, duration and limitations), operating procedures, calibration and maintenance. Particular attention is given to the sand (refined Ottawa River, kiln-dried, 30-40 grit) and the sand-raking procedure. Sand depth should be maintained at approximately 15 inches.

Both the Acoustical Society of America and the American Society of Mechanical Engineers are administrative co-sponsors of the committee that developed the standard. C. E. Crede of the California Institute of Technology is committee chairman.

Copies of American Standard S2.1-1961 are available at $1 each from the American Standards Association, 10 East 40th St., New York 16, N. Y.

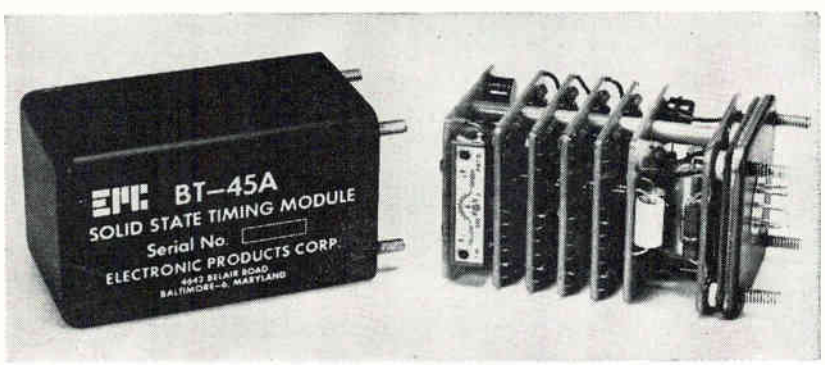
New On The Market



Thumbwheel Switches
THREE PRINTED-CIRCUIT TYPES

CHICAGO DYNAMIC INDUSTRIES, INC., 1725 Diversey Blvd., Chicago 14, Ill. Line of 3 p-c thumbwheel switches, which occupy only ½ in. panel space, incorporate outputs of all-shorting-but-one (type TTS-2722), progressively shorting (TTS-27150), and progressively unshorting (TTS-27158). Savings in systems space and cost are effected because the special functions eliminate relays, stepping switches and other components formerly needed. All 3 types are also available in multiwafer combinations to produce additional digital and binary functions.

CIRCLE 301 ON READER SERVICE CARD



Solid State Timing Module
ADJUSTABLE FROM 1 MINUTE TO 4 HR

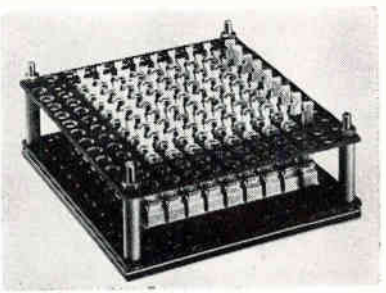
ELECTRONIC PRODUCTS CORP., 4642 Belair Road, Baltimore 6, Md. This 7 oz solid state electronic timing module, capable of switching either a positive or negative voltage, is remotely adjustable from 1 minute to 4 hours at 5 percent accuracy. Hermetically sealed and foamed, the unit is designed for rugged missile and satellite environmental conditions per MIL E-5272 C. Dimensions are 1¾ in. by 1¾ in. by 3 in. high; stud or flange mounted with miniature 7-pin solder hook or plug-in connector.

CIRCLE 302 ON READER SERVICE CARD

Microwave Plastic

BRAND-REX DIVISION, American Enka Corp., 31 Sudbury Road, Concord, Mass., introduces Rexolite 600, which has a dielectric constant of 6 (±0.2) in the 10^6 to 10^{10} cycle range and a dissipation factor of less than 0.002.

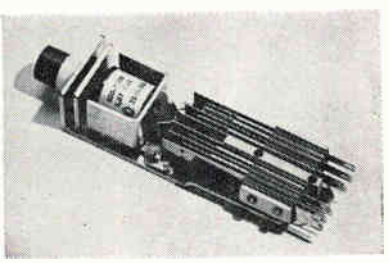
CIRCLE 303 ON READER SERVICE CARD



Program Boards
SINGLE-CONTACT

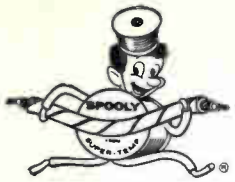
SEALECTRO CORP., 139 Hoyt St., Mamaroneck, N.Y. Single-contact Sealectoboard provides individual, isolated terminations for every coordinate point on the matrix. The upper deck provides a common bussed line for combining parallel input signals, while the lower deck with its individual contacts permits distribution of the combined output to isolated or associate circuitry. Model shown provides a control point for programming multiple inputs and outputs and allows paralleling circuits.

CIRCLE 304 ON READER SERVICE CARD



Magnetic Push Buttons
TWO-COLOR, 22 MODELS

INTERNATIONAL TELEPHONE AND TELEGRAPH CORP., Clifton, N.J. A line of 22 two-color magnetic push



HOTTEST NEWS *in the industry*

Super-Temps new versatile wire and cable with an operating temperature of 1000°F.... flexibility... moisture resistant properties is bringing a new high standard of quality to today's most demanding industries.

New design potentials with MGT are literally unlimited and new economies and more efficient operations are being obtained in present equipment.

MGT wires are ideally suited for incorporation in cables of single or multi-conductor constructions. Braided wide shielding of various metals including stainless steel can be used. Jackets of Glass Fiber Braids or other materials compatible with high temperature usage are obtainable.

Below is a test chart showing results from our own and other laboratories.

MGT

WIRE AND CABLE

Specimen #1–#24 (AWG) 7/32 N.P.C. Specimen #2–#20 (AWG) 7/28 N.P.C.

TEST	SPECIMEN #1	SPECIMEN #2
Dielectric 1.5 KV 1 Min. 5% Salt Solution Test #1	Passed	Passed
1000°F. for 30 Minutes Dielectric	1500 for 20 sec.	1500 for 60 sec. 1550 Breakdown
Insul. Res.	6000 Megohms	12,000 Megohms
Cycle Test		
4.1 800°F. for 30 Minutes Cool to Room Temp. Insul. Res.	infinite	infinite
4.2 Saltwater Both 1 Hr. Insul. Res.	infinite	infinite
4.3 800°F. for 30 Minutes Cool to Room Temp. Insul. Res.	infinite	infinite
4.4 Hi-Pot 1 KV for 1 Min	Passed	Passed
4.5 Breakdown	4.8 KV	2.7 KV
Cycle Test (conducted on single specimen)		
5.1 1000°F. for 30 Minutes Cool to Room Temp. Insul. Res.	infinite	infinite
5.3 1000°F. for 30 Minutes Insul. Res.	infinite	infinite
5.4 Hi-Pot 1 KV for 1 Min	Passed	Passed
5.5 Insul. Resist.	300,000 Megohms	infinite
5.6 Breakdown	2 KV	2.2 KV

INSULATION RESISTANCE CHECKED AT 500 VOLTS D.C. EXCEPT WHERE NOTED ABRASION TEST–(JANCO) Specimen #1–39.8 Inches; Specimen #2–61.3 Inches.

Super-Temp has the largest line of wire and cable, the best production facilities, and a nationwide network of engineering representatives ready to serve you at a moment's notice ...good reasons to always specify Super-Temp.

For information on availability and prices of amazing new MGT wire and cable write, wire or phone...your inquiry will receive prompt attention.

Super-Temp

AMERICAN SUPER-TEMPERATURE WIRES, INC.

A Subsidiary of Haveg Industries, Inc.

West Canal Street, Winooski, Vermont—UNiversity 2-9636
General Sales Office: 195 Nassau St., Princeton, N. J.—WAlnut 4-4450

Keep Ahead with HAVEG

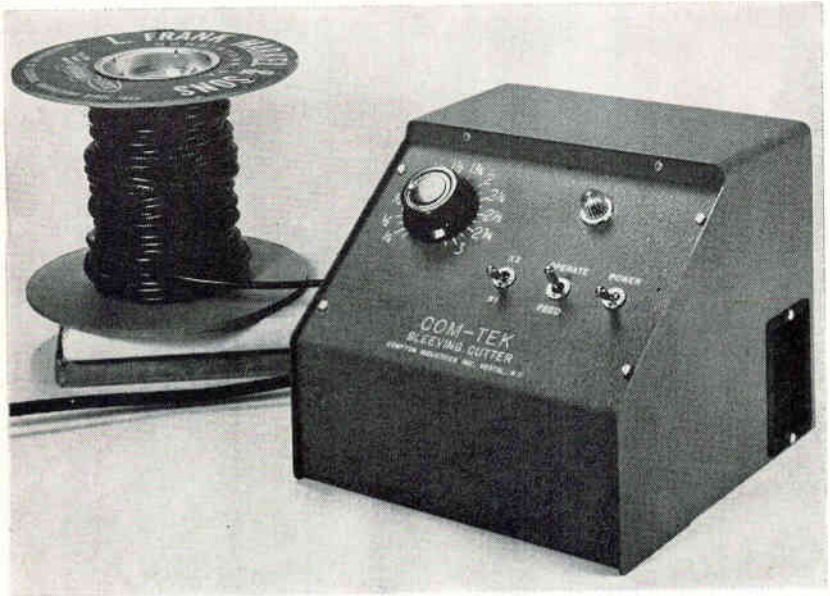
FIRST IN *Engineered* PLASTICS

Super-Temp is a specialist in Teflon and Silicone Rubber Insulations. Products include: Magnet Wire, Airframe Wire, Hook-up Wire, Coaxial Cables, Miniature & Jumbo Cables and Tapes.*

*Dupont's TFE FEP Resins

buttons combine the features of position indicators and holding relays. They are held in actuated position by tiny built-in electromagnets; they release by switching off the holding current. Operating voltage of the buttons is 12 v d-c, holding current is 15 ma, and contact carrying capacity is 3 amperes (noninductive).

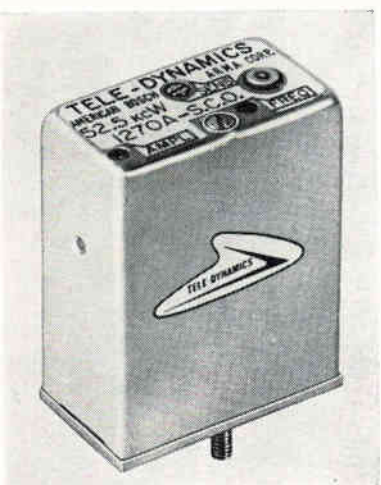
CIRCLE 305 ON READER SERVICE CARD



Automatic Sleeving Cutter
ELECTRICALLY-POWERED UNIT

COMPTON INDUSTRIES INC., 333 Vestal Parkway, East Vestal, N.Y. The Com-Tek automatic sleeving cutter measures and cuts insulating sleeving or bare wire for printed circuit boards, while maintaining length tolerances of ± 2 percent. It adjusts to any cutting length from ½ in. up to 6 in. and operates at the rate of up to 7,200 cuts per hr. It handles tubing of up to ⅛ in. o-d, wire of up to No. 20 gage, solder, and several diameters of fiber glass and Teflon tubing. Material to be cut feeds automatically into one side of the cutter while the cut-to-size pieces slide out the other side.

CIRCLE 306 ON READER SERVICE CARD



Oscillator
VOLTAGE-CONTROLLED

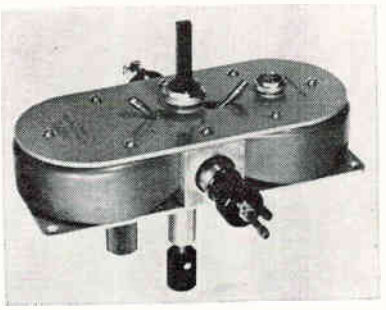
TELE-DYNAMICS DIV., American Bosch Arma Corp., 5000 Parkside Ave., Philadelphia, Pa. Type 1270A voltage-controlled oscillator is a high input level unit, only 2 cu in. in volume. Working from either a 0- to 5-v or a ± 2.5-v signal, its linearity is ± 0.25 percent. Distortion is 1 percent. It is rated at unlimited altitude, 30 g random vibration, and 100 g acceleration and shock.

CIRCLE 307 ON READER SERVICE CARD

Wideband Transformer

NORTH HILLS ELECTRONICS, INC., Alexander Place, Glen Cove, L. I., N. Y. Type 1900 transformer provides isolated coupling between 75 ohms unbalanced, to 1,200 ohms balanced, over a frequency range of 200 Kc to 50 Mc.

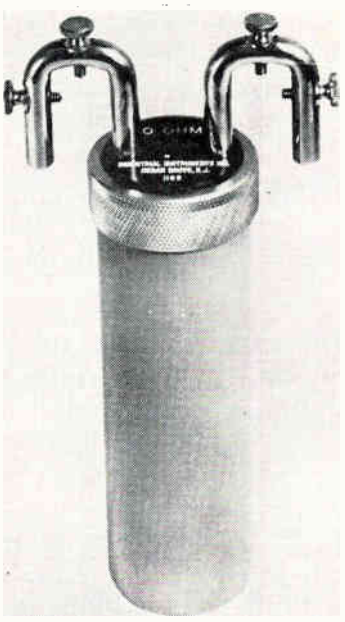
CIRCLE 308 ON READER SERVICE CARD



Klystron Oscillators
FLOATING DRIFT TUBE

LITTON INDUSTRIES, 960 Industrial Road, San Carlos, Calif., has available three floating drift tube klystron oscillators. The tunable high power 4 m/m klystrons are water-cooled harmonic generators operating in the frequency range 68 to 80 Gc with a tuning range ± 750 Mc. Average life is estimated at 500 hr minimum. The L-3689 provides a power output of 500 mw average; the L-3690 operates at 100 mw minimum; and the L-3691 supplies 100 mw average power.

CIRCLE 309 ON READER SERVICE CARD



Resistor Standards
NBS-TYPE

INDUSTRIAL INSTRUMENTS, INC., 89 Commerce Road, Cedar Grove, N.J., announces the SR series of resistor standards for use in research labs and standardization groups for ap-

why use two? when one will do!

JFD LC tuner

WHY USE TWO...?

a trimmer capacitor and inductor when one JFD LC Tuner will do!

When your tuned circuit "package" calls for higher stability, greater economy, finer tuning – it's time for the versatile JFD LC Tuner.

This unique package combines the characteristics of a precision variable capacitor and a metalized inductor in one compact tuneable LC circuit. It improves performance, simplifies specifying, speeds assembly, and enhances high frequency capability.

JFD LC Tuners are available in 16 different standard panel and printed circuit types. The inductance, capacitance range, Q and other parameters can be designed to suit individual circuit requirements. Performance characteristics can also be varied by using other core materials or other lead configurations, by having the piston grounded or ungrounded, and by various types of loading.

For complete information, contact your local JFD Field office or your local JFD franchised Industrial Distributor, or write direct for Bulletins 216 and 216-1.

FEATURES: Rugged shock-proof, vibration-proof electromechanical construction. • Glass or quartz dielectric and invar assures low temperature coefficient • No derating at high temperature. • Precisely repeatable tuning—no reversals. • Single resonating frequency for each adjust screw setting.

(shown actual size)	Self-Resonating Freq. Range, Mc.		Nominal Q of Inductor Over Tuning Range	Nominal Inductance uh.	
Model	Min.	Max.		Min.	Max.
LC 303	400	725	170-200	.025	.028

JFD ELECTRONICS CORPORATION

Components Division • 6101 16th Avenue • Phone DEwey 1-1000 • TWX-NY25040

JFD WESTERN
P.O. Box 3416
7311 Van Nuys Blvd.
Van Nuys, Calif.
Phone STate 1-3530

JFD MIDWESTERN
6414 W. Higgins Ave.
Chicago, Illinois
Phone: SPring 4-4175

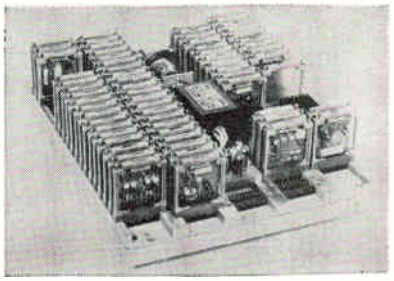
JFD NEW ENGLAND
Ruth Drive
Marlboro, Mass.
Phone: HUntley 5-7311

JFD CANADA
51 McCormack Street
Toronto, Ontario, Canada
Phone: ROger 9-1129

VARIABLE TRIMMER PISTON CAPACITORS • FIXED METALIZED INDUCTORS • LC TUNERS • DIPLEXERS
FIXED AND VARIABLE, DISTRIBUTED AND LUMPED CONSTANT DELAY LINES • PULSE FORMING NETWORKS

plications requiring a reliable standard of resistance. Resistor elements are bifilar wound, aged and relieved of strain to prolong permanency. Immersion of the complete elements in moisture free oil permits higher current ratings and temperature equalization. Units have heavy duty leads and four terminal connections are provided.

CIRCLE 310 ON READER SERVICE CARD



Counter/Timer
PROGRAMMABLE

ERIE-PACIFIC, Division of Erie Resistor Corp., Hawthorne, Calif., announces a high speed preset electronic counter/timer. The instrument is programmable and is for use with the TRACE electronic missile checkout system designed for the Lafayette-class Fleet ballistic missile submarines.

CIRCLE 311 ON READER SERVICE CARD

Trimmer Delay Line
MINIATURIZED

ESC ELECTRONICS CORP., 534 Bergen Blvd., Palisades Park, N.J. With a delay time of 0.05 μsec minimum at maximum position, the unit is 2.25 in. in length, 0.35 in. wide, and 0.75 in. deep (not including leads). It has a terminating resistance of 1,000 ± 10 percent. Its output rise time is 0.05 μsec maximum with input rise time a step function. The dielectric strength is 500 v d-c.

CIRCLE 312 ON READER SERVICE CARD

Converter

SOLID STATE ELECTRONICS CO., 15321 Rayen St., Sepulveda, Calif. The

Freqmeter will linearly convert frequency or repetition rate of signals to a proportional d-c voltage.

CIRCLE 313 ON READER SERVICE CARD

Circuitboard Laminate
IN COLORS

FORTIN PLASTICS, INC., 14811 Keswick St., Van Nuys, Calif. Type G-10 circuitboard copper clad and unclad color coding laminates are available in red, blue, gray and jet black. All colors exhibit the same dielectric strength as the natural green which conforms to the requirements of MIL-P-18177B and MIL-P-13949B. All colors are available in standard thicknesses. Sheet size is 24 by 42 in.

CIRCLE 314 ON READER SERVICE CARD

Chopper Amplifier
MICROVOLT STABILITY

RIDGEFIELD INSTRUMENT GROUP, Schlumberger Corp., Ridgefield, Conn. The C-2 low drift, low frequency d-c amplifier of all solid state construction is a plug-in unit for use with RIG's wide-bandwidth (200 Kc) amplifier A-2 in instances where an improved drift specification is required either for operational amplifier use or in data handling preamplifier applications. With the C-2, input d-c is converted to a-c at 94 cps with a mechanical spdt chopper, a-c amplified in 3 stages, demodulated by the same chopper, and then filtered.

