electronics

A McGraw-Hill Weekly 75 Cents April 12, 1963

DEUTERIUM THYRATRON

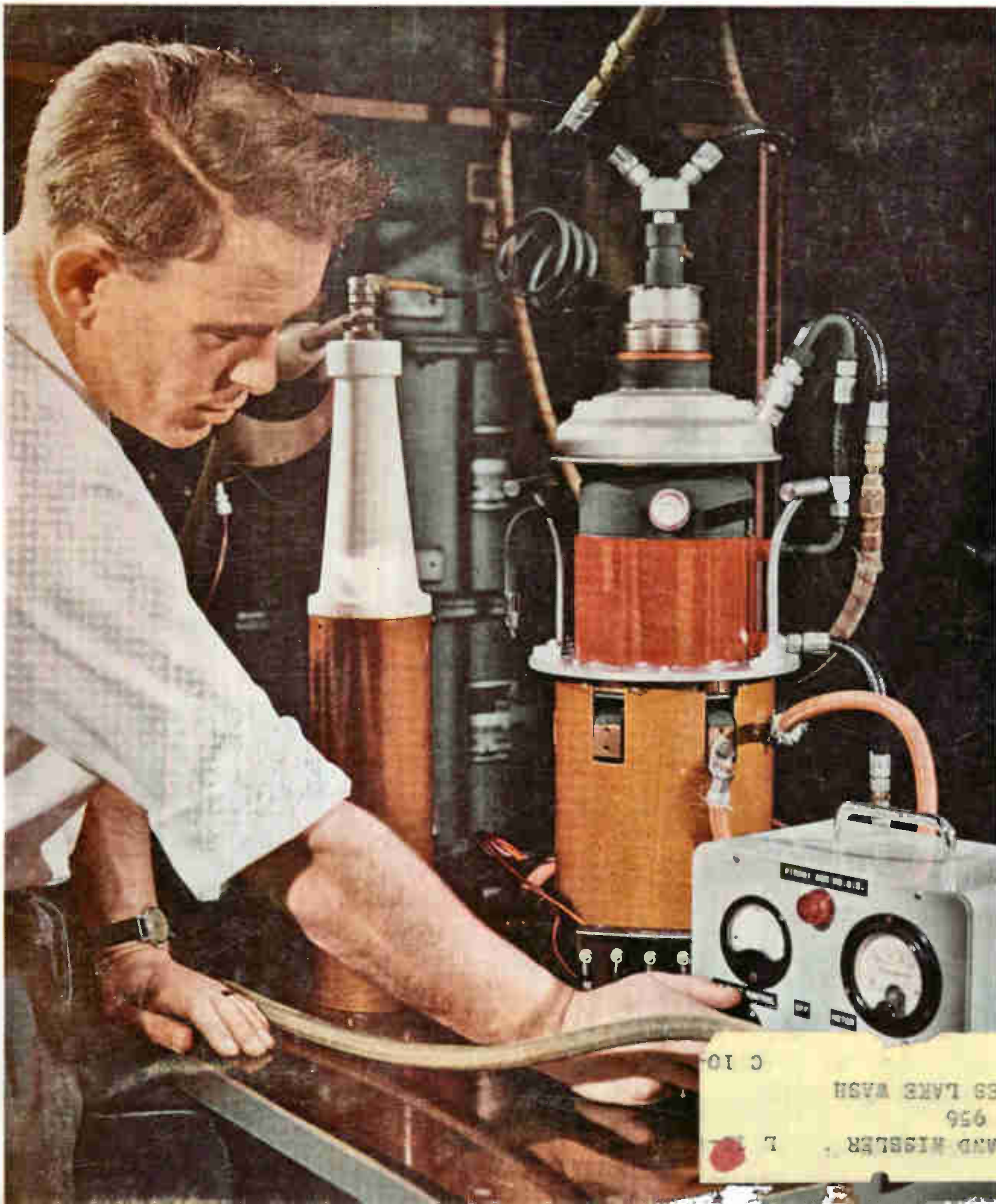
New pulse modulator handles 150 Kw, p 94
(photo below)

SEISMIC-WAVE COMMUNICATIONS

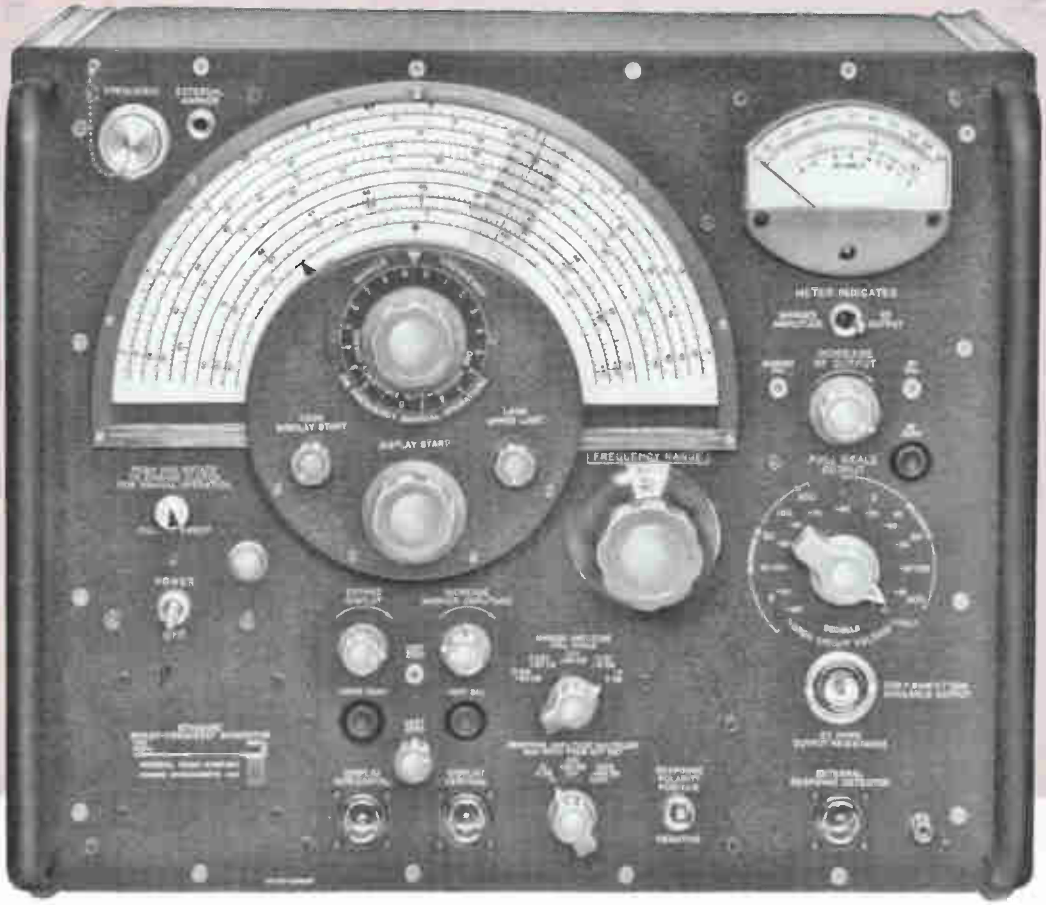
Latest medium: the earth itself, p 51

ARMY AIR FORCE REBORN

Non-nuclear forces plan inventory, p 32



New STANDARD
Sweep-Frequency Generator



Sweep Generator

CW Generator

Marker Generator

Attenuator

and Output Meter

Type 1025-A Standard Sweep-Frequency Generator
Price: $3250 in U. S. A.

... In One Instrument ... Everything you need for Quantitative Frequency Response Measurements

Ranges:

0.7-1.4 Mc	4-8 Mc	40-80 Mc
1.3-2.6 Mc	7-14 Mc	65-140 Mc
2.4-4.8 Mc	13-26 Mc	100-230 Mc
	24-48 Mc	

Bandspread Ranges: 400 to 500 kc and 10.4 to 11 Mc. Other ranges available on special order.

Sweep Width: Entire selected range is swept. However, visual presentation of swept range can be expanded to permit full oscilloscope display of portions of range as small as 10% with EXPAND DISPLAY and DISPLAY START controls.

Selected range is swept from low end to high end in 22.2 msec twenty times a second. Output is blanked off during return sweep. A saw-tooth sweep voltage is provided which is synchronized with frequency, and adjustable in starting point and amplitude (DISPLAY START and EXPAND DISPLAY controls, respectively).

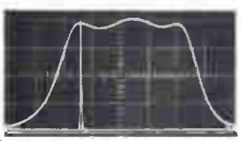
Stability: Drift less than ±0.1% for frequency for 5 hours after one-hour warm-up. Frequency dial accuracy is within ±0.5%.

Marker: Continuously adjustable from 3mv to 1v; multiplier effectively extends range to 100v. Accuracy of indication is typically better than ±10%. Shape and width of marker permit resolution to better than ±0.1% of indicated frequency.

RF Output: Adjustable from 0.3μv to 1v behind 50 ohms (−123 to 7 dbm power into 50 ohms.) Output is flat to within ±1% up to 100 Mc and within ±3% up to 230 Mc. RF amplitude indicated to a typical accuracy of better than ±10%.

★ Covers 0.7 to 230 Mc in ten overlapping octave ranges plus two bandspread ranges (400 to 500 kc and 10.4 to 11 Mc).

★ Has the "perfect marker" . . . continuously adjustable both in frequency and amplitude . . . accurately calibrated in frequency and amplitude . . . lets you take data directly from display . . . does not interfere with response display . . . a single unambiguous marker, not a confusing string of pips.



★ Marker permits frequency measurements to 0.5% directly from display.

★ Instantly converts from sweep to cw operation for accurate point-by-point measurements *without* changing adjustments or connections. Separate output drives frequency counters directly for accurate measurements of low-level devices.

★ Meter measures both rf input and detected output of device being tested.

★ Accessory high-impedance detector probe supplied with instrument simplifies response measurements — minimizes circuit loading.

"What signal generators are to oscillators this instrument is to sweep generators"

★ Accurate . . . frequency calibration ±0.5% of reading.
★ Stable . . . no annoying drift of displayed response. Low residual fm permits investigations of steep response slopes.
★ Motor-driven capacitor produces a high-level swept signal free from harmonic distortion and spurious outputs.
★ No awkward interactions between controls.
★ Low leakage permits measurements to 0.3 μv.
★ Accurate, 120-db attenuator has low 1.01 VSWR.

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CIRCLE 900 ON READER SERVICE CARD

April 12, 1963

electronics

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electronics

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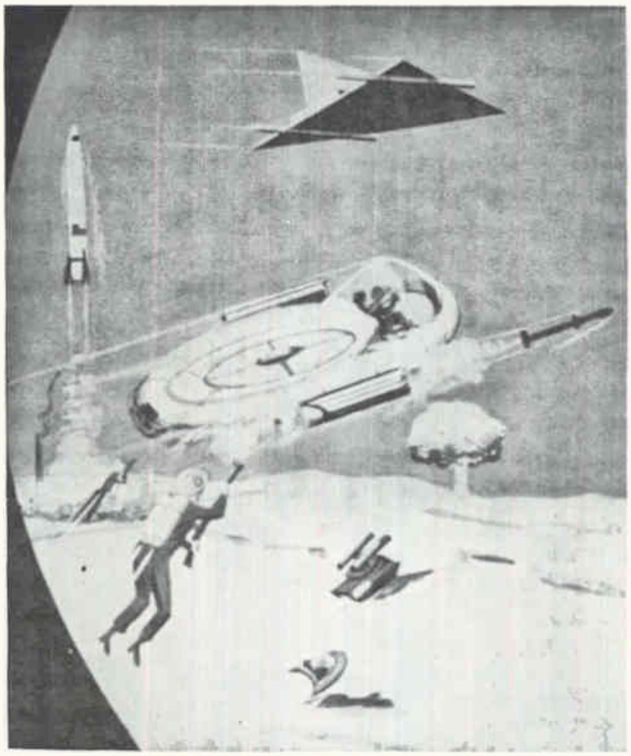
DEPARTMENTS

The New Army



THE ILLUSTRATION reproduced here isn't from science fiction. It's taken from the *Army Information Digest* and it represents a guesstimate of what the Army will look like in the not-too-distant future. The missiles are already on hand, the jet-propelled soldiers, weapons delivery systems and transport will come.

The groundwork for this Army of the future is being laid right now, through the plans and programs outlined this week on p 32 through 36. The Army is concentrating on modernizing its forces, making its firepower more versatile, acquiring mobility, tightening its command and control functions.

Foot-slogging won't disappear, but a significant portion of the Army will return to the air to give the Army greater ability to perform any kind of land mission—in any climate, over any terrain, from small local actions through general nuclear war and its aftermath. Aviation is an important part of this overriding aim because, the Army says, it permits substantial improvement in tactical mobility on the battlefield.

Before strategic warfare concepts shifted to missiles, massive force represented by armies was the clincher in a war. Now the Army must be prepared to unleash swift action while keeping brute force carefully in reserve.

"Tactical nuclear war and large-scale non-nuclear war will be subject to increasing restraints on both sides because of the danger of escalation into a general nuclear exchange," says Gen. Barksdale Hamlett, Army vice chief of staff. Unless the USSR achieves a technical breakthrough—like an effective ICBM defense—to upset the present condition of nuclear deterrence, Hamlett expects the cold-war pattern of small, local conflicts to continue. The Army stresses that it must be able to fight both the big wars and the small wars, but it sees the latter as more likely.

Soviet ground forces, the Army figures, is thinking along the same lines. Army expects the USSR to emphasize mobility, increasing nuclear and non-nuclear firepower, better communications, missile and rocket artillery and battlefield surveillance—in short, everything the U.S. Army believes is essential.

By 1970, the Army expects to be able to field more air-mobile and combat support units, to have new types of aircraft to move and supply troops and for reconnaissance and surveillance. Airborne target-sighting systems will feed data to ground computers that direct artillery fire. Antitank weapons will be operated by automatic fire control and command guidance systems. Troops will be well-supplied with Pershing, Sergeant, Lance, Redeye, Mauler and other missiles. For short range communications, systems like Rada (ELECTRONICS, p 18, April 5) will be used, and for long range communications, satellite systems. Portable reactors will power command and communications centers, radar, depots, weapons systems and other field units—the prototypes are already in operation. Behind the scenes, inventory control systems, communications nets between depots and contractors and many other electronic logistical aids will be in operation.

The list of modern equipment that the Army will have in 1970 is far longer than that and will undoubtedly include systems not yet conceived.

Any electronics engineer or company that feels he can make a contribution to Army equipment will find a willing ear. But, says Gen. Earle G. Wheeler, Army chief of staff, Army is not looking for minor improvements in what it already has. It wants large-scale technical improvements that will make material contributions to the toughness and flexibility of land forces. "Gadgets and frills," says Wheeler, won't be bought.

COMMENT

Servo Amplifiers

I was very interested in the article, Designing Servo Amplifiers For High Efficiency (p 62, Feb. 8), by J. A. Walston and J. E. Setliff of Texas Instruments, since it followed closely after my article, Versatile Servo Amplifier for 50, 60 or 400-Cycle Operation (p 44, Jan. 18).

I think, however, that a section on the advantages and disadvantages of unfiltered d-c should have been added. Using a full-wave rectified, unfiltered, a-c sinewave for power to a push-pull servo amplifier can also generate quite a few problems.

As advantages I would list: (1) theoretically high efficiency approaching 100 percent at full output; (2) low power-supply impedance; (3) low distortion in the output sinewave especially at full output; and (4) quadrature rejection due to the fact that the power supply voltage is zero at the point of maximum quadrature signal.

As disadvantages:

(1) Poor stability of power-supply voltage because of line fluctuation requires higher-voltage transistors.

(2) Line spikes and transient pulses will be directly passed to the output transistors and can be extremely dangerous.

(3) Input phase must be locked to power-supply voltage or line phase. An a-c servomotor's torque is reduced by only the cosine of the phase angle as it varies with respect to the motor's reference voltage. This means that phase in a standard amplifier is not too critical. Phase shift of the input voltage, however, with unfiltered d-c will reduce gain and affect full torque directly.

(4) The maximum torque from the motor will be less than a comparable standard amplifier because the standard amplifier can supply a square wave at full output. This square wave increases motor torque due to its higher fundamental, assuming constant d-c supply voltage. The square wave also increases motor heating, but also increases the amplifier's efficiency.

(5) Often, 90-deg phase shift is desired through the amplifier. This, of course, is not possible with the supply voltage locked to the line without shifting the line voltage.

MICHAEL BODNAR
Diehl Manufacturing Company
Somerville, New Jersey

Author Walston replies:

Two comments should be added to Mr. Bodnar's remarks. First, destructive voltage transients may appear across an inductive load when the driving current is nonsinusoidal. This condition may sometimes occur. when a standard amplifier is overdriven to produce square waves or a high-efficiency amplifier receives a large quadrature signal. Parallel tuning of the load will reduce the transient, but it also increases amplifier dissipation. Series tuning may not help at all. Avalanche diodes are a way out, if one allows for their a-c impedance after avalanche, but there goes more expense! You can't win.

Second, even though a 90-deg phase shift is difficult within a high-efficiency amplifier the reference phase of the servo can often be shifted instead.

JOSEPH A. WALSTON
Texas Instruments Inc.
Dallas, Texas

CGE, not CSF

We greatly appreciate the publication (p 15, March 1) of a photograph of our booth at the Quantum Electronics Exhibition in Paris, February 8-15, where our Research Center displayed among other lasers, a ruby laser telemeter with instant digital display of the distance to be measured.

We only regret that, due to some kind of misunderstanding, this new product was attributed to our competitor, C.S.F.

It is C.G.E. which was chosen by the French Centre National d'Etudes des Télécommunications as industrial designer for the construction of the Space Communication Center of Pleumeur Bodou in Brittany, which received and transmitted the first Telstar messages across the Atlantic a year ago.

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Paris, France

Lambda announces 3 new LE models

Environment-Engineered at competitive prices

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Note these quality design features

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against—short circuit and electrical overload; input line voltage transients; excessive ambient temperatures. No voltage spikes due to "turn-on, turn-off" or power failure.

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by automatic switchover.

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Voltage continuously variable over entire range. Programmable over voltage and current range.

WIDE INPUT RANGE
Wide input voltage and frequency range —105-135 VAC, 45-66 CPS and 320-480 CPS in two bands selected by switch.

OTHER FEATURES

- All solid state.
- Adjustable automatic current limiting.
- 0°C to + 50°C ambient.
- Grey ripple finish.
- Ruggedized voltmeters and ammeters per MIL-M-10304B on metered models.

LE SERIES CONDENSED DATA

DC OUTPUT (VOLTAGE REGULATED FOR LINE AND LOAD)(1)

Model	Voltage Range	Current Range	Price(2)
LE101	0-36 VDC	0- 5 Amp	$420
LE102	0-36 VDC	0-10 Amp	525
LE103	0-36 VDC	0-15 Amp	595
LE104	0-36 VDC	0-25 Amp	775
LE105	0-18 VDC	0- 8 Amp	425
LE106	0-18 VDC	0-15 Amp	590
LE107	0-18 VDC	0-22 Amp	695
LE109	0- 9 VDC	0-10 Amp	430
LE110	0- 9 VDC	0-20 Amp	675

(1) Current rating applies over entire voltage range.
(2) Prices are for nonmetered models. For models with ruggedized MIL meters add suffix "M" to model number and add $40 to the nonmetered price. For metered models and front panel control add suffix "FM" and add $50 to the nonmetered price.

REGULATED VOLTAGE:
Regulation (line and load) ...... Less than .05 per cent or 8 millivolts (whichever is greater). For input variations from 105-135 VAC and for load variations from 0 to full load.
Remote Programming .... 50 ohms/volt constant over entire voltage range.
Ripple and Noise .... Less than 0.5 millivolt rms.
Temperature Coefficient .. Less than 0.015%/°C.

AC INPUT: .... 105-135 VAC; 45-66 CPS and 320-480 CPS in two bands selected by switch.

PHYSICAL DATA:
Mounting .... Standard 19" rack mounting.

Size		
LE 101, LE 105, LE 109	3½" H x 19" W x 16"	D
LE 102, LE 106, LE 110	5¼" H x 19" W x 16"	D
LE 103, LE 107	7" H x 19" W x 16½"	D
LE 104	10½" H x 19" W x 16½"	D

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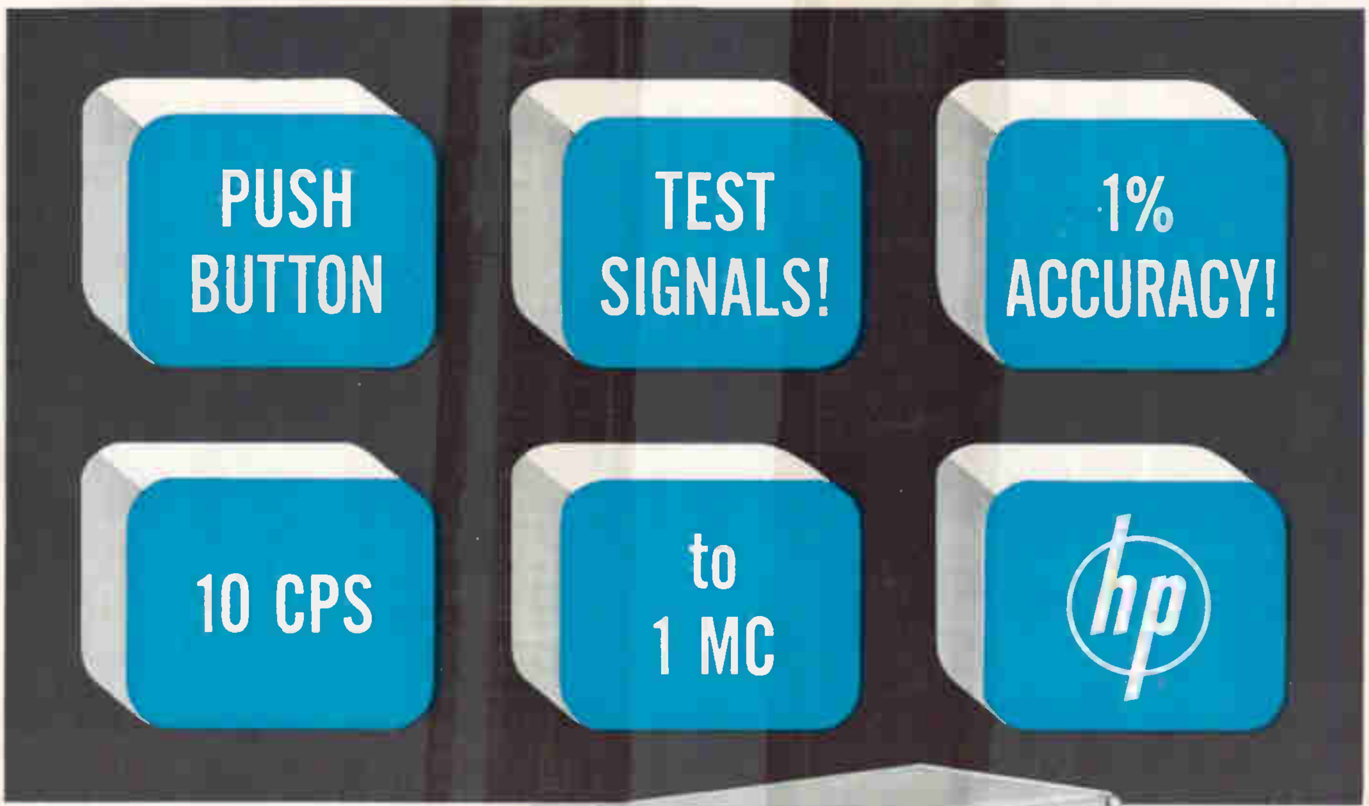

Push-button convenience and repeatability for selecting frequencies from 10 cps to 999 KC makes the new hp 241A Oscillator ideal for supplying stable test signals for lab or production work. Just push one of five decade multipliers and three frequency push buttons to select any of 4,500 discrete frequencies. You get accuracy of ±1% and repeatability typically better than 0.005%.

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High repeatability, positive push-button operation and compact, rugged solid-state design make the hp 241A especially suitable for production line or other repetitive testing.

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hp 241A Oscillator

SPECIFICATIONS

Frequency:	10 cps to 1 MC, 5 ranges, each with 900 frequency increments with vernier overlap
Calibration Accuracy:	±1%
Frequency Response:	±2% into rated load
Output Impedance:	600 ohms
Distortion:	1% maximum
Hum and Noise:	0.05% maximum of output
Output:	+10 to −30 dbm into 600 ohms (2.5 volts max.)
Dimensions:	6½" high x 7¾" wide x 8" deep. 13 lbs.
Price:	$425.00

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

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Radiation Decay Nil in Van Allen Belt

BEDFORD, MASS.—Since late October there has been little decrease in intensity of trapped radiation injected into Van Allen Belt by July 9, 1962 U. S. high-altitude nuclear detonation in Pacific, it was reported last week at AF Cambridge Research Laboratories.

Ludwig Katz said data from Beta Kappa 1962 AF Satellite launched Oct. 26 shows an apparent state of equilibrium has been reached in the magnetic shell in which the detonation took place. Present level within this shell is considerably higher than prior to shot, Katz said.

Results of measurements contradict James A. Van Allen's prediction (p 7, Nov. 23, 1962 and p 220, Dec. 14) that the artificial belt will have vanished by July, 1963. Van Allen recently revised his estimate to 5 to 10 years.

Katz disclosed that the satellite also acquired data on Oct. 27 and 28 on Russian detonations. Bulk of particles injected from Soviet tests lasted only a few days, rapid decay probably resulting because detonations took place in polar region. AFCRL also disclosed:

- Geophysicists will next month fire ruby laser beam 30 miles to test laser-beam bounce off geodetic satellites for more accurate determination of earth distances. Late this summer, AFCRL will fire a laser beam at S-66 geodetic satellite.
- AFCRL scientists stepping up plasma sheath studies point out that proposed solutions for blunt body vehicles like Mercury (p 7, Feb. 22) may not work for boost-glide reentry vehicles like Dyna-Soar or for superorbital vehicles like Apollo. While a few minutes of communications blackout could be tolerated in Mercury, the estimated 20 to 30 minutes could be critical in other missions. AFCRL will study reentry effects next March with Trailblazer vehicle equipped with transmitters at 200 Mc, 400 Mc and 3 Gc, and a telemetry transmitter at 9 Gc. RCA's transmitter for Dyna-Soar is also at 9 Gc.
- In a Project Firefly experiment, AFCRL scientists bounced tv signal from Shreveport, La., to Florida by an artificially created electron cloud. Concept could be used for over-horizon reception of vhf, h-f, and m-f significant to military. Firefly experiments have also aided studies of detection of missiles by their gas exhaust trails.

Titanium Oxide Shows Microelement Potential

FARMINGDALE—New class of microcircuit elements may result from studies underway at Republic Aviation. Franz Huber reports that thin-film *p-n* junctions in semiconducting titanium oxide on a flexible plastic substrate show piezoresistive and piezoelectric effects.

The diodes are formed by anodic oxidation of a titanium film. Oxide film is about 300 Å thick, counter electrodes are palladium and junction area is 1 sq mm. As junctions are deformed by bending the substrate, junction resistance decreases. Voltage polarity depends upon whether compression or tension is applied. Up to 100 mv has been obtained by deformation with 1 cm radius of curvature.

Although the phenomenon is not yet completely understood or controllable, it conceivably could lead to strain gages and microphones where the junctions are deposited directly on the membrane. Since titanium oxides can also be insulators and conductors, it points to a compatible thin-film microelectronic technology (effect is anticipated for tantalum oxides also.)

Switching matrices have been made with 10-Kc diode switching times. Huber feels field-effect transistors should be possible and is trying to lick problems of contact fabrication and oxide preparation. He also has observed light emission from titanium films in an electrolyte, but not yet in a diode.

Laser Welds Shut Holes in Retina

TECHNIQUE has been developed at Stanford University to correct retinal detachment by welding shut the puncture or hole in the retina. Laser beams can also be used to scar and essentially destroy certain blood vessel tumors in the eye and to make a new pupil in a blocked or out-of-position iris. Laser, built by

Texas Science Gets a Boost from NASA

DALLAS—Southwest electronic and aerospace industry leaders are beginning to see part of the "scientific awakening" they had hoped NASA's Manned Spacecraft Center in Houston would bring their area (p 28, Nov. 17, 1961).

An ambitious Science Research Center (SRC) in Dallas is showing signs of getting off the ground. Area universities are beginning to create departments and curricula geared to supporting space research and training. In Houston, funds are being raised for a $250,000 technical information center to serve the area's scientists and engineers.