CIRCLE 315 ON READER SERVICE CARD

D-C Power Supply

PERKIN ELECTRONICS CORP., 345 Kansas St., El Segundo, Calif. Transis-

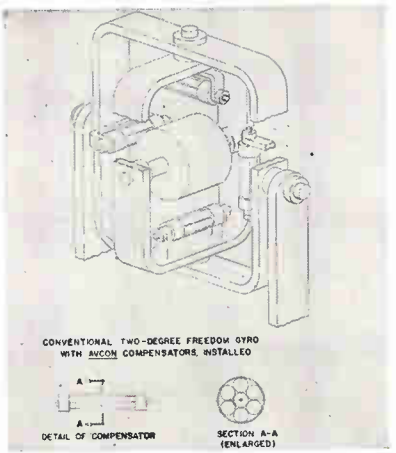
tor-controlled silicon rectifier power supply features ± 6 v dynamic load regulation.

CIRCLE 316 ON READER SERVICE CARD

T-R Duplexer
WEATHERPROOF CABINET

DECIBEL PRODUCTS, INC., 3184 Quebec St., Dallas 7, Texas, announces a T-R Duplexer in models for both the 150 Mc and 450 Mc bands. It permits simultaneous transmission and reception from a single antenna. Principal applications are mobile repeater stations and duplex operations as used by radio common carriers. Unit is contained in a weatherproof cabinet measuring 30 by 17 by 6 in. deep suitable for outdoor, indoor, or rack mounting.

CIRCLE 317 ON READER SERVICE CARD



Mass Shift Compensator
FOR BALANCING GYROS

AVCON CORP., Scarsdale, N.Y., announces a device to keep all types of gyroscopes in perfect balance by inducing electrically precisely the right amount of compensating torque. Drawing shows a conventional two-deg freedom gyroscope with several small units bundled together to make up a large mass shift compensator. They are shown mounted orthogonally—two to a gimbal—to provide effective control over any mass shift that may take place.

CIRCLE 318 ON READER SERVICE CARD

Microwave Systems

ALPHA CORP., P.O. Box 1891, Dallas 21, Texas. Series of microwave transmitters and receivers operate

ELECTROLYTIC CAPACITORS—*Reliability is our first ingredient*

Actual size 50V (1uf)

The "space saver" of Tantalytic* Capacitors

Because it packs the most uf into the smallest package, the General Electric 62F510 Porous Anode Tantalytic Capacitor frees up valuable circuit space. It's the smallest (.075" x .250"), lightest (15 grams) 85C tantalum capacitor.

Though small, it provides more V-uf than larger units. In fact, it has almost four times greater volumetric efficiency than the smallest solid type.

* Reg. Trade-mark of General Electric Co.

But it offers superior reliability because of these special features:

1. **Non-acid electrolyte.** No free liquids are used. "Gel" electrolyte eliminates acid-attack problems.
2. **Paper spacer** between case and anode prevents impurity migration and scintillation at the anode.
3. **Re-healing capability** contributes to long life in rugged applications including high ripple and low impedance. And it's used at full-rated voltage at 85C!

Yet, this G-E unit is lower in price than other tantalum types, and the low price includes insulated sleeving.

Ask your G-E Sales Engineer about the five case sizes rated from 60V (2.5uf) to 6V (325uf). Or write for bulletin GEA-7008 to General Electric Co., Schenectady, N. Y. *Capacitor Dept., Irmo, S. C.* 430-04

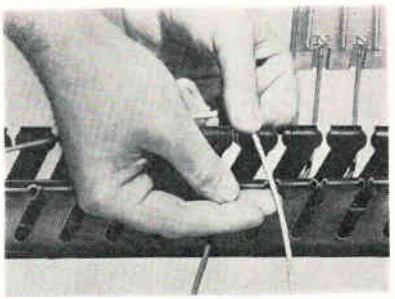
Progress Is Our Most Important Product

GENERAL ELECTRIC

General Electric also offers these reliable Tantalytic capacitors

in the 6 to 8 Gc and 11 to 15 Gc frequency ranges.

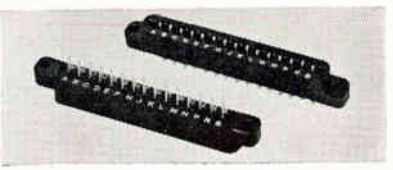
CIRCLE 319 ON READER SERVICE CARD



Wiring Raceway
OPEN-END WIRE SLOTS

STAHLIN BROTHERS, INC., 384 Maple St., Belding, Mich. Wiring raceway permits wires to be inserted through the top of the channel wall, but prevents them from springing out of position before connections are made. It has wire slots with contoured top openings through which wires can be slipped in place. The openings are shaped to hold the wires in position after insertion. Surfaces are rounded so wires can be inserted without damage to insulation. Wiring time is reduced and revisions made easier.

CIRCLE 320 ON READER SERVICE CARD



P-C Connector
ERROR-FREE WIRING

ARCON ELECTRONICS, Box 31, 3052 Burney Place, Los Alamitos, Calif. Error-free, speedy wiring is assured with these p-c connectors. The white-on-black lettering prominently identifies each contact. For additional ease of assembly, both sides of the connector top are lettered plus a single row on the bottom. Maximum fatigue resistance is achieved by the beryllium copper contacts which have a gold over silver finish. Flash-over voltage is 2,500 v d-c at sea level and 1,000 v d-c at 60,000 ft.

CIRCLE 321 ON READER SERVICE CARD

Tap-Setting Device

DEJUR-AMSCO CORP., Northern Blvd. at 45th St., Long Island City 1, N. Y., offers a tap-setting device

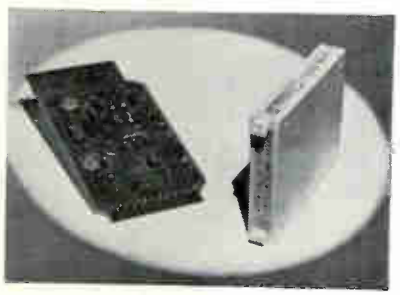
for inserting push-in type taps in wirewound precision pots.

CIRCLE 322 ON READER SERVICE CARD

Computer Switch
TWO STANDARD LINES

ULTRONIC SYSTEMS CORP., 7300 N. Crescent Blvd., Pennsauken, N.J., announces the 1000 series Ultra-Switch for computer and instrument systems. Both standard lines are 10 key units, the 1000-V with a single row of keys mounted vertically, the 1000-H with a double row of 5 keys each mounted horizontally. They are available as spdt or dpdt models rated at 5 amperes at 125 and 250 v a-c by UL and have 20 v d-c ratings of 3 amperes at sea level and 2.5 amperes at 50,000 ft, inductive.

CIRCLE 323 ON READER SERVICE CARD



Logic Module
10 MC FLIP FLOP

HARVEY-WELLS ELECTRONICS, INC., 14 Huron Drive, Natick, Mass. A 10 Mc flip flop logic module is available in two package styles. The Data Bloc model 1012 and the Data-Pac model 2012 are electrically identical. Data Bloc features logic diagram front panel and connectors, and is intended for basic test equipment and prototype system design applications. The compact p-c board Data-Pac is intended for use in final systems.

CIRCLE 324 ON READER SERVICE CARD

Telemetry Calibrator

DYTRONICS CO., 5485 N. High St., Columbus 14, O. Model 612 is in-

tended for the setup and calibration of the subcarrier discriminators of an f-m/f-m telemetering station.

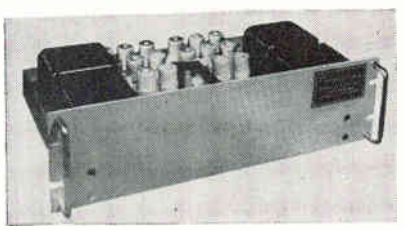
CIRCLE 325 ON READER SERVICE CARD

Varactor Multipliers

HIGH-POWER

MICROMEGA CORP., 4134 Del Rey Ave., Venice, Calif. Four new modular, high-power, high-efficiency varactor frequency multipliers are available. Included are two doublers and two triplers. Conversion efficiency of the doublers ranges from 55 to 75 percent; that of the triplers is from 40 to 60 percent. The narrow-band units can be tuned over a 5-percent bandwidth. They provide up to 4 w output power in the 800 to 1,250 Mc range when driven from a 10-w source in the h-f or vhf region.

CIRCLE 326 ON READER SERVICE CARD



Converters

DIGITAL-TO-ANGLE

ASTROSYSTEMS, INC., 220 E. 23rd St., New York 10, N.Y. Series A-203S-RC compact tape-programmable synchro standards employ the ASI ratio-transformer circuit for generating synchro test signals. They achieve an absolute accuracy of ± 2 sec of arc (± 0.001 percent) at every 5, 10, or 15 deg angular increment over the full 0-360 deg range. Applications include automatic test equipment for radar, inertial guidance devices, missile checkout, servo components and systems.

CIRCLE 327 ON READER SERVICE CARD

Crystal Protectors

BOMARC LABORATORIES, Salem Road, Beverly, Mass., has developed three

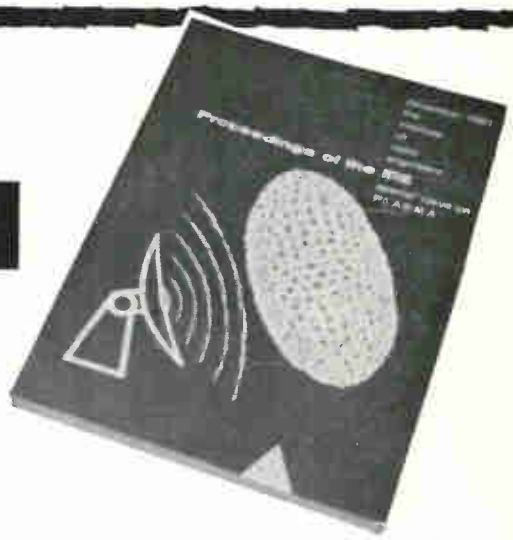
All that's new in PLASMA research

read

December

Proceedings

for the facts!



No matter what your field in electronics, having a working knowledge of plasmas is greatly to your advantage. Why? Because plasmas are becoming increasingly important in electronics research and application.

Think of the major new developments in this field. Scientists are using gaseous plasmas to convert heat directly into electricity. Will this affect your work? Of course it will! Others are designing new vacuum pumps, again with gaseous plasmas helping to increase efficiency. Do you see the impact this will have on vacuum tubes, on a whole host of electronics products?

Much specialized research has been done on gaseous plasmas in the last few years. Much more is being planned. To catch up with it, you'd have to read a mass of technical papers, weed through conflicting theories, and often find at the end that the research is not pertinent to your work at all.

Realising this . . .

Proceedings of the IRE devotes its entire December issue to a survey of plasma research and findings to date . . . More than 15 technical papers, each one written by an authority, will spell out what plasmas are, how they behave, what they can do. Guest editor is Dr. E. W. Herold, Vice President, Research, Varian Associates.

Every special issue of *Proceedings* in the past has remained a definitive reference work for years. Many were sold out almost immediately. If you are not a member of the IRE, make sure of your copy of the December special issue on plasmas by sending in the coupon immediately.

more than 15 definitive papers covering the following areas of plasma research and application:

1. Fundamental plasma processes
2. Applications to communications
3. Electric power generation
4. Propulsion systems
5. Low density plasma explorations
6. Generation and amplification of oscillations in plasmas
7. Diagnostic procedures

Proceedings of the IRE

The Institute of Radio Engineers
1 East 79th Street, New York 21

The Institute of Radio Engineers
1 East 79th Street, New York 21

Please send me the December 1961 issue of **Proceedings of the IRE**, containing a survey of the research carried out on plasmas.

☐ Enclosed is $3.00 (for non-members only).*

☐ Enclosed is company purchase order.

*Extra copies to IRE members, $1.25 each (limit: 1 extra to a member).

NAME.....

COMPANY.....

ADDRESS.....

.....

SPERRY ELECTRONIC TUBE DIVISION

microwave memo

Sperry extends 30-day delivery to cover ECM and augmenter TWT's operating in L, S, and X bands

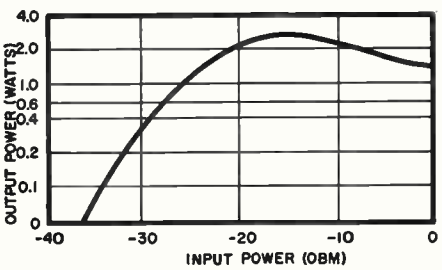
In a dramatic extension of its capability for delivering high-performance microwave tubes on short notice, Sperry Electronic Tube Division has added three system-proved traveling wave tubes to the list of those available in 30 days. Included in the move are tubes operating in L, S, and X bands. They cover a frequency range 1.1 to 11.0 kMc.

APPLICATION FLEXIBILITY

The tubes in this series are particularly suited to application in augmenters and ECM equipment. The inherent broadband characteristic and unusual ruggedness of these PPM focused tubes makes them unusually versatile in airborne applications. A full course of MIL and environment tests, as well as considerable in-system experience have verified these characteristics.

INCREASED POWER POSSIBLE

Although these tubes nominally operate in the 1-2 watt power output range, optimum tuning can increase power to as much as 5 watts. A high-mu control grid adds to the versatility of these tubes by allowing remote switching, modulation control and gain adjustment.



Drive characteristics at mid-band for a typical Sperry ECM/augmenter TWT.

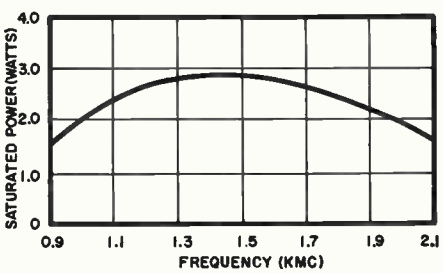
SYSTEM DESIGN SIMPLIFIED

Use of these Sperry tubes greatly simplifies system design problems. Low voltage and high gain reduce power supply requirements. Application is further simplified, since ambient cooling is sufficient in most applications and the tubes may be mounted in any position.

For FREE technical information on these Sperry Traveling Wave Tubes, write to Section 303, Sperry Electronic Tube Division, Gainesville, Florida.

The L-Band tube is priced at $1,900., the S-Band tube at $2,195., and the X-Band at $2,540.

For application assistance and quotation, consult your nearest Cain & Co. representative. His address and phone number appear on the opposite page.



A typical saturated power versus frequency curve for an L band Sperry TWT.

SPERRY ELECTRONIC TUBE · DIVISION

GAINESVILLE, FLA. / GREAT NECK, N. Y.

SPERRY RAND CORPORATION

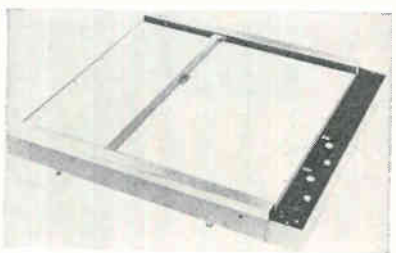
high-frequency crystal protectors to provide reliable protection from 16.0 to 70.75 Gc.

CIRCLE 328 ON READER SERVICE CARD

Thermal Switch
SNAP-ACTING

THERMEL, INC., 669 Elmwood Ave., Providence, R. I. Subminiature hermetically sealed, snap-acting thermal switch is resistant to vibration, shock and salt spray. It meets or surpasses all applicable military specifications. It is suitable for electronic communications equipment, missile and air craft controls. Creeping and false cycling have been eliminated by an instantaneous make and break action.

CIRCLE 329 ON READER SERVICE CARD



X-Y Graphic Recorder
LARGE RECORDING AREA

F. L. MOSELEY CO., 409 N. Fair Oaks Ave., Pasadena, Calif. The Autograf model 7 X-Y graphic recorder features a 30 in. by 30 in. recording area. It combines in one instrument all the facilities needed for rapid, accurate recording of a variety of test instruments involving two variables. Accuracy is better than ±0.1 percent of full scale and maximum pen speed is 20 in./sec for each axis. Price is $6,500.

CIRCLE 330 ON READER SERVICE CARD

Coax Terminations
50-OHM UNITS

MECA ELECTRONICS, INC., P. O. Box 645, Dover, N. J., announces a line

of 50-ohm coaxial terminations. Specifications include an average power rating of 3 w, frequency range of 0 to 5,000 Mc, and a vswr of 1.09 or less at any frequency up to 5,000 Mc. Available in eight standard connector configurations, including types N, C, BNC, TNC male and female. Small quantity prices range from $30 to $40, depending on type.

CIRCLE 331 ON READER SERVICE CARD

Zener Diodes

DURABLE DEVICES

AMERICAN SEMICONDUCTOR CORP., 3940 N. Kilpatrick Ave., Chicago 41, Ill. A line of highly reliable silicon Zener diodes have passed the toughest shock, vibration, fatigue and acceleration tests and still perform to exacting specifications in a temperature range from −65 C to +150 C. Designed for circuits exposed to severe environments.

CIRCLE 332 ON READER SERVICE CARD

D-C Power Supply

HEWLETT-PACKARD CO., 1501 Page Mill Road, Palo Alto, Calif. Model 723A d-c power supply's output can be programmed by external resistance for fast repetitive testing.

CIRCLE 333 ON READER SERVICE CARD

Voltage Reference

100 DB ISOLATION

CIRUITDYNE CORP., 480 Mermaid St., Laguna Beach, Calif. Isolation from line voltage changes in the

This semiconductor network data processor was developed by Texas Instruments Incorporated under the direction of Manufacturing and Electronic Technologies Laboratories, Aeronautical Systems Division, Dayton, Ohio.

Now Reduce Your Microelectronic Design Time

with Series 51 SOLID CIRCUIT* semiconductor networks

HERE'S HOW:

- designed to fulfill logic functions of complete equipment assemblies—compatible with most of today's logic circuitry.
- low power drain minimizes thermal problems and reduces power supply requirements.
- advanced manufacturing techniques including diffused planar structures, deposited leads, oxide protection, and hermetically sealed package—offer you the potential for improved circuit reliability.
- today's ultimate in microelectronics—with the highest function/size ratio for your digital circuits or equipments.
- provide reduced microelectronic cost through TI's standard silicon wafer design.
- meet military requirements:

Power Drain	2-4 mw @ 3 volts
Fan-Out (TI SN 510, 512, 514, 515)	4
Fan-Out (TI SN 511, 513)	20
Propagation Delay	75 to 450 nsec
Power Supply	3 to 6 volts
Temperature Range	−55° to +125°C

UNIT	TI SN 510	TI SN 511	TI SN 512	TI SN 513	TI SN 514	TI SN 515
FUNCTION	Flip Flop, Counter	Flip Flop with emitter follower output	NOR/NAND Gate (6 input)	NOR/NAND Gate (6 input) with emitter follower output	Two NOR/NAND Gates (3 inputs each)	Exclusive OR
	Clock pulse is internally capacitive-coupled					

CONTACT YOUR NEARBY TI SALES ENGINEER TODAY FOR COMPLETE TI SPECIFICATIONS AND CUSTOM DESIGN ASSISTANCE.