SRC is a new name for the Graduate Research Center of the Southwest. Its backers have had difficulty getting the center going but now, NASA is providing a much-needed boost with a $1.5-million contract for space experiments.

SRC presently has a 50-man staff in temporary facilities at Southern Methodist University. Permanent facilities are being constructed on a 1,400-acre campus north of Dallas

Optics Technology Inc., is used in conjunction with a Zeiss photocoagulator, which utilizes light from a xenon gas tube. Prof. Arthur L. Schawlow, co-discoverer of laser principle, took part in the project, along with two Stanford ophthalmologists.

Navy Plans to Buy 2 Sidewinder Types

WASHINGTON—Navy's shopping list for the year starting July 1 includes funds to buy Sidewinder 1-C air-to-air missiles with alternate guidance heads. One version will have Sarah heads (Semi-Active Radar Homing) produced by Motorola. The other version will be equipped with less-expensive Irah heads (Infrared Homing) produced by Philco. All-weather fighter - interceptor planes will be equipped with both versions of the missile.

Conveyor Speeds Film Through Vacuum Chamber

ENDLESS CONVEYOR line that moves straight through a high-level vacuum chamber and back into the air has been developed by Western Electric. Process makes tantalum thin films economically feasible, firm says. Production speed is 50 square inches of tantalum film per minute. Machine is designed for computer control and is compatible with other in-line operations. Western Electric says metal evaporation, electron-beam welding and glass sealing are also well-suited for such machines.

Britain Rewrites Rules On Exports to Reds

LONDON—Britain has revised its rules on strategic goods subject to embargo in trade with the Soviet bloc and Communist China.

Controls have been reduced on synchronous motors; electronic measuring, testing and calibrating instruments; modular insulating panels; measuring, calibrating, counting and time-interval measuring apparatus; radio-relay communications equipment; radio spectrum analysers, recording and reproducing equipment; certain semiconductor diodes, telegraph apparatus; and low-frequency and switching-type transistors.

New controls are being imposed on semiconductor hall-field probes, certain electrochemical semiconductor and radioactive devices, certain gravity meters, electron-beam welding and machining equipment and electric-arc devices.

Spaceships Leave Trail in Ionosphere

RADAR TRANSMITTERS may not be needed to track spaceships in flight, says Prof. Floyd V. Schultz of Purdue University. Schultz, who has analyzed the behavior of the ionosphere in mathematical terms, says it sends out electromagnetic waves when it is disturbed by a moving object. These could be picked up on earth with only an antenna and receiver, according to Schultz. His theoretical results are now being checked experimentally.

Pyrometer Will Use Thermistor for Moon Scan

CAMBRIDGE — Radiation pyrometer built at Harvard College Observatory uses thermistor for ir scanning of moon's surface from the earth. Filters allow only narrow band of ir, between 8 and 14 microns, to fall on thermistor. To get thermal profile of moon, 35-mm camera is attached to pyrometer.

Explorer 17 Carrying Electrometer Amplifier

SUCCESSFUL LAUNCH of Explorer 17 marks the first orbiting of a highly sensitive electrometer amplifier and a new 40-channel pcm telemetry system providing 500-mw output power.

High-impedance linear amplifier is used to detect tiny ion currents from two mass spectrometers and can pick up signals as small as 10^{-16} amp. Built by Consolidated Systems Corp., device measures amounts of helium, oxygen and nitrogen atoms, water vapor, and nitrogen and oxygen molecules.

In Brief . . .

RUSSIANS INSIST that Lunik IV, which they say passed within 8,500 kilometers of moon on April 6, is fulfilling its scientific mission. They do not specify what the mission is.

AF IS CONFIDENT it will get approval for construction of multiplate antenna facility at Bedford, Mass. (p 39, Sept. 7, 1962).

SALES by microwave components manufacturers hit $75 million last year, EIA says.

PHILCO signed a $33,797,565 contract to provide flight information and control display equipment for the Integrated Mission Control at NASA's Manned Spacecraft Center (p 20, Feb. 8).

CHRISTIAN HERTER, President Kennedy's special trade envoy, will negotiate with the Japanese for lower tariff rates, including those on electronic equipment.

FAIL-SAFE electronic altimeter and improved failure-warning devices would be a big help to aircraft safety, David S. Little, of Air Line Pilots Association, said last week.

ARMY SIGNAL CORPS has ordered $18,667,000 worth of vehicular command communications systems from Magnavox.

ELLIOTT-AUTOMATION, a British firm, will build 25 NCR 315 computers for National Cash Register. Order totals $30 million.

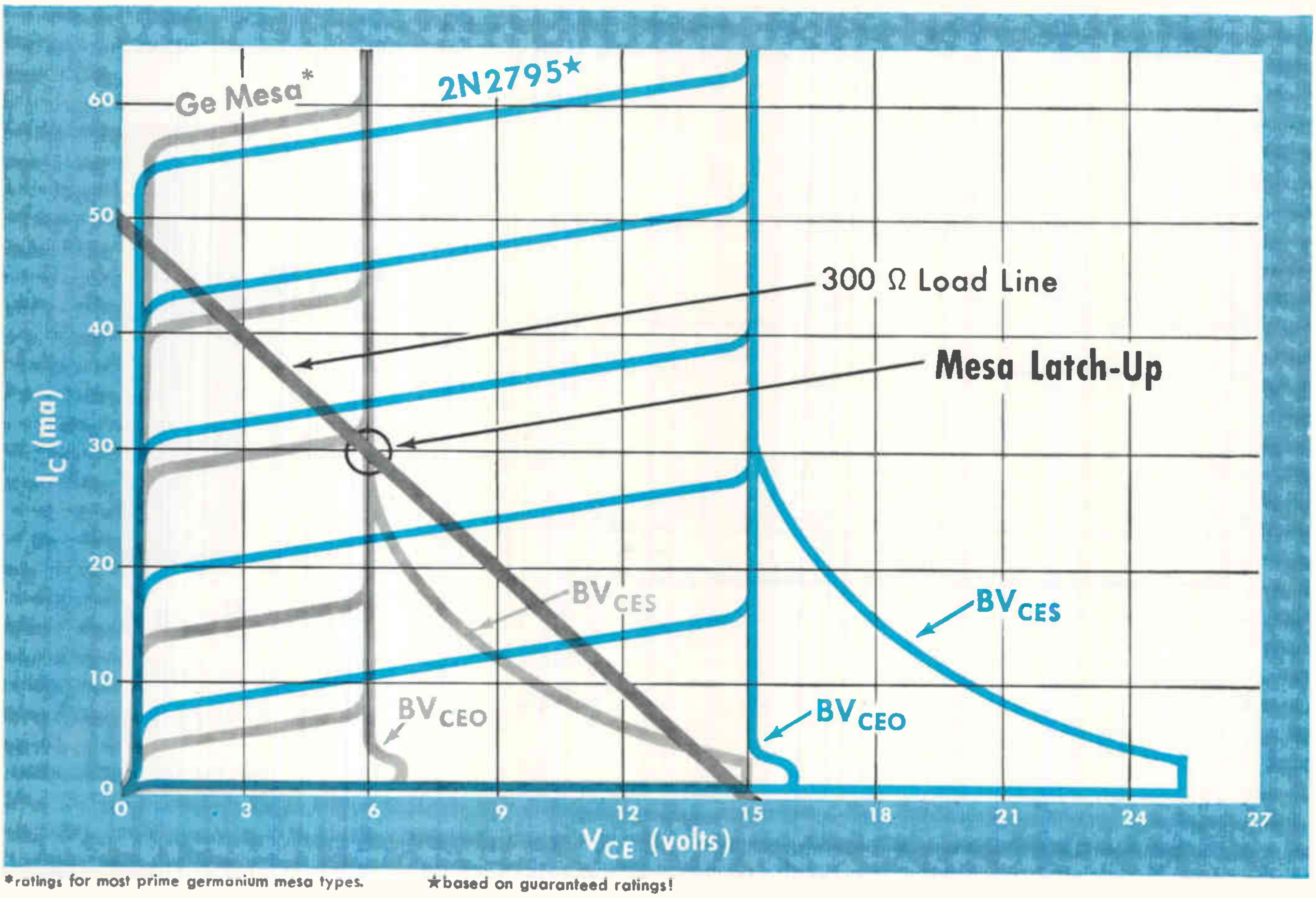
STOCK OFFER is in the works that would cover start-up costs of proposed pay-tv system in Santa Monica, Calif.

GERMAN GOVERNMENT has placed $18-million order for military communications equipment with Standard Telephones and Cables of London, an ITT subsidiary.

STUDY of superheterodyne-receiver techniques for above 100 Gc will be made for NASA by Electronic Communications, Inc.

FAA GAVE Telecomputing Corp. $4.3 million contract for delivery of 52 air traffic control radars.

SPRAGUE LOGIC TRANSISTORS GIVE SUPERIOR LATCH-UP PROTECTION!



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2N2796	450 mc	20 volts	12 volts
2N984	350 mc	15 volts	10 volts
2N979	150 mc	20 volts	15 volts
2N980	150 mc	20 volts	12 volts
2N2048†	250 mc	20 volts	15 volts

(†TO-9 Case)

● For additional information on Sprague High Voltage Logic Transistors, write to the Technical Literature Service, Sprague Electric Company, 35 Marshall Street, North Adams, Massachusetts.

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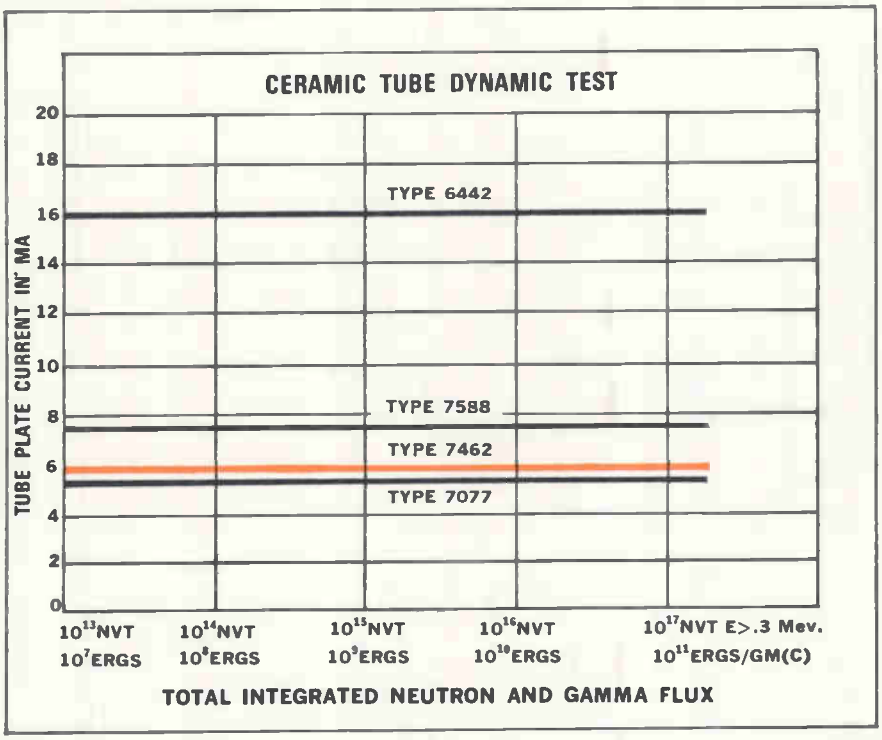


New tests confirm G-E ceramic tubes survive high nuclear radiation levels

Recent tests confirm that G-E ceramic tubes show no measurable changes in operation or characteristics during and after receiving total integrated flux of 5.6 x 10^{16} N_fVT (E_n>0.3Mev) and 7 x 10^{10} ergs/gm (c).

This exposure is in excess of all estimated requirements for presently conceived weapons systems. Tests were conducted by the radiation effects group of a leading airframe manufacturer and proved: *G-E ceramic tubes will meet all currently anticipated requirements for steady-state radiation tolerance in weapons systems, communications and other military electronic equipment.*

Three types of G-E tubes (five samples of each)—6442, 7077 and 7588—were irradiated under D-C operating conditions. Also, 18 samples of type 7462 were irradiated while operating in three 6-stage, 60-megacycle IF amplifiers. No significant changes were noted in tube currents, gain, bandwidth, or noise. Final complete and detailed information on these most recent tests will be available after June 1963.

New flexible-lead photoconductive cell for street-lighting applications

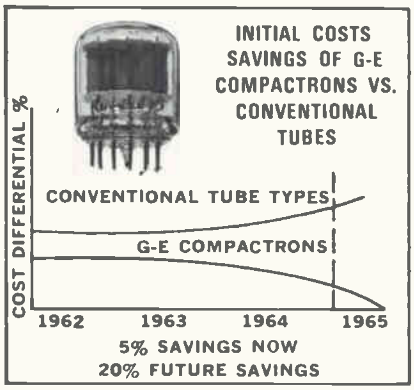
The B-1035 is G.E.'s newest photoconductive cell, and the first of its type to offer these important *value-analyzed* features:

1. Flexible Leads—The B-1035 allows fast, easy, direct-soldering installation. No sockets or clamp-on clips are required, resulting in definite savings of time and materials.
2. Low Moisture Level—Like all G-E photoconductive cells, the new B-1035 is hermetically sealed after reducing the moisture level within the envelope to an extremely low level. This assures longer life and increases over-all performance. As an added benefit in designing, the B-1035 has a ½″ lower seated height than G-E type B-935 which it replaces.

MAXIMUM RATINGS AND CHARACTERISTICS—Photoconductive material: Cadmium sulfide. Spectral response: S-15. Voltage between terminals, DC or peak AC: 350 volts. Power dissipation: 0.35 watts. Photo current: 50 ma. Ambient temperature range: −75 to +60°C. Diameter: 1.26 in.

CHARACTERISTICS AT 25°C.—Voltage between terminals, 50 VAC. Illum. sens., 2000 ua/fc. Max. dark current, 40 ua.

DEVELOPMENTS FROM G-E RESEARCH



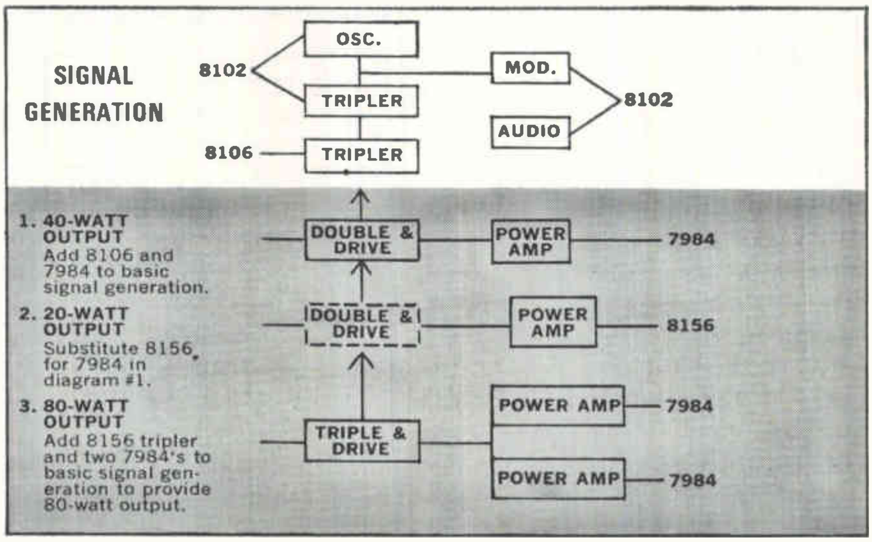
More G-E compactrons in tomorrow's radio, TV, hi-fi and industrial equipment

Two major reasons account for the mushrooming growth of G-E compactrons in new, critical circuit design: (1) performance; (2) lower costs. Compactrons overcome the limitations of tubes and transistors and deliver more watts per cubic inch than any other component. They have a lower initial cost per function and offer savings in labor and materials.

By combining several functions into one low-profile envelope requiring fewer pins, stems, sockets, welds and handling, compactrons provide increased reliability and more compact circuitry, when compared to present-day components.

SPECIFIC VALUE-ANALYZED BENEFITS OF G-E COMPACTRONS

- They use up to 35% less power to perform the same function.
- Cost less than tubes or transistors to perform any given function. Lower initial costs, plus fewer compactrons needed in a given circuit, reduce hardware, wiring and soldering connections, and assembly time.
- Wide range of 52 production types to meet all requirements.
- Dissipate heat up to 35% better than conventional tubes, increasing life and reliability.
- Provide more compact circuits, allowing use of a smaller chassis and cabinet with resultant savings in materials.



20-80 watt power output range possible from four new communication tubes

A 20, 40 or 80-watt transmitter, working from the same basic signal-generation unit, can be built with the use of these two new compactrons and two new 9-pin miniatures. Specifically designed for use in mobile communications equipment, they help reduce circuit design and assembly costs without any loss in quality or transmitter performance. The above diagram shows the three different transmitter outputs which are possible using only these four basic new tubes:

7984 high-power transmitting tube. Power output: 46 watts at 175 MC. Single-ended construction, low seated height, multiple cathode and screen connections, low output capacitance and low driving-power requirements. Compactron T-12 tube.

8156 medium-power transmitting tube. Power output: 21 watts at 175 MC. Low output capacitance: 4.8 pf. Compactron T-12 tube. 1 15/16 inches seated height.

8106 175-MC. driver and multiplier. Miniature beam pentode. Low cathode-and-screen inductance, multiple leads, T-6½ bulb. 1 15/16 inches seated height.

8102 FM modulator and frequency tripler. Miniature triode-pentode.

Progress Is Our Most Important Product

GENERAL ELECTRIC

For more information: Write G-E Receiving Tube Dept., Technical Information and Product Service (TIPS), Room 7003, Owensboro, Ky. Please specify product(s).

WASHINGTON THIS WEEK

PENTAGON PONDERS DEPRECIATION ALLOWANCE

PENTAGON OFFICIALS have a tough decision to make on the amount of depreciation allowance they will permit defense contractors whose productive equipment is eligible for the 7 percent investment credit. DOD's decision is apt to be followed by other departments who face the same problem.

The question, simplified, is: for determining costs under defense contracts should contractors' costs be based on 100 percent of the cost of the equipment involved? Or should cost formulas be adjusted down to 93 percent of the purchase price of the equipment, as the so-called Long Amendment to last year's tax credit legislation requires companies to do in figuring their depreciation allowances for tax purposes?

SHIFT TO COMPETITIVE PROCUREMENT ACCELERATED

DEFENSE SECRETARY McNAMARA has set a $2.7-billion cost reduction target for the upcoming year. Costs were cut $1.9 billion this year. About one-quarter of the anticipated savings next year will come from trimming procurement of spare parts and the like. He's also pushing for increased use of excess inventory in place of new contracting.

Cost reductions amounting to $402 million are forecast by shifting from noncompetitive procurement from sole sources to price competition; an even greater saving is expected by accelerating the shift from cost-plus fixed-fee contracting to fixed or incentive-price procurement. Last year, $760 million of contracting was shifted from noncompetitive procurement to price competition with an average saving of 25 percent. In another two years, officials figure that about $2 billion more in procurement will be handled through price competition than in fiscal 1961. The drive for price competition will be toughest in procurement of parts.

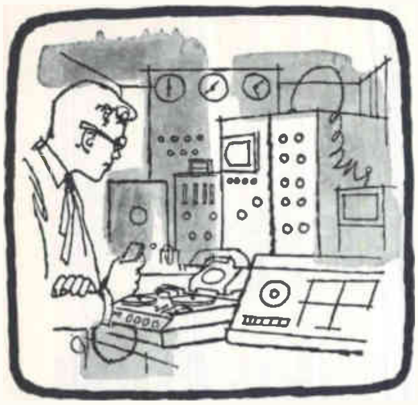
SENATE CUTS DEFENSE BILL, ADDS TO RS-70

DEFENSE BUDGET has advanced another step in the congressional appropriation machinery with the approval of a $14.9-billion aircraft-missiles-ships authorization bill by the Senate Armed Services Committee. The sum is $900 million less than the amount authorized by the House and $407.3 million under the administration's request.

The Senate Committee went along with expanding the RS-70 program by $363.7-million. But it voted a 3-percent cut in R&D, spare parts procurement and weapons modifications. It also stretched out plans for procurement of some weapons already in production, and rejected the House's $134-million addition for two extra nuclear attack submarines.

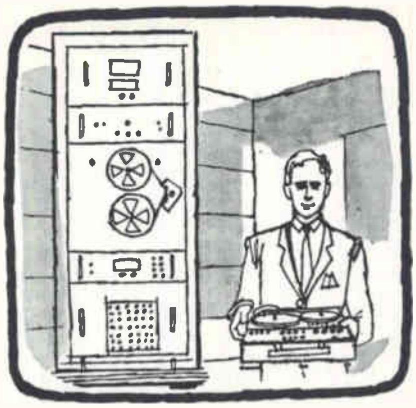
NASA DEFENDS R&D CENTER IN BOSTON

CONGRESSIONAL criticism of NASA's proposed $50-million electronics center in Boston (ELECTRONICS, p 7, Jan. 25) is not expected to affect the program. NASA officials deny it will be a "gigantic operation" —they are sticking to predictions the maximum staff will be 2,000, at least until 1970. They also deny the site selection was political, stating the site was selected before last fall's elections and that they wanted the center close to New England's industrial and scientific complex, where important electronics research is being done, to fill a technological gap in NASA's in-house capability.

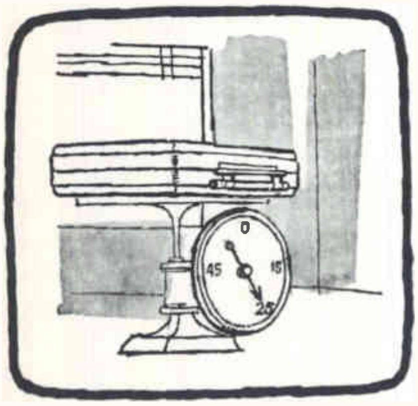


IF YOU ARE RECORDING IN THE LAB...

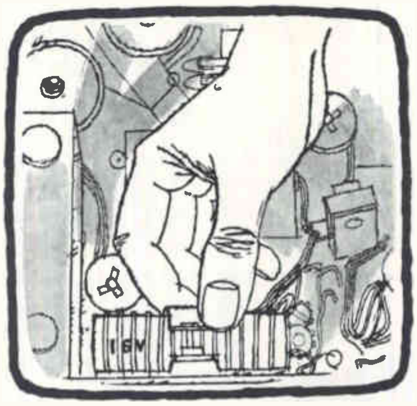
OR IN THE FIELD, YOU CAN NOW...



GET PRECISION PERFORMANCE...

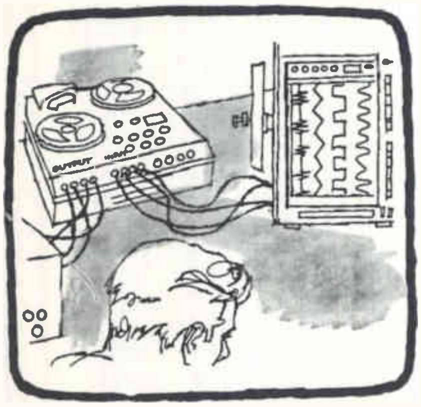


IN A 25-POUND RECORDER/REPRODUCER



THAT IS COMPLETELY SELF-POWERED,

CAN BE HAND-CARRIED ANYWHERE.



CAN SIMULTANEOUSLY RECORD/REPRODUCE 4 TRACKS.

DIRECT SYSTEM

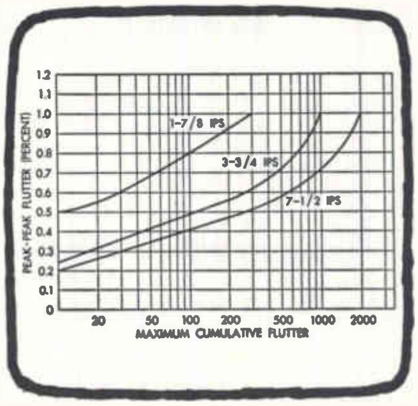
*Tape Speed	Frequency Response ± 3db
1⅞	50—5,000
3¾	50—10,000
7½	50—20,000

FM SYSTEM

Tape Speed	Frequency Response ± ½ db
3¾	0—1,000
7½	0—2,000

*optional speeds available

FM OR DIRECT,



WITH EXTREMELY LOW FLUTTER.

THE NEW LOCKHEED 411 INSTRUMENTATION RECORDER

MAIL COUPON TODAY FOR FULL INFORMATION

LOCKHEED ELECTRONICS COMPANY/TAPE PRODUCTS DEPT., INDUSTRIAL TECHNOLOGY GROUP, Metuchen, New Jersey

Mr. Bernard Mayer: Send me free product specification folders on the Lockheed 411 instrumentation recorder/reproducer.

NAME ....

TITLE ....

COMPANY ....

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CITY.................... STATE ....

LOCKHEED ELECTRONICS COMPANY
A Division of Lockheed Aircraft Corporation/Metuchen, N. J.

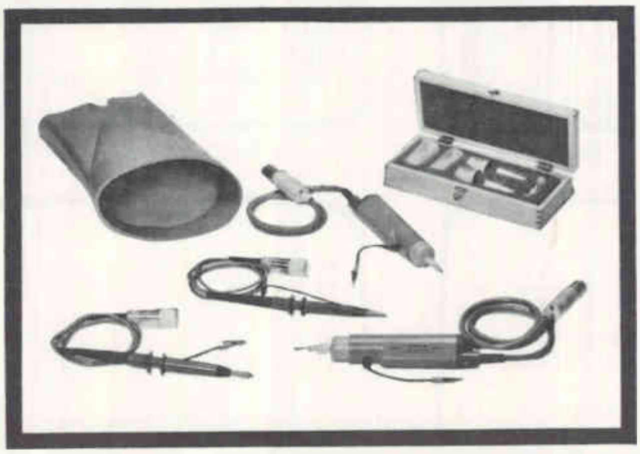
E-4

CIRCLE 13 ON READER SERVICE CARD

PHILIPS

GM 5603 broad-band oscilloscope

points of special interest to users



complete set of accessories

delivered with oscilloscope includes:
2 cathode follower probes
2 attenuator probes (10 : 1)
1 viewing hood

unvarying performance

stable calibration; amplification factors remain constant; time-base speeds will not vary

differential input

real voltage and current differences may be measured anywhere in a circuit
measurements can be made free of earth; hum and other disturbances are automatically rejected; rejection factor approx. 300

simple and reliable trigger setting

no stability adjustment needed, only trigger level control to set

brightness setting

does not influence focus or astigmatism

high brightness

10 kV E.H.T.

cathode follower probes

provide high sensitivity with low capacity at measuring point with full DC to 14 Mc/s bandwidth
probes require no external power supply

convenient screen photography

graticule brightness uniform over entire screen at all illumination levels
instant mounting of cameras and other optical accessories

optional accessories

recording camera equipment
attenuator probes 1 : 20
1 : 50
DC-coupled cathode follower probes

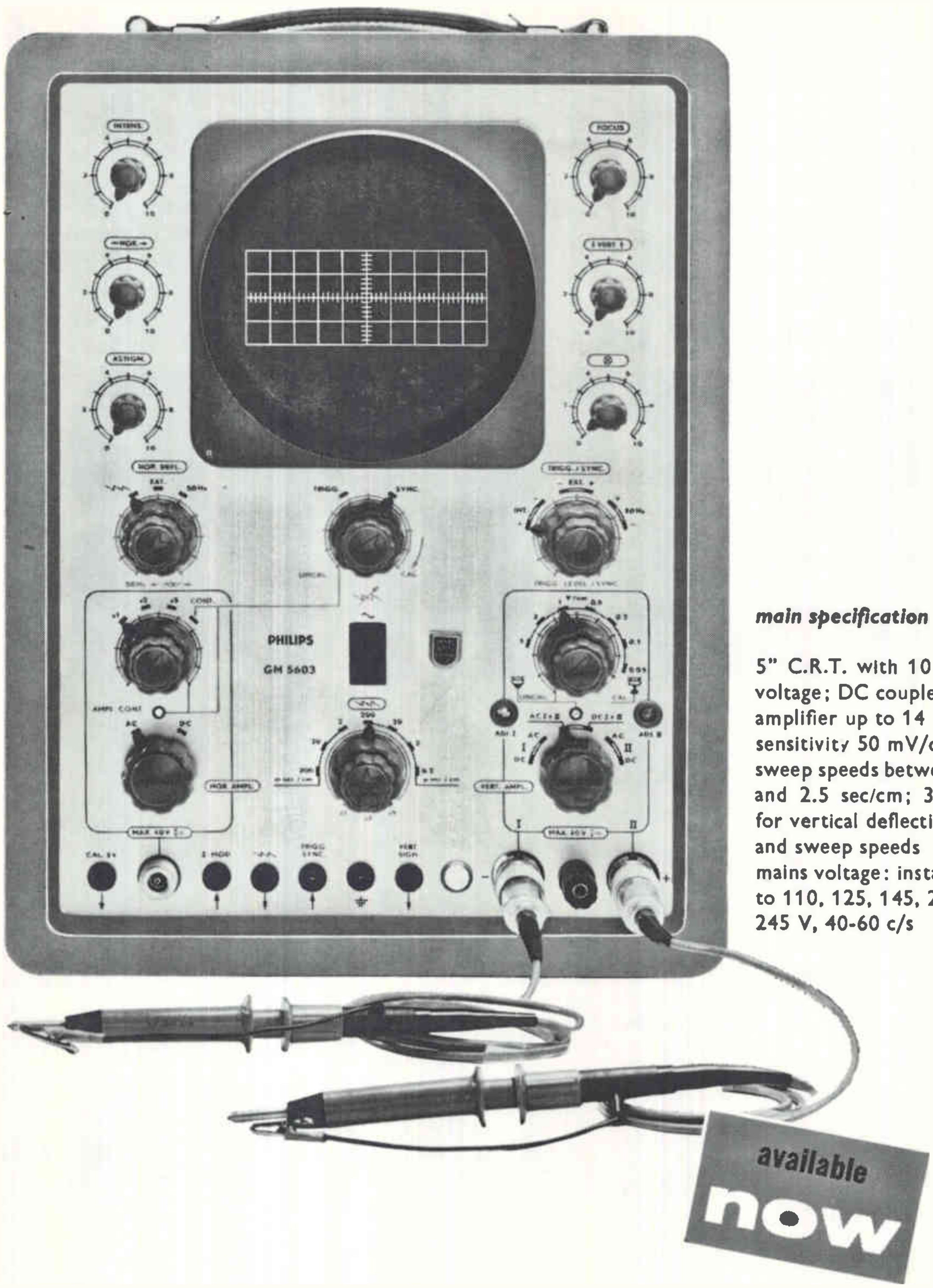
PHILIPS *electronic measuring*

Sold and serviced by Philips Organizations all over the world

Further information will gladly be supplied by:

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

For Canada: Philips Electronic Equipment Ltd., 116 Vanderhoof Ave., Toronto 17, Ont.