**Trademark of Texas Instruments Incorporated*

COMPONENTS DIVISION
CAPACITORS. DIODES.
RECTIFIERS RESISTORS.
SEMICONDUCTOR NETWORKS.
SILICON CONTROLLED RECTIFIERS

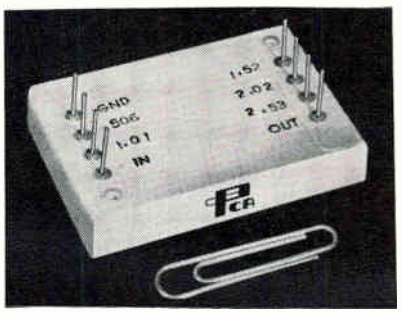
18686

TEXAS INSTRUMENTS
INCORPORATED
13500 N. CENTRAL EXPRESSWAY
P. O. BOX 5012 • DALLAS 22, TEXAS

CIRCLE 173 ON READER SERVICE CARD

order of 100 db is a primary feature of the solid-state type RPI voltage reference supply. Unit is available in models to accept both 115 v and 6.3 v inputs, from 50 to 400 cps. Outputs may be specified at 5.9, 8.6, 11.0, 14.5, 17.2 and 22.0 v, nominally. Standard versions are packaged in hermetically sealed containers measuring 2 in. high by 1¼ in. in diameter with octal plug-in sockets. Prices range from $30 to $130.

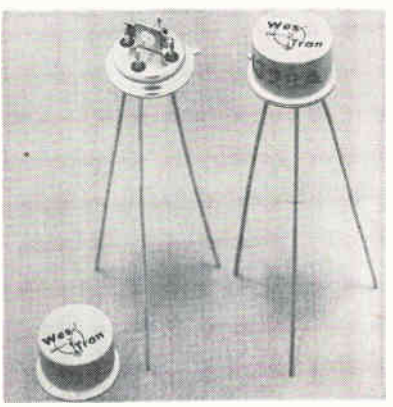
CIRCLE 334 ON READER SERVICE CARD



Delay Lines
LUMPED CONSTANT

PCA ELECTRONICS, INC., 16799 Schoenborn St., Sepulveda, Calif. Series of PCDL lumped constant delay lines are packaged in hermetically sealed cases and designed for application on p-c cards. They have a 500 v d-c rating, low temperature coefficient, maximum attenuation of 0.7 db/μsec for rise times less than 0.15 μsec, and 0.35 db/μsec for rise times greater than 0.15 μsec. Tolerances can be maintained through an environmental temperature range from −55 to 125 C.

CIRCLE 335 ON READER SERVICE CARD



Transistors
400 MILLIWATT

WESTERN TRANSISTOR CORP., 13021 S. Budlong, Gardena, Calif., announces *pnp* silicon alloy transistors for switching and chopping;

The world-famous

AEROCOM 1046 TRANSMITTER

1000 W CARRIER POWER WITH HIGH STABILITY

The Aerocom 1046 Transmitter is designed to give superior performance for all point-to-point and ground-to-air communications. It is now in use throughout the world in climates ranging from frigid to tropical (operates efficiently at −35° to +55° Centigrade).

As a general purpose High Frequency transmitter, the 1046 supplies 1000 watts of carrier power with high stability (above −10° Centigrade: ±.003% for telegraph and telephone. Temperature controlled oven for FSK). Multichannel operation is provided on telegraph A1, telephone A3 and FSK (Radio Teletype). It can be remotely controlled using one pair of telephone lines plus ground return with Aerocom Remote Control Equipment. Front panel switches and microphone are included for local control.

Four crystal-controlled frequencies (plus 2 closely-spaced frequencies) in the 2.0 - 24.0 megacycle range can be used one at a time, with channeling time only two seconds. Operates into either balanced or unbalanced loads. The power supply required is nominal 230 volts, 50 - 60 cycles, single phase.

The housing is a fully enclosed rack cabinet of welded steel, force-ventilated through electrostatic filter on rear door.

Telegraph keying (A1): Up to 100 words per minute. Model 1000 M Modulator (mounts in transmitter cabinet) is used for telephone transmission; a compression circuit permits the use of high average modulation without overmodulation. Model 400 4 Channel exciter is used for FSK.

Output connections consist of 4 insulated terminals (for Marconi antenna) and 4 coaxial fittings Type SO-239, which can be used separately or in parallel in any combination. For 600 ohm balanced load, Model TLM matching network is used, one for each transmitter channel.

As in all Aerocom products, the quality and workmanship of Model 1046 are of the highest. All components are conservatively rated. Replacement parts are always available for all Aerocom equipment.

Complete technical data on Aerocom Model 1046 available on request.

Also available—Aerocom Model 446 with 350 watts nominal carrier power and Model 100TFA—100 watts

AER-O-COM

3090 S. W. 37th AVENUE MIAMI 33, FLORIDA

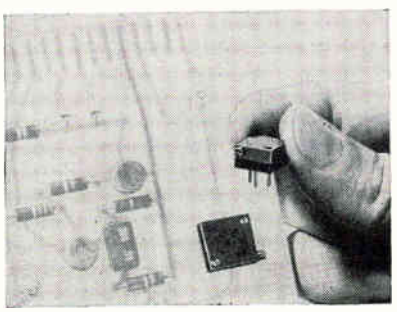
they feature high reliability and meet MIL-S-19500B specifications. Their low collector saturation resistance (less than 10 ohms) provides a desirable characteristic for switching applications. Low offset emitter voltages, leakage currents into the nanoampere range, and high voltages in the reverse configuration suit them for good chopper service.

CIRCLE 336 ON READER SERVICE CARD

Frequency Standard
TUNING FORK TYPE

MELPAR, INC., 3000 Arlington Blvd., Falls Church, Va. Miniature frequency standard is a transistorized electromechanical oscillator designed for systems that require a precise a-f sine wave or square wave for reference, measurements, time bases, and marker or clock pulses. Design consists of the tuning fork and associated amplifier-oscillator p-c board, both enclosed in a small hermetically sealed evacuated case (MIL-T-27 type AH), and weighing less than 2.9 oz.

CIRCLE 337 ON READER SERVICE CARD



P-C Trimmers
SQUARE CONFIGURATION

SPECTROL ELECTRONICS CORP., 1704 S. DelMar Ave., San Gabriel, Calif.

Types 50-4-1 and 60-4-1, $\frac{3}{8}$ in and $\frac{1}{2}$ in. square respectively, feature humidity proof construction in compliance to MIL-STD-202A, Method 104, Condition A and MIL-E-5272C, Procedure 1. The 50-4-1 weighing 1 gram, is rated at 1 w at 50 C and is available in resistances from 50 ohms to 50,000 ohms. The 60-4-1, weighing 2 grams, is rated at 2 w at 50 C and is available in resistances from 50 ohms to 100,000 ohms.

CIRCLE 338 ON READER SERVICE CARD

Test Console
FOR TACHOMETERS

AMERICAN ELECTRONICS, INC., 9503 W. Jefferson Blvd., Culver City, Calif., is marketing a tachometer test console designed to evaluate the operating characteristics of both the integrating and damping tachometers at a temperature range of −60 F to 220 F. Four test tachometers are accommodated at a time. Company says the console speeds up the testing process of the high precision servo components by 800 percent.

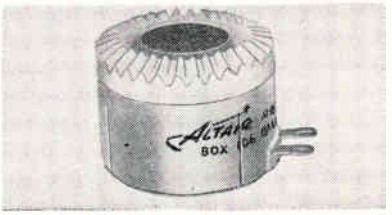
CIRCLE 339 ON READER SERVICE CARD

Power Supply
VERSATILE UNIT

NJE CORP., 20 Boright Ave., Kenilworth, N. J. Constant voltage and/or current power supply features automatic electronic changeover for forming and aging electrolytic capacitors. It can be operated at either constant voltage with adjustable current limiting or constant current with adjustable voltage limiting. Operating with constant

voltage, it has an output range of 2-300 v and 0-6 amp. At constant current, output range is 0-300 v and 0.3-6 amp.

CIRCLE 340 ON READER SERVICE CARD



Magnetic Clutch
MINIATURE DEVICE

ALTAIR RESEARCH & MFG. CO., Box 106 Baldwin Park, Calif. Model MC541, fitted with steel housing and a nylon gear mounted on ball bearings, is designed for incorporation in multiple clutch-potentiometer assemblies. Engineered to meet critical space requirements, it is only 1 in. in diameter and 1 in. long. It has a minimum torque of 6 oz in. and exerts no drag on potentiometer when de-energized. Available with coil voltages of 6 to 110 v d-c.

CIRCLE 341 ON READER SERVICE CARD

Card Reader
HOPPER-FED

COMMERCIAL DATA PROCESSING, INC., 3444 Lindell Blvd., St. Louis 3, Mo. Photoelectric 80-column hopper-fed card reader was designed for use in data processing systems, machine tool control, and automatic circuit check-out devices. Maximum reading speed is 150 characters per sec. Average pulsing speed is 30 characters per sec. Hopper capacity is 450 cards. Price is $1,500.

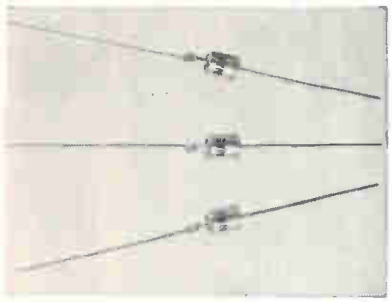
CIRCLE 342 ON READER SERVICE CARD

C-W Oscillator

TELONIC INDUSTRIES, INC., Beech Grove, Ind. Model CP-20 is a cavity

type miniature oscillator for c-w, plate, or grid pulse service with outputs of up to 10 w.

CIRCLE 343 ON READER SERVICE CARD



Zener Regulators
AS LOW AS 2.8 V

NORTH AMERICAN ELECTRONICS, INC., 71 Linden St., West Lynn, Mass., offers a line of 1-w Zener regulators with voltages ranging from 2.8 v to 200 v. They are storage tested at 200 C. Units give excellent stability and regulation in control and similar circuits over a wide operating range and can carry up to 150 ma test current.

CIRCLE 344 ON READER SERVICE CARD

Dropout Eliminator
FOR TAPE PLAYBACK

MINCOM DIVISION, Minnesota Mining and Mfg. Co., 2049 S. Barrington Ave., Los Angeles, Calif. Skew in redundant predetection recording playback is virtually eliminated by the Tracklok unit. Dropouts, caused by dust and ferric oxide nodules, do not appear in the demodulated information. Phase locking of the two inputs permits combination of two tracks to recover all telemetered information.

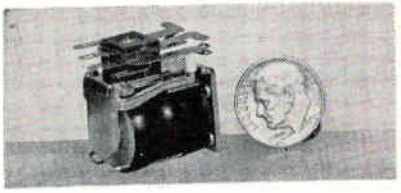
CIRCLE 345 ON READER SERVICE CARD

Heat-Sink Wafers
WITH EXTREME FLATNESS

GIBSON ELECTRIC SALES CORP., Delmont, Pa., announces heat-sink wafers of pressed powdered metal or punched metal sheet for assem-

bly of silicon rectifiers, diodes and other electronics devices. Normal production provides extreme flatness and tight dimensional tolerances.

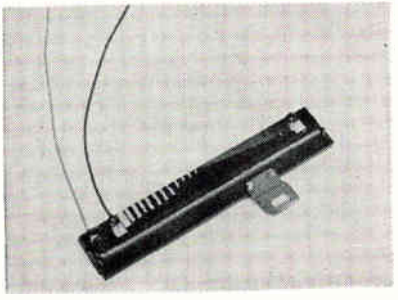
CIRCLE 346 ON READER SERVICE CARD



Subminiature Relay
TELEPHONE TYPE

DAVIS ELECTRIC CO., Cape Girardeau, Mo., announces a subminiature telephone type relay design less than 1 in. high featuring a diallyl phthalate molded stack pile-up. Contacts are dpdt gold alloy for low level loads or 3 amp palladium for general purpose applications. D-C operating power required is 0.5 w for standard units, but 0.15 w sensitivity can be supplied on request.

CIRCLE 347 ON READER SERVICE CARD



Pot Pick-Off
INFINITE RESOLUTION

COMPUTER INSTRUMENT CORP., 92 Madison Ave., Hempstead, L. I., N. Y. Model 10111 is intended to act as a converter of linear wiper motion into linear or nonlinear voltage with virtually infinite resolution. Linearity better than 0.05 percent per in. of travel can be provided, along with compensation for electrical loading, linear outputs with non-linear motion and vice-versa, and resistances between 500 ohms and 100,000 ohms per in. Sensitivity as high as 300 v per in. can be obtained.

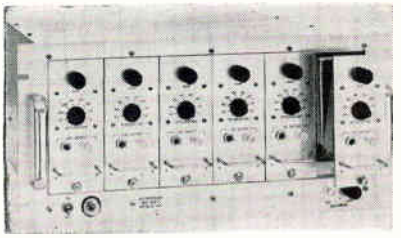
CIRCLE 348 ON READER SERVICE CARD

Delay Line

COLUMBIA TECHNICAL CORP., Woodside 77, N.Y. The CTC-F618ME

compact delay line features a delay of 5.0 μsec at an impedance level of 2,500 ohms.

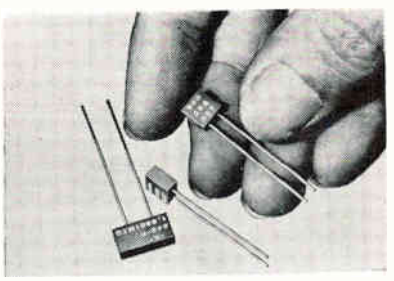
CIRCLE 349 ON READER SERVICE CARD



VLF Receiving System
MULTICHANNEL

DEVELCO, INC., 440 Pepper St., Palo Alto, Calif., has developed a 6-channel vlf receiving system covering the 10 to 30 Kc range. System includes whip or loop antenna, remote preamplifier and broad-band filter, and six separate plug-in channel units. Sensitivity is better than 1 μv/meter for 0 db signal-to-noise ratio in 100 cps i-f noise bandwidth. All circuits are solid state.

CIRCLE 350 ON READER SERVICE CARD



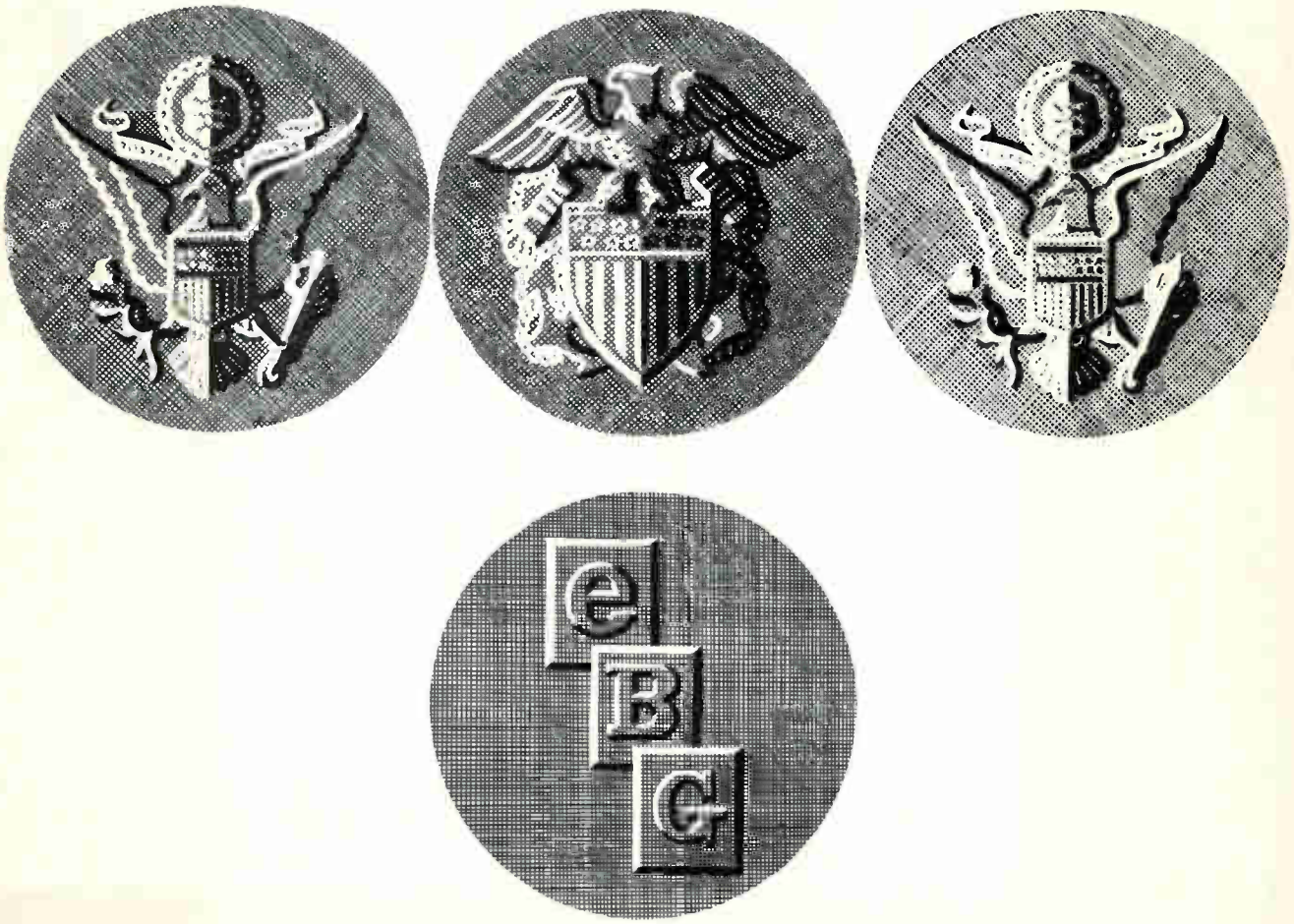
Wirewound Resistors
P-C TYPE LEADS

KELVIN ELECTRIC CO., 5907 Noble Ave., Van Nuys, Calif. Type 447-P precision wirewound resistor has a flat configuration, ¼ by ¼ by ⅛ in. with printed circuit type leads. Type 446-P measures ½ by ¼ by ⅛ in. The form factor permits high density packaging. All units are wound with a single length of wire (no splices are permitted) using "relaxed" winding techniques. This method, by allowing a winding tension of between 1½ to 3 grams, minimizes resistance drift with age and "opens" or "shorts" resulting from overstressed wire.

CIRCLE 351 ON READER SERVICE CARD

Silicon Transistors

GENERAL ELECTRIC CO., Syracuse, N. Y. Series of planar, epitaxial,



HOW TO SELL TO THE GOVERNMENT

Key reference is your 1961 electronics Buyers' Guide and Reference Issue. Your 1961 EBG Reference Section includes a survey of military and government procurement methods with phone numbers, addresses and procurement officers' names. EBG lists main government books, pamphlets, and periodicals on the subject, and the military and government agencies that buy electronic equipment and services and what these agencies buy . . . plus a helpful run-down on specifications for this important segment of the electronics industry. And that's only part of the Reference Section; only part of your 1961 EBG.

MORE EBG EXCLUSIVES

1. Actual name of the man to call on in each company for key information about prices, delivery dates, specifications, etc.—a first-time exclusive.

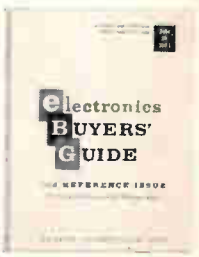
2. Company statistics—another new exclusive—that give you dollar-volume, number of engineers, number of employees, etc., for each company listed.

3. Complete index of editorial articles that have appeared in electronics during the last 12 months.

4. Abstracts of feature articles listed in the editorial index from electronics. Plus these EBG features:

- Specific product listings—accurate, complete, authentic, more than 3,000 of them cross-indexed.
- Registered trade name index—lets you find the manufacturer of a product when you know it only by its trade name.
- Local sales office listing—makes it easy to find name, address and phone number of a manufacturer's nearest sales office.

These are all factors that make your EBG the most essential buying and selling reference in the electronics industry. Keep your EBG close at hand—it will pay off in more ways than one.

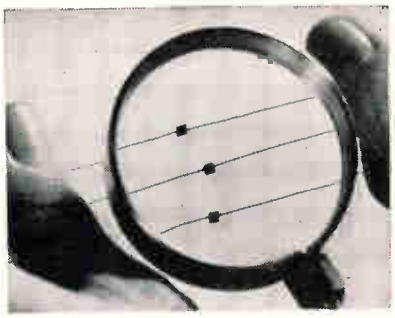


electronics buyers' guide and reference issue *The Basic Buying Guide in Electronics since 1941*

A McGRAW-HILL PUBLICATION 330 West 42nd St., New York 36, N. Y.

passivated silicon transistors operate at frequencies from 50 Mc to above 120 Mc.

CIRCLE 352 ON READER SERVICE CARD



Ceramic Capacitor
MICROMINIATURE

GULTON INDUSTRIES, INC., 212 Durham Ave., Metuchen, N. J. Maximum size of this axial-lead ceramic capacitor is 0.085 in. sq by 0.035 in. thick, with a rating of 50 wvdc. Capacitance values are available in the range from 10 to 300 $\mu\mu$f, with a maximum capacitance change of ± 10 percent over the temperature range of − 55 C to + 85 C. Tolerances of ± 15 percent are available to 150 C.

CIRCLE 353 ON READER SERVICE CARD

All Epoxy Module
HEADERS AND CASES

EPOXY PRODUCTS DIVISION, Joseph Weldman & Sons, 137 Coit St., Irvington 11, N. J., has available all epoxy module packages (headers and cases) which will plug into standard 8 or 10 pin crystal can relay sockets. A friction fit between the header and the case prevents liquid epoxy from leaking during encapsulation. Cases are open at the top for easy filling in production line applications. Module will withstand continuous operating temperatures of 400 F.

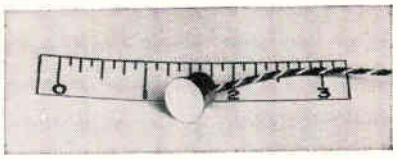
CIRCLE 354 ON READER SERVICE CARD

Twin Tetrode

AMPEREX ELECTRONIC CORP., 230 Duffy Ave., Hicksville, L.I., N. Y. Type 7983 miniature, fast-warmup

twin tetrode provides 3 db power output in 0.7 sec.

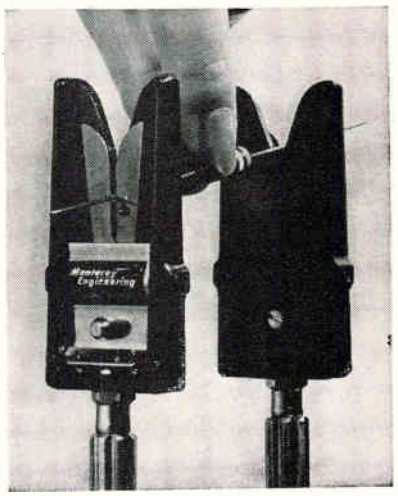
CIRCLE 355 ON READER SERVICE CARD



Pressure Cell
SOLID STATE

KULITE-BYTREX CORP., 50 Hunt St., Newton 58, Mass. Miniature pressure cell utilizes semiconductor strain gages. Capacities from 5 to 500 psig all provide outputs in excess of 100 mv with natural frequency in excess of 50 Kc. The HF series cells will withstand 1,000 g in all axes with a maximum error of 0.005 percent per g.

CIRCLE 356 ON READER SERVICE CARD



Test Clip
EASY INSERTION

MONTEREY ENGINEERING, P. O. Box 3083, Granada Hills, Calif. Model B-1003 Monte-clip may be used to test any components with wire leads, or even components which have flexible insulated wire leads. Scissors action of thin stainless steel blades creates high contact pressure on the lead while requiring only a minimum insertion effort by the operator. Production rates of 1,200 pieces per hr typify a go/no-go resistance test.

CIRCLE 357 ON READER SERVICE CARD

Tape Perforator

SOROBAN ENGINEERING, INC., Box 1717, Melbourne, Fla. Model LP-2

60 NOW 50 WATTS! IN A *DURABLE* SOLDERING PENCIL

EXTRA-LONG-LIFE ELEMENT
DOUBLE-LIFE CLAD TIP

Does the work of 100 watts yet weighs but 2 ounces!

New unique design in handle ventilation, plus stainless steel housing, insures a cool handle.

A new development makes possible a multi-coated copper tip which gives long life under the severe conditions brought about by the powerful 60 watt rating.

MODEL 24S —
Equipped with ¼" XTRADUR TIP for extra long life. Solder adheres to working surface only. No drip or creep.

WRITE FOR CATALOG
showing most complete line of Industrial Irons and Long-Life Clad Tips.

INDUSTRY'S No. 1 HEXACON SOLDERING IRON

HEXACON ELECTRIC CO.
130 WEST CLAY AVENUE, ROSELLE PARK, N. J.

SERVING INDUSTRY FOR A QUARTER OF A CENTURY

CIRCLE 240 ON READER SERVICE CARD

AUGAT POWER TRANSISTOR SOCKETS

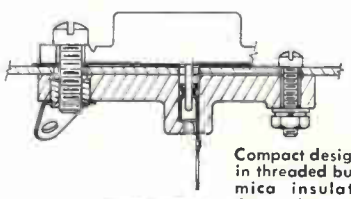
Augat Power Transistor Sockets bring you the benefits of maximum heat dissipation by conduction because they allow you to mount semiconductors, with mica insulator, directly to the chassis.

They're molded in your choice of insulating materials; General Purpose Black Phenolic per MIL-M-14, Type CFG; Melamine per MIL-M-14, Type MME; Diallyl Phthalate per MIL-M-18794A (Navy) Type SDG.

Contacts are Spring Temper Phosphor Bronze, electro tin plated. Bushings are Brass per MIL-B-895 (Ships), Nickel plated per QQ-N-290, Class 2. Terminals are Copper, hot tin dipped.

For complete specifications, write for Bulletins 561 and 760.

New socket for JEDEC TO-3 outline power transistors, diodes, rectifiers.

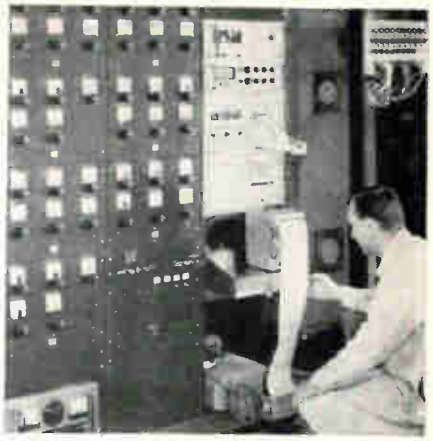


Compact design, molded-in threaded bushings and mica insulator allow direct chassis mounting.

Socket designed for complete series of Clevite Spacesaver Power Transistors.

AUGAT INC. 30 Perry Avenue Attleboro, Mass.

CIRCLE 241 ON READER SERVICE CARD



Associated Offers You A Complete Reliability Testing Facility

Engineering Direction. Associated's staff of 230 experts includes at least one engineer for each three technicians. A team of specialists, skilled in Weibull distribution and other reliability mathematics, directs the development of specfic test programs.

Diversified Experience. A background of reliability testing accomplished for several hundred companies has equipped Associated to carry out testing of virtually any type of component or assembly.

Simulation Facilities. An unparalleled scope of equipment and laboratory facilities enables Associated to simulate any climatic or dynamic environmental condition and to simulate functionally any installation in aircraft, missiles and shipboard equipment.

Automated Data Processing. Associated's Digital Data Reduction equipment permits large quantities of parts to be processed rapidly and economically, eliminates human error and assures absolute accuracy in recording data.

Regional Service. Fully equipped regional testing divisions in New Jersey, Massachusetts and Florida offer the advantages of close-by local service to companies in these areas, make it easy for your own personnel to supervise test programs when desired.

For detailed facilities information, or a proposal on your requirements, contact the Associated laboratory in your area.

Associated TESTING LABORATORIES, INC.

WAYNE, NEW JERSEY
155 Route 46 • CLifford 6-2800

BURLINGTON, MASS.
Northwest Industrial Park • BRowning 2-9050

WINTER PARK, FLA.
1112 Solana Avenue • Mldway 4-1800

CIRCLE 187 ON READER SERVICE CARD

perforator operates at punching speeds up to 120 codes per sec.

CIRCLE 358 ON READER SERVICE CARD

Electronic Welder
DUAL-RANGE

WELDMATIC DIVISION, Unitek Corp., 950 Royal Oaks Drive, Monrovia, Calif. Model 1059 is a solid-state, capacitor-discharge voltage regulated welder power supply which achieves maximum versatility by rapidly switching from a low range of 0.04 to 9 watt-seconds to a high range of 0.2 to 45 watt-seconds, as required. Typical applications include fine whisker-wire attachment to semiconductor leads.

CIRCLE 359 ON READER SERVICE CARD

Fiber Optics CRT's
DISTORTION-FREE PLATE

AMERICAN OPTICAL CO., Southbridge, Mass., is marketing fiber optics crt's which print recording directly from the tube face without the use of conventional lenses and at speeds up to 50 times faster than possible with a lens system. The tube is a joint development of American Optical Co. and Sylvania Electric Products, Inc. The tubes are available with either electrostatic deflection and focus or electromagnetic deflection and focus. They are designed for high speed data print and for computers and associated devices.

CIRCLE 360 ON READER SERVICE CARD

Small Relay

NEW PRODUCTS, INC., Box 10763, Cameron Village Station, Raleigh, N. C. Relay weighing only ¼ oz is

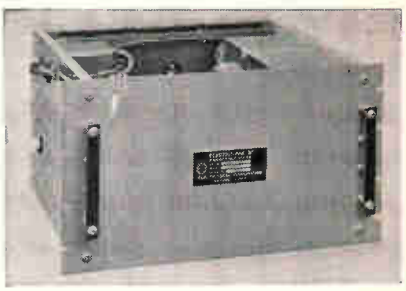
rated 20,000,000 operations at low load, has a capacitance of less than 1 pf.

CIRCLE 361 ON READER SERVICE CARD

Voltmeter
SOLID STATE

ELECTRONIC ASSOCIATES, INC., Long Branch, N. J. Series 5001 digital voltmeter combines solid state reliability and speed with features normally found only in electromechanical voltmeters. Automatic range and polarity selection are provided on ranges of ± 1.1999, ± 11.999, ± 119.99 and ± 1199.9 v. An average of 200 readings per sec is achieved (not including sign or range change) with a maximum error of ± 0.01 percent of full scale ± 1 digit.

CIRCLE 362 ON READER SERVICE CARD



Standby Power System
ZERO SWITCHOVER TIME

ELECTRO-SEAL CORP., 938 North Ave., Des Plaines, Ill., has announced a standby power system that prevents loss of intelligence or control data sequences due to a-c line voltage failure in the operation of electrical equipment and complex control systems. The Electro-Pac "A" cuts in with zero switchover time. It then provides the load with a-c voltage from battery or other d-c source, regulated to ±7 percent.

CIRCLE 363 ON READER SERVICE CARD

Heat Sink

VEMALINE PRODUCTS CO., Franklin Lakes, N. J. Series 6030 low cost

JULY 20, 1961

eBG

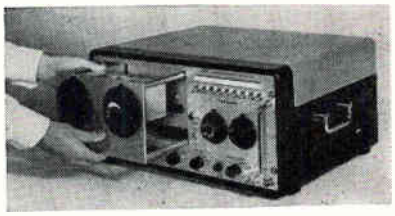
electronics
BUYERS' GUIDE
and
Reference Issue

PRODUCTS, MATERIALS and SERVICES LISTINGS
•
Registered TRADENAMES
•
MANUFACTURERS' SALES OFFICES
•
ANNUAL electronics INDEX of ARTICLES

VOL. 34 28A

heat sink has universal mounting hole patterns and coined mounting area to minimize contact resistance.

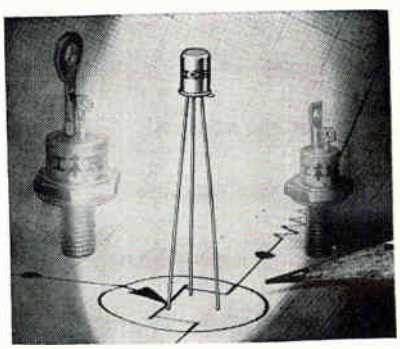
CIRCLE 364 ON READER SERVICE CARD



Sweep Generator
PLUG-IN OSCILLATORS

TELONIC INDUSTRIES, INC., Beech Grove, Ind. Sweep signal generator with changeable plug-in type oscillators covers frequency range of audio to 3,000 Mc. Model MS-2000 accepts any of 19 different oscillator heads. Construction is of the mil-slotted type allowing quick convenient range-changing with only one basic instrument.

CIRCLE 365 ON READER SERVICE CARD



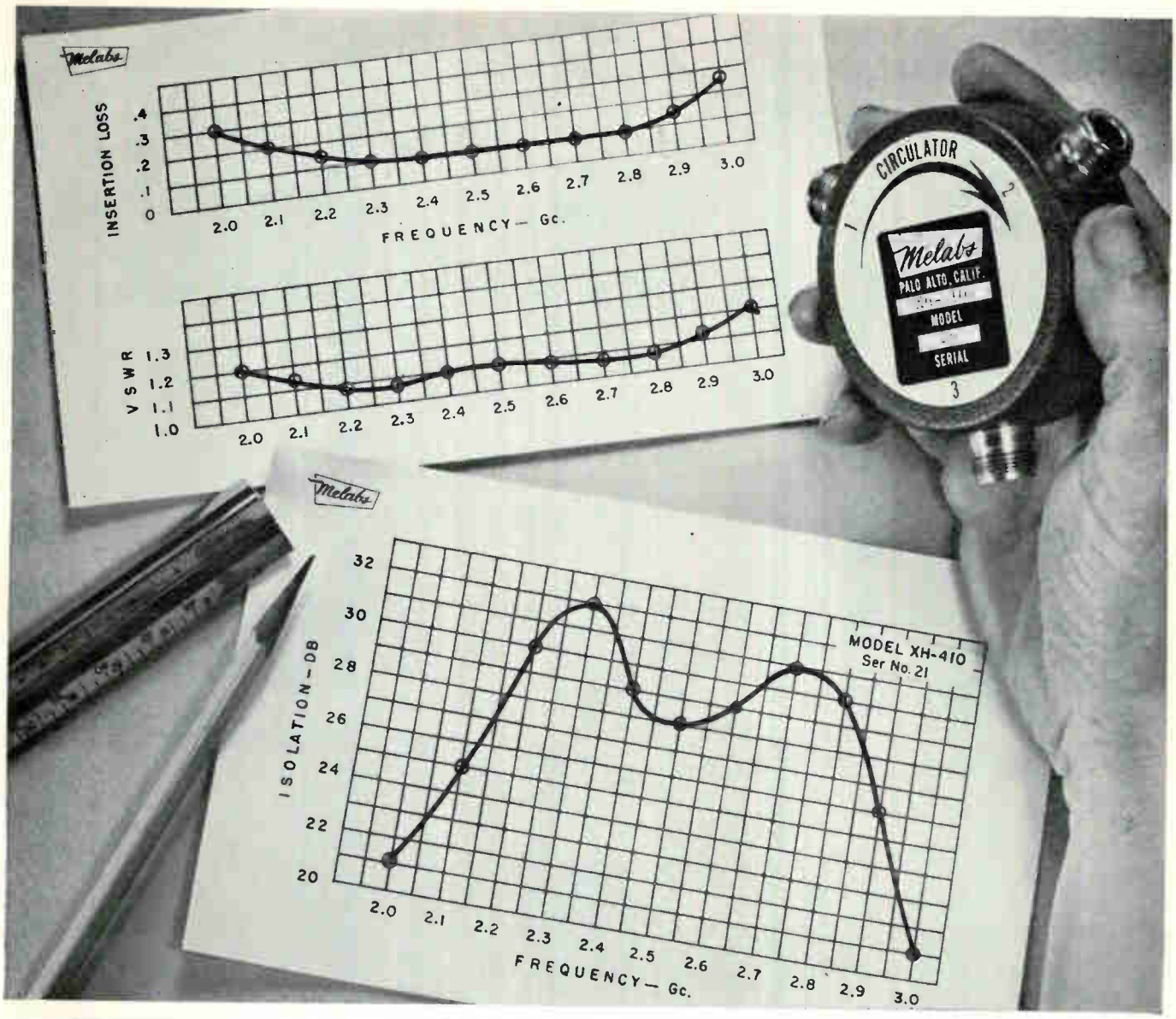
SCR Trigger
HIGH STABILITY

INTERNATIONAL RECTIFIER CORP., 233 Kansas St., El Segundo, Calif., offers an scr trigger designed for industrial controlled rectifier firing circuits. It is a silicon transistor that exhibits a negative resistance characteristic when a predetermined emitter-to-base firing voltage is exceeded. This characteristic is stable over a range from −65 to +140 C. Unit has a rated rms power dissipation of 250 mw, and max rms emitter current of 50 ma.

CIRCLE 366 ON READER SERVICE CARD

Plotting Board

KAY ELECTRIC CO., 14 Maple Ave., Pine Brook, N. J. The Mega-Plotter is a plexiglass plotting board for



NEW... VERY BROADBAND low loss COAXIAL CIRCULATORS

Now available . . . an entirely new series of coaxial Y circulators providing complete overlapping coverage of "S" and "C" bands. (Continuous 1.7 to 8.0 Gc.)

These very broadband, low loss circulators are light in weight and comparable in physical size to 10% bandwidth units. Typical measured performance is shown on curves above.

	Model		Model	
FREQUENCY RANGE:	XH-409	1.7-2.3 Gc	XH-412	3.0-4.0 Gc
	XH-410	2.0-3.0 Gc	XH-420	3.5-5.0 Gc
	XH-411	2.5-3.5 Gc	XH-421	4.5-6.5 Gc
			XH-422	6.0-8.0 Gc

Inquiries are invited on a completely new line of high average power coaxial circulators and isolators. Power capability is 400 watts average without cooling at S and C bands.

OTHER IMPORTANT NEW MELABS CIRCULATORS

Complete line, 4-port circulators, 800 mc to 8 Gc range. Illustrated: XH-415 ultra-miniature, 5.4-5.9 Gc. Insertion loss, typical 0.15 db at center, maximum 0.3 db at ends. 5 ounces—stable to 105°C.

Melabs

3300 HILLVIEW AVENUE / STANFORD INDUSTRIAL PARK / PALO ALTO, CALIFORNIA

TELEPHONE: DA 6-9500, AREA CODE: 415; TWX: PAL AL 138

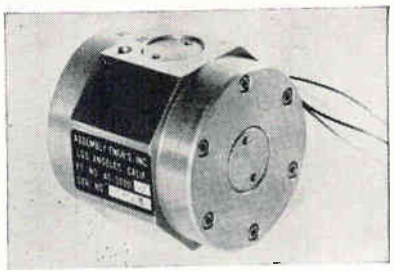
Employment opportunities at Melabs are exceptional for ambitious engineers and physicists; write in confidence.