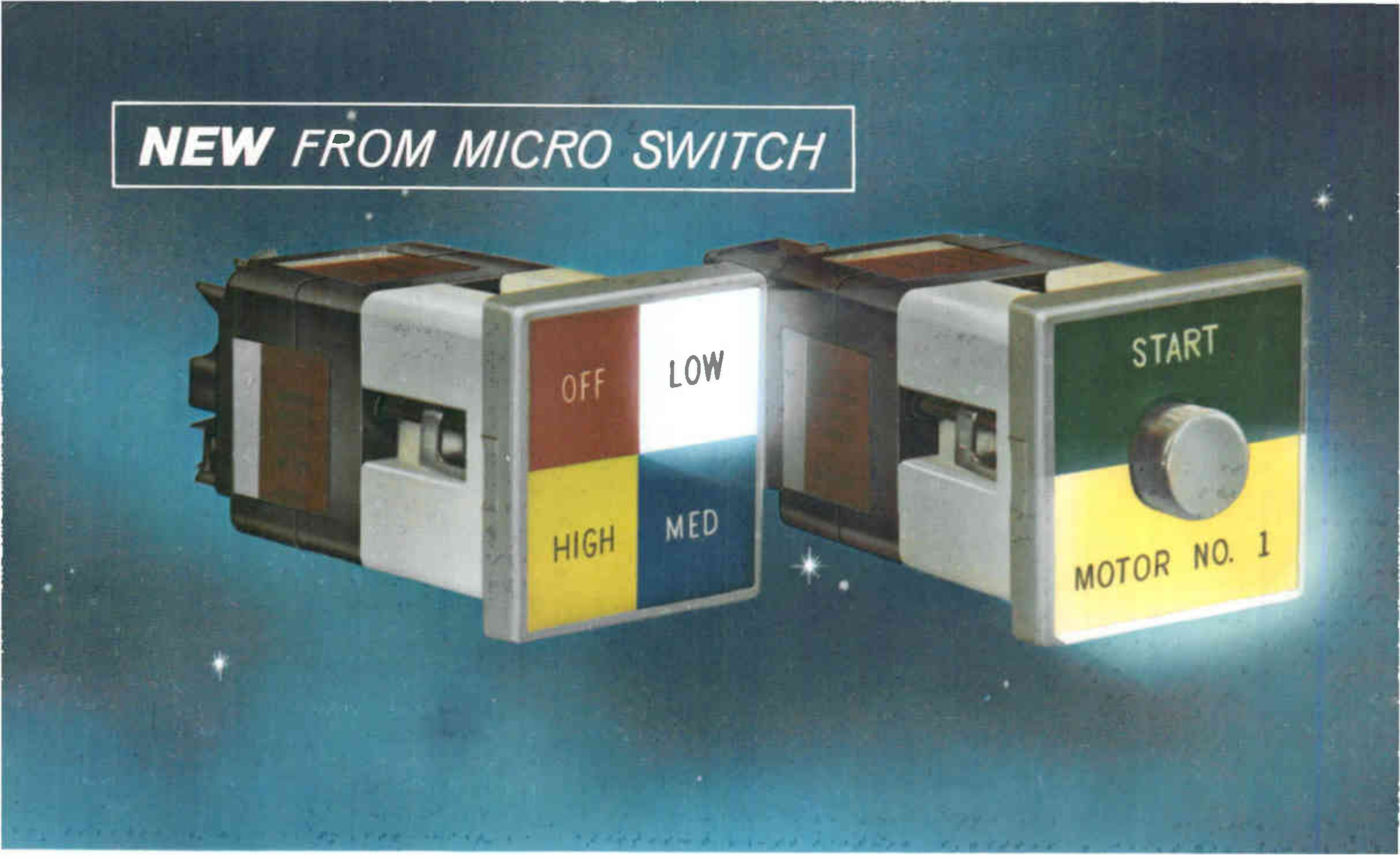


main specification

5" C.R.T. with 10 kV accelerating voltage; DC coupled differential amplifier up to 14 Mc/s
sensitivity 50 mV/cm
sweep speeds between 40 mμsec/cm and 2.5 sec/cm; 3% accuracy for vertical deflection and sweep speeds
mains voltage: instantly adjustable to 110, 125, 145, 200, 220 and 245 V, 40-60 c/s

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

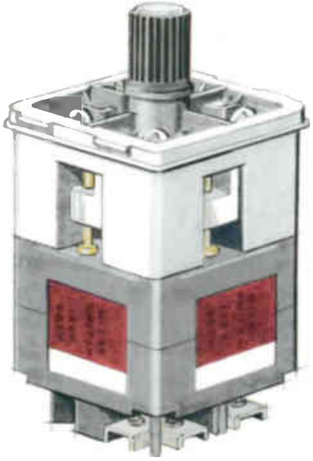
PHILIPS



A wide selection of legend display and color coding.

Coordinated

110 vac or 220 vac display units available.



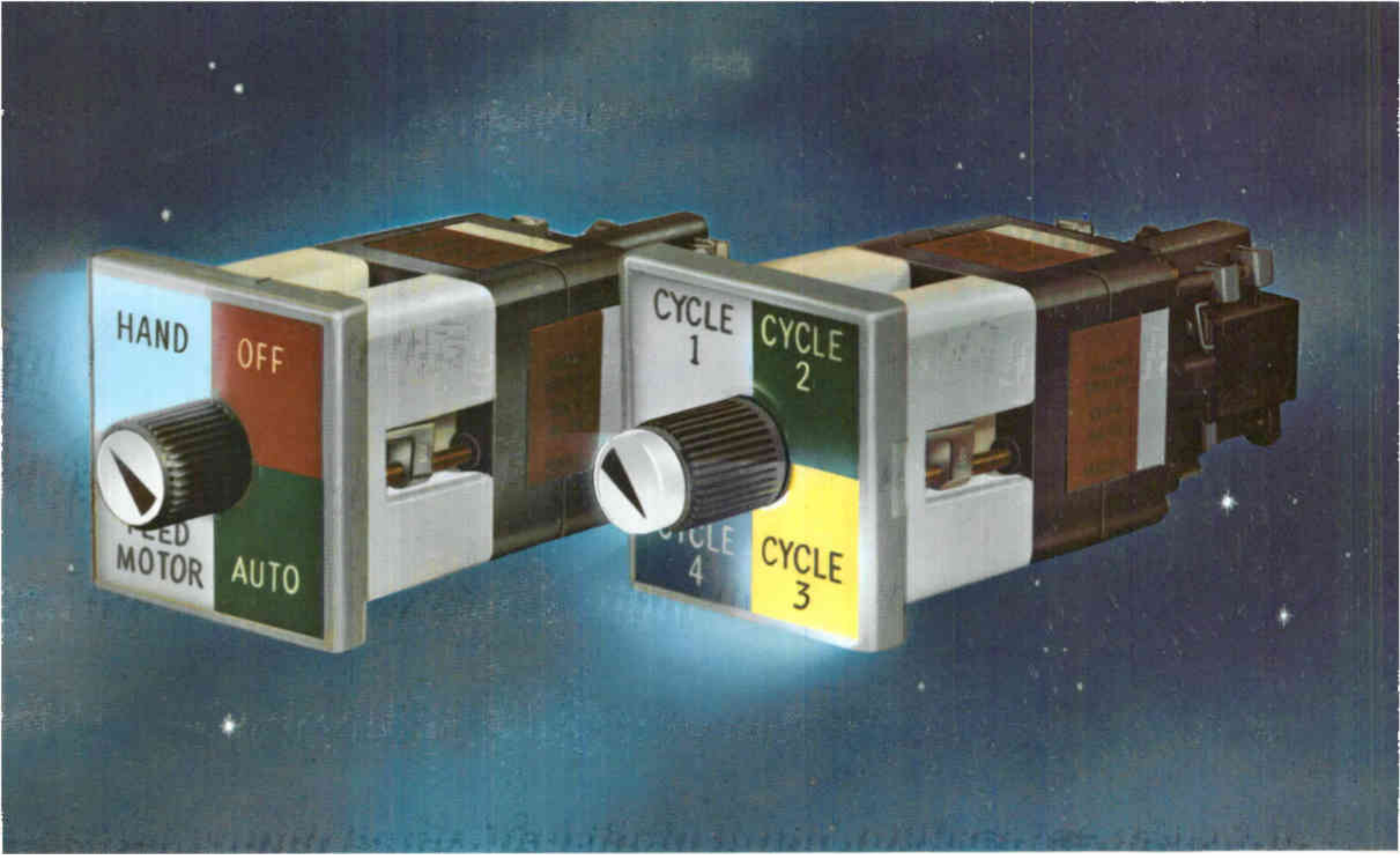
The Coordinated Manual Control system of manual control and lighted display is an innovation in the control field. Included are three operator-indicator units and one indicator unit...each, oil-tight. The wide variety of operators and contact blocks, together with an exclusive legend and color system, make Coordinated Manual Controls the most versatile, efficient and functional units in the field. They are adaptable to an enormous range of applications—stretching from machine tools to missile ground support equipment.

All are designed for different and varied functional requirements...all feature distinctive and compatible panel appearance with legends an integral part of the display field to save space on the panel; a wide variety of easily labeled and color-coded display; unlimited industrial pilot and electronic control capabilities.

CHOICE OF UNITS

There are four units...one indicator for legend display and three operator-indicator units (a Pushbutton, a Selector and a Selector-Push) for control and display. The colored, lighted legend display furnishes system or control status feedback, or conventional industrial control signals.

Heavy Duty or Electronic Duty contact blocks. May be tandem mounted.



Manual Controls

... with lighted legend display

CHOICE OF CONTACT BLOCKS

Two basic types of double-break contact blocks are available... Heavy Duty with butting contacts, and Electronic Duty with either silver or gold sliding contacts. Each Heavy Duty plunger operates a single-pole double-throw double-break switch. Each plunger of an Electronic Duty contact block operates two single-pole double-throw double-break switches... twice the circuitry previously available in the same size contact block. Both the Heavy Duty and the Electronic Duty contact blocks are available with one or two plungers. They can be combined in any order on the same operator. Tandem mounting permits control of many and different types of circuits from one operator.

CHOICE OF COLORS AND LEGENDS

All units offer a choice of five colors of inserts. The legend plate is transparent and can contain as many as four different color inserts.

The new square styling provides for up to seven lines of legend. Legend plates are supplied either blank, with standard legends, with a combination of standard and custom legends, or with all-custom legends.

The complete color and display arrangement includes the four selected color inserts which snap into the legend plate. This sub-assembly then snaps into the cover plate to complete the assembly. As a unit they provide a brilliant colored legend display area almost equal to the total space utilized on the panel.

Write for Catalog No. 69

...colorful, fully illustrated catalog, complete with circuitry, dimensions, legend and color information.

HONEYWELL

MICRO SWITCH

FREEPORT, ILLINOIS

A DIVISION OF HONEYWELL

IN CANADA: HONEYWELL CONTROLS LIMITED, TORONTO 17, ONTARIO

HONEYWELL INTERNATIONAL SALES AND SERVICE OFFICES IN ALL PRINCIPAL CITIES OF THE WORLD. MANUFACTURING IN UNITED STATES, UNITED KINGDOM, CANADA, NETHERLANDS, GERMANY, FRANCE, JAPAN

WHAT MAKES "INSTRUMENTATION CABLE" DIFFERENT?

It is no more like power or control cable than a Ferrari is like the old family sedan. Not knowing this can cause you a lot of grief: project delays, costly replacements, malfunctions.

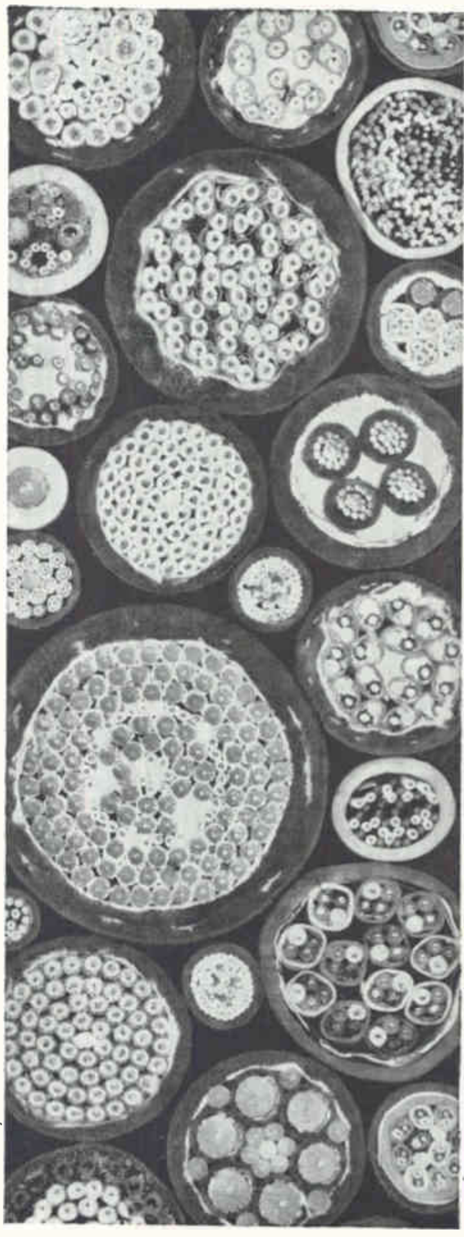
THE THIN BLACK LINE On your schematics, instrumentation cable is a black line from launching pad to blockhouse or from one part of a computor to another. In the broadest sense, it connects data or signal sources with display or recording or control devices. Its function is to carry those signals unfailingly and with the required reliability. In this day and age, it's no easy job.

WHAT CAN GO WRONG The improperly designed cable can simply fail. This has happened and at important sites. An untried saturant, lacquer or compound ingredient used in the cable may destroy the electrical integrity of this primary insulation. This sort of deterioration need not be sudden; only experts know which impregnants will migrate in a week or a month or more.

Or a relative lack of art in manufacture may create problems for the future. Under certain circumstances in use, variations in insulation thickness, conductor placement, or conductor unbalance in the cable lay-up may cause spurious or ambiguous signals to arrive at the display, recording or control panel. Your sharp, precise pulses become displaced in time, are a little too fuzzy, or are joined by other unwanted signals from another line.

DESIGN IS HALF THE STORY Configuration of conductors within the cable is important, for physical as well as for electrical reasons. For example, positioning of coaxial components within the cable is critical in order to assure maintenance of minimum standards of concentricity between the inner and outer conductors when the cables may be subjected to bending operations during installation work.

Selection of insulating, filler and jacketing materials requires expert knowledge and judgment. Some materials, as mentioned above, tend to migrate. Others harden or soften with cold or heat. Some change their electrical characteristics in time. These are not fundamentally new problems in cable design, *but in instrumentation cable the standards are far more severe than ever before.*



MANUFACTURE IS THE OTHER HALF Even a properly designed cable may well become unacceptable sooner or later if it is not manufactured to new standards of precision. This requires stranding machines that reduce circular eccentricity to remarkably low figures and help assure insulation uniformity, insulating machines of considerable precision, and highly precise cabling equipment. It also requires, as is so often the case in precision manufacture, an indefinable skill on the part of machine operators.

ASK THE EXPERTS To protect the functioning of your system, there's only one way to make sure the thin black lines on your schematics become cables with the requisite dependability: have them designed by experts, in consultation with you, and constructed by experts.

Rome-Alcoa is, frankly, one of the very few companies that qualify. We've been designing and constructing these cables since their first conception. If you're going to need instrumentation cable soon, call us, the sooner the better.

We now have a 24-page booklet titled "Instrumentation Cables, Cable Assemblies and Hook-up Wires." In it, we describe instrumentation cable constructions, production, military specifications and our qualifications. For your copy, write Rome Cable Division of Alcoa, Dept. 27-43, Rome, N.Y.

ALCOA
ROME CABLE
DIVISION

CIRCLE 21 ON READER SERVICE CARD

Laser Meetings Double Up

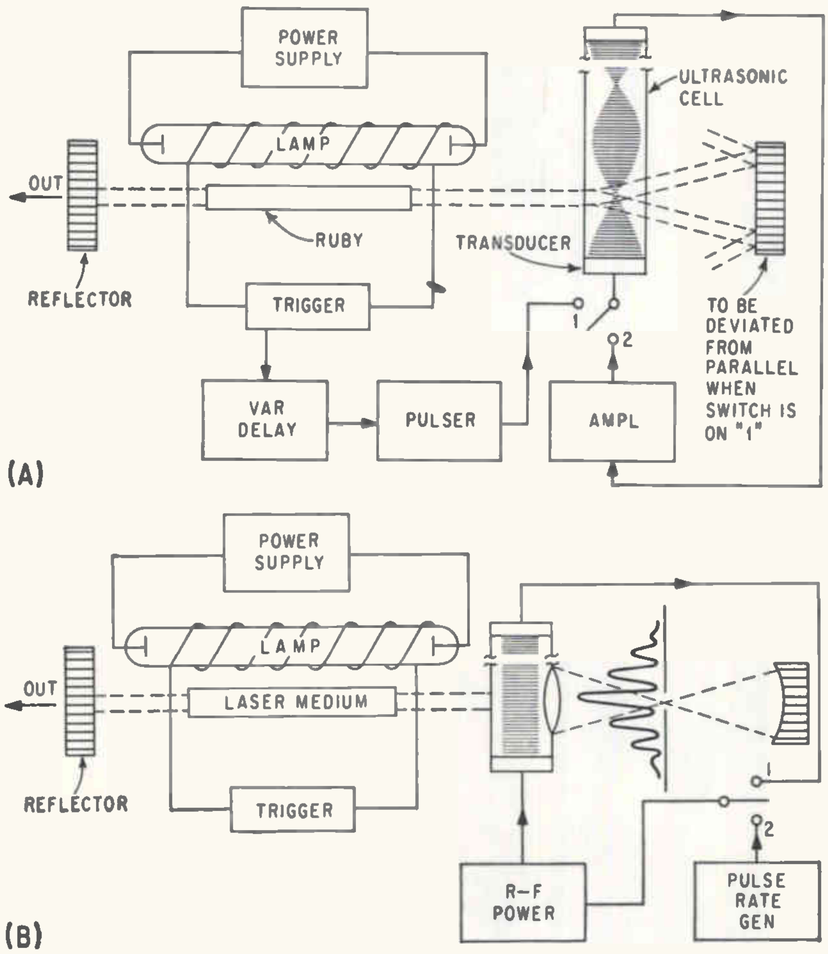
Next week there'll be two—one in New York, another in Pittsburgh

NEW YORK—First U. S. meeting designed to give a broad picture of both the physics and technology of lasers opens here at the Waldorf-Astoria for three days beginning next Tuesday. New phenomena, new directions in lasers and advances in such techniques as modulation and detection will be reported.

The symposium was organized by Polytechnic Institute of Brooklyn, in cooperation with IEEE, Optical Society of America, and the Air Force, Navy and Army research offices.

The first session will be primarily invited review papers. In one, Benjamin Lax, of MIT Lincoln Lab, is expected to discuss possibilities for three new classes of semiconductor masers:

- Cyclotron-resonance. This approach, under study for a few years, may produce a laser that is magnetically tunable, by a field of 100 kilogauss, over 10 to 20 percent of its center frequency. Emission is stimulated by electrical pumping and then by cyclotron resonance transitions between neighboring levels within the valence band.
- Magneto-optical masers. These would use population inversion in forward-biased tunnel diodes, would require 100-kilogauss pulsed fields and might be made of indium antimonide.
- Indirect-transition masers. Now being investigated at the Ecole Normal Superieure in Paris, they would utilize electrical pumping in a germanium *pin* junction.



EXPERIMENTAL *arrangement of ultrasonic refraction shutter (A) and diffraction shutter (B). These setups are used at United Aircraft to control laser action*

MODULATION—Ultrasonic control of laser beams will be described by A. J. DeMaria, R. Gagosz and G. Barnard, of United Aircraft Research Labs. The refractive index of the medium in the Fabry-Perot cavity (see diagram) is varied by propagating ultrasonic energy in the medium. Resulting interaction can accentuate either refraction or diffraction effects.

The refraction effect can be used as a shutter for generating single pulses of short duration and large amplitude, as in setup (A) when the switch is on position 1 and the reflectors are not parallel. Pulses 70 times stronger than normal have been obtained with rise times around 25 nsec and total duration of 70 nsec.

Refraction has also synchronized the usually random output pulses of a ruby laser with ultrasonic frequencies from 50 to 200 Kc. The switch is placed in position 2 to establish a standing-wave operating mode.

Amplitude has been modulated at 8 Mc by using the diffraction effect in the standing-wave mode as in (B). The ultrasonic cell was driven by an *x*-cut quartz crystal resonating at 4 Mc with 150 v r-f peak (Switch is on "1".) Since a ruby system is relatively insensitive to variations in its positive feedback, this technique can also modulate other laser systems.

Millimetric photo-mixing using surface waves will be proposed by A. L. Cullen, of the University of Sheffield, England. In one approach laser beams cause photoelectrons to be emitted from a corrugated photoemissive surface that is capable of supporting a surface wave at the millimeter or sub-millimeter output frequency. The electrons are then collected by an anode that does not play a part in the interaction. In a second approach the

IN PITTSBURGH—CHELATES AND GAS

Electrochemical Society meeting in Pittsburgh next week will put the emphasis on chelate lasers during the laser symposium Monday and Tuesday. Laser emission from europium chelate solutions will be discussed by Alexander Lempicki and Harold Samelson, of General Telephone & Electronics Labs. N. E. Wolff and R. J. Pressley, of RCA Labs, will describe laser action in an organic matrix containing trivalent europium.

Basic advantage of the chelate laser (ELECTRONICS, p 7 and p 14, March 1, and p 7, March 7) is that large organic molecules are efficient absorbers of energy. This energy can be then transferred to a metal ion (europium) imbedded within the organic molecule. The metal ion emits energy in short-line fluorescence, and is thus a suitable material for laser action.

Another significant development, a new pulsed helium-neon gas laser that uses transient phenomenon in the gas, will be reported by E. Byerly, J. Goldsmith and W. McMahan, of Martin Co. A rapid inversion technique is claimed to yield between 2 to 3 orders of magnitude power increase. One watt can be obtained from a gas laser that normally produces between 1 and 10 mw

anode is corrugated and can support a surface wave.

Latest experimental data on their internal laser modulation will be reported by K. Gurs and R. Muller, of Siemens and Halske, Munich (ELECTRONICS, p 15 and 16, March 1). An electrical birefringent material inserted in the laser feedback path provides full modulation of the emitted light by only a small rotation of the plane of polarization within the modulating material.

NEW EFFECTS — Considerable medical interest is expected from a paper by V. T. Tomberg, of Kollsman Instrument. He will discuss the possibility of using laser beams to build up strong electrical fields to induce biological effects.

The field of more than 10^8 volts per meter that a laser can produce reportedly can produce chemical effects in tissue. Electrolytical changes have been obtained in blood and plasma irradiated with a pulsed ruby laser. Possible applications may include brain surgery.

An unusual phenomenon for generating coherent light will be discussed by Martin Hertzberg, of Republic Aviation. He says it is theoretically possible to produce coherent light in a luminescent exothermic chemical reaction.

Paper on optical coherence theory by E. Wolf, of the University of Rochester, will touch on one of the most controversial subjects in laser theory today—how adequately does purely classical coherence theory describe the coherence properties of laser beams. Laser beam fluctuations are nongaussian and there is considerable argument about how much quantum mechanics may be needed to generalize the theory developed so far. This has practical implications because, for example, an estimate of the ultimately limiting noise properties of a laser communications system would depend upon an adequate theory of coherence.

Radar Guards Nike Base

BISTATIC *doppler radar installed by Sylvania at Nike Hercules missile base detects person stepping inside electromagnetic field*

BUSIEST BIRTHDAY WE'VE HAD SO FAR
[OUR 25th, THAT IS]

It sneaked up on us, as anniversaries do. Made us stop short to ask ourselves a few inevitable questions: Where are we? Where are we going? What are we doing for *you*—a designer, a plant engineer, a manufacturer?

We are, for one thing, busy in places we never dreamed of a quarter of a century ago, when the first Du Pont TEFLON fluorocarbon resin was born. In satellites braving the hard vacuum and radiation of outer space, in arctic radar installations, in the nerve systems of giant computers. There we're helping you meet standards of reliability that a while ago would have seemed fantastic or just plain impossible. We're busy, too, in more familiar places—in candy factories and processing plants, helping you dispose of problems as old as too-sticky taffy pullers and leaky steam valves.

You're putting us to work in hookup wire and hoses, packings and piston rings, coil forms and coaxial cables, lined pipe and sand-chute liners, relays and ribbon cables, seals and stand-off insulators. You're using us to save weight

when every pound counts, to save space when every cubic inch is precious, to cut maintenance when every hour of downtime is more costly than ever. You're using us when it gets too hot or too cold or too corrosive for ordinary materials—or when you simply get tired of replacing a gasket once every three or four days.

You're taking advantage of one thing we've spent 25 years in proving: the utmost reliability in use.

Where are we going? We like to think of ourselves as growing along with your needs. We've already grown to a full line of twelve different fluorocarbon resins. The newest members of our family, the FEP resins, are meeting your requirements for long extruded insulation and jacketing, for complex molded shapes, for foamed wire insulation. Our fabricators are offering us an increasing variety of constructions for your electrical, mechanical and chemical uses.

Our next 25 years, like the last, depend entirely on what we can do for you. We'd like you to tell us about any problems we might help with. And we'd like to tell you more about ourselves, including our full technical credentials. Write to: E. I. du Pont de Nemours & Co. (Inc.), Dept. E-412 63TX, Rm. 2526, Nemours Building, Wilmington 98, Delaware.

In Canada: Du Pont of Canada Ltd., P.O. Box 660, Montreal, Que.