AN EQUAL OPPORTUNITY EMPLOYER

DEPT. A5

use with standard size Kay Smith Charts (8½ by 11 in.).

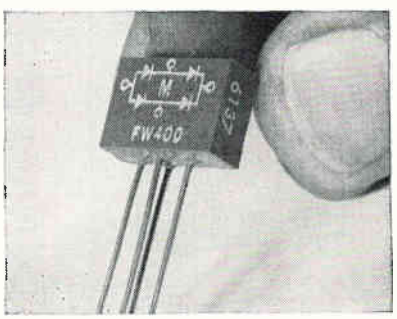
CIRCLE 367 ON READER SERVICE CARD



Dual Pressure Switch
WEIGHS 12 OZ

ASSEMBLY ENGINEERS, INC., 3640 Holdrege Ave., Los Angeles, Calif., has developed a special dual switch for applications requiring two spdt normally closed, which may be separately actuated as two switches in one. Its actuation pressure range is 1.0 in. to 10.0 in. Hg, with a calibration accuracy of ± 0.05 in. Hg. Its contacts are rated at 3 amperes inductive load at 28 v d-c. A maximum inrush of 15 amperes can be tolerated.

CIRCLE 368 ON READER SERVICE CARD



Bridge Circuit
SILICON RECTIFIER

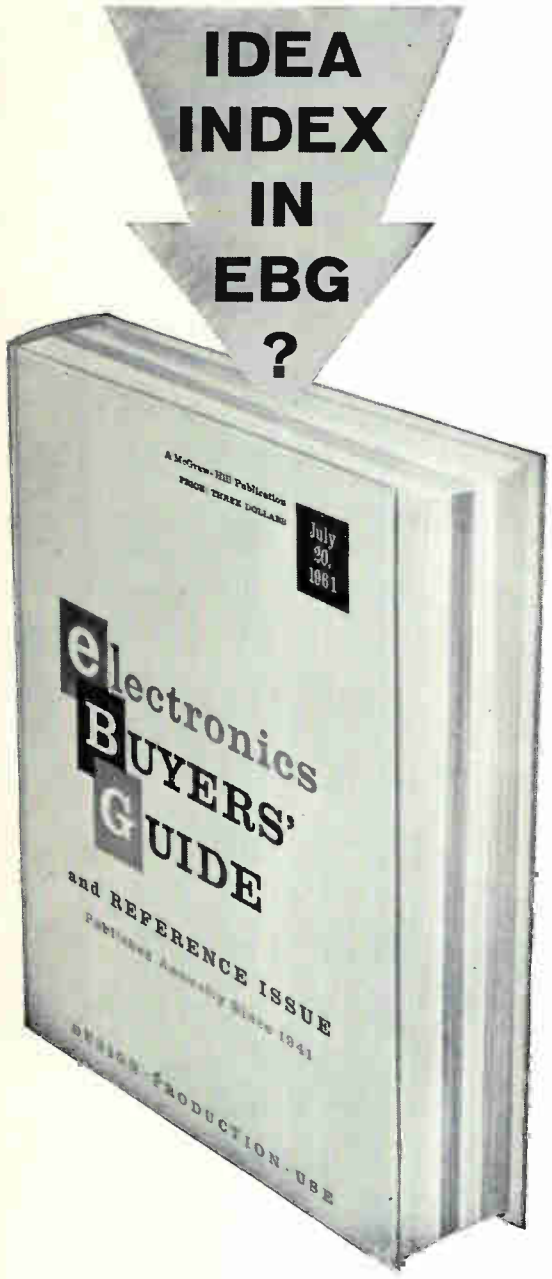
MALLORY SEMICONDUCTOR CO., Du Quoin, Ill. Type FW silicon rectifier circuit package has 50 percent fewer lead connections to solder and can thus reduce assembly costs for users. Its initial cost is less than that of four single rectifiers, and inventory is simplified because there are 75 percent fewer units to stock. Unit price is $1.30 to $2.00 each in lots of 1,000 to 4,999, depending on voltage rating.

CIRCLE 369 ON READER SERVICE CARD

Tubular Capacitor

GULTON INDUSTRIES, INC., 212 Durham Ave., Metuchen, N. J. The CT10

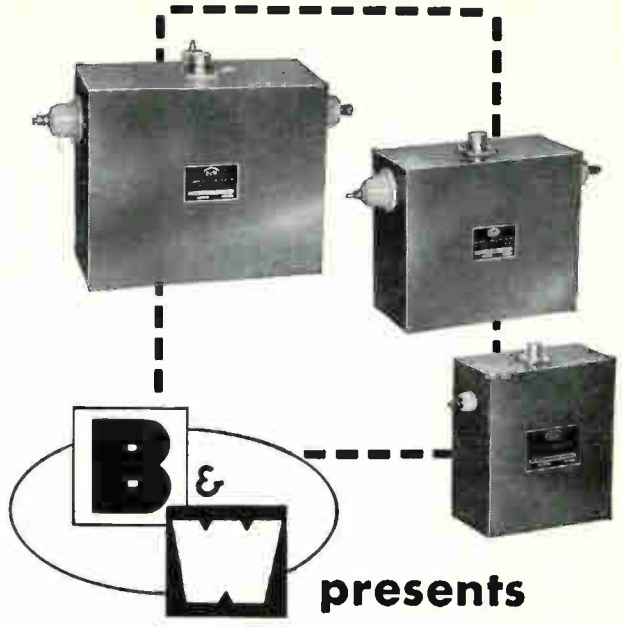
SEEN THE NEW



The INDEX to the editorial articles in electronics magazine, previously published annually in a December issue, now appears ONLY in the EBG. Another original EBG idea that saves time and trouble for users! Keep your EBG copy on your desk!

EXTRA!

Also in the EBG are condensed ABSTRACTS of *all* the editorial feature articles which have appeared to date in 1961. Another reason why EBG is used more by all four – men in research, design, production and management.



B&W presents

a Series of Broadband High-Frequency Matching Transformers

Frequency range 2 to 30 mc . . . low insertion loss . . . low SWR . . . good balance.

Power ratings: 1KW, 5KW and 20KW.

These high frequency transformers are ideal for matching unbalanced radio transmitter outputs to balanced amplifiers and balanced antennas. Standard impedance transformations: 50 to 70 ohms unbalanced to 150, 300 or 600 ohms balanced as required. Other impedance ratios available on special order.

Pioneers in the development of baluns and unique RF coupling devices B&W again sets a standard.

Drop us a card requesting Spec Sheet.

Barker & Williamson, Inc.

Beaver & Canal, Bristol, Pa.

Specialists in designing and building equipment to operating specifications

A few other B&W products: I. P. TRANSFORMERS • COMMUNICATIONS EQUIPMENT • AUDIO PHASE SHIFT NETWORKS • TEST EQUIPMENT • and many types of standard and special electronic components and equipment.

tubular capacitor with weldable gold flash Dumet leads exceeds requirements of MIL-C-11015.

CIRCLE 370 ON READER SERVICE CARD

Coaxial Connectors
AND ADAPTORS

GENERAL RADIO CO., West Concord, Mass., announces new versions of the type 874 coaxial connectors, including locking cable and panel, and recessed locking panel types. The vswr is lower—up to 8 Gc—than the N, C, BNC and UHF types; also leakage is very low for the locking version and higher voltages than formerly can be tolerated for both locking and non-locking types. Instruments equipped with the recessed-locking connectors can be fitted quickly with locking adaptors for a semipermanent conversion to other connector systems, with a minimum of space added in front of the panel.

CIRCLE 371 ON READER SERVICE CARD

Digital Multimeter
ALL-ELECTRONIC

ELECTRO INSTRUMENTS, INC., 8611 Balboa Ave., San Diego 11, Calif. The Eitronic 851 is a four-digit multimeter for measuring d-c volts, d-c ratios, a-c volts and resistance. Use of solid state circuitry eliminates contact maintenance and greatly reduces balance times for either up or down scale determinations.

CIRCLE 372 ON READER SERVICE CARD

Linearity Tester

IB INSTRUMENTS, Box 2460, Cleveland 12, O. Model 113 d-c meter

yes*

Gamewell made a sector pot with .0006″ wire

This subminiature sector pot is wound with .0006″ wire at over 1000 turns per inch. Required winding length tolerance is only .005″. Here's one example of the hundreds of "special" pot design requests that Gamewell is answering with an unqualified YES. Find out what Gamewell YES service — Your Engineered Specials service — can do for you. Write for the facts.

*Your Engineered Specials service

BLISS Gamewell®

THE GAMEWELL COMPANY, POTENTIOMETER DIVISION, 1417 CHESTNUT STREET, NEWTON UPPER FALLS 64, MASS. A SUBSIDIARY OF E. W. BLISS COMPANY.

CIRCLE 247 ON READER SERVICE CARD

MAKING ROOM AT THE TOP

See the 41 additional EICO instruments helpful for your lab and line work. Write for free catalog and name of neighborhood distributor.

EICO® Dept. E-11B
3300 N. Blvd., L.I.C. 1, N. Y.
Export Dept.: Roburn Agencies, Inc.
431 Greenwich St., N. Y. 13, N. Y.

EICO creates a new, professional lab quality test instrument series at moderate prices.

EICO®

AC VTVM & AMPLIFIER #250

Kit $49.95, Wired $79.95

VTVM: 12 ranges from 1mv to 300v rms; response absolutely flat from 10 cps to 600 kc; input impedance 10MΩ shunted by 15μμf; accuracy ±3% of full scale.

Note: Average responding meter calibrated in rms. Linear 0-1, 0-3 scales. Decibel scales based on 0db=1mw in 600Ω with 10db interval between ranges.

AMPLIFIER: 60db gain on 1mv range; response +0, −3db from 8cps to 800kc; output to 5V rms undistorted, variable down to zero by attenuator control at output; input impedance 10MΩ, output impedance 5KΩ; hum & noise −40db for signal inputs above 2mv.

DESIGN QUALITY: All frame-grid tubes; 60db frequency-compensated input attenuator ahead of cathode follower with 10db/step attenuator following; two-stage R-C coupled amplifier and full-bridge meter circuit in one overall feedback loop; no response adjustment required in amplifier circuit; single sensitivity adjustment; voltage-regulated power supply. 50/60 cycle operation.

Add 5% in the West.

EICO MODEL 255 AC VTVM
Identical to Model 250 described above, but less amplifier facility. 50/60 cycle operation.
Kit $44.95 Wired $72.95

CIRCLE 248 ON READER SERVICE CARD

ELECTRICAL INSULATION

EUROPE and the BRITISH COMMONWEALTH

A British Company, with first-class modern plant in England and a live marketing organization covering Europe and the British Commonwealth, is open to handle or manufacture under license new materials in this field.

Details to:
Managing Director

RA-7774, Electronics
Class. Adv. Div., P.O. Box 12, N.Y. 36, N.Y.

Specify...

POWERTRAN MINIATURE REGULATED D.C.

POWER SUPPLIES

Smallest Available! Short Circuit Protected!

FEATURES: 115 V., 60 or 400-cy. operation, 2000-cy. types also available ● Tubeless, trouble-free ● No warm-up required ● Guaranteed long life ● Encapsulated, hermetically sealed construction ● Temperature range: —40° C. to 85° C.

MIDGET SERIES (EB Case—1¾" x 1⅞" x 2⅜")

Model	D.C. Volts	D.C. Current	% Reg.	% Ripple (60 cy.)	Price
M5	5 V.	50 ma.	1.5	.26	$50
M10	10 V.	50 ma.	1.0	.15	45
M12	12 V.	45 ma.	1.5	.15	45
M15	15 V.	45 ma.	1.5	.15	45
M18	18 V.	45 ma.	2.0	.25	45
M20	20 V.	45 ma.	2.0	.30	45
M25	25 V.	40 ma.	2.0	.25	45
M28	28 V.	40 ma.	2.0	.25	45
M30	30 V.	40 ma.	2.0	.20	50
M40	40 V.	35 ma.	2.0	.30	50

Over 300 stock models available-see EEM page 623

FERROTRAN ELECTRONICS CO.
693 BROADWAY ● N. Y. 12, N. Y. ● AL 4-5810
Makers of A-F and I-F Amplifiers · Transistor Power Supplies and Transformers · Test Equipment

CIRCLE 197 ON READER SERVICE CARD

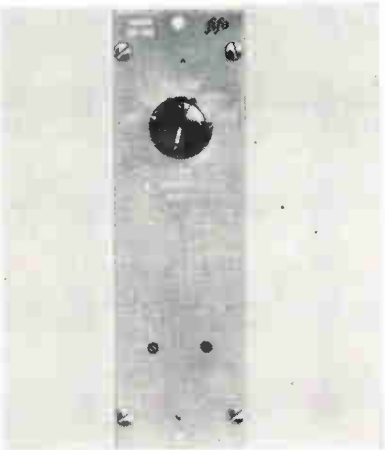
linearity tester checks 10 cardinal points on each meter with an accuracy of ±0.2 percent or better.

CIRCLE 373 ON READER SERVICE CARD

Remote Readout
FOR DIGITAL VOLTMETER

ELECTRONIC ASSOCIATES, INC., Long Branch, N. J. Readout assembly, with storage and decoder cards, measures 3½ by 19 by 17½ in. and can be either case or rack mounted. It accepts binary-coded-decimal 8421, gives decimal visual readout and supplies binary-coded-decimal and decimal data outputs.

CIRCLE 374 ON READER SERVICE CARD



D-C Amplifier
WIDE BAND

SANBORN CO., 175 Wyman St., Waltham 54, Mass., announces a low level floating input and output d-c amplifier with 10 Kc bandwidth. The transistorized unit may be used for many channels of commutated information at the amplifier input. Gain of 1,000 makes it suitable also for low level scanning devices. Linearity is ± 0.1 percent.

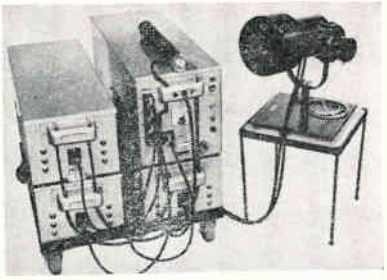
CIRCLE 375 ON READER SERVICE CARD

Miniature Plug

CANNON ELECTRIC CO., 3208 Humboldt St., Los Angeles 31, Calif. The KM Mark 2 offers through-grommet insertion and extraction of contacts for wiring and maintenance simplicity, and also exceeds

all the requirements of MIL-C-25955.

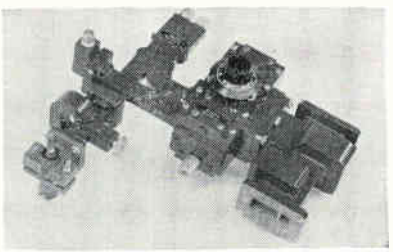
CIRCLE 376 ON READER SERVICE CARD



Laser Power Supply
FOR RAPID CYCLING

ELECTRO POWERPACS, INC., 5 Hadley St., Cambridge 40, Mass. Model 275 optical maser light pump power supply is available for rapid cycling. Improved circuitry and components allow cycling rates of 2 sec at 2,000 joules 4 Kv, and 5 sec at 4,000 joules 4 Kv for limited periods. The power supply and capacitor banks are designed as versatile laboratory tools to permit laser research under widely variable conditions of pumping.

CIRCLE 377 ON READER SERVICE CARD



Parametric Amplifier
C-BAND

AERONCA MFG. CORP., Friendship Airport, Baltimore, Md. The PA-C-3 parametric amplifier, which complies with MIL-E-5400, is a reflection type, negative resistance, low noise r-f amplifier designed for wide use in radar and communications systems. A model of this amplifier installed on an AN/MPS-16 C-band radar provided an improvement of 6 db in signal to noise ratio and 40 percent increases in range.

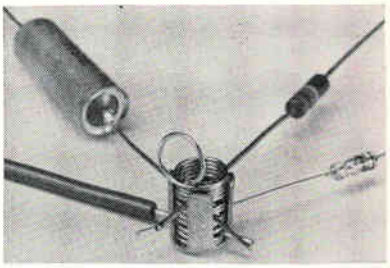
CIRCLE 378 ON READER SERVICE CARD

Microwave System

LENKURT ELECTRIC CO., INC., San Carlos, Calif. Type 76A microwave system is for operation in the 6,000-Mc band for transmission of

color tv, up to 600 carrier-derived voice channels, or equivalent amounts of other signals.

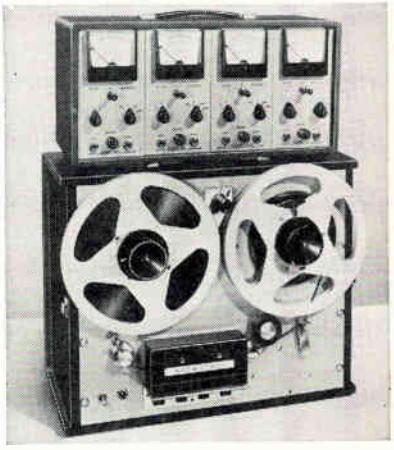
CIRCLE 379 ON READER SERVICE CARD



Solderless Connector
TIME SAVING DEVICE

COSMIC VOICE, INC., Box 11, Jackson, Mich. The Omni-Grip type A connector was designed for use with educational electronic experimenters' kits and demonstration boards for making rapid yet positive connection of wire leads from various components. It will hold a multiplicity of leads stranded or solid up to No. 14 wire size. Price is $1.20 per package of 12.

CIRCLE 380 ON READER SERVICE CARD



Data Recording System
MULTICHANNEL

MNEMOTRON CORP., 47 S. Main St., Pearl River, N.Y. Designed around the pulsed f-m principle, compact transistorized circuitry, and modular assembly system, the portable 4-channel model M204 handles all analog data from 0-800 cps. It performs time scale contraction and expansion, dynamic simulation, programming, and computer read-in and read-out. System achieves 0.2 percent precision and sells for $3,495 complete with tape transport.

CIRCLE 381 ON READER SERVICE CARD

PRODUCT BRIEFS

BAND PASS FILTERS for audio frequencies. Circuitdyne Corp., 480 Mermaid Ave., Laguna Beach, Calif. (382)

SILICON TUNNEL DIODES high current. Hoffman Semiconductor Division, 1001 N. Arden Drive, El Monte, Calif. (383)

INSTRUMENT RECTIFIER subminiature. Conant Laboratories, Box 3997, Bethany Station, Lincoln, Neb. (384)

FERRITE ISOLATORS lightweight, broadband. Sylvania Electric Products Inc., 1100 Main St., Buffalo 9, N. Y. (385)

TRANSISTORIZED OSCILLOSCOPES weigh under 27 lb. Allan B. Dumont Laboratories, 750 Bloomfield Ave., Clifton, N. J. (386)

CARRIER AMPLIFIER miniaturized. Crescent Engineering & Research Co., 5440 N. Peck Road, El Monte, Calif. (387)

NANOSEC DELAY LINES for logic circuits. Bel Fuse Inc., 198 Van Vorst St., Jersey City, N.J. (388)

MICROAMMETER ultrasensitive. De-Jur-Amsco Corp., Northern Boulevard at 45th St., Long Island City 1, N.Y. (389)

STATIC INVERTERS solid state. Pesco Products Division, Borg-Warner Corp., 24700 N. Miles Blvd., Bedford, O. (390)

MAGNETIC AMPLIFIERS d-c to d-c. Military & Computer Electronics Corp., 900 N.E. 13th St., Ft. Lauderdale, Fla. (391)

FREQUENCY STANDARD crystal controlled. Greenray Industries, Inc., 5281 E. Simpson Road, Mechanicsburg, Pa. (392)

ELECTRONIC PROCESS TIMER aid to automation. Richard Allan Radio Ltd., Box 3, Taylor St., Batley, Yorkshire, England. (393)

RELATIVE HUMIDITY INDICATOR compact, light-weight. Cybernetics, Inc., 136 Washington St., Paterson 1, N.J. (394)

SYNCHRO RESOLVER size 15 winding compensated. Kearfott Div., General Precision, Inc., 1150 McBride Ave., Little Falls, N.J. (395)

Literature of the Week

VSWR MEASUREMENT PRD Electronics, Inc., 202 Tillary St., Brooklyn 1, N. Y., has available a report entitled "Measurement of VSWR in Coaxial Systems." (396)

MINIATURE CONNECTORS General RF Fittings, Inc., 702 Beacon St., Boston 15, Mass., has issued an 8-page catalog on miniature TPS connectors. (397)

LABORATORY CONTROLLER Brooks Instrument Co., Inc., Hatfield, Pa. Bulletin 850 covers the Brookstat laboratory controller, a portable instrument for automatic regulation of temperature. (398)

INDUSTRIAL SOLDERING IRONS General Electric Co., Schenectady 5, N. Y. Bulletin describes industrial soldering irons rated 6 to 230 v, 12 to 1,250 w. (399)

VARACTOR HARMONIC GENERATORS Microwave Associates, Inc., Burlington, Mass. A 12-page booklet, "Varactor Harmonic Generators as Power Sources at Microwave Frequencies," is available. (400)

SNAP-ACTION SWITCHES Fansteel Metallurgical Corp., North Chicago, Ill. Data bulletin describes subminiature snap-action switches. (401)

COATED PRODUCTS Minnesota Mining and Mfg. Co., 900 Bush Ave., St. Paul 6, Minn. Brochure on coated products for temperature Class H applications. (402)

THERMOCOUPLE SIGNAL CONDITIONER Astra Technical Instrument Corp., 9905 W. Jefferson Blvd., Culver City, Calif. Bulletin 201 describes model TSC-1 thermocouple signal conditioner. (403)

RECEIVER PREAMPLIFIERS Defense Electronics, Inc., 5451-B Randolph Rd., Rockville, Md. Description, specifications and prices of the RPA series receiver preamplifiers are given in a data sheet. (404)

SWEEP SIGNAL GENERATOR Telonic Industries, Inc., Beach Grove, Ind. Technical bulletin T-233A describes model SM-2000 sweep and signal generator. (405)

TELEMETRY FILTERS PCA Electronics, Inc., 16799 Schoenborn St., Sepulveda, Calif., has available a

catalog sheet on band pass telemetry filters. (406)

INTERROGATORS Information Products Corp., 156 Sixth St., Cambridge, Mass. Random access file interrogators are covered in a 24-page technical brochure. (407)

TRANSFER VOLTMETER Ballantine Laboratories, Inc., Boonton, N.J., offers a 4-page catalog folder on the model 393 high frequency transfer voltmeter. (408)

CIRCUIT MODULES General Instrument Semiconductor Division, 65 Gouverneur St., Newark 4, N. J. Bulletin deals with a line of encapsulated circuit modules. (275)

CARBON FILM RESISTORS Asahiohm Co., Ltd., No. 745 Iwamurada, Asama-Machi, Nagano Prefecture, Japan, has issued a brochure on fixed precision deposited carbon film resistors. (276)

H-F CAPACITORS Erie Resistor Corp., 644 W. 12th St., Erie, Pa. Gold-Seal Button-Mica capacitors are described in a 10 page bulletin 500-1. (277)

SILICON RECTIFIERS Slater Electric Inc., 45 Sea Cliff Ave., Glen Cove, L.I., N.Y. Data sheet covers a series of miniature hermetically sealed rectifiers. (278)

ELECTRICAL RESINS Marblette Corp., 37-31 Thirtieth St., Long Island City 1, N.Y., has issued a revised edition of its "Maraset Electrical Resins Selector." (279)

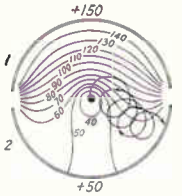
SILICON SOLAR CELLS Bausch & Lomb Inc., Military Products Division, Rochester 2, N. Y., has published a report on the emissivity enhancement of solar cells for temperature control. (280)

LINE VOLTAGE REGULATORS Perkin Electronics Corp., 345 Kansas St., El Segundo, Calif., has issued a bulletin listing specifications of a-c line voltage regulators. (281)

POWER CONNECTORS The Lionel Corp., 1226 Flushing Ave., Brooklyn 37, N.Y. Data sheets contain information on two series molded pin power connectors. (282)

DELAY LINES Computer Devices Corp., 6 W. 18th St., Huntington Station, N.Y. Bulletin describes standard magnetostrictive delay lines covering the range from 2 to 5,000 μsec. (283)

NEW BOOKS



Electron paths in a split-anode magnetron

Functional Circuits and Oscillators

By HERBERT J. REICH

D. Von Nostrand Co., Inc. Princeton, N. J., 1961, 466 *p*, $12.50

EMPHASIS on analysis and characteristics of basic circuits, rather than on a step-by-step approach to the design of specific circuits, provides a valuable design tool. With this book the reader can synthesize circuits to meet given requirements. Even with this general approach, many of the 327 figures provide numerical values of circuit elements.

Circuits covered are in three general groups: oscillators, negative-resistance devices and other functional circuits. Summing circuits, differentiators, integrators, clippers, gates and non-linear simulators are some of the functional circuits treated.

Usefulness of the book has been enhanced by dividing the subject into sections rather than chapters. Of the 93 sections, 22 treat sine-wave oscillators. Detailed contents and index aid in pinpointing location of the many topics. An indication of the scope of Prof. Reich's work are the references. Over 300 different authors (many with more than one citation) are listed.

This text helps fill the gap between the many detailed works that are mostly mathematical exercises and the handbooks that take a cookbook approach to circuit design.— M.M.P.

Electronic Maintainability, Volume 3

Edited by F. L. ANKENBRANDT

Engineering Publishers, Elizabeth, N. J., 312 *p*, $10

THIS BOOK is based on the Third Electronic Industries Association

Conference on Maintainability of Electronic Equipment. It contains a group of papers written by workers in this field. Their authoritative discussions include a broad range of subject material: military equipment, including aircraft and shipboard, and problems of maintaining space flight equipment are among the specifics discussed. A number of more general subjects are presented. These include human factors, system maintainability, cost factors, maintainability measurement, and spare parts requirements. Altogether, the book has a great deal of valuable information for electronic engineers engaged in a wide range of activities.—L.D.S.

Field Theory of Guided Waves

By ROBERT E. COLLIN
McGraw-Hill Book Co., Inc, New York, 606 *p*, $16.50.

AS STATED by the author in his preface, "Field Theory of Guided Waves" is "a comprehensive account of guided wave theory at the graduate level". It is one of the first few text books where a coherent and logical account of the mathematical techniques and electromagnetic solutions for waveguide structures, waveguide discontinuities, and coupling apertures, are presented. The title emphasizes the more basic and more general field approach to guided waves as opposed to the equivalent circuit approach.

The outstanding quality of the book lies in the wealth of mathematical techniques made available to the reader and their applications to the solution of many guided wave problems. The author is to be commended on his treatment of Green's functions in solving differential equations with specified boundary conditions such as excitation of waveguides.

As mentioned by the author in his preface, no attention is given to the theory of cavities and electronic waveguides. It is hoped that they may be included in a companion volume.

An excellent set of problems is included at the end of every chapter. The book is to be recommended to physicists, electrical engineers, and researchers engaged in the theory and practice of microwave structures.—H. HODARA, *Head of Space Communications, Research and Development Div., The Hallicrafters Co., Chicago, Ill.*

Traveling—Wave Engineering

By RICHARD K. MOORE
McGraw-Hill Book Co., Inc., New York, 360 *p*, $11

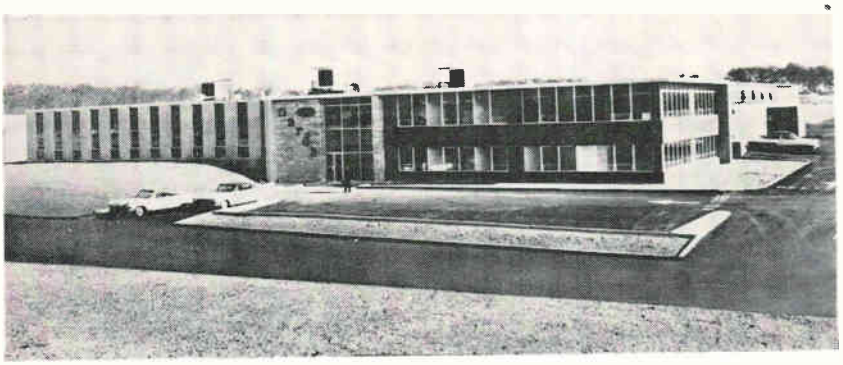
USE OF this book as a college text permits broadening the traditional electrical engineering courses in transmission lines. Each topic is first taken up for the transmission line or for electromagnetic waves in space. Examples are drawn from transmission lines and from the various non-electrical waves. This is the first book to be published which discusses the analogies between so many different types of waves. Thus it can be very valuable to both the student and the practicing engineer.

Examples illustrating each new principle follow the introduction of the principle itself. Problems are included, both to illustrate the principles and to acquaint the student with practical magnitudes in the various fields. Rationalized mks units are used throughout to avoid the complication of conversion factors—L.D.S.

Field Computations in Engineering And Physics

By A. THOM and C. J. SPELT
D. Van Nostrand Co., Inc., London, England 1961, 165 *p*, $5.75.

SQUARING, a numerical methods approach used to solve problems in applied mathematics, is the real subject of this book. In essence the squares method, first developed by co-author Thom in 1928, is a systematic method of iteration to which special techniques have been added for accelerating convergence to an actual solution using either desk calculators or more sophisticated electronic computers. Engineers who are looking for numerical solutions to partial differential equations of the elliptic type will find that this comprehensive, clearly-written and practical book will make their work simpler and less time consuming.—WEB



Narda Completes Expansion Move

IN A MAJOR EXPANSION of its facilities, Narda Microwave Corp., recently moved to its new $500,000 plant at Plainview, N. Y. The move doubles Narda's manufacturing capacity. Covering 40,000 sq ft on a 3½-acre site, it is located at Engineers Hill, an industrial park. The park will provide more than 500,000 sq ft of manufacturing facilities eventually.

The new plant has a split-level design, uniting the best features of a one-level plant with a bi-level plant's space efficiency. The one-story section is used for manufacturing and assembly area, while the two-story section houses a laboratory and administrative offices.

Narda manufactures microwave and uhf components and test equipment. Company reports its products are being used in almost every U. S. missile and space program.

The move (over a weekend) from five small buildings in Mineola and Westbury is Narda's sixth expansion since it was incorporated in 1954. A model of the new plant was built for planning purposes. Under the direction of Narda's assembly foreman, Joseph H. Delaney, a comprehensive schedule of the actual move was begun a year ago so that there would be a minimum interruption of production.

Dunn Engineering Names Rudd

WALTER E. RUDD, formerly with Electro-Instruments, Inc., has been named Northwest district sales manager of Dunn Engineering Corp., Cambridge, Mass.

Prior to serving with Electro-Instruments, Rudd was a research engineer with the Lockheed Missile and Space division and the Autonetics division of the North American Aviation, Inc.

Frenchtown Porcelain Forms New Division

GENERAL BATTERY AND CERAMIC CORP. has created an electronic components division at its Frenchtown Porcelain Co. subsidiary, Frenchtown, N.J., to meet the demand for design and assembly of alumina and beryllia ceramics-to-metal seals, and similar components for the electronic industry.

At the same time, Ralph L. Sherwood, former manager of industrial device design of RCA's semiconductor and material division, was appointed a vice president and manager of the new Frenchtown division.

Servomechanisms Hires Moyer

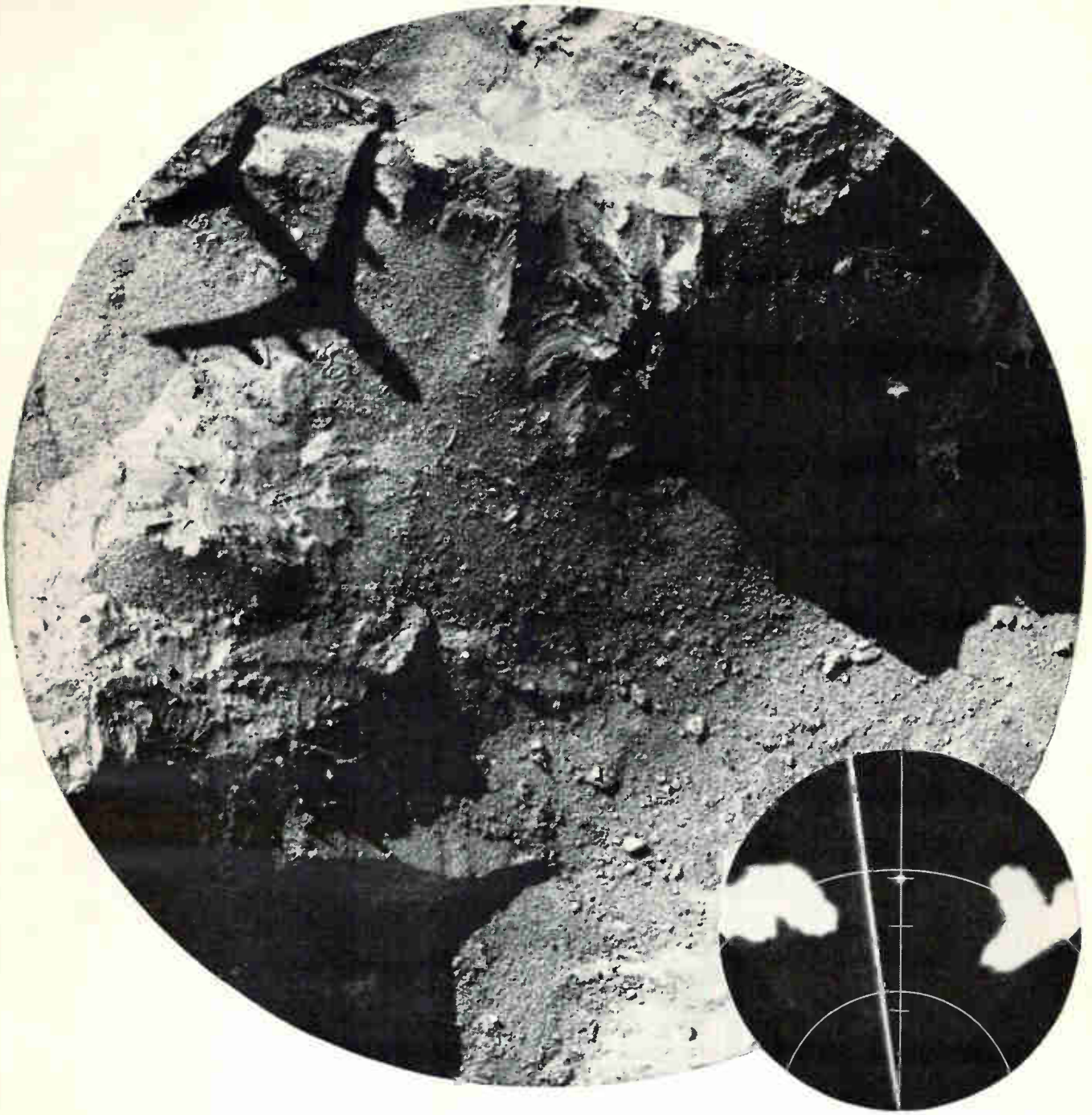
JAMES W. MOYER has joined Servomechanisms/Inc., Santa Barbara, Calif., as director of research of the company's R&D Center.

Before coming to SM/I, Moyer was director of research at the Sperry Rand Research Center, Sudbury, Mass.

Elsner Moves Up At Motorola

RALPH W. ELSNER has been appointed engineering manager of Western Center, Motorola Military Electronics division, Scottsdale, Ariz. He will plan and direct the business and technical efforts of both the radar systems laboratory and the communications, navigation and data processing laboratory.

Elsner was formerly manager of the radar systems laboratory. He has been with Motorola for the past 12 years as project leader, section



ENGINEERS ARE CHARTING A NEW COURSE AT AC

AC's newest assignment is Systems Integrator for the modified B-52C&D Bombing Navigation System. AC's responsibility includes program and engineering integration, and coordination of associate contractors in the production phase. ■ Other programs at AC include a new, miniaturized inertial guidance system for the TITAN II missile. In addition, AC's Los Angeles Advanced Development Laboratory is currently developing Advanced INertial Guidance Systems. ■ AC is seeking qualified men to work on these important projects. If you have a BS, MS or PhD in Electrical Engineering, Mechanical Engineering or Physics, please contact Mr. G. F. Raasch, Director of Scientific and Professional Employment, Dept. 5753, 7929 South Howell, Milwaukee 1, Wisconsin. An Equal Opportunity Employer. ■ Immediate positions available:

Milwaukee

Radar Systems Engineers • Radar Test Engineers
Radar Reliability Engineers • Design Review Engineers
Contact Engineers • Field Service Engineers

Los Angeles

(Advanced Inertial Guidance Systems—Airborne Computers)
Transistor Circuit Design Engineers
Sr. Digital Computer Development Engineers

■ AChiever Inertial Guidance Systems for TITAN II, THOR and MACE—Bombing Navigation Systems for the B-52C&D and B-47—AChieverfone mobile radiotelephones.

AC SPARK PLUG ⚛ THE ELECTRONICS DIVISION OF GENERAL MOTORS

MILWAUKEE • LOS ANGELES • BOSTON

head, assistant chief engineer, and laboratory manager.

Brite Assumes New Position

LEIGH A. BRITE was recently named vice president in charge of the Technical Products division of Packard Bell Electronics, Los Angeles, Calif. He will be responsible for the company's broadened activity in the communications and industrial electronic fields.

Brite was formerly associated with the Aeronutronic Division of Ford Motor Co. as manager of space electronics.

Eitel-McCullough Appoints Cisne

LUTHER E. CISNE has joined Eitel-McCullough, Inc., San Carlos, Calif., as manager of the Microwave Tube division.

Prior to joining Eimac he was assistant to the division manager of the Sperry Electronic Tube division in Gainesville, Fla.

Announce Opening Of New Company

ADVANCED MICROELECTRONICS CO., a newly organized firm, was recently opened in Silver Spring, Md. According to its president, Martin A. Karp, the company is designing

and fabricating evaporated thin film circuits.

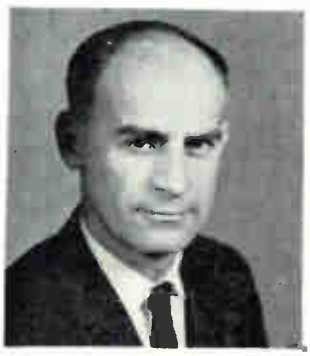
Other officers of the firm include: J. C. Karp, vice president; Aubrey A. Arnn, treasurer; James Connell, secretary; and Victor J. Orsinger, a director. Saul Naimark, a former National Research Corp. scientist, will be in charge of the vacuum system line.