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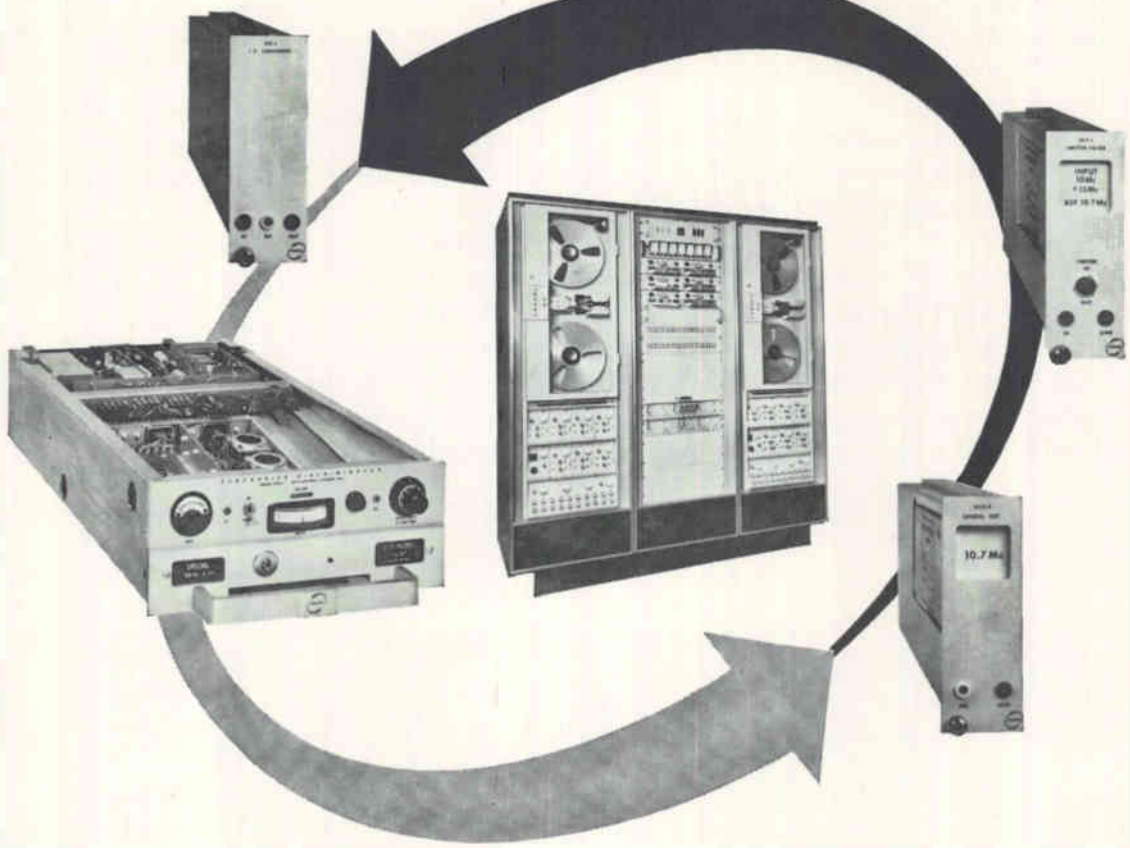
FLUOROCARBON RESINS

DU PONT
REG. U.S. PAT. OFF.

TEFLON is Du Pont's registered trademark for its family of fluorocarbon resins, fibers and films, including TFE (tetrafluoroethylene) resins and FEP (fluorinated ethylene propylene) resins.

BETTER THINGS FOR BETTER LIVING...*THROUGH CHEMISTRY*

CIRCLE 25 ON READER SERVICE CARD



Predetection Recording by DCS gives you these 7 features:

• Best s/n performance • Best transient characteristics
• Up to 800,000 bit/second response • Tape speed compensation
• Off-the-shelf modular flexibility • 100% solid state • Usable with most receivers and recorders

Considering predetection recording? Only DCS can give you *all* these advantages:

First, the phase lock loop design of the GFD-4 Discriminator permits playback at the recorded frequency without incurring the noise and transient degradation typical of up-conversion systems. And in addition, response from DC to beyond that required for 800 Kilobit NRZ PCM is provided, for full IRIG requirements.

What's more, DCS has the only system providing tape speed compensation of reproduced data. Components are all solid state . . . modular (just plug 'em in!) . . . and available off the shelf.

Whether you need a complete predetection recording system, or want to build one using your present receiver and recorder (DCS components are compatible with most), DCS can help you.

Write us for complete information. Address: Dept. E-7-2.

DCS

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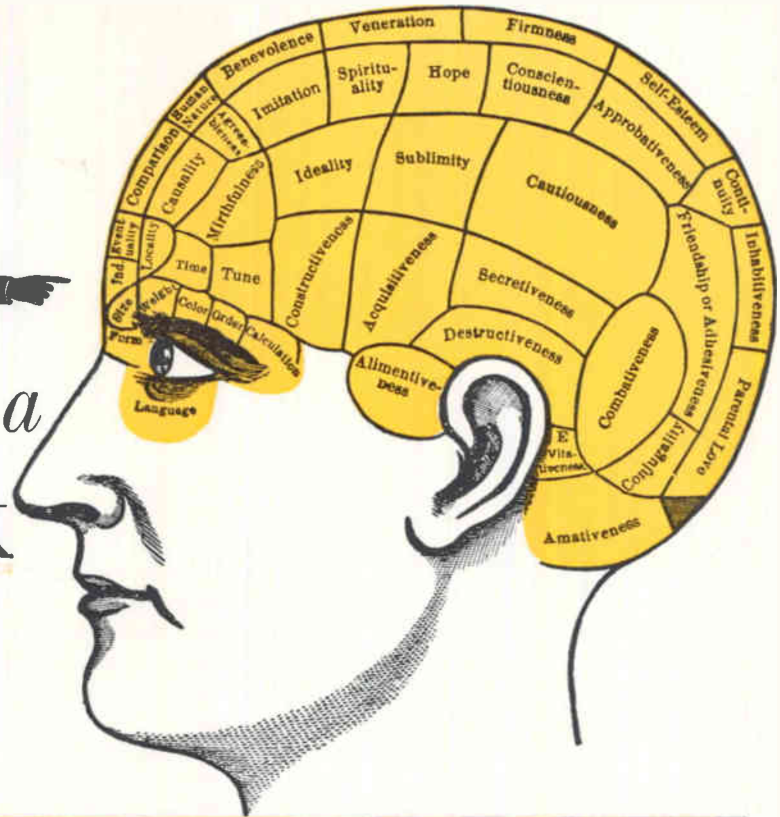

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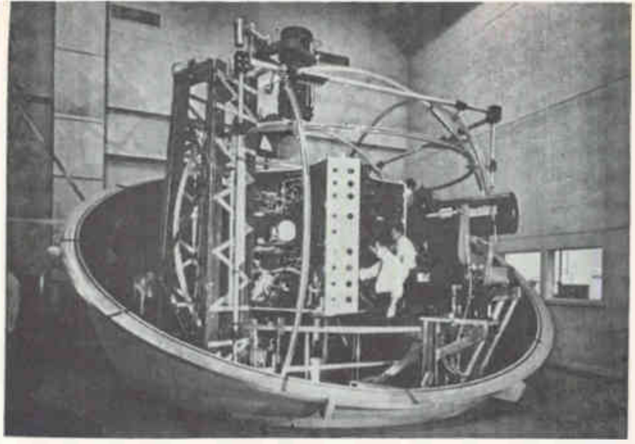
ORBITING OBSERVATORY Nears Flight



OUTER SPACE *conditions are simulated at test facility. System is on air-bearing table that provides frictionless movement*

Stabilization system "flies" for first time in test chamber

BETHPAGE, L. I.—Stabilization and control system of the Orbiting Astronomical Observatory (OAO) has made its first flight—under simulated space conditions — at Grumman Aircraft Engineering Corp. here.

Qualitative tests, demonstrating that the system will work in space, were being completed this week. Quantitative tests of system performance will begin about June 15. The flyable satellite system will be tested this fall. Launching of a series of OAO's is to begin in 1964-65.

OAO's mission will be to study cosmic phenomena—including X-ray, ultraviolet and infrared—that are normally obscured by the earth's atmosphere (ELECTRONICS, p 58, July 29, 1960; p 36, Oct. 28, 1960; p 99 and 102, Nov. 17, 1961, and p 22, Feb. 23, 1962).

Grumman says that OAO will be one of the most precisely stabilized satellites ever orbited. It is designed to track a star within 0.1 second of arc, using a combination of on-board sun and star sensors and computer controls.

In actual flight once OAO is in orbit photocell sensors acquire the sun line. Tumbling is reduced by gyros. Then six star trackers, positioned 90 degrees apart in all axes, acquire stars to orient the satellite. Coarse jets then turn the satellite until the spacecraft locks onto a particular star. The lock-on command comes from a ground controller, who views star pictures transmitted from a low-light tv camera mounted on a telescope, and selects the star. All command signals are processed by a digital computer and sent by a narrow-band transmitter to the satellite.

TEST FACILITY—To test out the stabilization system, Grumman puts it onto a table that floats on a cushion of air. This air-bearing table provides frictionless motion of the system. The table is in an aluminum vacuum chamber. Vacuum pumps, serving the chamber and air-bearing independently, evacuate the chamber to 0.001 atmosphere, equal to the pressure at 250,000 feet.

Chamber's solar simulator consists of 18 6-Kw xenon arc lamps placed atop the table to test for sun-line acquisition. The unit emits 14 Kw of light in the 0.6 to 1.2 micron band.

To simulate the star search, five star collimators provide −1 to +6 magnitude "stars," the magnitude sensed by the star trackers. For the tests, only three star trackers are used.

FIELD SIMULATOR — Earth's magnetic field is simulated with Helmholtz coils. Fixed field windings null out the earth's magnetic field within the test facility. Variable field windings simulate the magnetic field in space that varies with the orbital path.

Data on aerodynamics, earth's gravity and solar pressure are provided with a magnetic torquer, consisting of three sets of coils, acting like an induction motor. Five 3-inch cubical mirrors are positioned over an auto-collimator to sense the motion in the three axes during lock-on simulation. One odd-shaped mirror with 2-degree facets permits tests of slew maneuvers (reorientations with subsequent lock-ons) from 2 degrees in 30 seconds to 30 degrees in 3 minutes.

A seismic block supported by 12 large spring coils eliminates earth tremors from outside the test facility. Outer space conditions are duplicated as far as possible.

GROUND STATION *console provides digital gimbal angle and 366 analog status readouts to Walter Muench, OAO test director, shown giving instructions to spacecraft controllers during a test*

BUTTONED-UP CHAMBER. *Men at top adjust solar simulator, while those at left control simulated space phenomena*

SA-84WA
10-63,680 mc

This instrument was the microwave "hit" last August at WESCON. They were standing three deep to see it in October, at N.E.C. At NEREM, in November, we were demonstrating it **continuously.** At IEEE, eight months after its introduction, it was a **standout** attraction!

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- **WIDE-RANGE VARIABLE-FREQUENCY MARKERS** . . . ±40 mc in the SA-84WA!

We can only touch the high spots here — but our brand-new 40-page Spectrum Analyzer Bulletin A63 gives the complete specifications. Use this card—we'll send your copy by return mail!

Incidentally, we make seven classes of spectrum analyzers, in 35 standard versions, hundreds of standard variations. Turn the page for a brief summary.

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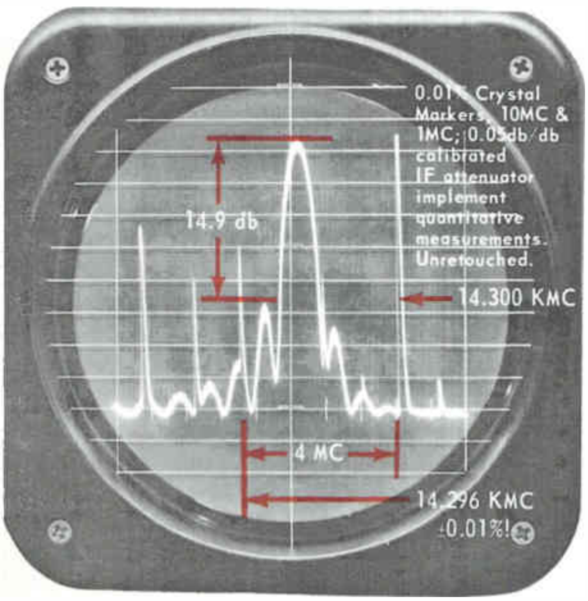

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MODEL	PRICE	Configuration	Freq. Range	Resolution	Dispersion	Display	Additional Features	Max. & Min. Sensitivity (S+N=2×N)	REMARKS
TSA	$3,990.*	Multiple PLUG-IN HEADS	10 mc to 40 gc	1 kc to 80 kc	100 kc to 25 mc	LIN-LOG	Video Filter	−115 dbm to −50 dbm	Lowest cost analyzer for specific frequency application.
TSA-W	$4,335.*	Multiple PLUG-IN HEADS	10 mc to 44 gc	1 kc to 80 kc	25 kc to 80 mc (25 mc on STU-1 band)	LIN-LOG	Sweep and Video Outputs. Video Filter	−115 dbm to −50 dbm	Lowest cost analyzer for specific frequency application requiring wide dispersion.
TSA-S	$4,635.*	Multiple PLUG-IN HEADS	10 mc to 44 gc	Spect. Anal. { 5 kc, 50 kc; Synchro. { 500 kc, 5 mc	400 kc to 25 mc	LIN	Sweep and Video Outputs. Trigger Output	−105 dbm to −50 dbm	Combined spectrum analyzer & synchroscope for frequency & time domain displays.
SA-84	$5,000.	Universal MULTI-BAND	10 mc to 40.88 gc	25 kc	500 kc to 25 mc	LIN	Military Standard UPM-84	−90 dbm to −40 dbm	Lowest cost analyzer for wide frequency coverage
SA-84T	$5,650.	Universal MULTI-BAND	10 mc to 40.88 gc	20 kc	500 kc to 25 mc	LIN	41 DB Calibrated IF Attenuator	−105 dbm to −55 dbm	Transistorized, portable, battery or line operated, wide frequency coverage.
SA-84W	$6,290.	Universal MULTI-BAND	10 mc to 40.88 gc	1 kc to 80 kc	25 kc to 80 mc (25 kc to 100 mc on special order $100 add'l)	LIN-LOG	20 DB Calibrated IF Attenuators IF & RF Crystal Markers, Video Filter	−105 dbm to −55 dbm	Wide frequency coverage with wide dispersion.
SA-84WA	$6,490.	Universal MULTI-BAND	10 mc to 63.68 gc	1 kc to 80 kc	25 kc to 80 mc (25 kc to 100 mc on special order — $100. add'l)	LIN-LOG	20 DB Calibrated IF Attenuator IF & RF Crystal Markers, Video Filter	−115 dbm to −45 dbm	Widest frequency coverage with wide dispersion.

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SA-84, SA-84T, SA-84W, SA-84WA: Single unit covers all bands

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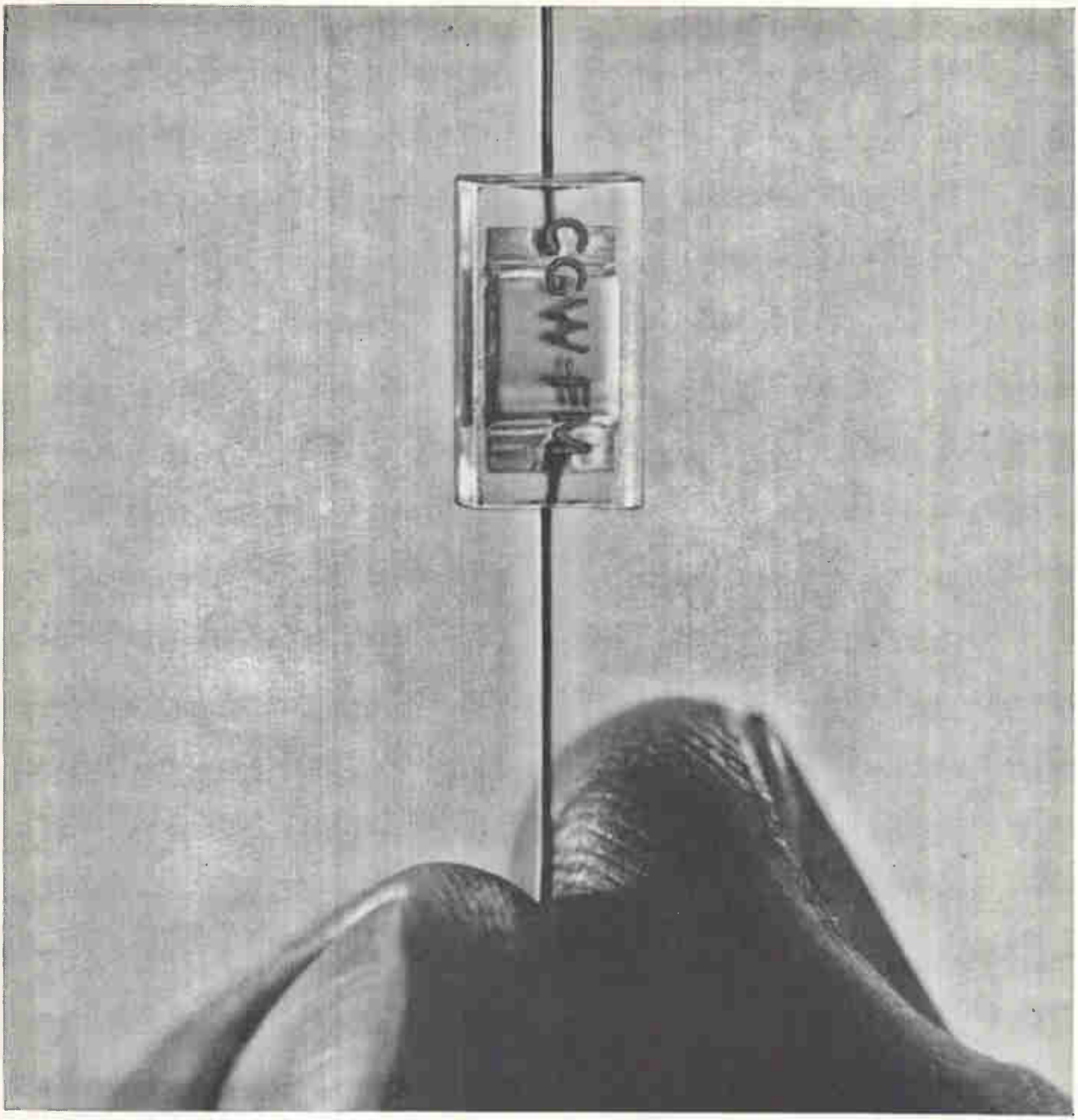

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All in all, the CYFM is a positively sealed capacitor for complete environment-proof performance (it goes far beyond MIL-C-11272B), and it sells for less.

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You can get its reliable capacitive element of foil and ribbon glass, *frozen* inside glass with hermetic seals at the leads, in four types. The CYFM10 gives *pf* values from 0.5 to 300; CYFM15, 220 to 1200; CYFM20, 560 to 5100; CYFM30, 3600 to 10000.

But, when you must have the ultimate in *guaranteed* reliability to your specifications, specify the CYFR. It's available in the same sizes and capacitance range. The CYFR is second to none.

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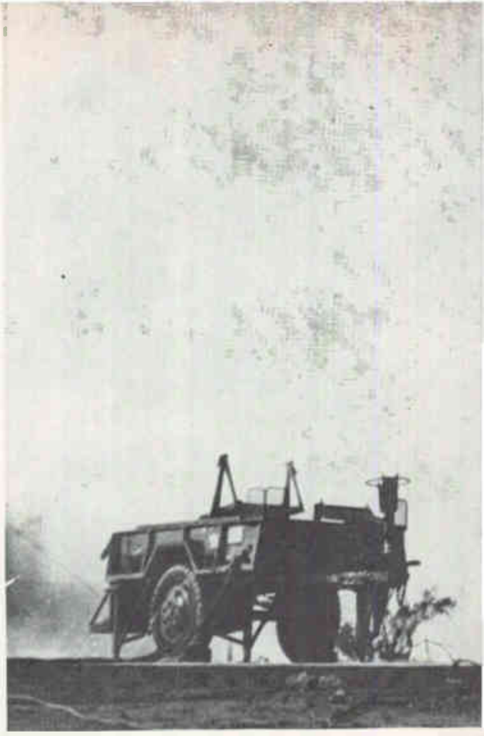
ARMY

OF THE AIR CREATES NEW MARKET

Air-mobility and non-nuclear capability call for new gear



COMBAT *surveillance drone, SD-2, carries side-looking radar, ir, and photographic cameras. Raw and photographed data are telemetered back to headquarters*

By JOHN F. MASON
Senior Associate Editor

THE NEW ARMY is creating a new market that will phase out some old Army contracts and open the door for others. Army needs a new kind of equipment to bring its new fighting concept into being.

Mobility (by air instead of ground whenever possible) and non-nuclear capability are the main characteristics of the revamped Army posture. It must be able to move quickly to any spot in the world, it will be more self-contained, and it will be bigger. Army will grow to a 22-division force by the end of fiscal 1964, requiring "a high annual level of funding for several years," Army's Chief of Staff, Gen. E. G. Wheeler, said.

NEW ARMY AIR FORCE—Army will buy 1,600 planes to test the effectiveness of two new types of completely air-mobile combat units: air-assault divisions and air-cavalry combat brigades. Special-purpose air units will appear, and both air transport and corps aviation brigades.

Army helicopters and light fixed-wing aircraft will replace or augment trucks, ground fire support and armored combat vehicles, Army Secretary C. R. Vance said.

Secretary of Defense Robert S. McNamara and Army generals are enthusiastic over the plan—recommended by the (Lt. Gen. H. H.) Howze board—and see no big obstacle to its success. Once checked out, the plan will call for many more aircraft and associated gear for years to come.

Besides the $522.1 million for aircraft procurement in 1964, $68.8 million, from "Communications and Electronic Equipment" (table, p 36), will buy navigation, communication and surveillance gear.

For improved and future planes,

THE KEY IS "NON-NUCLEAR"

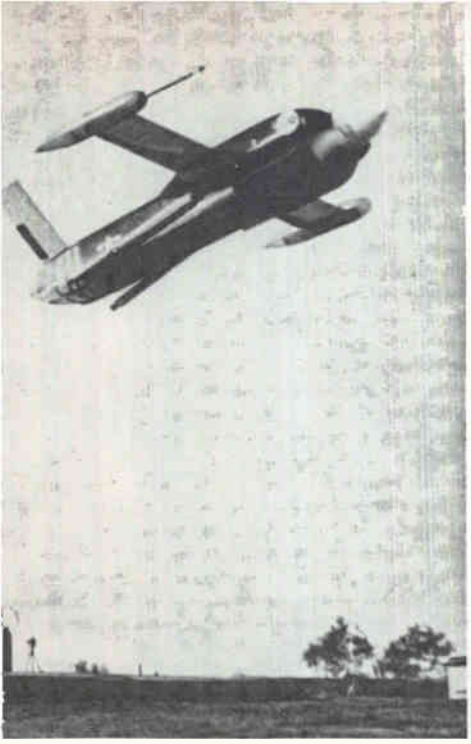
Although nuclear weapons on order will be bought, the importance of the non-nuclear aspect cannot be over emphasized in understanding this new, big market.

The non-nuclear requirement is based on the administration's nuclear stalemate theory, articulated by Defense Secretary Robert S. McNamara, and Harold Brown, director of defense research and engineering.

"An analogy can be drawn to a mathematical equation in which the first order terms (nuclear weapons) cancel out, and so the second order terms (conventional weapons), though smaller than the first order, nevertheless become determining," Brown has said.

McNamara says this was proven in the Cuban crisis last October: ". . . the forces that were the cutting edge of the action were the non-nuclear ones," he told the NATO ministers. "Nuclear force was not irrelevant but it was in the background. Non-nuclear forces were our sword, our nuclear forces were our shield"

IROQUOIS *helicopter carries six SS11 wire-guided missiles to tanks and other targets. Other missiles being considered for helicopters are ENTAC, Shillelagh, and Tow*



Army will initiate R&D work on the Mohawk surveillance (both electronic and photographic) plane, Iroquois helicopter, Chinook medium transport helicopter, Caribou II tactical transport plane, light observation helicopter, a new surveillance plane, operational evaluation of V/STOL concepts, a research helicopter, heavy lift helicopter, a weapons helicopter, and exploratory development of air mobility.

Added to the $82.1 million for aircraft RDT&E is $40.6 million, from "Other Equipment," to buy development of tactical communications ($4 million), combat surveillance ($24 million) and navigation ($12 million). These amounts are bound to escalate rapidly when Army learns more about specific needs for their new airborne operations.

AIR TRAFFIC CONTROL (ATC)—Where central ground control of airborne operations will be needed, and to what extent, still haven't been determined. Army now feels that light planes in the forward area will not need a command and control system. Air transport and cargo planes will require some ATC system, as will air cavalry brigades when crossing air cargo routes. Some kind of command and control will be required when Army's air missions coincide with Air Force and Navy operations. IFF will be an important device, in such a menage, especially when an enemy air force is attacking Army's low-flying planes.

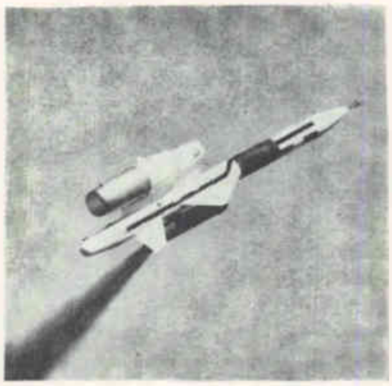
Army's present ATC system relies on pilot reports for position information, recorded manually at the ground center. Detailed system concept for an automated system is now being drafted by Army's Combat Development Command at Fort Belvoir, Va. Requirements should be firmed up during early 1964. Development and hardware contracts will follow.

AIRBORNE COMMUNICATIONS —Unless someone comes up with a real breakthrough, Army communications—complex though they might be due to the low altitudes at which the planes fly—do not offer R&D contract possibilities at this time. Although no development work is planned for h-f gear, used between Army planes and the ground, Army is studying Navy's h-f ssb equipment. Army has just bought new f-m and vhf systems. F-m is used to talk with Army's ground net, vhf on civil air routes in Europe and the U. S., and vhf and uhf to communicate with USAF and Navy planes.

NAVIGATION—A real need exists in the field of navigation. System must be cheap enough for widespread use, and frequencies low enough to provide over-the-horizon coverage. Bendix-Pacific has delivered a low-frequency ground-based, grid system for testing at Fort Huachuca, Ariz. Called the Position Fixing Navigation System, AN/GRN-14, the system can be set up and grid maps produced in hours.

Although neither type is under development, Army is testing off-the-shelf doppler and inertial equipment. Cost militates against either for the time being.