Duramic Products Elects Saso

CHARLES SASO has been elected president of Duramic Products, Inc., Palisades Park, N.J.

With the firm since it was organized in 1955, Saso was vice president and general plant manager prior to his elevation to the presidency. He succeeds Herbert Schwartz, who left the company in July.

Duramic produces ceramic tools and molds for semiconductor and other electronics manufacturers.



Avco Division Names Flowers

HAROLD L. FLOWERS has been appointed general manager of engineering for the electronics operation of Avco's Electronics and Ordnance division, Cincinnati, O. He was formerly director of weapon systems for the Goodyear Aircraft Corp. in Akron, O.

(continued on p 214)

Wellington Electronics Names Two Executives

APPOINTMENT of Pat R. Pondy and Harland S. Fisher to executive staff positions is announced by Wellington Electronics, Inc., Englewood, N.J.

Pondy, formerly a member of the technical staff of Bell Telephone Laboratories, was named director of research and development.

Fisher, formerly vice president, engineering, of the Crompton & Knowles Packaging Corp., becomes director of engineering.

Wellington Electronics manufactures etched foil and automatic machinery for the capacitor manufacturing industry.

PEOPLE IN BRIEF

Sylvania advances **Murray Falkowitz** to manager of the project management office at its Reconnaissance Systems Laboratory. **Robert L. Rudolph** leaves Heintz Div. of Kelsey Hayes Co. to join Synthane Corp. as assistant chief engineer. **Charles A. Savant**, ex-Northrop Corp., named associate director of the systems analysis and data processing group at Space-General Corp. **Leon Levitt**, formerly with Telecomputing Corp., appointed director of corporate planning at Monogram Precision Industries, Inc. Cohu Electronics, Inc., Kin Tel Div., has promoted **Melvin A. Zentz** to factory superintendent. **John A. Hrones**, v-p for academic affairs of Case Institute of Technology, elected a director of CompuDyne Corp. **Carl A. Georgi** of the Bendix Corp. moves up to asst. g-m of the Friez Instrument div. **Joseph Petras**, previously with Radiation, Inc., is now project engineer of the instrumentation group at EDP Corp. Westinghouse Electric Corp. promotes **Clarence H. Lewis** to manager of its astroelectronics laboratory. **Edward H. Twaits**, formerly with the Plessey Co., joins Amphenol-Borg Ltd. as g-m of the electronics div. **Andrew Kaul III**, chairman and chief executive officer of Speer Carbon Co., Inc., elected a director of the parent firm, AirReduction Co., Inc. **Louis P. Polries** leaves Franklin Mfg. Co. to join Seco Electronics Inc., as director of R&D.

EMPLOYMENT OPPORTUNITIES

electronics

WEEKLY QUALIFICATION FORM FOR POSITIONS AVAILABLE

ATTENTION: ENGINEERS, SCIENTISTS, PHYSICISTS

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

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

STRICTLY CONFIDENTIAL

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

WHAT TO DO

1. Review the positions in the advertisements.
2. Select those for which you qualify.
3. Notice the key numbers.
4. Circle the corresponding key number below the Qualification Form.
5. Fill out the form completely. *Please print clearly.*
6. Mail to: D. Hawksby, Classified Advertising Div., ELECTRONICS, Box 12, New York 36, N. Y. (No charge, of course).

COMPANY	SEE PAGE	KEY #
A C SPARK PLUG Electronics Div. of General Motors. Corp. Milwaukee, Wisconsin	211	1
ESQUIRE PERSONNEL Chicago, Illinois	137*	2
HUGHES AIRCRAFT COMPANY Tucson Engineering Lab. Tucson, Arizona	111*	3
I B M CORP. New York, New York	217	4
INTERNATIONAL NICKEL CO., INC. New York, New York	137*	5
JET PROPULSION LABORATORY Pasadena, California	216	6
JOHNSON CONTROLS Milwaukee, Wisconsin	221	7
LAWRENCE RADIATION LABORATORY Livermore, California	221	8
LOCKHEED CALIFORNIA CO. A Div. of Lockheed Aircraft Corp. Burbank, California	21*	9
MOTOROLA, INC. Military Electronics Div. Western Center Scottsdale, Arizona	220	10
NATIONAL CASH REGISTER CO. Electronics Division Hawthorne, California	60*	11
NATIONAL SCIENTIFIC LABORATORY, INC. Washington, C. D.	220	12

CONTINUED ON PAGE 221

(cut here) (cut here)

electronics WEEKLY QUALIFICATION FORM FOR POSITIONS AVAILABLE

Personal Background

NAME .....

HOME ADDRESS.....

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

HOME TELEPHONE.....

Education

PROFESSIONAL DEGREE(S).....

MAJOR(S) .....

UNIVERSITY .....

DATE(S) .....

FIELDS OF EXPERIENCE (Please Check)

11171

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

CATEGORY OF SPECIALIZATION

Please indicate number of months experience on proper lines.

	Technical Experience (Months)	Supervisory Experience (Months)
RESEARCH (pure, fundamental, basic)	.....	.....
RESEARCH (Applied)	.....	.....
SYSTEMS (New Concepts)	.....	.....
DEVELOPMENT (Model)	.....	.....
DESIGN (Product)	.....	.....
MANUFACTURING (Product)	.....	.....
FIELD (Service)	.....	.....
SALES (Proposals & Products)	.....	.....

CIRCLE KEY NUMBERS OF ABOVE COMPANIES' POSITIONS THAT INTEREST YOU

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25

does

$$X^n + Y^n = Z^n$$

?

Pierre de Fermat's last theorem states that the above equation has no solutions in which x, y, and z are positive whole numbers if "n" is a whole number greater than two. Mathematicians have yet to prove him wrong.

But their attempts to prove the theorem (or conjecture, since it *hasn't* been proved) have produced some of the most revolutionary concepts in modern algebra and number theory!

Questions are what answers are made of. Questions about our universe, for example. What is the Moon made of? Is there life on other planets? The answers are coming from Cal Tech's Jet Propulsion Laboratory for the National Aeronautics and Space Administration.

JPL scientists and engineers are supervising the design of spacecraft and their instruments to be sent to the Moon and planets. Ranger, Surveyor, Mariner. Some day, they'll be remembered as our first steps into space.

Today, they're a job to do. And a fascinating job at that. If you'd like to put your experience to work on this kind of a job, maybe JPL is your kind of place. Write to us and find out. It never hurts to ask questions.

JET PROPULSION LABORATORY

4814 OAK GROVE DRIVE, PASADENA, CALIFORNIA

Operated by California Institute of Technology for the National Aeronautics & Space Administration

All qualified applicants will receive consideration for employment without regard to race, creed or national origin/U.S. citizenship or current security clearance required.

Within the next few years a powerful astronomical observatory will be placed in orbit outside the distortion of the earth's atmosphere. The space observatory will look at interstellar matter, map the sky's ultraviolet light and perform other experiments to help scientists understand how stars and nebulae are born.

IBM is developing an advanced memory system to go aloft in this satellite and store its observations. The system will receive instructions from the ground, help aim the satellite's instruments and hold collected data for periodic radio transmission back to earth.

The new space memory, being developed by IBM for Grumman Aircraft Engineering Corporation and the Goddard Space Flight Center of the National Aeronautics and Space Administration, called for some unusual solutions from IBM engineers. For example, they were able to reduce power demands considerably by designing the memory to read out information over and over without writing it back into memory each time. Another significant accomplishment is the remarkable design reliability of the new system, achieved through new techniques of redundant circuitry.

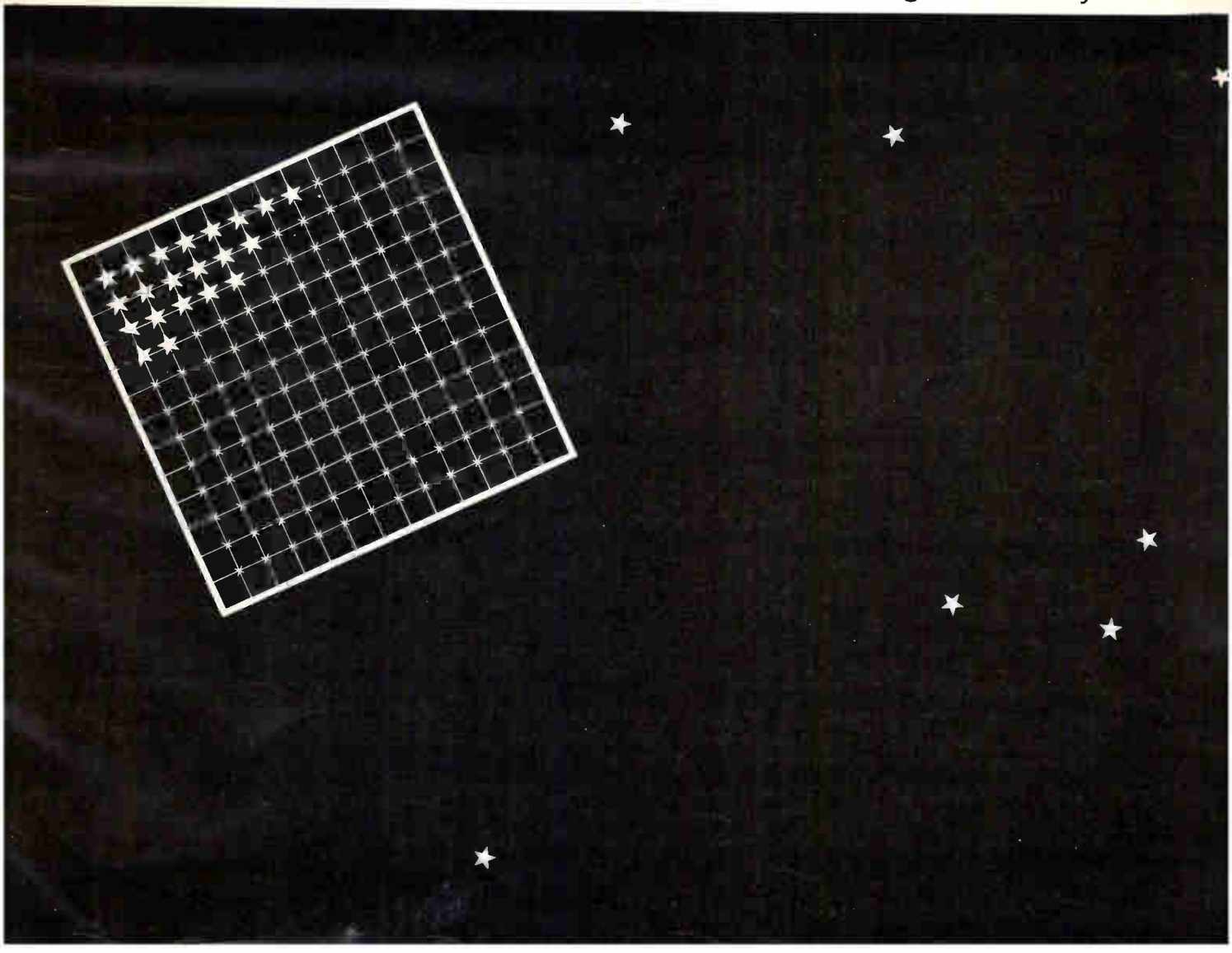
Solving problems like these in systems development requires imagination that can travel easily back and forth across technical disciplines. At IBM, people with this kind of imagination are making important advances in such areas as semiconductors, microwaves, magnetics and superconductivity. If any of these fields interests you —and you have a degree and experience in engineering, mathematics or one of the sciences—we'd like to hear from you.

All qualified applicants will receive consideration without regard to race, creed, color or national origin. Please write:

Manager of Technical Employment
IBM Corporation, Department 554L3
590 Madison Avenue
New York 22, New York

IBM

SATELLITE MEMORY SYSTEM: Control Center For An Orbiting Observatory



Philco WDL has immediate and challenging engineering positions open in Discoverer, Midas and Advent programs in these categories:

Data systems engineering

Technical Staff — communications and data systems

Systems test planning

Systems reliability analysis

Design Engineering — surface and vehicle electronics

Human factors and operations analysis

Field tracking station activation

Tracking and control systems design

Logistics and station support

And others

All qualified applicants will receive consideration for employment without regard to race, creed, color or national origin; U. S. citizenship or current transferable Department of Defense clearance required.

if your future is for growing...

People at Philco's Western Development Laboratories are proud of their achievements, secure in the steady growth of their company, enthusiastic about their future.

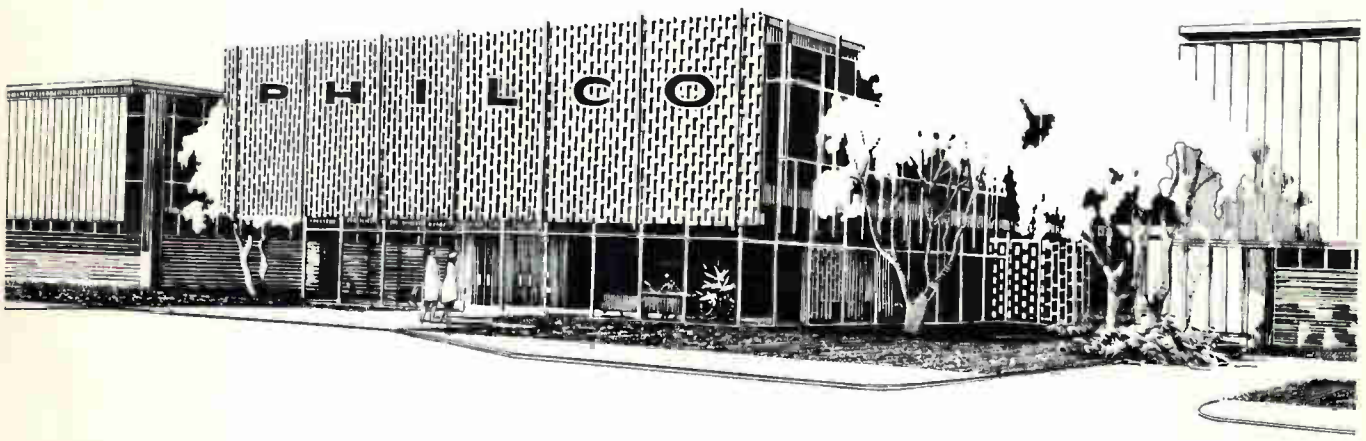
In just four years, Philco WDL has expanded from a staff of 18 to more than 2,000. At the end of this year WDL will open a new 250,000-square-foot facility which will accommodate a continually expanding complement of engineers, scientists and supporting staff members.

Philco WDL, the space organization which designed and built the Courier satellite, conducts an ever-growing development program in tracking, satellite instrumentation, communications, data processing and command—moving hand in hand with the federal government in space exploration and space age defense.

Your growth with a growing company, ideal living on the Northern California Peninsula, professional and monetary advancement commensurate with your own ability—these are some of the advantages and satisfactions of working at Philco Western Development Laboratories.

If yours is one of the fields listed at the left, write today to Mr. W. E. Daly, in confidence, of course, Department E-11.

This new 250,000-square-foot addition to Philco Western Development Labs will open by the end of the year.



PHILCO
Famous for Quality the World Over

WESTERN DEVELOPMENT LABORATORIES
3875 Fabian Way, Palo Alto, California

NEW OPPORTUNITIES and warm winter SUNSHINE can be yours at MOTOROLA in PHOENIX

Motorola's widely-diversified activities in advanced military electronics assure engineers and scientists the fullest measure of growth potential—in the immediate future and in the years ahead. As a member of a project team, you participate in challenging state-of-the-art assignments spanning a broad field of engineering concepts. Your career will prosper at Motorola in Phoenix, where initiative and creativity earn recognition and rewards.

Your family will prosper, too, in a dry, sunny climate that's world-famous. You can play golf, swim, enjoy patio barbecues every month of the year. There are many near-by lakes for boating, water-skiing and fishing. Skin diving and deep-sea fishing are sports you can enjoy any weekend in the warm waters of Old Mexico.

Investigate the new career opportunities at Motorola in Phoenix.

POSITIONS IMMEDIATELY AVAILABLE

- **Systems Test Equipment Design**
- **Communications and Navigation**
- **Systems Analysis and Preliminary Design**
- **Missile and Space Guidance and Control**
- **Digital Circuitry Design**
- **Microwave and Radar**
- **Reliability and Components**
- **Solid State**

Write Phil Nienstedt (Dept. 1105)

MOTOROLA

MILITARY ELECTRONICS DIVISION, WESTERN CENTER

P. O. Box 1417, Scottsdale, Arizona

Motorola also offers opportunities at
Chicago, Illinois, and at Culver City and Riverside, California

An Equal Opportunity Employer

BSEE

2 or more years experience in Electronics-Radar-Radio-Avionics. Field Engineering experience desirable.

Assignments—U. S. and overseas.

Send resume to I. F. Markham

National Scientific Laboratories, Inc.
2010 Massachusetts Ave. N. W.
Washington 6, D. C.

POSITION VACANT

Positions Available at the Naval Air Material Center. Philadelphia 12, Pa. Engineers (mechanical, general, electrical, structural and electronic) and Technologists (aviation survival equipment, rubber, plastics and packaging and preservation) are urgently needed at the Naval Air Material Center. The Center is engaged in research, development, evaluation and test of aircraft and aeronautical materials and the standardization of Naval weapons. Responsibilities extend into the fields of missiles, space and nuclear energy. Starting salaries range from $5355 to $10,635 per annum. Application for employment should be filed with the Naval Air Material Center, Philadelphia 12, Pa.

FOR INFORMATION

About Classified Advertising

Contact The McGraw-Hill Office Nearest You

ATLANTA, 9
1375 Peachtree St. N. E. *TRinity 5-0523*
D. HICKS

BOSTON, 16
Copley Square COngress 2-1160
M. SHOUVLIN

CHICAGO, 11
645 No. Michigan Ave. MOhawk 4-5800
W. J. HIGGENS · W. SONZSKI

CLEVELAND, 13
1164 Illuminating Bldg. SUperior 1-7000
I. C. HILL

DALLAS, 2
1712 Commerce St., Vaughn Bldg.
RIverside 7-9721
J. GRANT

DENVER, 2
1700 Broadway, Tower Bldg.
ALpine 5-2981
J. PATTEN

DETROIT, 26
856 Penobscot Bldg. WOodward 2-1793
WM. H. GINDER, JR.

HOUSTON, 25
Prudential Bldg., Room W-724
Holcombe Blvd. JA 6-1281
GENE HOLLAND

LOS ANGELES, 17
1125 W. 6th St. HUntley 2-5450
W. C. GRIES

NEW YORK, 36
500 Fifth Ave. OXford 5-5959
H. T. BUCHANAN—R. P. LAWLESS
T. W. BENDER-P. BOND

PHILADELPHIA, 3
Six Penn Center Plaza LOcust 8-4330
W. B. SULLIVAN

PITTSBURGH, 22
4 Gateway Center EXpress 1-1314

ST. LOUIS 3
7751 Carondelet Ave. PArkview 5-7285
R. BOWMAN

SAN FRANCISCO, 11
255 California St. DOuglas 2-4600
J. A. HARTLEY

LAWRENCE RADIATION LABORATORY

ELECTRONIC ENGINEERS: B.S. or higher degree in E.E. Openings in:

Systems Engineering
Environmental Instrumentation Engineering
Digital Computer Circuitry
Transistor Circuitry
Pulse Circuitry
General Design
Reliability
Quality Control
Liaison Engineering

The Lawrence Radiation Laboratory in the San Francisco Bay Area is operated by the University of California for the United States Atomic Energy Commission.