SURVEILLANCE — Biggest area of interest is surveillance. Side-looking airborne radar (slar) will be used in USD-2 drone, now under development. It is used in the operational Mohawk, and will be used in the advanced Mohawk (ELECTRONICS, p 22, March 22). Army-sponsored work continues on slar at the University of Michigan and at Goodyear Aircraft. Present equipment now has a resolution of 50 feet. Goodyear is working on a



REDHEAD/ROADRUNNER *supersonic target missile was designed to train air-defense missile crews*

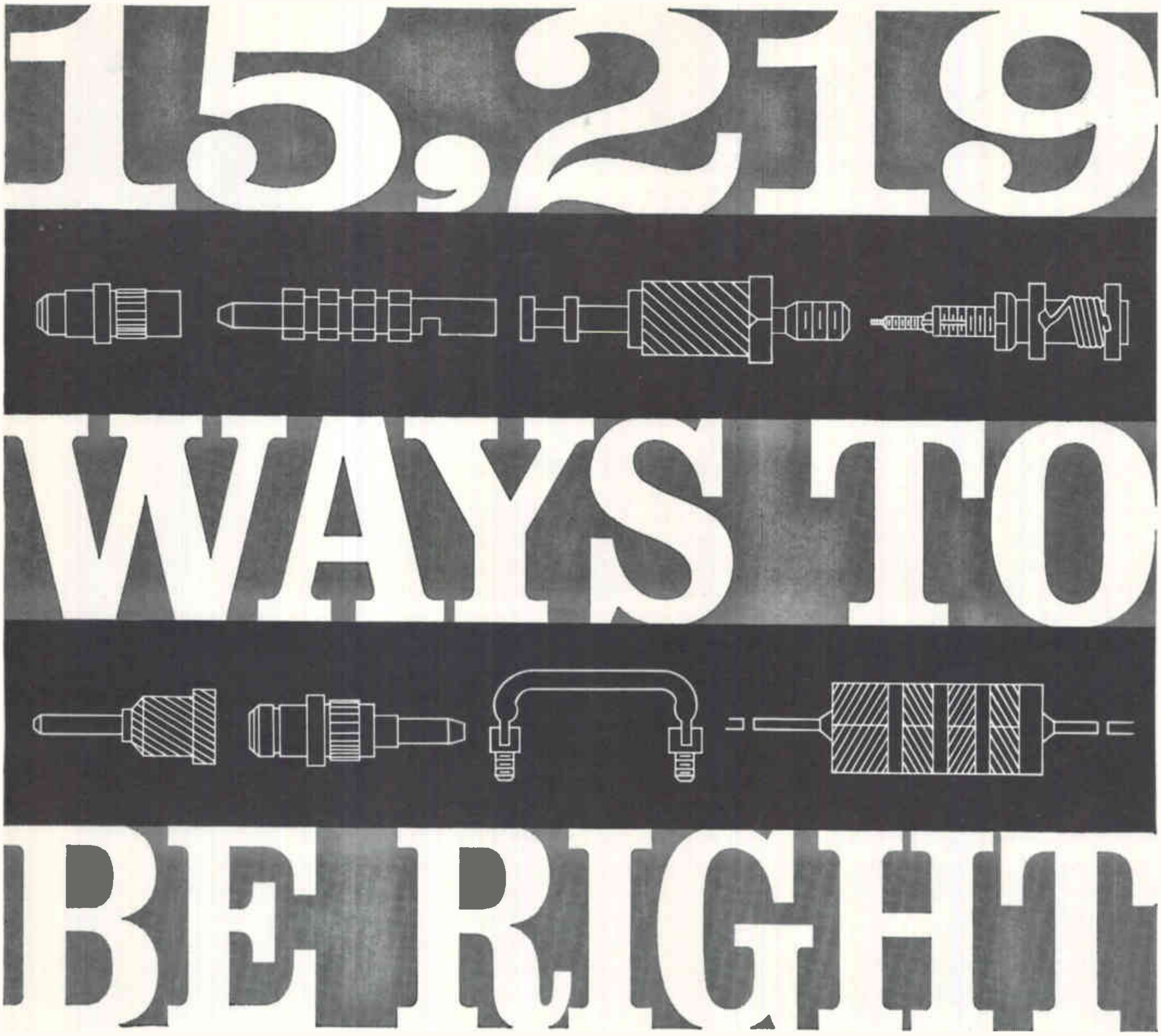
program definition for slar equipment with resolution from 2 to 6 meters. Transmission of slar data —both raw and filmed—is no problem, Army says.

A far greater headache is image interpretation. The quantity of film that comes back can not possibly be examined quickly enough by men. Equipment is needed to identify target patterns automatically. Army has researched this problem on a modest scale, but would like some technological solutions before starting development work.

Although infrared gear has improved greatly over the past year and a half, more work is needed. Texas Instruments has a study contract for a high resolution ir set with a new type scanning device. The present rotating mirror is undesirable, Army says. Rotation speeds are high, and the device is heavy.

Army says the ideal surveillance system would be a sensitive, lightweight, passive device. Sperry Gyroscope is working on two infrared surveillance devices, both passive: ground-based ranging equipment for the Army, and airborne detection gear for the Navy. Navy's $98,000 contract is about a year old, and calls for development and delivery of one flight test model. Tests will begin soon. Sperry Microwave Electronics is developing an airborne microwave radiometer for passive detection, designated AN/AAR-26, for the Army. Problems are sensitivity and weight.

MISSILES—A big part of the $558.4 million for missiles will go



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for the electronic portion of the missiles and for tactical ground support gear. This includes acquisition and tracking radars, test sets, training kits, simulators, and nuclear warhead adaption kits. The $22.3 million for missile spare parts pertains mainly to ground support items, such as electron tubes and electronic assemblies.

Production will continue for Hawk and Hercules missiles for another year. The initial procurement of Mauler air defense missiles is planned for 1964 with larger buys in later years. The proposed procurement of Little John and Sergeant missiles should be final buys for both. More Pershings will also be bought. About $45 million is included for Entac and SS-11 antitank, wire-guided missiles.

Army will buy two target missile systems. The mach 2 Redhead is capable of 60,000-ft altitude, uses command guidance and is recovered by parachute. Another version, Roadrunner reaches speeds of mach 0.9 to 1.2, and flies at 300 ft and up. Investment through 1964 will be $31 million; through 1968, $68.5 million. North American is prime contractor.

RDT&E FOR MISSILES—Apart from the $576.6 million RDT&E for missiles, $51.9 million from other budget categories will be spent for work on items such as electronic fuses, radar trainers, and antitank weapon systems. The latter includes developmental efforts on Shillelagh and Tow, antitank systems using a missile as well as conventional or rocket capability.

Lance (formerly Missile B) will be a going concern for a long time. R&D alone on this surface-to-surface missile will last until 1969. Ling-Temco-Vought is the developer.

Hawk will be equipped to knock down short range tactical ballistic missiles under a $10-million program. Development of Mauler will cost $83.3 million in 1964, $8.8 million of which will be spent for Multi-purpose Missile Test Equipment (MTE).

Nike Zeus will get $89 million, and Nike X, $246 million (ELECTRONICS, p 24, March 8).

GROUND COMMUNICATIONS—Largest item, $59 million, is for Starcom, Army's strategic communications system. About $20 million is requested for a large number of AN/PRC-25 portable radios, and $22 million for 5,000 AN/VRC-12 vehicular radios.

Biggest Army communications expenditure depends on the outcome of three one-year study contracts on Rada (Random Access Discrete Address) communications system signed two weeks ago with RCA, Motorola and Martin-Marietta (ELECTRONICS, p 8, March 29, p 18, April 5). If successful, the broadband, dial system could revolutionize tactical communications.

MAULER *missile system will defend troops against aircraft and short-range missiles. First buy is this year*

SIDELOOKING *radar antenna protrudes from below Mohawk OV-1 surveillance plane. Better systems are needed*

DATA PROCESSING—Army needs a new data processing system for the field. For equipment beyond the obsolescent Mobidic, software studies are being carried out at Ft. Huachuca by Thompson-Ramo-Wooldridge. The project, called the Command and Control Information System 1970 (CCIS-70), is broken down into five parts: tactical operational center (contracted separately to Ford Motor's Aeronutronics), fire support, intelligence, administration and personnel, and logistics. TRW's work on this five-part package will lead to tactical use of computers in the field army.

Using Mobidic as a test bed, TRW is working out the procedure and computer programs. By 1964, Army will be ready to specify actual hardware for the new central processor. If the program continues as planned, it will create a substantial market.

PROCUREMENT EQUIPMENT AND MISSILES, ARMY (PEMA)

	(in millions of dollars) 1963	1964
Aircraft	$207.5	$488.3
Aircraft Spare Parts	19.4	33.8
Missiles	512.1	558.4
Missile Spare Parts	17.8	22.3
Weapons & Combat Vehicles	535.0	488.6
Tactical & Support Vehicles	346.3	343.1
Communications & Electronic Equipment	315.6	405.9
Other Support Equipment	216.2	213.1
Ammunition	359.0	589.3
Production-Base Support	114.8	143.2
Total	$2,643.7	$3,316.0

RESEARCH, DEVELOPMENT, TEST & EVALUATION (RDT&E)

	(in millions of dollars) 1963	1964
Military Sciences	$199.4	$220.5
Aircraft	80.7	82.2
Missiles	453.1	576.6
Astronautics	51.0	20.2
Ships & Small Craft	1.2	1.2
Ordnance, Combat Vehicles	166.9	175.4
Other Equipment	263.0	317.5
Management & Support	71.2	76.3
Total	$1,286.5	$1,469.9*

* Industry will get 64% ($940.74 million) of these 1964 RDT&E funds

ARMY'S AN/GRG-106 mobile ssb radio (p 7, Feb. 1) will have a range of at least 50 miles, can use any one of 28,000 1-Kc channels. Contractor is General Dynamics

U. S. Trade Center Opening in Tokyo

TOKYO—Nearly 60 U.S. manufacturers will display their products at an exhibit of industrial instruments and laboratory equipment this month in the new U.S. Trade Center here.

About 500 products will be shown. Some 20,000 representatives of Japanese users, manufacturers and trading firms have been invited to view them.

The trade center, the fourth to be set up overseas, is run by the U.S. Depts. of Commerce and Agriculture. This will be its first show.

Japan Tv Firm Deaf To Competitor's Pleas

TOKYO—Competing manufacturers of tv receivers have tried without success to persuade Sanyo to cancel its plans to sell a 19-inch portable set for $180, the price of a deluxe 16-inch set. Sanyo says fears that the market will be disrupted are unfounded. The attempt to alter Sanyo's course was made at a meeting of the tv committee of the Electronic Industry Association of Japan.

Sanyo's move is expected to force competitors to bring out similarly priced sets. These should be on the market in several months. By the end of the year, monthly production of 19-inch sets may go as high as 100,000. This is also expected to increase tv exports.

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Here's how they work:

When a signal is applied, a galvanometer suspension act vates a shutter which exposes a mirror. This mirror, attached to the front terminal post, can be adjusted for spot position on the record. Under "signal" conditions, a straight-line trace, similar to a static reference, is recorded. When the "no signal" condition exists, the shutter is in place in front of the mirror, and no trace is recorded.

Just the way you see it in the illustration above.

Thus, in addition to giving you a response time capability much greater than that of the pen type, CEC's new Event-Marking Galvanometers permit you to use more channels of any CEC oscillograph with greater effectiveness.

For complete information and specifications, call your nearest CEC office. Or, write for Bulletin CEC 7371-X3.

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CIRCLE 38 ON READER SERVICE CARD

Computer Runs Steel Plant

TOKYO—Nippon Kokan Kaisha, a steelmaker, and Hokushin Electric Work have developed a system to control the basic oxygen process for production of steel and steel alloys. It is now controlling two furnaces at a plant near Tokyo.

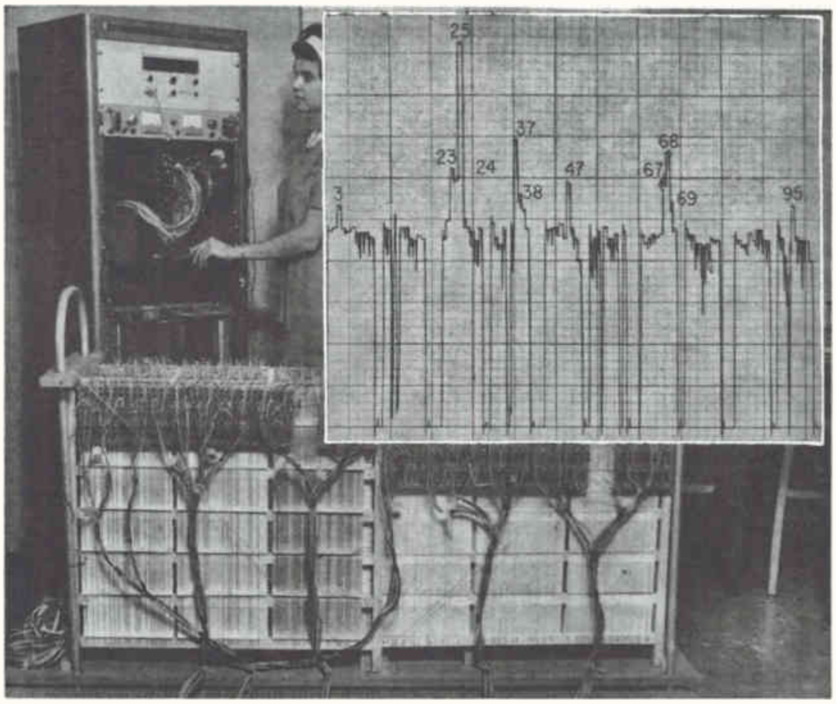
Computer operation is based on stored mathematical models for process variables, including nine equations for composition, temperature and weight. Measured values and data on the types of steel to be produced are also stored in advance in the 8,192-word memory. Calculated control variables are used to automatically adjust oxygen flow and raw materials feeds.

The system is linked to the computer of a spectrometer that analyzes iron and steel composition. Presently, the system has 144 inputs and 74 outputs. NKK plans to investigate applications in blast furnace, sintering, rolling and energy supply processes.

Stellar-Interial System Tested on Surface Ship

STELLAR - INERTIAL autonavigator system built by North American is being giving shakedown tests aboard *U.S.N.S. Range Tracker*, used to track and recover missiles along the Pacific Missile Range. System is the same as that used on Polaris submarines, with the addition of an automatic star-tracking telescope.

Researches Real-World Associations

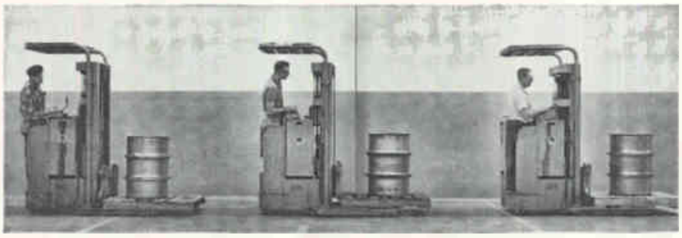


ACORN 4 *is latest in series of experimental associative information retrieval devices under development at A. D. Little, Inc. (see p 7, March 29). When voltage is put across term to be associated, the associated terms are read out in order of decreasing output voltage. Output levels are determined by resistive paths representing stored information. Graph shows response of Acorn 3 to input term tv cameras. Tv cameras (25) are used in Ranger (37) and Tiros (23) satellites. Tiros, built by RCA (68) also contains infrared sensors (47) and is used for solar research (67). Ranger is fired by an Atlas-Agena rocket (38) and placed into parking orbit (69). Tiros is launched by a Thor-delta rocket (24). Both contain other cameras (95) and are launched from Cape Canaveral (3)*

Kodak reports on:

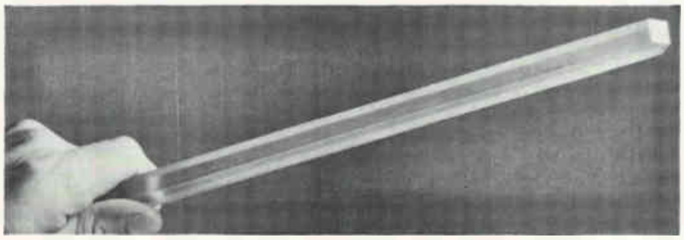
the brew for masks . . . a big one with a low threshold . . . the awful consequences of the soldering ladies' retirement

We can hardly believe it ourselves



The business of photographically converting a drawing into the thing drawn has attained some volume. Look at how we are now putting up the liquids that are hardened by light into etchant resists in making masks. KODAK Photo Resist (KPR) can be ordered from graphic arts dealers in 425-lb. drums, KODAK Metal-Etch Resist (KMER) in 400-lb. drums, and KODAK Ortho Resist (KOR) in 450-lb. drums. Also available on a less ambitious scale. As to which does what, consult Graphic Arts Division, Eastman Kodak Company, Rochester 4, N. Y.

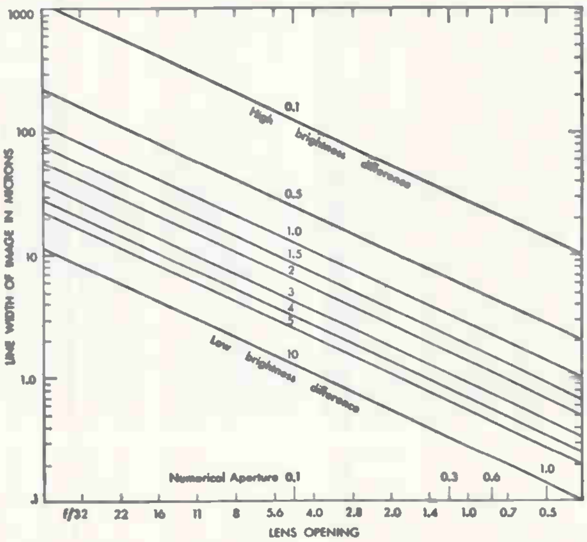
Lase, friend!



We can make laser rods big because we make them out of glass. A big piece of homogeneous glass is far more likely than a big homogeneous crystal. Homogeneity and long experience in precision prism-polishing help keep beam divergence small. The problem with glass has been threshold. Fortunately, with non-silicate glass it's no problem. Low, low, low. Inquiries about KODAK Neodymium Glass Laser Rods welcomed by Eastman Kodak Company, Apparatus and Optical Division, Rochester 4, N. Y. (Phone 716-562-6000, Ext. 5166).

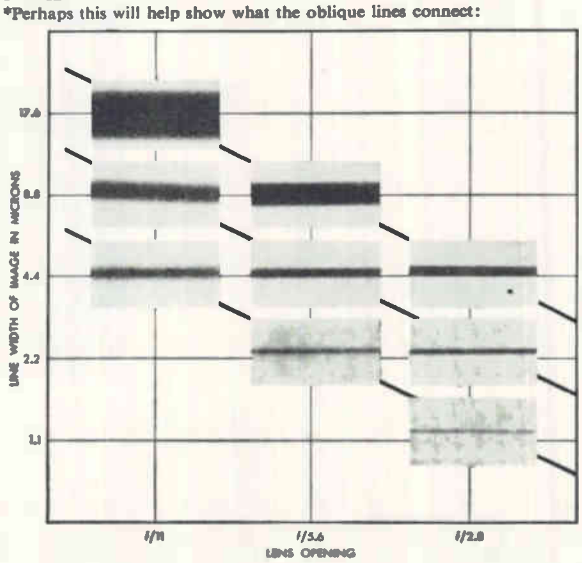
Microphotography for microelectronics

The optics of microscopy, the fabrication of electronic circuitry, and the techniques of the graphic arts are now all entwined. Girls who once lived by the soldering gun now devote themselves to baking bread and planning P.-T.A. carnivals. To manufacture a thin-film circuit or a micromodule, one carefully draws it all up (perhaps 200 times actual size) and then converts the drawing into the thing drawn. Incredible to the incredulous. Very difficult. Requires an understanding of the following:



This tells how wide a lens opening is required at the very least when photographically reducing a white line on a black background down to the width represented on the ordinate. Each diagonal plot represents a quality level.* "1.0" indicates quality so good that for practical purposes you'd never need it any better; "0.1" is ten times as good and "10" is ten times as bad. This scale is arbitrary and is for the benefit of those who have to know stuff like this but who are too tired in the evening to study the literature on modulation transfer concepts in photography and therefore send for a how-to-do-it booklet entitled "Techniques of Microphotography" to Eastman Kodak Company, Special Sensitized Products Division, Rochester 4, N. Y. It covers much more than what lens apertures to use.

*Perhaps this will help show what the oblique lines connect:



This is another advertisement where Eastman Kodak Company probes at random for mutual interests and occasionally a little revenue from those whose work has something to do with science

NEW S-BAND ATTENUATOR!

Direct reading attenuation, 0 to 60 db; ±1% accuracy, 2.6 to 3.95 gc!

HIGHEST ACCURACY RESOLUTION RESETTABILITY

Here's a new S-band rotary attenuator that offers highest accuracy, resettability and resolution in an instrument only 25¼" long. The new hp S382B and S382C Attenuators feature dielectric loading that achieves the long electrical length necessary for high accuracy, yet keeps the physical length small. ● These direct-reading instruments are calibrated in both db and "degrees of rotation". Resettability is enhanced by the fact that the ball-bearing-mounted rotating barrel is driven by a backlashless spring-loaded drive train. ● The two attenuators differ in their calibration, with the S382B scale divided in 0.1 degree increments. The S382C scale is calibrated in 0.01 degree increments and incorporates a scale with an effective length of 53 feet. Thus, the S382C, for example, offers 0.01 db resolution at 30 db on the dial. ● Each attenuator is capable of handling 10 watts of continuous power, and they are unaffected by changes in humidity or temperature. Contact your Hewlett-Packard representative today for a demonstration on your bench.

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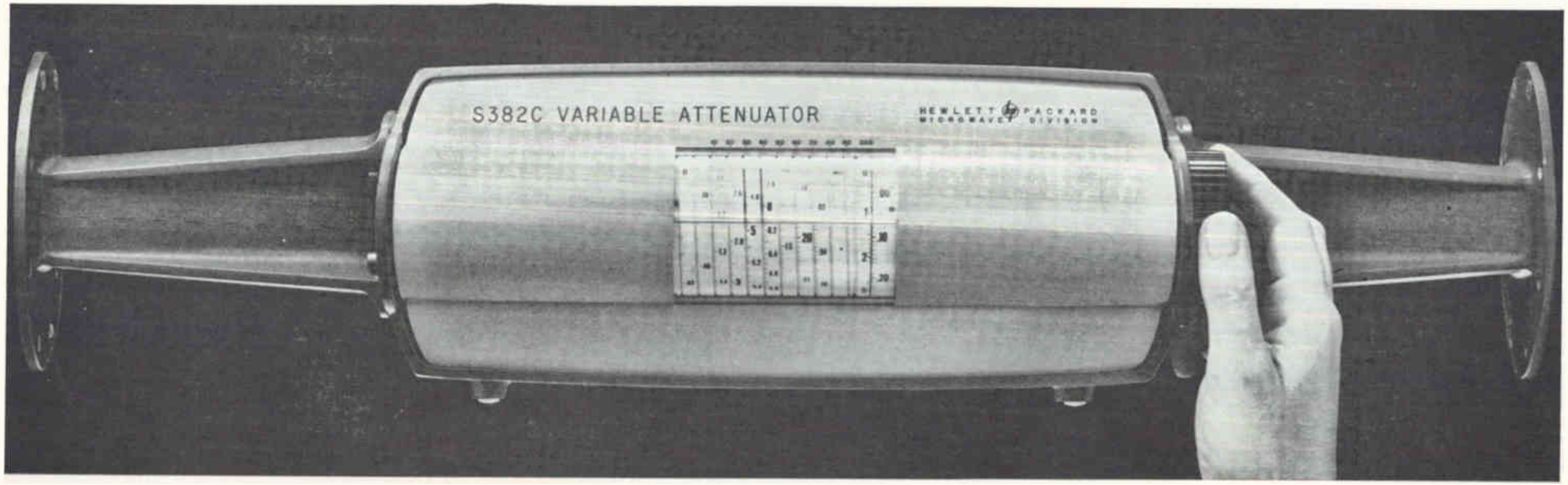
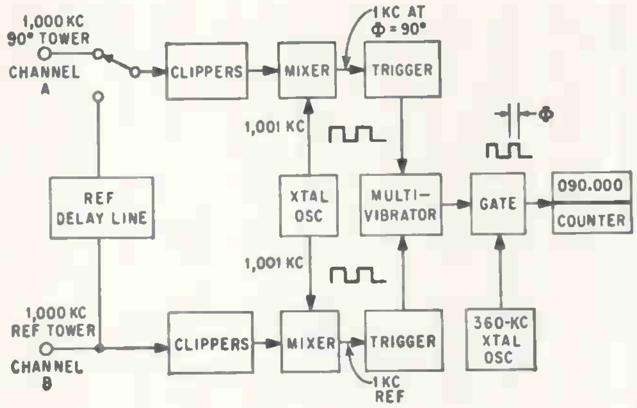
SPECIFICATIONS

Frequency Range:	2.6 to 3.95 gc
Calibrated Attenuation Range:	0 to 60 db
Accuracy:	±1% of reading in db or 0.1 db from 0 to 50 db, whichever is greater; ±2% of reading above 50 db
Insertion Loss:	Less than 1 db
SWR:	Less than 1.15
Phase Shift Variation:	Less than 3° from 0 to 60 db
Power:	10 watts continuous duty
Degree Dial:	0 to 90°; S382C calibrated in 0.01°; S382B calibrated in 0.1° increments
Size:	25¼" long, 6" high, 8" deep; may be rack mounted
Price:	S382B, $600; S382C, $650

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



CIRCLE 41 ON READER SERVICE CARD



DIGITAL phase meter is part of phase monitoring system described by J. K. Birch, of Vitro Electronics, as meeting FCC requirements. Phase angle can be read with long-term repeatibility to within 0.15 degree

F-M Plus A-M Yields

Another broadcast advance is four-vidicon cameras for sharper color tv

CHICAGO — "Three-dimensional" audio broadcasting, four-vidicon color tv cameras and a regulation-anticipating triplex monitor were featured at the NAB Broadcast Engineering Conference last week.

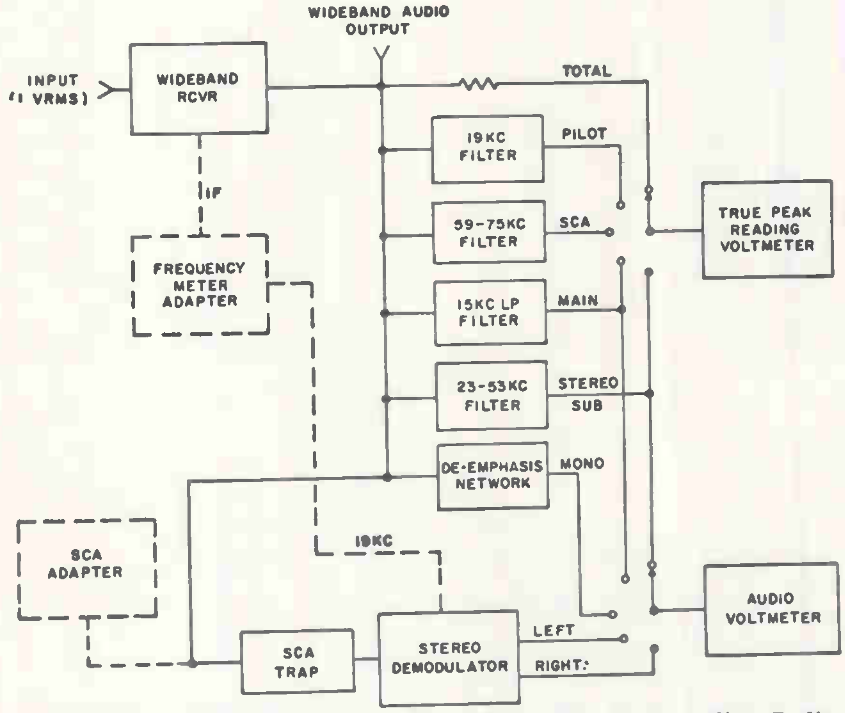
Three-channel stereo — simulcasting a-m with f-m multiplex—delivers a "significant" increase in fidelity, reported Kenneth Hamann, of station WDOK, Cleveland.

An experimental setup developed during a nine-year study found an overhead center-stage cluster of three directional cardioid microphones adequate for all but the monophonic audience.

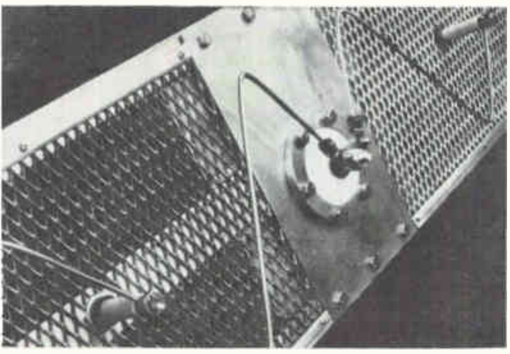
Listeners place their a-m receiver either in line—between stereo speakers—or behind them.

COLOR TV—Adding a "luminance" tube sharpens up tv transmissions of both color and black and white pictures, reported J. C. Abrahams, of General Electric.

Additional tube—mounted above



MULTIPLEX MONITOR, *reported by C. E. Dixon, of Collins Radio, anticipates future FCC stereo requirements. Self-checking, it continuously reads total modulation percentage and carrier frequency and will perform other proof-of-performance measurements*



ZIG-ZAG PANELS *like this one are assembled by GE into uhf-tv radiating arrays are computer designed*

3-D Stereo

three conventional vidicons exclusively picks up detail brightness which determine quality of the compatible signal, Abrahams said.

In coloring-book terms. the broadband luminance vidicon sketches the black and white image, which is filled in with appropriate color by three other vidicons. Image registration of the three color channels becomes much less critical, since they contribute only to chromaticity of the picture.

RCA demonstrated its four-tube color-tv camera. The black-and-white vidicon is a 1½-incher, while the color tubes are 1 inch. The larger vidicon, for a separate monochrome or luminance channel, enriches the color hues and picture quality, RCA said.

REMOTE UNIT FILTER—Interference reducing filter, described by J. L. Hathaway, of National Broadcasting Company, improves mobile unit broadcasts from the vicinity of a powerful a-m transmitter.

The interfering signal is tuned in by a highly selective circuit, whose next stage amplifies it to precisely the required degrees for reinsertion—in phase opposition—to cancel the interference.

Ampex introduced an automatic editing and animation system for tv tape. It permits scene-by-scene program assembly, recording in any convenient sequence. Scenes may be inserted into existing tapes or lengthened or shortened. Splice time-base errors are said to be reduced to less than 1 μsec.

MEETINGS AHEAD

OPTICAL MASER SYMPOSIUM, Electrochemical Society; Penn Sheraton Hotel, Pittsburgh, Pa., April 15-16.

THIN FILM ELECTRONIC APPLICATIONS SYMPOSIUM, Electrochemical Society; Penn Sheraton Hotel, Pittsburgh, Pa., April 15-18.

OHIO VALLEY INSTRUMENT-AUTOMATION SYMPOSIUM, ISA, et al; Cincinnati Gardens, Cincinnati, Ohio, April 16-17.

CLEVELAND ELECTRONICS CONFERENCE, IEEE, Case Institute, Western Reserve University, ISA; Hotel Sheraton, Cleveland, O., April 16-18.

OPTICAL MASERS SYMPOSIUM, IEEE, American Optical Society, Armed Services, et al; Waldorf-Astoria Hotel, New York City, April 16-18.

INTERNATIONAL NONLINEAR MAGNETICS CONFERENCE, IEEE; Shoreham Hotel, Washington, D. C., April 17-19.

SOUTHWESTERN IEEE CONFERENCE & ELECTRONICS SHOW, IEEE (Region 5); Dallas Memorial Auditorium, Dallas, Texas, April 17-19.

PLASTICS FOR ELECTRONICS SYMPOSIUM, Society of Plastics Engineers; Syracuse University, Syracuse, N. Y., April 18.

BIO-MEDICAL ENGINEERING SYMPOSIUM, IEEE, et al; Del Webb's Ocean House, San Diego, Calif., April 22-24.

NATIONAL ELECTROMAGNETIC RELAY CONFERENCE; Oklahoma State University; OSU, Stillwater, Okla., April 23-25.

POWER INDUSTRY COMPUTER CONFERENCE, IEEE; Westward-Ho Hotel, Phoenix, Ariz., April 24-26.

IMPACT OF MICROELECTRONICS CONFERENCE, Armour Research Foundation and ELECTRONICS Magazine; Illinois Institute of Technology, Chicago, Ill., June 26-27.

WESTERN ELECTRONIC SHOW AND CONFERENCE, WEMA, IEEE; Cow Palace, San Francisco, Calif., Aug. 20-23.

ADVANCE REPORT

DESIGN AND USE OF MICROWAVE VALVES (TUBES), INSTITUTION OF ELECTRICAL ENGINEERS: *IEE, Savoy Place, London W.C.2 Covent Garden 1871, England, during Sept. April 30 is deadline for submitting papers in triplicate to: Organizing Committee, The Institution of Electrical Engineers, Savoy Place, London W.C.2 Covent Garden, 1871, London, England. Fundamental design, performance and use of tubes in systems are aspects to be covered in following areas: radio astronomy, plasma physics, microwave links, c-w and f-m radar, pulse radar.*

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2 OUTSTANDING CANNON® PLUG SERIES MEETING REQUIREMENTS OF MIL-C-26482C

KPT SOLDER POT

- SMOOTHER ENGAGEMENT AND SEPARATION FORCES, INHERENTLY PERFORMING IN A NARROWER RANGE, PROVIDED BY A REVOLUTIONARY BOWSPRING* SOCKET CONTACT DESIGN.
- HIGHLY CONDUCTIVE LEADED-COPPER, PROBE-PROOF, CLOSED-ENTRY SOCKET CONTACT HAS LOWER MILLIVOLT DROP.
- LOWER COUPLING FORCES REQUIRED ON THE CANNON QUICK CONNECT-DISCONNECT BAYONET LOCK.
- SUPERIOR INSULATORS COMPLETELY MANUFACTURED AND QUALITY-CONTROLLED BY CANNON.
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- SIZES 8 THRU 24; 2 TO 61 CONTACTS.
- ACCOMMODATES AWG SIZE 26 THRU 16 WIRE.
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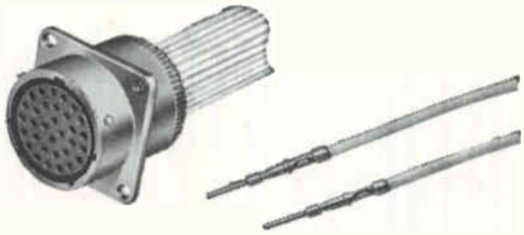
- HIGH STRENGTH IMPACT EXTRUDED HOUSINGS.
- AVAILABLE FOR QUICK DELIVERY THRU CANNON AUTHORIZED DISTRIBUTORS.

KPTM CRIMP TYPE

- IMPROVED RELIABILITY BECAUSE OF SIMPLE ONE-PIECE MOLDED INSULATOR/GROMMET CONSTRUCTION —DUAL SHORE* OF SPECIALLY COMPOUNDED POLYCHLOROPRENE RUBBER.
- HIGHLY CONDUCTIVE LEADED-COPPER, PROBE-PROOF, CLOSED-ENTRY CONTACT HAS LOWER MILLIVOLT DROP PLUS MEETS REQUIREMENTS OF MIL-C-23216.
- INTEGRALLY-MOLDED POSITIVE STOP PREVENTS CONTACT OVER-INSERTION.
- DUAL SHORE INTEGRALLY-MOLDED INSULATOR/GROMMET FOR DEPENDABLE SEALING OF CONTACTS.
- RAISED BARRIERS AROUND EACH PIN, MATING WITH LEAD-IN CHAMFER AROUND SOCKET, PROVIDE INDIVIDUAL INTERFACIAL CONTACT SEALING.
- REAR HARDWARE FOR KPT/KPTM COMPLETELY INTERCHANGEABLE.
- SEALED IN TRANSPARENT, ENVIRONMENTAL PROOF BAG, WITH COMPLETE ASSEMBLY INSTRUCTION; CONTACTS, WITH SPARES, AND SEALING PLUGS PROTECTED IN SEPARATE VIAL.



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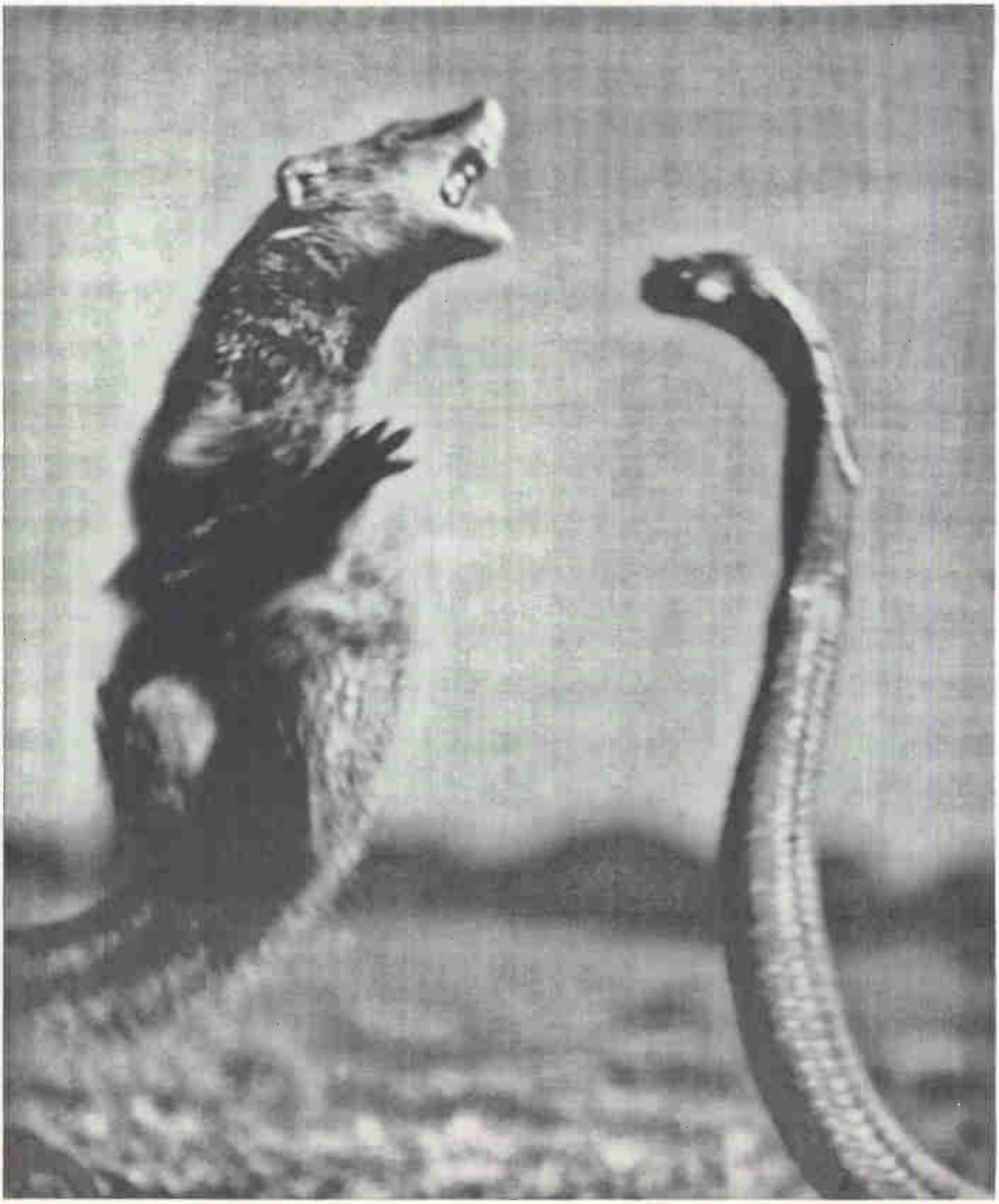
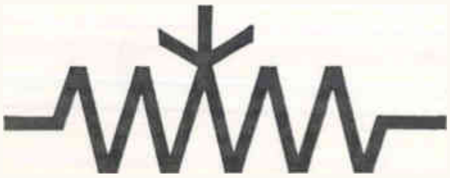
to a warehouse of several million OHMITE components
*Ohmite Stock Catalog 30



Fast shipment off the shelf
Eight different Ohmite component lines
Thousands of values
Quantities for production "short-runs"

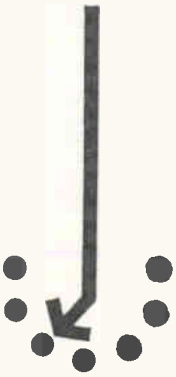
RESISTORS, WIRE-WOUND, POWER (1 TO 1500 WATTS)

Axial-Lead • Lug Type • Fixed • Variable • Brown Devil® • Corrib® • Powr-Rib® • Dividohm® • Vitreous Enamel Covered • Silicone Ceramic Coating (Series 88) • Molded • Non-Inductive • Precision • Thin Type • MIL-R-26C • MIL-R-19365C



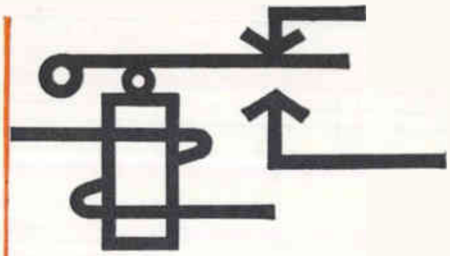
RHEOSTATS, WIRE-WOUND, POWER (12½ TO 1,000 WATTS)

All Ceramic and Metal • Unenclosed • Enclosed • Heat Control • MIL-R-22A • Tandem Kits • MIL-R-6749



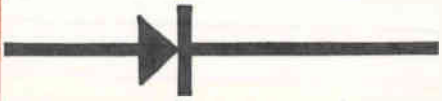
ROTARY TAP SWITCHES (3 TO 100 AMP)

All Ceramic • Enclosed • Open • Non-Shorting • Shorting • Single Pole • Up to 12 Taps • Tandem Units • U.L. Listed



RELAYS (5 TO 25-AMP CONTACTS)

General Purpose • Sensitive • Telephone Type • Latching • Plug Type • Hermetically Sealed • Dust-tight • Indicator Type • Above Chassis Mounted • Below Chassis Mounted • U.L. Listed



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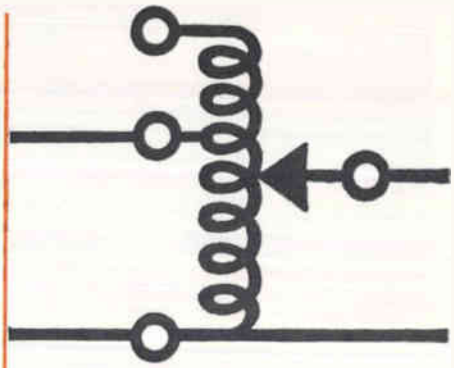
Germanium, Gold Bonded • Hermetically Sealed Glass Envelope • MIL-E-1D • MIL-S-19500C

R. F. CHOKES (0.2 TO 84 uh)

Solenoid Type • Single Layer Wound • 3 to 520 Mc • Axial Leads • Lug Terminals • Power Line Type



VARIABLE TRANSFORMERS, V.T.® (1.4 TO 25 AMPS)

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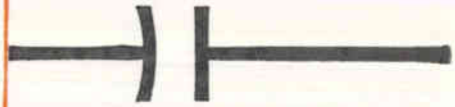

TANTALUM CAPACITORS, TAN-O-MITE® (0.1 TO 560 MFD)

85°C and 125°C • Wet Electrolyte Type • Foil, Etched and Plain • Non-Polar • Polar • Slug • Wire • Insulated • Uninsulated • MIL-C-3965B

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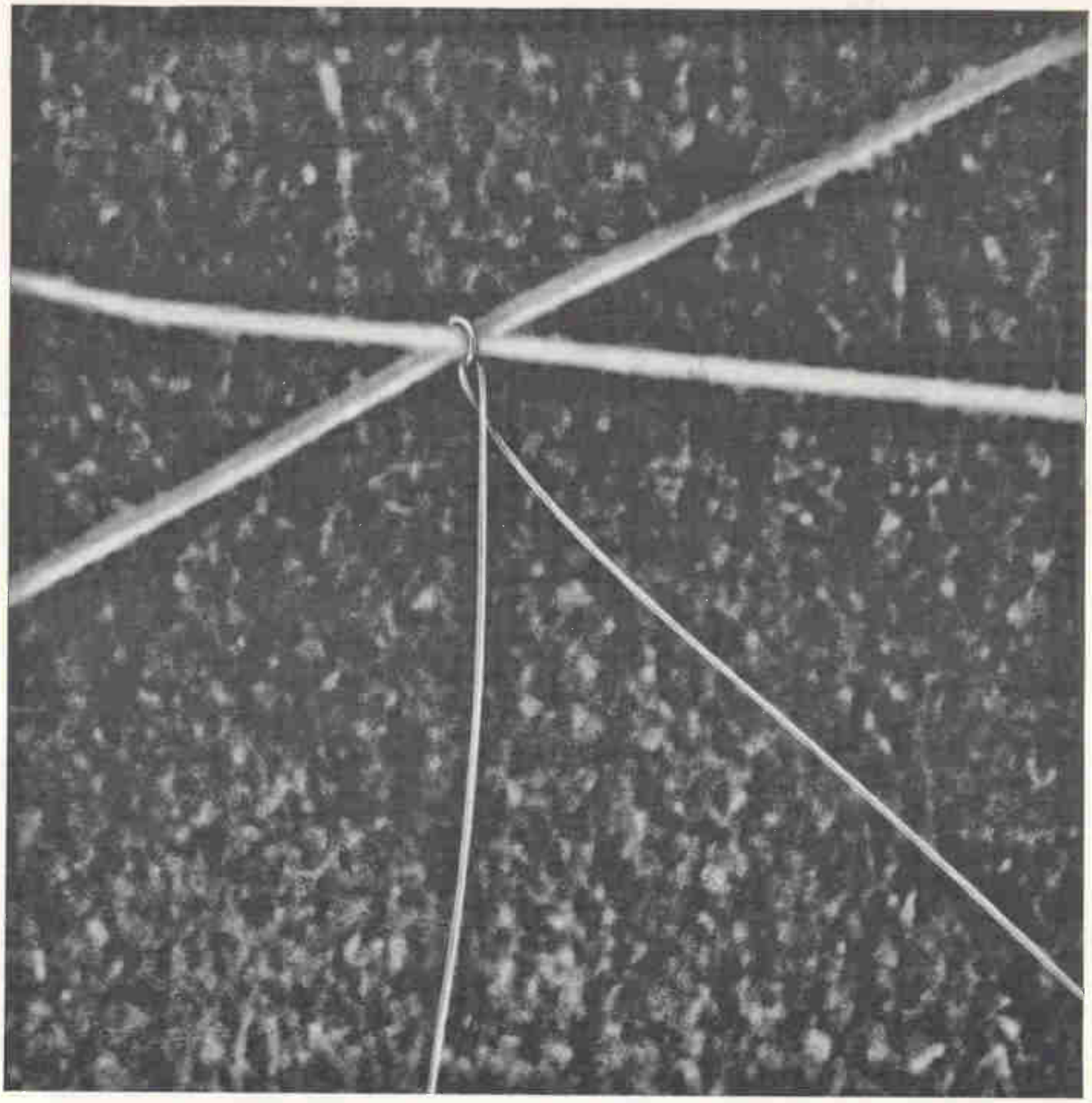

How fine can you get?

(with nickel alloy wire, ⅓ the thickness of a human hair)

The two thick bars in this magnified photograph are actually human hairs!

They're tied together with nickel alloy wire 0.0009-inch in diameter. Wire so fine that the men who make it work by touch rather than sight as they draw it through their diamond dies. Wire so fine that a pound of it would stretch more than 80 miles.

That's just one size. You can get the unique properties of Huntington high-nickel alloys in practically any wire size you need...and as thick as the giant forgings used for the gate stems of Boulder Dam, if that's what you want.

You can get these remarkable properties in strip, tubing, and in the various other shapes and sizes needed for electronic applications.

More information? The important facts you want about each of these high-nickel alloys are summarized in the *free* booklet, "Huntington Alloys for Electronic Uses." A copy is yours for the asking.

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HUNTINGTON ALLOY PRODUCTS DIVISION
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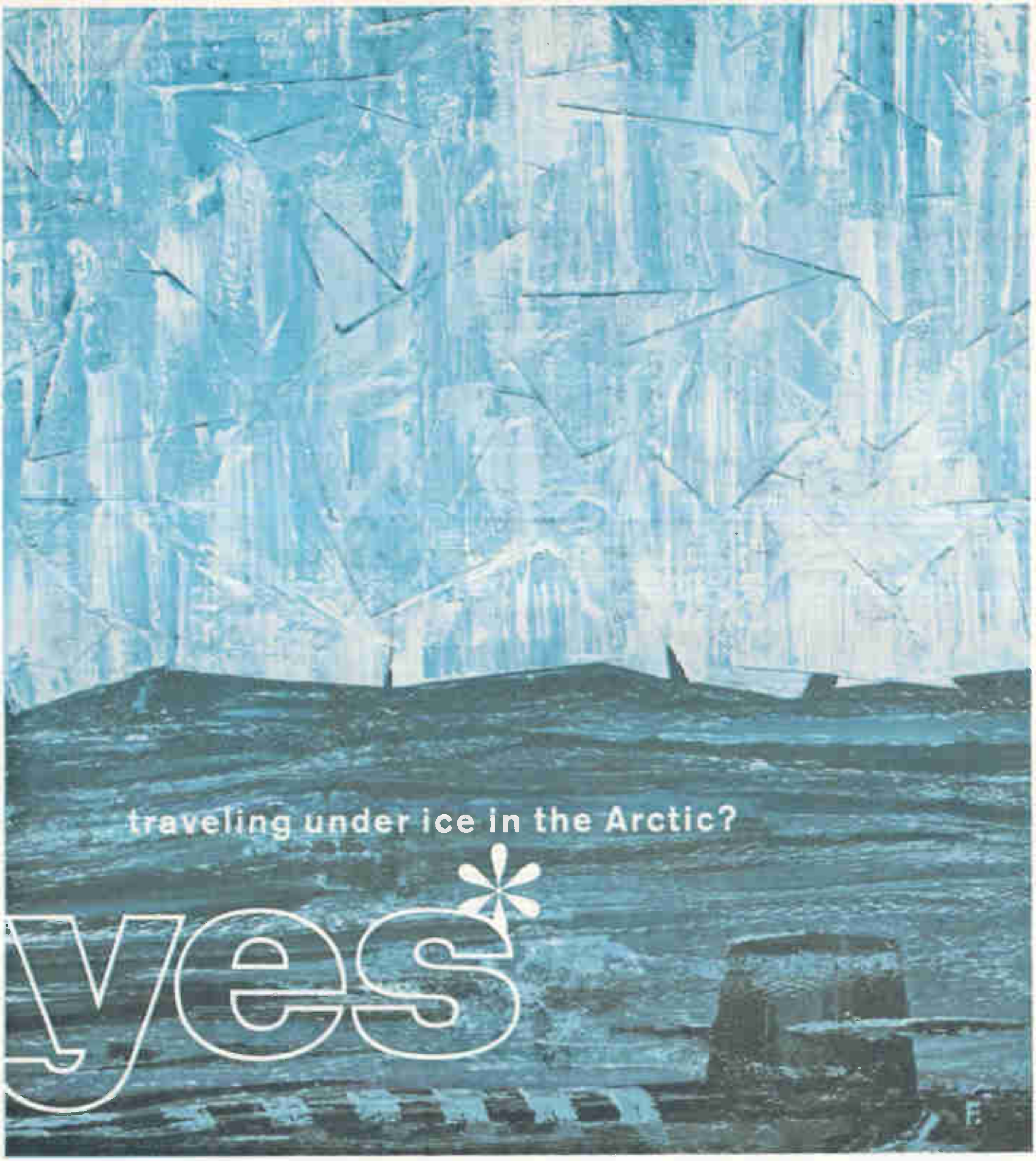

Only a submarine can reach the North Pole by sea — with continuous Sonar operation to determine distances from sea bottom, ice ceiling and other hazards. In critical applications like this, where extreme accuracy in sending and receiving signals is required, Gamewell Precision Rotary Switches have proved completely dependable. Characteristics include: tolerance of ±0.5° for any segment width over 1°; phasing to ±0.25%; torque less than 1 oz. in. with sleeve bearings at room temperature; high resistance to shock, vibration, temperature and acceleration. For special switches to meet your circuit sampling, sequencing, programming or similar applications, take advantage of Gamewell's YES service — *Your Engineered Specials service. Send us details.

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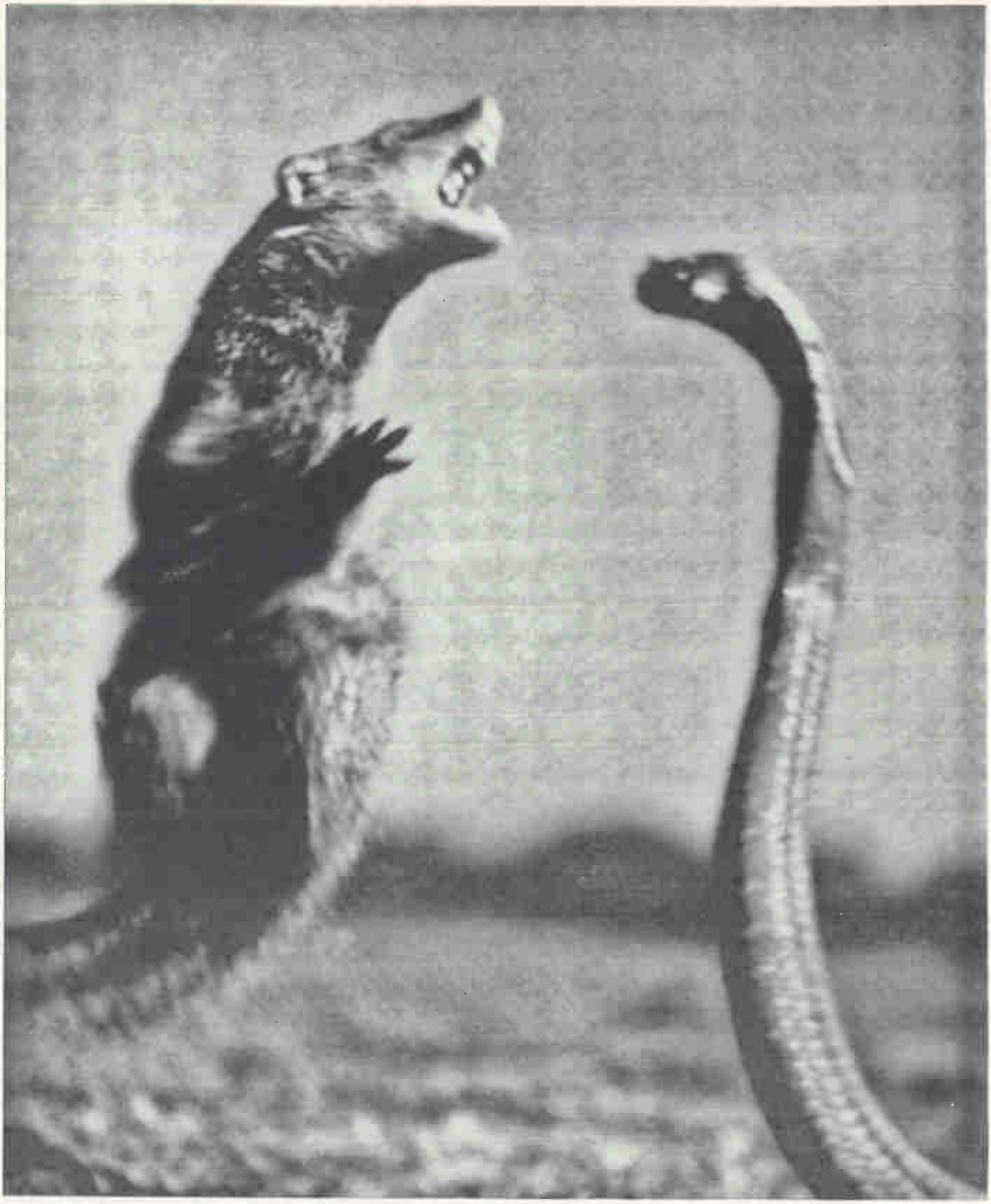
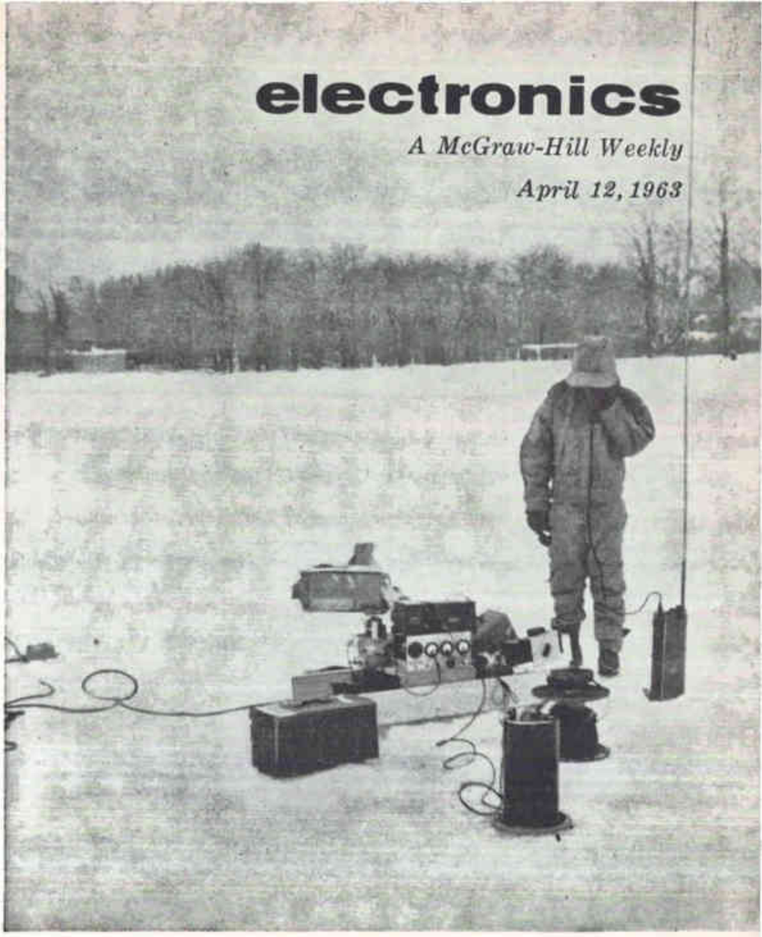
ELECTRONICS DIVISION

THE GAMEWELL COMPANY, 1603 CHESTNUT ST., NEWTON 64, MASS. A SUBSIDIARY OF E. W. BLISS COMPANY

CIRCLE 49 ON READER SERVICE CARD



SEISMIC TRANSDUCERS *being tested on the ice of Lake Waramaug, Connecticut this winter*



ANCIENT ART, NEW SCIENCE

The study of seismic wave propagation is an old art and science . . . earthquakes at some dim moment in prehistoric times must have aroused curiosity as well as fear. But it has been only in recent years that man has given serious attention to the possible use of much more moderate seismic waves as a medium for communication. The seismic transducers and experiments of this story are described by the authors as a "modest beginning" in the development of earth transmitters and receivers

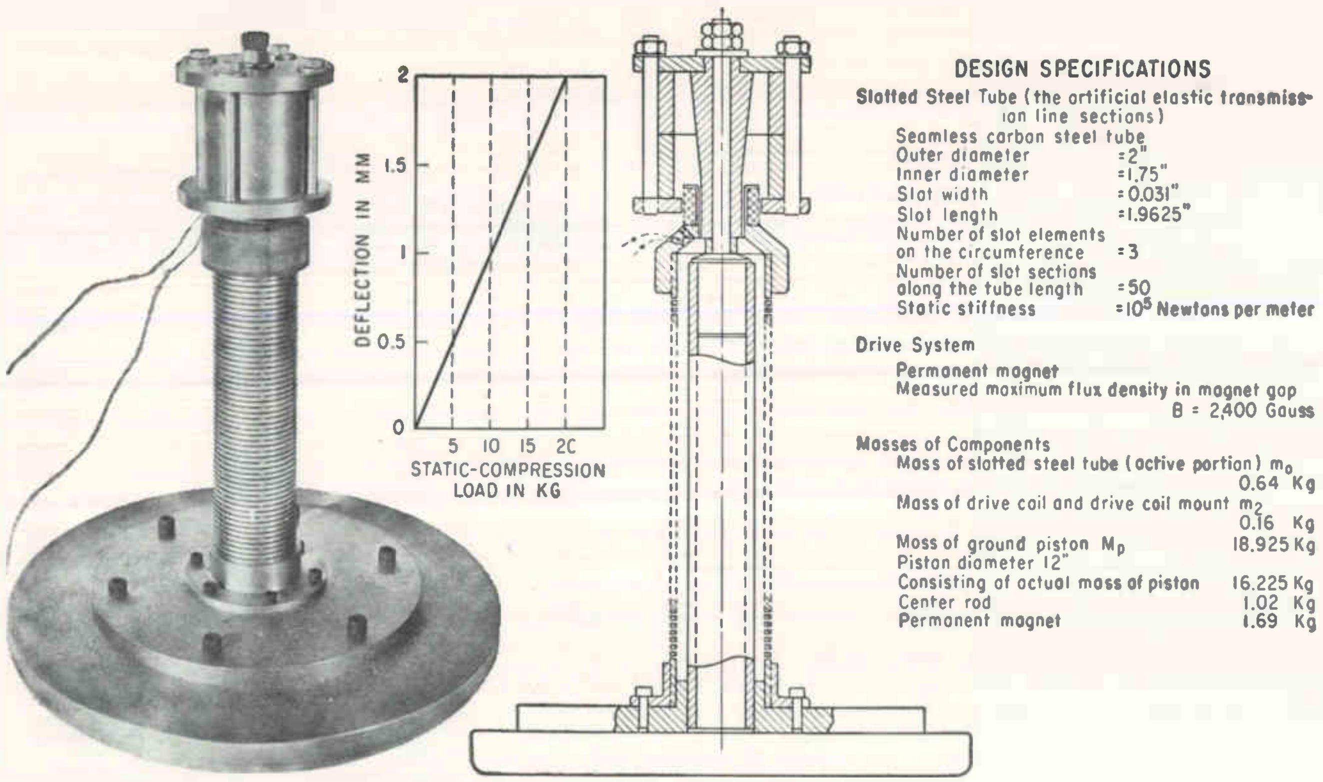
By K. IKRATH and W. SCHNEIDER
Institute for Exploratory Research.
U.S. Army Electronic R & D Lab, Ft. Monmouth, N. J.