Current projects are in the area of nuclear explosives for industry and defense, nuclear propulsion, controlled thermonuclear reaction, space physics, and other advanced problems in nuclear physics and engineering.

For additional information, address inquiries to the

PERSONNEL DEPARTMENT

LAWRENCE RADIATION LABORATORY

P.O. BOX 808 MG
LIVERMORE, CALIFORNIA

U. S. Citizenship Required

An Equal Opportunity Employer

IMMEDIATE OPENINGS . . . . . .

For men with following qualifications in R&D (In Milwaukee, Wisconsin)

B.S.E.E. 2-4 years experience in Industry. Experience in Logic and Telephone Typeswitching circuits necessary. Knowledge and modification of commercially available components are essential. Vacuum Tube and solid state design experience desirable.

SALES ENGINEERING . . . . . .

(In variety of locations across U.S.)

B.S. in any branch of Engineering. Sales Aptitude.

John M. Hilgers
Johnson Controls
Milwaukee 1, Wisconsin

---

electronics

WEEKLY QUALIFICATIONS FORM FOR POSITIONS AVAILABLE

(Continued from page 215)

COMPANY	SEE PAGE	KEY #
PAN AMERICAN WORLD AIRWAYS INC. Guided Missiles Range Div. Patrick AFB, Florida	67	13
PHILCO WESTERN DEVELOPMENT LABS. Palo Alto, California	219	14
REPUBLIC AVIATION CORP. Farmingdale, L. I., New York	218	15
TEXAS INSTRUMENTS INCORPORATED Apparatus Div. Dallas, Texas	221	16

* These advertisements appeared in the 11/10/61 issue.

ADVANCE WITH TI!

NEW GROWTH OPPORTUNITIES IN SYSTEMS AND COMPONENTS

ANTENNA THEORY SPECIALIST: Advanced degree desired. Position requires application of electromagnetic theory toward development of new antenna concepts as opposed to specific antenna design, antenna viewed as an information processor in a system as well as a collector of energy. Three to five years' experience.

MICROWAVE SPECIALIST: MS or PhD in physics or EE. Should have at least three years' experience in microwave device research. To assume responsibility for conducting research program on broadband parametric amplifiers, microwave plasma devices, millimeter wave devices, etc.

DIGITAL CIRCUIT SPECIALIST: Advanced degree in physics or EE desirable. Three to five years' experience, with good background in switching circuits, digital modulation and detection techniques, and other digital processing techniques as applied to sonar, radar and communications.

TEST EQUIPMENT ENGINEER: For advanced work in high-speed switching and pulse circuitry for computer applications. Broad experience in industrial areas of component instrumentation design, in quality control work, with background in systems intergradation.

Advance your career with Texas Instruments. Send confidential resume to:

HUGH WILLIAMS, Dept. 17,
APPARATUS DIVISION
TEXAS INSTRUMENTS
INCORPORATED
BOX 6015, DALLAS 22, TEXAS

An equal opportunity employer.

SEARCHLIGHT SECTION

(Classified Advertising)

BUSINESS OPPORTUNITIES

EQUIPMENT - USED or RESALE

DISPLAYED RATE

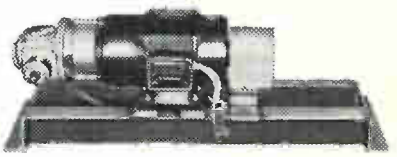
The advertising rate is $24.75 per inch for all advertising appearing on other than a contract basis. Contract rates quoted on request. AN ADVERTISING INCH is measured 7/8 inch vertically on one column, 3 columns—30 inches—to a page. EQUIPMENT WANTED or FOR SALE ADVERTISEMENTS acceptable only in Displayed Style.

UNDISPLAYED RATE

$2.40 a line, minimum 3 lines. To figure advance payment count 5 average words as a line.
PROPOSALS, 2.40 a line an insertion.
BOX NUMBERS count as one line additional in undisplayed ads.
DISCOUNT OF 10% if full payment is made in advance for four consecutive insertions of undisplayed ads (not including proposals).

---

400 CYCLE GENERATOR SETS



2 KW, single phase, 17.4 amps., 115 volts, 400 cycle electric generator set. Ideal test generator for laboratory use. Manufactured by LELAND for U. S. Navy. Ball bearing construction. Complete with Raytheon Spark Gap Modulator type CRP-10249. Unit is mounted on welded steel base. Dimensions: 43" L. x 18" W. x 20" H. F.O.B. Chicago.

No. ASC400MG Our Price... **$189.50**

Same generator, mounted on base with:

3 H. P. motor, 60 cycle, 1 phase... $295
3 H. P. motor, 60 cycle, 3 phase... $289
3 H. P. motor, 110 volt D. C..... $275

FREE CATALOG . . . Hundreds of other equipment bargains . . . write TODAY!

GROBAN SUPPLY COMPANY

1139 South Wabash Avenue, Dept. AS-11,
Chicago 5, Illinois • WEbster 9-3793

CIRCLE 460 ON READER SERVICE CARD

AUTO-TRACK & TELEMETRY ANTENNA PEDESTALS
3 & 10 CM. SCR. 584 AUTOTRACK RADARS.
AN/TPS-1D SEARCH. AN/TPS-10 HT. FINDERS.
AN/FPN-32GCA. AN/APS-10 NAVIG. & WEATHER.
AN/APS-15B PRECISION. AN/APQ-35B PRECISION.
AN/APS-31A SEARCH. DOZENS MORE.
S-1-2 MEGAWATT HIGH POWER PULSERS.
MICROWAVE PLUMBING—TEST EQUIP.
LARGEST RADAR STOCK IN U.S.A.
RADIO RESEARCH INSTRUMENT CO.
550 Fifth Ave. New York Judson 6-4691

RADAR SYSTEMS & COMPONENTS / IMMEDIATE DELIVERY

CIRCLE 461 ON READER SERVICE CARD

THE URGE TO MERGE!

One of our clients, a national sales and manufacturing organization currently marketing widely-known electronic products for consumers in department and automotive stores, chains, catalog houses, etc., would like to affiliate with small-to-medium electronics manufacturing company. Interested in merger, stock exchange or outright purchase. All replies kept strictly confidential. For information, write **AJR Co., Room 2300, 400 N. Michigan, Chicago 11, Illinois.**

CIRCLE 462 ON READER SERVICE CARD

INDEX TO ADVERTISERS

Audited Paid Circulation

• See Advertisement in the July 20, 1961 issue of Electronics Buyers' Guide for complete line of products or services.

• See Advertisement in the July 20, 1961 issue of Electronics Buyers' Guide for complete line of products of services.

CLASSIFIED ADVERTISING
F. J. Eberle, Business Mgr.

INDEX TO CLASSIFIED ADVERTISERS

• See Advertisement in the July 20, 1961 issue of Electronics Buyers' Guide for complete line of products or services.

This index and our Reader Service Numbers are published as a service. Every precaution is taken to make them accurate, but ELECTRONICS assumes no responsibilities for errors or omissions.

electronics

Audit Bureau of Circulations

Associated Business Publications

Audited Paid Circulation

JAMES T. HAUPTLI
Advertising Sales Manager

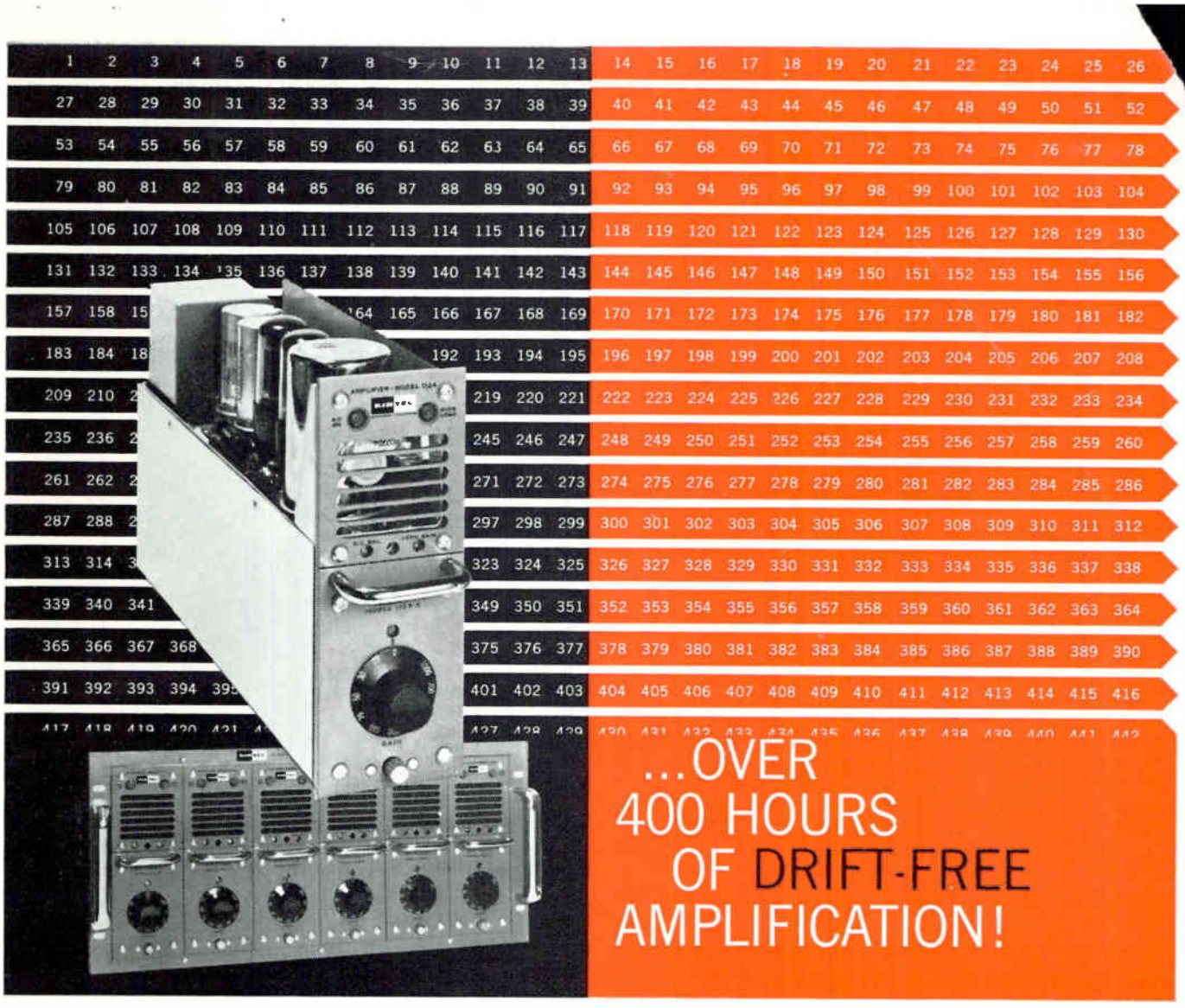
R. S. QUINT:
Assistant Publisher Buyers' Guide and Business Manager
FRED STEWART:
Promotion Manager
B. ANELLO:
Marketing Service Manager

RICHARD J. TOMLINSON:
Production Manager
GEORGE E. POMEROY:
Classified Manager
HUGH J. QUINN:
Circulation Manager

ADVERTISING REPRESENTATIVES

NEW YORK (36):
Donald H. Miller, Henry M. Shaw, George F. Werner, Robert M. Denmead
500 Fifth Avenue, OXford 5-5959
BOSTON (16):
William S. Hodgkinson, Donald R. Furth
McGraw-Hill Building, Copley Square, Congress 2-1160
PITTSBURGH (22):
David M. Watson
Four Gateway Center, Express 1-1314
PHILADELPHIA (3):
Warren H. Gardner, William J. Boyle
6 Penn Center Plaza, LOcust 8-4330
CHICAGO (11):
Harvey W. Wernecke, Martin J. Gallay
645 North Michigan Avenue, Mahawk 4-5800
CLEVELAND (13):
Paul T. Fegley
55 Public Square, Superior 1-7000
SAN FRANCISCO (11):
T. H. Carmody, R. C. Alcorn
255 California Street, Douglas 2-4600
LOS ANGELES (17):
Marshall Freeman, Peter S. Carberry
1125 W. 6th St., Huntley 2-5450

DENVER (2):
J. W. Patten
Tower Bldg., 1700 Broadway, Alpine 5-2981
ATLANTA (9):
Michael H. Miller
1375 Peachtree St. N.E., Trinity 5-0523
HOUSTON (25):
Joseph C. Page, Jr.
Prudential Bldg., Holcomb Blvd., Jackson 6-1281
DALLAS (1):
Frank Le Beau
The Vaughn Bldg., 1712 Commerce St.
Riverside 7-9721
LONDON W1:
Dennis McDonald
34 Dover St.
FRANKFURT/Main:
Stanley R. Kimes
85 Westendstrasse
GENEVA:
Michael R. Zeynel
2 Place du Port



...OVER 400 HOURS OF DRIFT-FREE AMPLIFICATION!

Less than 2μv of drift for over 400 hours of continuous operation! That's just one of the many outstanding features of KIN TEL's new 112A wideband DC amplifier—the unit that is the successor to KIN TEL's 111 series DC amplifiers. Frequency response is from DC to beyond 40 kc, output capability up to 45 volts. It has an integral power supply, fits the same cabinets and modules, and can be used to replace any KIN TEL Model 111 amplifier.

HIGH ACCURACY. The 112A amplifies microvolt-level signals from DC to 2 kc with a gain accuracy of ±0.5% on any gain setting, better than ±0.01% accuracy on individual gain settings by means of the Micro-Gain adjustment.

RELIABILITY. Overall dissipation has been reduced and reliability enhanced by replacing the tubes used in the 111 amplifier power supply with silicon rectifiers in the 112A. Special heat-conducting shields, heat sinks, and an improved mechanical layout further improve cooling efficiency. Polystyrene capacitors are used in all critical areas. Rugged, militarized components are used wherever compatible with required performance characteristics. Write today for technical information or demonstration.

PRICES:

112A Amplifier with a 112A-A plug-in unit that provides 10 gain steps from 20 to 1000 with 1 to 2 times vernier adjustment at each step . . . $625

112A Amplifier with a 112A-AO unit having the same 10 gains plus provisions for an external summing, integrating, or other operational network . . . $635

112A Amplifier with a 112A-B plug-in unit that converts the amplifier to a +1 unit having an input impedance over 10,000 megohms, a gain accuracy within ±0.001% . . . $615

112A Amplifier with a 112A-O empty plug-in unit for installing an internal summing, integrating, or other operational network . . . $575

Immediate delivery from stock in reasonable quantities.
Representatives in all major cities.

5725 Kearny Villa Road, San Diego 12, California, Phone: BRowning 7-6700

COHU ELECTRONICS, INC
KIN TEL DIVISION

RCA ANNOUNCES

New High-Voltage Silicon Rectifiers covering the full range from 1,200 to 10,000 PIV

10 RCA Diffused-Junction rectifiers with integral voltage-equalizing networks offer outputs up to 825 ma DC for military and industrial applications

Here's important new flexibility for your critical high-voltage rectifier applications—RCA's broad line of encapsulated, insulated multi-cell rectifiers. Check the benefits these rectifiers can bring to your designs:

- Integral voltage equalization—Resistor-capacitor equalization network across each internal rectifier cell equalizes voltage distribution under both transient and steady-state conditions.
- Ratings you can use with confidence—RCA rectifiers are designed to provide top performance at maximum published ratings. Conservative RCA ratings provide built-in safety factor.
- High output current:
  - —550 to 825 ma at 60°C. Single-phase, half-wave circuit.
  - —Up to 2.2 amps.—6 rectifiers in 3-phase full-wave bridge circuit.
  - —Up to 1.65 amps.—4 rectifiers in single-phase full-wave bridge circuit.
- High efficiency and excellent regulation—Each diffused-junction cell has only 0.6-volt maximum voltage drop (full cycle average).
- Wide operating and storage temperature range. —65° C to +125° C.
- Compact Size—2⅜ to 5½ cubic inches.
- Unique case design—allows rugged mounting; provides extra long corona path for added safety.
- Designed to meet military mechanical and environmental test specifications.

HALF-WAVE RECTIFIER SERVICE

Absolute-Maximum Ratings for Supply Frequency of 60 cps, Single-Phase Operation, and with Resistive or Inductive Load.

	CR101	CR102	CR103	CR104	CR105	CR106	CR107	CR108	CR109	CR110
Peak Inverse Volts	1200	2000	3000	4000	5000	6000	7000	8000	9000	10000
RMS Supply Volts	840	1400	2100	2800	3500	4200	4900	5600	6300	7000
DC Blocking Volts	1200	2000	3000	4000	5000	6000	7000	8000	9000	10000
Average Forward Milliamperes: At 60°C ambient temperature	825	825	715	605	605	550	550	550	550	550
At 100°C ambient temperature	320	320	275	235	235	210	210	210	210	210
Peak Recurrent Amperes	5									
Peak Surge Amperes: (One-half cycle, sine wave)	15									
Ambient Temperature Range: Operating and storage	−65 to +125 °C									

- "CR"-Series types may be used in series up to 20,000 PIV without added voltage equalization.

Custom designs are available for higher voltages, higher temperature, oil submersion, special packaging requirements.

Call your RCA REPRESENTATIVE today for full particulars on these 10 new rectifiers. For additional technical information, write RCA Semiconductor and Materials Division, Commercial Engineering, Section K-19-NN-3, Somerville, N. J.

AVAILABLE THROUGH YOUR RCA DISTRIBUTOR

The Most Trusted Name in Electronics
RADIO CORPORATION OF AMERICA

RCA FIELD OFFICES...EAST: Newark, N. J., 744 Broad St., HUmboldt 5-3900 • (Camden, N. J. area) Erlton, N. J., 605 Marlton Pike, HAzel 8-4802 • Syracuse, N. Y., 731 James St., Room 402, GRanite 4-5591 • Baltimore, Md., ENterprise 9-1850 • NORTHEAST: Needham Heights 94, Mass., 64 "A" St., Hillcrest 4-7200 • SOUTHEAST: Orlando, Fla., 1520 Edgewater Drive, Suite #1, GArden 4-4768 • EAST CENTRAL: Detroit 2, Mich., 714 New Center Bldg., TRinity 5-5600 • CENTRAL: Chicago, Ill., Suite 1154, Merchandise Mart Plaza, WHitehall 4-2900 • Minneapolis, Minn., 5805 Excelsior Blvd., WEst 9-0676 • WEST: Los Angeles 54, Calif., Box 54074, RAymond 3-8361 • (San Francisco area) Burlingame, Calif., 1838 El Camino Real, OXford 7-1620 • SOUTHWEST: Dallas 7, Texas, 7905 Carpenter Freeway, FLeetwood 7-8167 • GOV'T: Dayton, Ohio, 224 N. Wilkinson St., BA 6-2366 • Washington, D. C., 1725 "K" St., N.W., FEderal 7-8500.