NEW TRANSDUCERS FOR Communicating By Seismic Waves

This experimental seismic transducer—essentially an elastic analog of a tuned radio transmitter—serves as either a transmitter or receiver of seismic waves. Full design details are given

SEISMIC WAVE PROPAGATION could conceivably be used for seismic communication, for seismic surveillance and for geological research provided there were available seismic transducers that could act effectively as transmitter and receiver. An approach to the development of such a transducer has been made with an elastic analog to tuned radio transmitters. A tuned radio transmitter uses a quarter-wave dipole antenna as a resonant matching transformer between the drive system and radio-propagation medium. Similarly, the seismic transmitter described here uses an artificial elastic transmission-line section as a resonant matching transformer between the electromechanical drive system and the hard seismic propagation medium. The experimental seismic transmitter-transducer that was developed works equally well as a tuned receiver-transducer.

A transducer with some of its design characteristics is shown in Fig. 1. The first and second resonant vibration-modes are about 80 and 260 cps, corresponding roughly to the one-quarter and three-quarter wave resonances. The exact operating frequency depends on the ground medium. The detuning by different ground media, that is, the load impedances for the transducer, is usually less than 3 cps. The 3-db bandwidth, which also depends on the mechanical impedance of the ground medium, is about 1 cps. The transducer can be operated continuously with 10 watts, and intermittently with up to 20-watts drive power. The electrical input impedance of the transducer depends on the ground medium and is between 3 and 6 ohms. The drive system is electrodynamic, employing a permanent magnet. The static load deflection characteristic of the slotted steel tube is also shown in Fig. 1. The slots correspond to shunt capacitance in the analogous electric transmission line, while the masses of the slot sections correspond to



TRANSDUCER DESIGN, *the static load deflection of the slotted tube, and some of the design specs are shown here with photo of the completed model—Fig. 1*

the serial inductances in this electrical transmission line.

As for any elastic element, the dynamic stiffness of the slotted steel tube is only a fraction of its static stiffness. The static stiffness can be accurately calculated by considering the slotted steel tube as a serial and parallel arrangement of stiffly coupled cantilever beams. The static stiffness of the slotted steel tube of Fig. 1 is $S_0 = 10\ K_g/\text{mm} = 10^5$ Newtons/meter.

The discrepancy between static and dynamic stiffness stems from the elastic relaxation in the material. Elastic relaxation denotes the time lag between the stress and the strain under dynamic load conditions. Lacking knowledge of the elastic relaxation parameters for the slotted steel tube material, we defined dynamic stiffness in terms of an equivalent homogeneous elastic line. We then determined the dynamic stiffness, indirectly by experiment, with approximately 40 percent of the static stiffness. The formula for the resonance frequencies of the transducer determines the dynamic stiffness S_0'

$$\tan\left(\frac{\omega}{\omega_0}\right) = \frac{-\left(\frac{\omega}{\omega_0}\right)\frac{M_1}{\omega_0}\left[1 - \frac{m_2}{M_1}\right]}{1 + \frac{M_1}{m_0}\cdot\frac{m_2}{m_0}\left(\frac{\omega}{\omega_0}\right)^2} \qquad (1)$$

where

$$\omega_0 = \sqrt{S_0'/m_0} \qquad (2)$$

The sum of the masses of the ground piston M_p and M_g is M_1. Mass M_g corresponds to the inertial reaction of the ground medium to the driving force, that is, the reactive component of the mechanical ground impedance at the transducer piston to ground interface. This mechanical ground impedance has also a resistive component R_1 that damps the transducer vibration. For a properly designed transducer that does not violate the elastic range limitations of the ground medium, this resistive component is equivalent to the mechanical radiation resistance R_g of the ground, if friction resistance R_f is neglected. The angular frequency ω_0 is a design parameter of the artificial elastic transmission line, that is, the slotted steel tube, or more precisely, a physical parameter of an equivalent homogeneous elastic transmission line. If the latter has an elasticity modulus E' and a mass density ρ, the longitudinal wave propagation velocity is

$$c = \sqrt{E'/\rho} \qquad (3)$$

Expand this formula by introducing the material cross section area q and the length of the line l to the identity

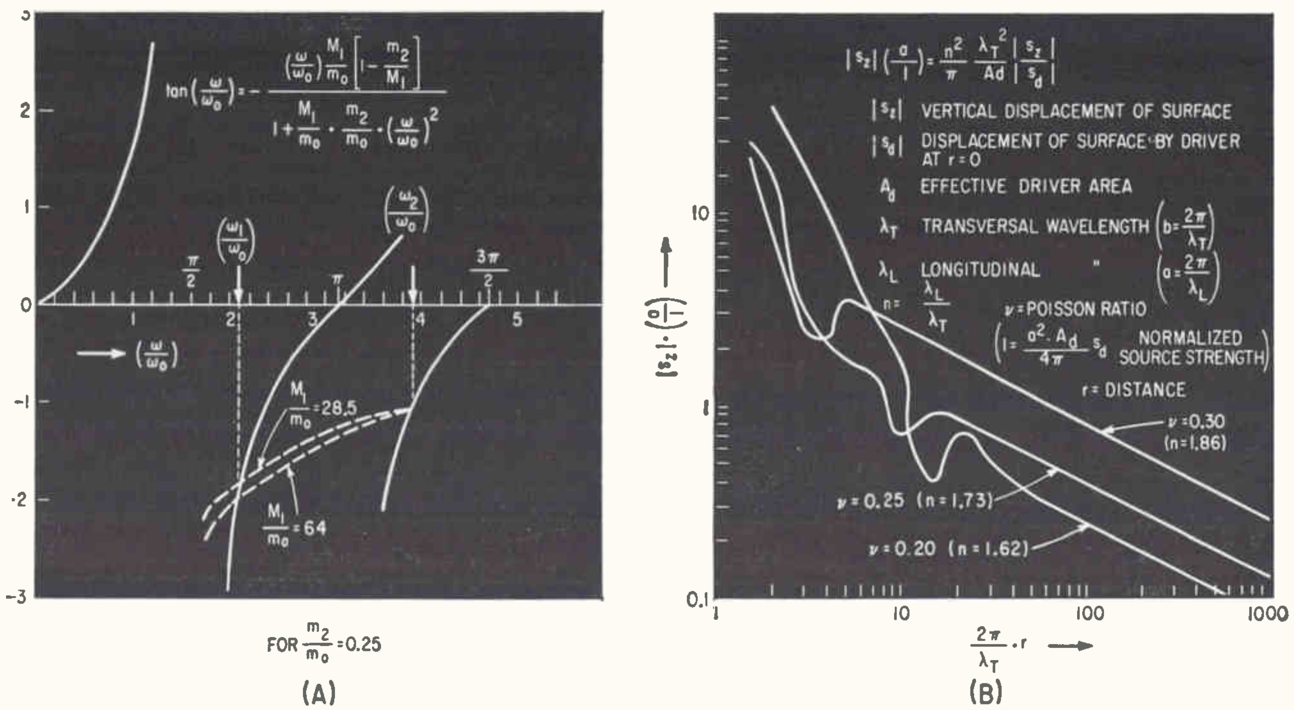
$$c = \sqrt{\frac{(E'q/l)l^2}{\rho q l}} = l\sqrt{\frac{S_0'}{m_0}} \qquad (4)$$

The term $(E'q/l)$ is dynamic stiffness, that is, the ratio of force to displacement where the force $E'q$ would double the length l of the elastic line; $\rho q l = m_0$ is the mass of the line. Substitution of Eq. (4) into Eq. (2) reveals the physical significance of

$$\omega_0 = c/l = 1/\tau_0 \qquad (5)$$

as the inverse of the elastic-wave propagation time τ_0 for the length l. Since the number of slot sections per wavelength is large, we can describe the performance of the slotted steel tube with an equivalent homogeneous elastic line of equal length l, mass m_0, and a dynamic stiffness S'_0.

Figure 2A shows the graphical solutions of Eq. (1) for the resonant frequencies ω_1 and ω_2. This spot shows the relative insensitivity of the operating frequency from the type of ground medium. Equation



GRAPHICAL SOLUTION *for ω/ω₀ shown in (A); vertical component of ground surface displacement |s_z| plotted against distance r from surface-based driving source (B) is normalized for different ground media—Fig. 2*

(1) also reveals that by extreme reduction of the drive-coil mass m_2, a lower resonance frequency will be obtained. The resultant frequency corresponds more closely to the quarter-wave resonance; but this reduction of the mass m_2 towards zero would increase the dependency of ω_1 on the ratio M_1/m_0, and cause a larger detuning of the transducer by different media.

The ratio $M_1/m_0 = 28.5 \equiv M_p/m_0$ used in Fig. 2A, corresponds to the situation where the transducer is fully decoupled from the ground medium, such as by lifting it off the ground by hand or by placing a compliant foam rubber cushion between piston and ground surface.

The ratio $M_1/m_0 = 28.5 \equiv M_p/m_s$ used in Fig. 2A, to 22 Kg of reactive mass contributed by the ground impedance. In this case $\omega_1/\omega_0 \doteq 2$ and $\omega_1 = 2\pi$ (80) cps = 500 sec^{-1} so that $\omega_0 = 500/2 = 250 = \sqrt{S'_0}/0.64$. This yields the dynamic stiffness $S'_0 = 0.64 \times 6.25 \times 10^4 = 0.4 \times 10^5$ Newton/meter. This is 40 percent of the static stiffness (which is reasonable).

POWER—If transducer internal losses are neglected and the damping of the vibration is attributed only to radiation, the radiated power at the resonance frequencies ω_n is given by:

$$P_n = \frac{F_n^2}{2\left(\frac{m_0}{M_1}\right)^2 R_{1n}} \frac{(\omega_n/\omega_0)^2}{(g_n)^2}\left[1+\frac{m_0}{M_1}\frac{g_n}{\left(\frac{\omega_n}{\omega_0}\right)}\right] \quad (6)$$

where $g_n = -\sin\omega_n/\omega_0 + (m_2/m_0)(\omega_n/\omega_0)(\cos\omega_n/\omega_0)$.

The radiated power P_n is in watts if the driving force F_n is in Newtons and the mechanical resistance $R_{1,n} = R_{g,n}$ is in kilograms per second. In this case $g_1 = -1.12$ and therefore radiated power at ω_1 is

$$P_1 \doteq \frac{(F_1)^2}{2(m_0/M_1)^2(R_g)_{\omega1}} \times \frac{(4.4)}{1.26}\left[1-\frac{m_0}{M_1}\times\frac{1.12}{2.1}\right] \quad (7)$$

If an electrodynamic system is used,

$$F_1 = LI_1B \quad (8)$$

where F_1 is in Newtons, L is the total length of the drive coil wire in the magnetic field given in meters, I_1 is the drive current in amperes, and B is the magnetic flux density in voltseconds per square meter (Weber/m^2).

The electromotional resistance of the transducer is then defined by setting the power equal to

$$P_1 = \frac{I_1^2}{2}(R_{elmo})_{\omega1} \quad (9)$$

so that by substitutions of Eq. (9) and Eq. (8) into Eq. (7), the transducer electromotional input resistance in ohms is obtained

$$(R_{elmo})_{\omega1} = \frac{[LB]^2}{\left[\left(\frac{m_0}{M_1}\right)^2(R_g)_{\omega1}\right]} 3.5\left[1-(0.55)\frac{m_0}{M_1}\right] \quad (10)$$

The mass ratio (m_0/M_1) is the transformation ratio of the mechanical ground impedance to a small mechanical impedance $(m_0/M_1)_1^2 R_g$ at the drive end of the elastic transmission line. This small mechanical impedance is transformed by its reciprocal value into the electric circuit as an electromotional impedance.

Figure 1 shows that the improvised magnetic circuit is not an ideal one for which Eq. (8) would be directly applicable. Only about one-third of the coil is within the magnetic gap proper, and the magnetic field distribution is inhomogeneous. Nevertheless, a practical rule of thumb is that the mean flux density is about one-third of the peak flux density measured close to the pole shoe edges. Taking into account that the effective coil wire length is only one-third of the total length, and that the mean flux density is only one-third the measured flux density, the effective $L B$ product is about

$$L B = 0.43 \text{ volt sec}/m \qquad (11)$$

Substituting Eq. (11) into (10), where we can also neglect the second term involving 0.55 m_o/M_1 for $m_o/M_1 << 1$.

$$(R_{elmo})_{\omega 1} = \frac{0.65}{\left(\frac{m_0}{M_1}\right)^2 (R_g)_{\omega 1}} \qquad (12)$$

Let us introduce numerical values for M_g and R_g which are representative for the mechanical ground impedances of various ground media. A first order approximation for the radiation resistance R_g was derived with

$$R_g = \frac{\rho c_l}{8} \times \frac{D_P^2 \pi}{4} \times \left(\frac{\omega}{c_l} D_P\right)^2 \qquad (13)$$

For the mass M_g associated with the inertial reactance,

$$M_g \doteq \rho(D_p^3/3) \qquad (14)$$

where ρ is the mass density of the ground medium, c_l is the longitudinal wave velocity in ground medium, ω is the angular frequency, and D_p is the piston diameter.

GROUND IMPEDANCE—The table indicates the order of magnitude of the mechanical ground impedances of various seismic media at 20 cps for circular transducer-to-ground interface of one-meter diameter. For this transducer, which has a piston diameter of 12 in. = 0.3 meters and which operates at 80 cps, the resistance values must be multiplied by a factor $(80/20)^2 (0.3)^4 = 0.13$ and the reactive mass values by a factor $(0.3)^3 = 0.027$ because the resistance is proportional to the square of the frequency and to the fourth power of the piston diameter; and the reactive mass is proportional to the third power of the piston diameter. Theoretical ground impedances at the transducer-to-ground interface for ground media referred to a piston diameter of 1 meter and a frequency of 20 cps are shown in the table. Sandstone comes closest to the sand-gravel medium in which we conducted initial tests. Thus, $R_g = 0.13 \times 2{,}960 = 385$ Kg/sec and $M_g = 0.027 \times 860 = 23$ Kg. Thus $M_1 = M_g + M_p = 42$ Kg. From Eq. 12, the electromotional resistance is 7.3 ohms.

These results were checked against the test data. Shear wave velocity in the sandy soil test medium was approximately 640 meters/sec. The corresponding compression wave velocity was roughly 1 Km/sec; the mass density was roughly 2.3 metric tons per cubic meter. These yield with Eq. 13 that R_g = 390 Kg/sec and with Eq. 14 that M_g = 20.6 Kg. The corresponding theoretical electromotional impedance is

$$R_{elmo} = 6.3 \text{ ohms} \qquad (15)$$

Even though this resistance figure, used as output impedance for the drive amplifier, gave about the maximum seismic signal amplitude observed with a geophone a few meters away from the transducer, this electromotional resistance need not be a direct measure of the actual radiated power. In addition to radiation damping, damping by friction enters also into the electromotional resistance, that is, $R_1 = R_g + R_q$ will produce an electromotional impedance that may be either smaller or the same as in Eq. 15. Tests have not yet been conducted in which the two mechanical resistance terms could be distinguished. Thus, the exact radiation efficiency of the transducer is not yet known.

EFFICIENCY—Using 2 volt-amperes of drive power, we measured the rms acceleration of the piston with 3 g's (roughly 3 meters per square second). The velocity is then, at 80 cps, equal to (3m/s^2) 500 sec^{-1} = 6 mm/sec. The piston mass has 19 Kg which gives a force of 19 Kg $\times$ 3 sec^2 = 57 Newtons. The force velocity product is then 342 mw. Thus, the efficiency is at least better than 10 percent.

The power density which might be expected in the ground is limited to the elastic range of the seismic medium. Almost all hard ground media could stand 6 w/cm^2 and some media up to 16 w/cm^2.

Only a fraction of this permissible power density can be exploited for radiation because of the strong curvature of the wavefront in the limited region of transducer excitation. Transducer arrays could achieve a wider region of ground excitation and a more planar wavefront.

Intimately associated with elastic range limitations in the medium, and hence in the efficiency of the transducer, is the requirement that the static weight of the transducer must not shift the elastic operating point into or close to the nonlinear region of the force displacement characteristic of the medium. The weight alone may give a good ground crusher but a bad seismic radiator. Local overstressing of the ground at the piston edges must be avoided.

Figure 2B is the theoretical plot of the relative vertical ground surface displacement vs distance from the surface-based transducer. Distance is counted in multiples of $1/2\pi$ times the shear wavelength. In the immediate vicinity of the radiating transducer, the attenuation follows an inverse square of the distance law for soft ground media (that is, media which have a Poisson ratio $\nu = 0.2$), and an inverse third power of the distance law for very hard ground media (that is, media with a Poisson ratio $\nu = 0.3$). The dips in the curves (e.g., at $2\pi r/\lambda = 15$ for $\nu = 0.2$) are associated with the transition from the higher order of the propagation modes which are dominant in the near zone, to the Rayleigh surface wave mode which is dominant in the far zone. The transition dip is closer to the transmitter for more rigid media. For $\nu = 0.2$, the dip occurs at 2.5 shear wavelengths; for $\nu = 0.25$, 1.6 shear wavelengths; and for $\nu = 0.3$, 0.6 shear wavelengths away from the transmitter. Because of the extreme domi-

TABLE—THEORETICAL GROUND IMPEDANCES

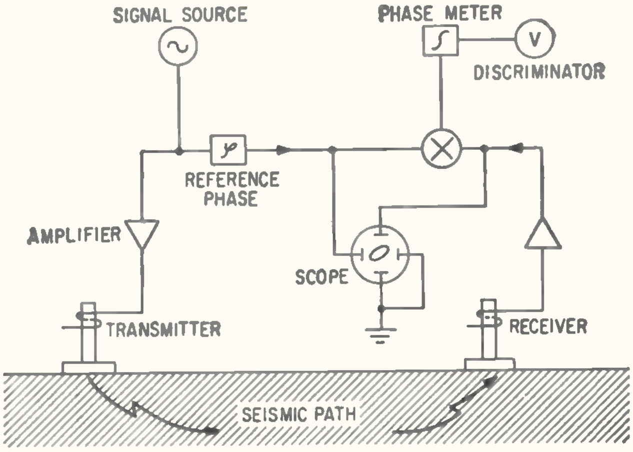
Ground medium	Mechanical resistance in kilograms per second (R_g)	Reactive mass in kilograms (M_g)
Granite........	960	850
Sandstone.....	2,960	860
Basalt	830	940
Lime Stone....	1,100	940

ance of the shear modes in the immediate vicinity of the transducer, the measurement of the shear wave velocity of a ground medium can be made with high accuracy in the near zone. For this purpose, measure only the relative phase of the transmitted to the received signal as a function of distance. For example, a 90 deg phase difference corresponds to a separation of two points of signal reception equal to a quarter shear wavelength. Similarly, the surface wave velocity can be measured in the far zone. In the transition zone, compression and shear displacements have about equal magnitudes. In fact, the undulations (relative minima and maxima) in the displacement amplitude curves are essentially produced by interference between compression and shear mode before the surface wave mode becomes dominant. Thus, shape and location of the dips are related to the reciprocal value of the difference of the inverse of the shear and compression wave velocity. The interference between these modes is described by a beat term cos b-a/2 r. The distance separation of maximum and minimum of the wiggle yields the compression wavelength in connection with the shear wavelength determined in the near zone.

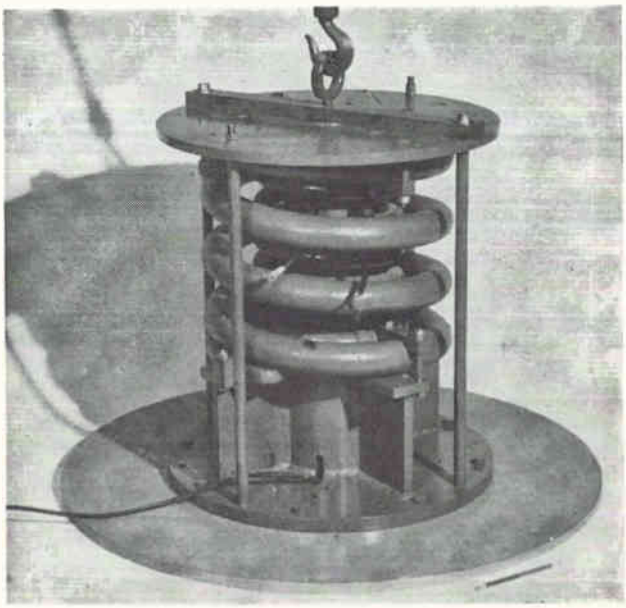
For example, for $\nu = 0.2$ with $b = 2\pi/\lambda_s$ and $a = 2\pi/\lambda_c$

$$\frac{\pi}{2} = \frac{1 - \frac{a}{b}}{2}\,[b(r_1 - r_2)] = \frac{1 - \frac{a}{b}}{2}\,8$$

Thus, $1 - a/b = \pi/8 = 0.39$ and $n = b/a = \lambda_c/\lambda_s = 1/(1\text{-}0.39) = 1.64$, which is correct within the graphical accuracy of the plot. In practice, the wiggles may not always be so sharp in detail if the intrinsic losses of the medium are large.



SEISMIC ELECTRIC FEEDBACK *circuit used for determining shear wavelength—Fig. 3*



RESONANT TRANSDUCER *(12 cps) with power capacity of 1 Kw—Fig. 4*

CONCLUSION—Several preliminary experiments with these seismic transducers confirm the validity of the design principle and the theoretical analysis. These experiments fall into three categories: those that demonstrate the practicability of seismic transducers as geological research tools; those that show the feasibility of seismic communication by modulation of the transmitted seismic signal; and those that show the possibilities for seismic surveillance.

Measurements of received signal strength as a function of distance from the transmitter transducer gave qualitative evidence of the sharp transition from the near to the far zone, even on sandy soil.

The determination of the shear wavelength in terms of distance between two points where the signals were received with a phase difference of 180 deg was carried out with the seismic electric loop circuit shown in Fig. 3. For the sandy soil medium, the wavelength was about 8 meters. This amounts to a shear wave velocity of 640 m/second at 80 cps.

The feasibility of a diversity-type communication with a seismic signal and an electric phase reference channel, or conversely, was demonstrated with the same loop circuit. Information can be encoded into phase. Because of the coherent detection by a phase discriminator and integrator, communication at high ambient noise is practical. The same circuit was employed for the detection of obstacles along the seismic propagation path on the ground surface.

These experiments represent only a modest beginning for the exploitation of resonant seismic transducer-transmitters and receivers for steady-state seismic wave regeneration and reception. The distances over which seismic communications will be practical with transducers of this type are still unknown. We expect, however, from several theoretical considerations, that communication over a few miles should be possible with relatively little power and simple instrumentation on hard ground and ice.

A large 12-cps resonant transducer has been built with a nominal power capacity of 1 Kw (Fig. 4).

The work on seismic communications is a cooperative in-house effort of the Laboratory of Electronics Command. Of many who contributed, we especially thank E. Nolan of Mechanical Engineering Branch, H. Wichello and G. Wilson of our shops, for their technical advice, support, and craftsmanship in the manufacture of the experimental models. We appreciate the interest of our Deputy Director, B. S. Levin, and gratefully acknowledge the editorial assistance of Mrs. L. Sacher, Institute for Exploratory Research, U. S. Army Electronic Research and Development Laboratory.

Unusual Waveform Analyzer

Automatic programmer-comparators can simplify measurements of a-c and d-c

problem in achieving fully automatic testing. Here is a device that converts

CONVENTIONAL methods of waveform analysis involve complex oscilloscope and period counters that are difficult to use and of questionable accuracy in the hands of an unskilled operator. Direct automation of these techniques is impractical, since the end product must meet the severe environmental requirements of military test equipment.

One solution is a unique but simple device that uses conventional, solid-state, analog-computer circuits. It can convert waveform parameters into an analog d-c voltage that may be evaluated automatically by limit-comparison techniques, or manually, by displaying the information on a d-c voltmeter.

The accuracy, range and repeatability of the equipment allows a relatively unskilled technician to make rapid waveform measurements with precision previously obtainable only under laboratory conditions, using skilled personnel and complex test equipment; these accuracies are shown in the table.

DESCIPTION—The unique features of the waveform analyzer evolve from its ability to accurately transform the peak amplitude of a train of video pulses into a proportional d-c voltage level. This is accomplished by several level sensors. Each is a high-gain, closed-loop, electronic servo using a tunnel diode as an error-sensing device. The remainder of the waveform analyzer circuit converts the waveform parameters into a train of video pulses whose peak-to-peak amplitude is proportional to the parameter under investigation.

LEVEL SENSOR—The heart of any servo mechanism is the error-sensing device. Here it is a one-milliampere tunnel diode exhibiting characteristics as shown in Fig. 1B. It is stable when reverse-biased, (point *A*) and retains stability when forward-biased, until the current equals one milliampere (point *B*). Then, the diode breaks down, and any further increase in forward-bias current causes the voltage-drop across the diode to rapidly switch from about 65 to 500 millivolts (point *C*).

Figure 2 is block diagram of the level sensor. The tunnel diode is current-driven by an amplitude detectable input pulse train. The tunnel diode is initially forward-biased at its firing point (point *B*), causing the forward current to exceed one milliampere. Then, the tunnel diode switches on and produces an output pulse. This pulse is amplified and triggers a one-shot multivibrator, the output of which charges an R-C network through an isolation diode. The charge on the network drives an emitter-follower supplying negative output voltage that is resistively coupled to the tunnel-diode input. This reverse-bias source nulls out the forward-bias current produced by the input pulse. The loop continues to function, building up the charge in the R-C network, until the reverse-bias current precisely equals the input pulse current. Thus, under null conditions, the emitter-follower output voltage is directly proportional to the peak-to-peak amplitude of the input pulse.

In this circuit only the error-sensing tunnel diode with directly connected input and feedback resistors is critical; wide operating parameters are tolerable in the remainder of the circuit due to servo-loop action.

A simplified diagram of the waveform analyzer is shown in Fig. 3. The tunnel-diode comparator in Fig. 2 is shown in detail in Fig. 4.

INPUT MODULE AND SENSOR—The input module contains the input amplifiers, attenuators and other circuits necessary to present a high impedance (100,000 dm) to the circuit under test, as well as to supply input signals scaled to the requirements of the conversion circuits.

Two level sensors operating back-to-back convert the input signal to d-c voltage levels. One level sensor converts the positive portion of the pulse train to a proportional negative d-c voltage level, while the other provides a similar positive d-c voltage level. The outputs of the dual level sensors supply a floating d-c voltage proportional to the peak-to-peak ampltude of the input signal and independent of the duty cycle.

PROPORTIONAL CONTROLLER—The proportional controller detects the 10, 50 or 90-percent levels of either the rising or falling edge of an input pulse, and supplies a narrow positive or negative output pulse aligned in time with the level detected.

Either of two tunnel diodes are used in the level-detection device, depending upon the polarity sense of the input pulse. In addition to the tunnel diodes, a precision pulse input resistor, one of three precision pairs of biasing resistors to determine the percent level, a stable current-source to statically bias the tunnel diode at its peak current value, and a reset circuit to allow operation of the low-current tunnel diodes with low-amplitude input pulses are also used.

For a given input pulse polarity

Aids Automatic Testing

voltages, resistances and voltage ratios. However, waveform analysis has still been a

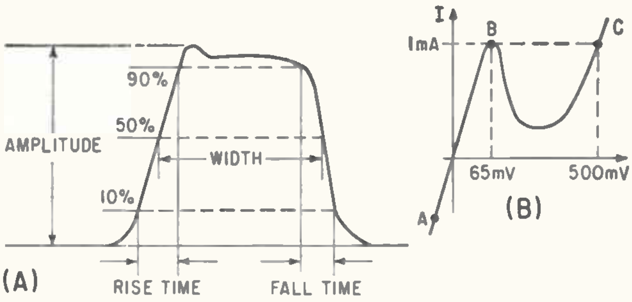
waveform parameters into a form suitable for an automatic programmer-comparator

By R. W. JONES, Light Military Electronics, General Electric Co., Johnson City, N. Y.

TABLE----PERFORMANCE ACHIEVABLE WITH ANALYZER

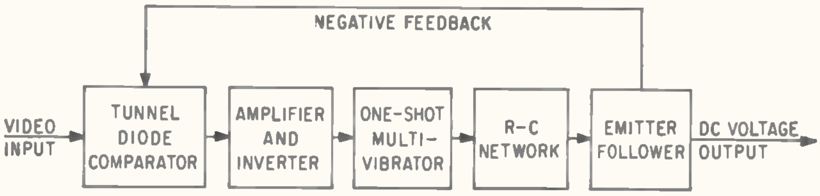
Parameter	Range	PRF	Accuracy
Amplitude	1 to 10V	50cps to 5Mc	±1% of Reading or ±50 mv
	10 to 100V	50cps to 5Mc	±3% of Reading
Time Interval	0.05 to 100μsec	50cps to 1Mc	±3% of Reading or 0.005μsec

These accuracies are realized over an operating range of 0 to 55 C; somewhat better accuracy may be obtained when operated in a controlled environment

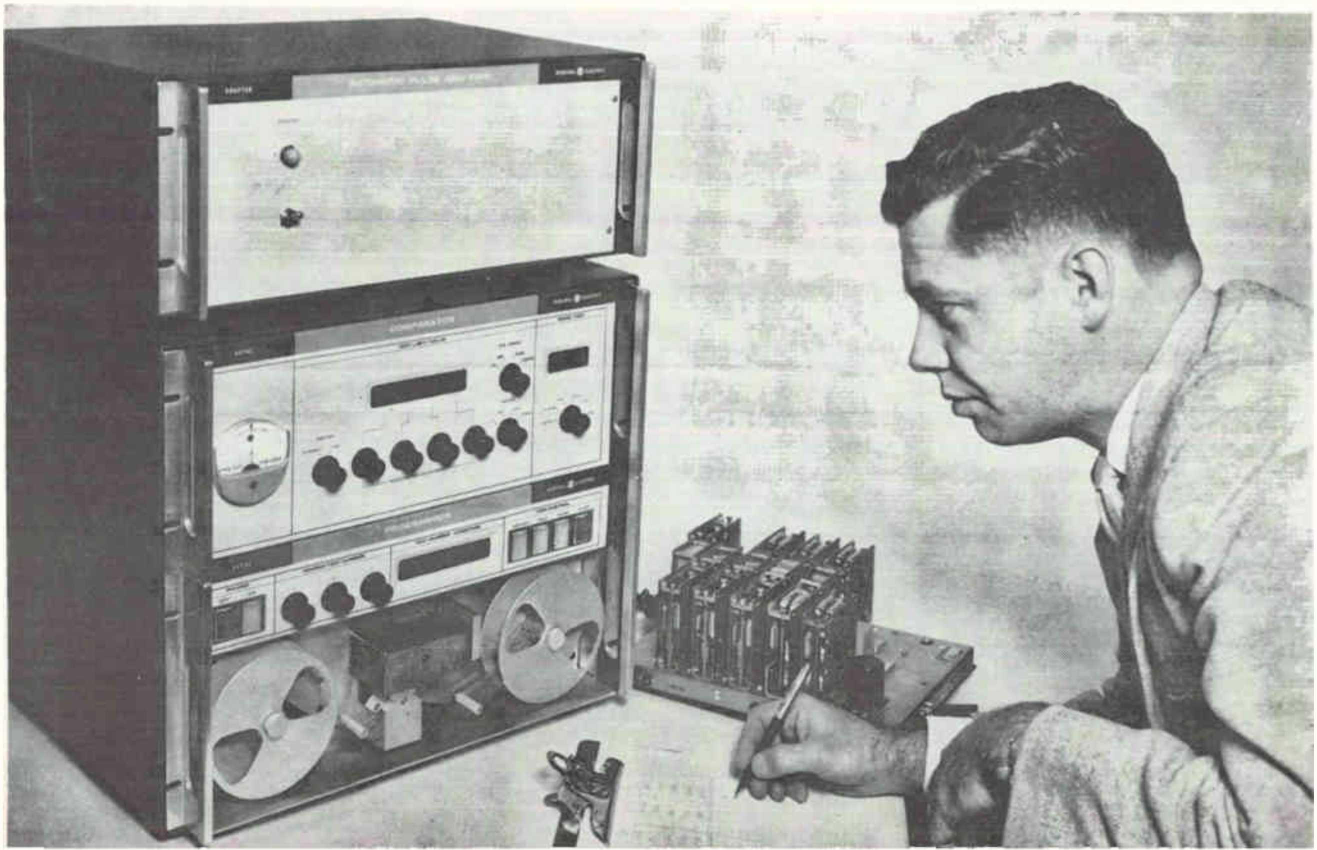


ANALYZER *will convert these parameters for programmer-comparator use (A). Characteristic curve of the 1 milliampere tunnel diode used in the level sensor (B)* **Fig. 1**

LEVEL SENSOR *uses tunnel diode for error sensing—Fig. 2*



AUTHOR *operates the waveform analyzer to check out an airborne digital computer*



SPEED AND SIMPLICITY

Automatic programmer-comparators can simplify and increase the speed of measurements. This waveform analyzer uses tunnel diodes to sense peak amplitudes, rise and fall time and pulse widths and converts these parameters into voltage analog outputs

and a desired level of either the leading or trailing edge, the forward or reverse-connected tunnel diode and a pair of biasing resistors are selected. The tunnel diode is statically biased at its peak current point of one milliampere. The use of the amplitude analog output from the dual level sensor across the pair of bias resistors, develops either a forward or reverse bias current through the diode. The input pulse is applied across the diode through the input resistor and currents from the three sources pass through the tunnel diode simultaneously. When the sum of the currents equals one milliampere in the forward direction, the diode breaks down, switches from low to high voltage state, and detection is accomplished.

After detection, combinations of current from the reset circuit, the input pulse and the reverse analog bias, prepare the tunnel diode for detection, by switching it from high to low-voltage state on the edge of the pulse opposite that detected.

The switching action of the tunnel diode is modified for operation as a trigger for the square-pulse generator, by a programmable-bipolar amplifier and passive differentiator. The bipolar amplifier has diode gates in its collector and emitter circuits, with a common output to an output emitter-follower and differentiator. By selecting either of the two gates, the correct polarity triggering spike for square-pulse-generator operation is present at the output and is aligned in time with the level detected.

SQUARE-PULSE GENERATOR—The square-pulse generator is a tunnel-diode gate circuit acting as a high-speed flip-flop. This circuit is actuated by the negative spike from channel one and disabled by the positive spike from channel two. The high-speed switching action of the tunnel diodes produces a pulse with a fast rise and fall time. The width of this pulse is proportional to the time interval between the negative and positive spikes, and is therefore, proportional to the time interval parameter under measurement.

LINEAR INTEGRATOR — The linear integrator converts the width of the square-pulse-generator output to a linear ramp with a peak value directly proportional to the pulse width. This is accomplished with a transistor switch, an R-C integrator network, buffer-amplifier, and bootstrap circuit.

The square-pulse-generator output disables the transistor switch, allowing the R-C integrator network to charge and generate a ramp voltage dependent on the R-C integration constant specified by the automatic programmer and the width of the square-pulse-generator output. In the absence of an input, the transistor switch conducts, shorting the R-C integrator. The buffer amplifier provides isolation and drives a boostrap circuit that supplies a feedback voltage to insure ramp linearity.

The ramp output is applied to the time interval level sensor where its peak value is converted to a d-c analog proportional to the time interval parameter.

PEAK AMPLITUDE MEASUREMENT—In measuring the peak-to-peak amplitude of an input pulse or symmetrical waveshape, only the channel one dual level sensor is used. Depending on the range selected, the input pulse is routed through either of the two identical input modules for scaling and is then applied to the channel one dual level sensor tunnel diode comparators. Positive and negative level sensors convert the peak-to-peak amplitude to proportional d-c voltage signals, and supply a floating d-c voltage analog of the input peak-to-peak amplitude.

On command, charge dissipating circuits (a diode and resistor to ground, physically located on the input module) remove the stored charge in the level-sensor R-C networks after the conversion is completed. This prepares the level sensors for the next measurement.

PULSE WIDTH — To measure pulse width, the input pulse is routed through either of the two input modules for scaling, and is then switched into both dual-level sensors. The resultant analog voltages are supplied as proportional bias to the controllers. The channel one proportional controller gives a negative triggering spike that corresponds to the point of 50-percent amplitude of the leading pulse edge. The proportional controller in channel two provides a positive triggering spike corresponding to the point of 50-percent amplitude on the trailing edge of the pulse. These spikes trigger the square-pulse generator and produce a pulse that triggers the linear integrator to supply a ramp voltage with peak amplitude proportional to the width of the input signal. The time-interval level sensor then measures peak amplitude and provides a d-c voltage analog of the input signal width.

RISE AND FALL TIME — The same technique used to measure pulse width is used to measure rise and fall time. However, for measuring rise time the proportional controller in channel one provides a negative triggering spike corresponding to one-tenth the amplitude of the leading edge of the input signal, and the proportional controller in channel two provides a positive triggering spike equal to 90-percent amplitude of the leading edge of the input signal.

To measure fall time, channel one triggers at 90 percent of the amplitude of the trailing edge of the input pulse, while channel two triggers at 10 percent amplitude of the trailing edge.

DELAY MEASUREMENT — To measure delay, the reference pulse is applied to channel one, and the proportional controller is programmed to give a negative triggering spike corresponding to 50-percent amplitude of the leading edge of the reference pulse. The signal pulse is applied to channel two and the proportional controller provides a positive triggering spike at the 50-percent amplitude point of the leading edge of the signal pulse.

Delay measurements may be made between the 10, 50 or 90-percent amplitude points of the leading or trailing edges of a reference pulse and the 10, 50 or 90-percent amplitude points of the leading or trailing edges of a second pulse. The pulses need not be of the same polarity; hence, measurements of turn-on time, propagation delay or storage time of amplifiers and inverters may be performed or the input and output of delay lines may be compared.

APPLICATIONS — A programmable switch capable of selecting any one of fifty-five different video signals is the interface between the waveform analyzer and the prime radar. An automatic programmer-comparator selects the signal to be monitored, sets up the scaling and mode selection relays in the waveform analyzer, sets high and low limits within the comparator, and measures all of parameters of interest on a go/no-go basis.

The unit is suited for in-flight performance monitoring in either the automatic or manual mode. By using an x-y recorder as a measuring device, a permanent record of in-flight performance data can be retained. Ground-based checkout equipment that performs low-confidence level static tests can be replaced by airborne checkout equipment to test and record the dynamic performance characteristics of radar systems, digital or pulse-time computers, encoders, pulsed control systems and other equipment.

When used with a recorder, the waveform analyzer operates as factory test equipment to perform life tests. This technique provides a continuous minotor throughout the complete test and a permanent record of all parameters interrogated. This eliminates the need for standby personnel to perform periodic manual tests.

Still another monitoring function of this equipment is to automatically analyze navigation or guidance equipment during the last stages of countdown at the missile launch pad. The analyzer can be at the launch pad to convert pulse information to d-c signals that are easily transmitted to the blockhouse. Without equipment of this type, last-minute, dynamic pulse measurements would be impractical or even impossible due to the normal attenuation of pulse signals over long transmission lines.

Although the waveform analysis technique is suited for automation, it also provides advantages in a manual configuration to assist the checkout and failure isolation of prime equipment on the flight line.

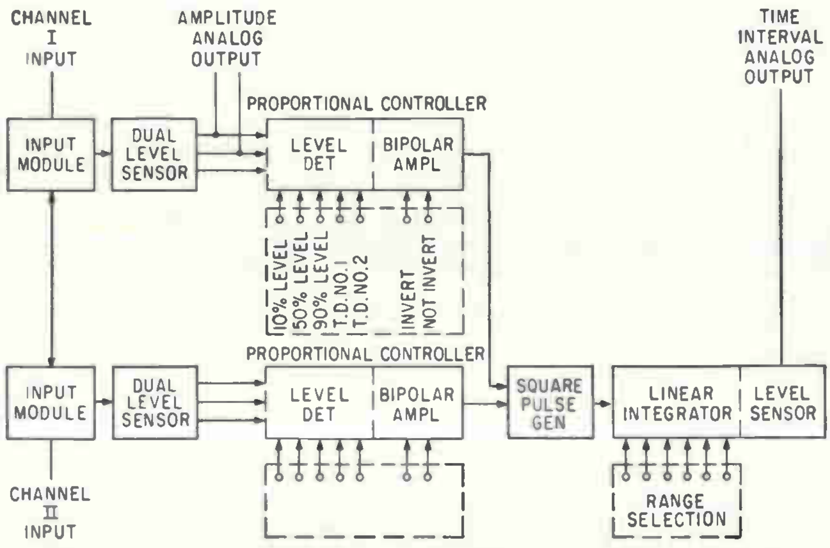
The d-c analog outputs of the measurement channels can be scaled or normalized, displayed on a d-c voltmeter, and directly monitored.

GAIN CONTROL—The waveform analyzer is suitable for many applications in automatic gain control. For example, in telemetry, it is used for monitoring steady-state signal conditions to identify change and provide feedback information.

The level-sensor circuit can be adapted to become the error-sensing element to precisely control the level of pulsed r-f signals. This technique was used to control the level of programmable, 30-Mc pulsed r-f simulation circuit for the automatic radar bench test system mentioned earlier.

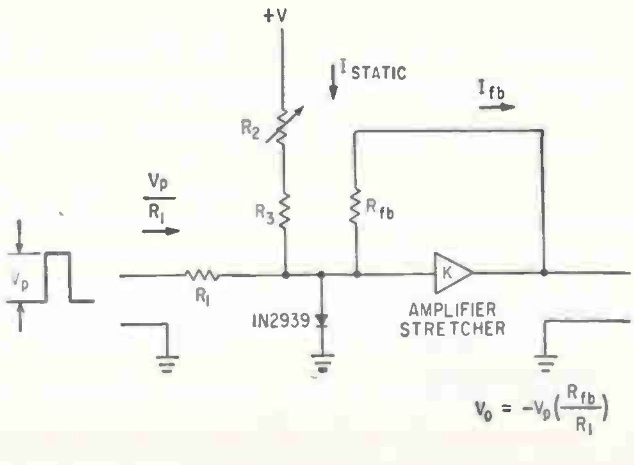
It is also feasible to control the rise time and width of pulsed signals with similar techniques utilizing rise time and width sensing circuits as programmable error detectors.

Since the output of the waveform analyzer appears as d-c voltage levels, it provides feedback information that is easier to control and might be impossible to extract in raw form.



COMPLETE *waveform analyzer has two channels feeding a square pulse generator, linear integrator and final level sensor—Fig. 3*

ADJUSTING *the I_{STATIC} to the peak current of the tunnel diode establishes zero point switch requirements. Steady-state pulse current conditions V_p/R_1 must equal the feedback current, I_{fb} to establish the relationship $V_o = V_p(R_{fb}/R_1)$—Fig. 4*



Frequency of a conventional multivibrator is determined by feedback-loop time constants. Although versatile, standard multis suffer from inherent instability, this circuit uses crystal control to achieve higher stability and improved rise and fall time

Crystal-Controlled Multivibrator

By HARRY R. NEWHOFF
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THE FREQUENCY of a conventional multivibrator is controlled by the R-C time constant of its feedback loops. This type of circuit has fairly good rise and fall time and will operate at repetition rates as high as 10 to 15 Mc. The main disadvantage of the standard free-running multivibrator is poor frequency stability. Also, the frequency will be affected by temperature, voltage variations, and variation (within tolerance ranges) between the capacitors and resistors used in the feedback loops, the latter affecting not only frequency but waveform symmetry.

With the circuit shown in Fig. 1, all of the previous disadvantages can be eliminated, while the advantages of a conventional multivibrator such as frequency range and simplicity, will not be lost. Moreover, the same total number of components are required, as the crystal or crystals replace the capacitor in one or both feedback loops.

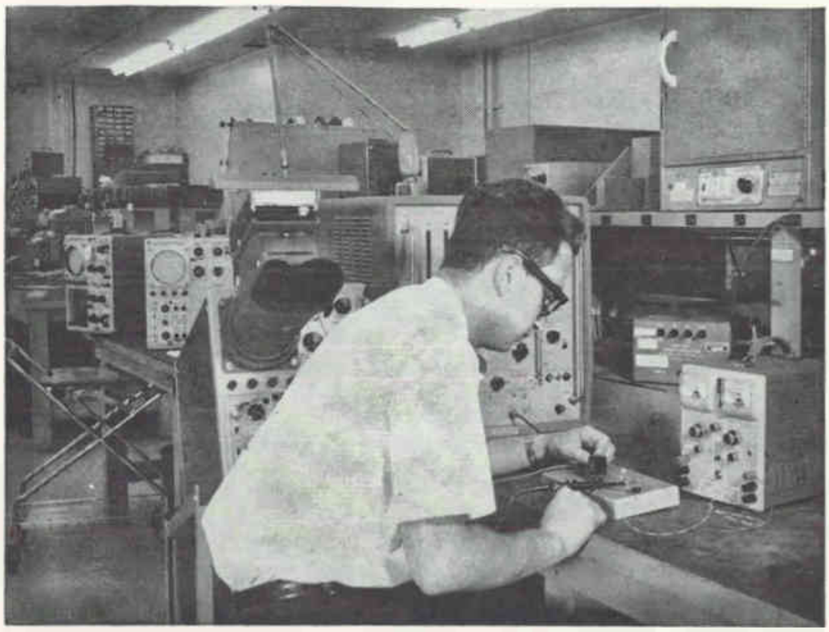
OPERATION—The circuit of Fig. 1 operates by using the piezo electric resonance of the crystal to control frequency. The rate of storage and release of energy depends upon the natural frequency of the crystal, and therefore determines the frequency of oscillation. The resistor value in the feedback loop is not critical when a crystal is used, because it no longer controls the time constant. It's value is still an important consideration, however, as it controls the base drive to the transistor and should, as with the collector load, be selected to drive the transistors at their best operating points.

In a single crystal unit, the R-C time constant of the noncrystal-controlled side can be designed using the same rules as for a free-running multivibrator.

The circuit of Fig. 1 was operated at frequencies as low as 750-Kc with minor resistor changes; however, crystal activity was down to about one tenth of its 7 Mc value. Operation below 750-Kc will probably not be possible without using a higher activity crystal.

EXPERIMENT—To prove that the crystal was controlling the frequency, the feedback resistor was first varied to change the frequency by 2:1 in a conventional free-running multivibrator. This had practically no effect on frequency with the crystal controlled multivibrator; it did, however, degrade the output waveform because the transistor became unsaturated. The capacitance of both crystals (7 Mc and 3.5 Mc) were measured on a Tektronix Model 130 L-C meter as 13 pf and 12 pf, respectively. These capacitance values are not in the range that create an R-C time constant that permits the circuit to work at these frequencies; therefore, there is no doubt that the frequency was being controlled by the crystal.

The effect of R-C loading on both a crystal controlled and a non-



AUTHOR *checking the circuit in the laboratory*

HIGH STABILITY MULTIVIBRATOR

There is often a need for a circuit that will generate either square waves or pulses with good stability and rise and fall time. Some conventional multivibrators may be useless for this application because they are basically unstable.

Here is a circuit that retains the advantages of conventional arrangements and does away with the disadvantages normally encountered. Moreover, it boasts simplicity and economy as bonuses.

Has Better Stability

crystal-controlled multivibrator was determined. Both circuits were operating at approximately 3.5 Mc and the load was a 33 pf capacitor in parallel with a 1,200-ohm resistor from collector to ground, on the side of the multivibrator connected to a scope. The crystal-controlled unit used one 3.5-megacycle crystal in the loaded side and showed absolutely no frequency excursion. The noncrystal controlled unit changed its frequency by approximately 16 percent and this shift was due to a change in the time constant on the loaded side; the unloaded side was not affected. Therefore, it is safe to assume that if both sides of the multivibrator were loaded, the frequency change would be twice as large, or about 32 percent.

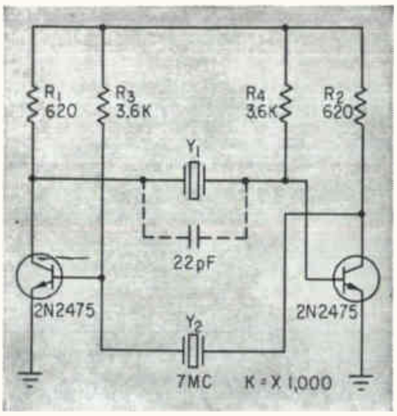
If the resistor or capacitor are slightly off value in the standard free-running multivibrator, the circuit will either operate at a different frequency, or if the values in only one feedback loop are incorrect, symmetry will be lost. With the crystal, however, the circuit can operate only at its rated frequency or multiple, or not at all. Frequency tolerances, in the order of 0.001 to 0.0001 percent can be obtained with this circuit.

The frequency change of the circuit in Fig. 1 was with a 20 percent supply voltage variation. However, the identical circuit with a second 7-Mc crystal in the alternate feedback loop held the frequnecy to 0.0001 percent (1.4 ppm) with a 20 percent supply-voltage variation. If voltage variations of this magnitude are not required, frequency tolerances can be even better. Normally, system voltage regulation is specified at 10 percent or better.

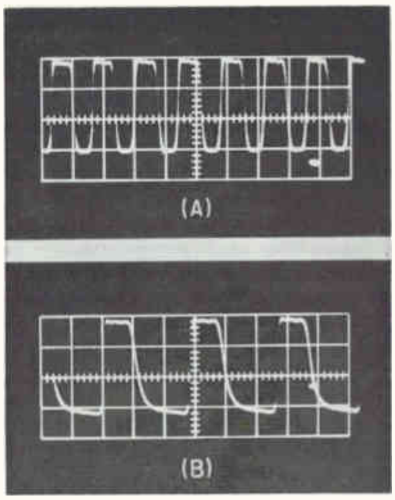
Resistor values shown satisfy the parameters of the 2N2475 that was used for these tests. If other transistors are selected, the values shown must be changed to compensate for differences in their beta and switching times.

The 2N2475 is an extremely fast switch; if another transistor is chosen, it does not have to be as fast, but should have a switching time that will permit operation at the desired frequency.

The circuit shown in Fig. 1 was modified to control symmetry by employing different frequency crystals in the two feedback loops. To accommodate this change, R_3 and R_4 were changed to 10,000 ohms, while Y_2 was selected for 3.5 Mc. The 7-Mc crystal remained in the second feedback loop. All other values are the same as shown in Fig. 1. This modification produced a symmetry change of 2:1 but



TEST *circuit uses a pair of 2N2475 transistors and a 7 Mc crystal with a low activity CT cut. Crystals with an AT cut are also suitable—Fig. 1*

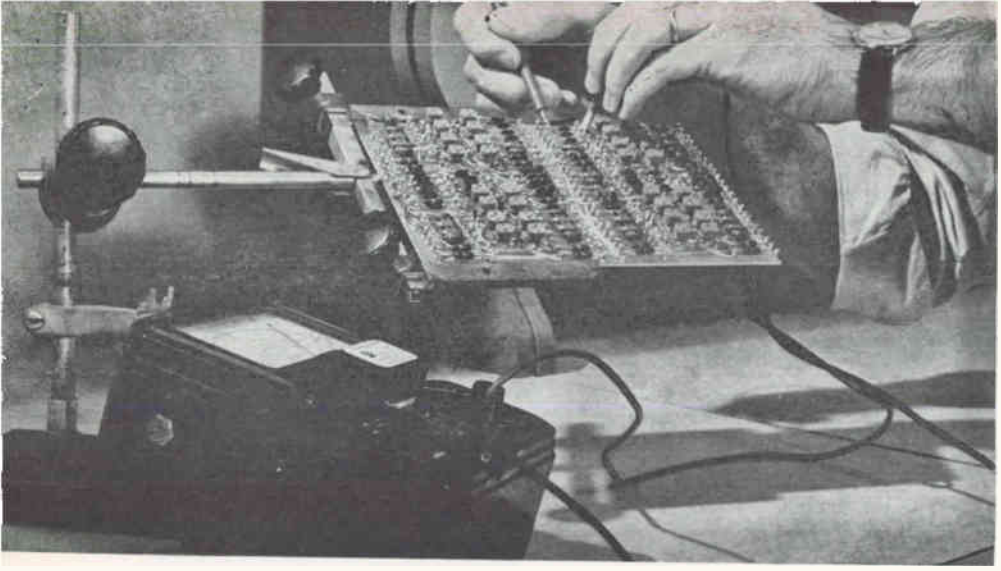


SCOPE *trace of the circuit in Fig. 1 (A), and trace showing a symmetrical operation with a 3.5 and a 7-Mc crystal (B). Scale settings in both cases are 2 v/cm vertical and 0.1 μsec/cm horizontal swept from left to right—Fig. 2*

maintained a frequency stability of 0.007 percent with a 20 percent supply voltage variation.

This modification has other advantages. For example, it can be used to produce an extremely stable asymmetrical square wave for use as a timing signal in a computer. Furthermore, this function can be generated in one, simple, two-transistor device. If additional current drive is needed, it can be followed by a simple pulse amplifier. Crystals selected for this type of operation must have a harmonic relationship in order to operate satisfactorily. Moreover, large changes in symmetry (greater than approximately 3:1) are not possible because the lower frequency crystal will look in at the higher frequency due to its higher activity level.

The circuit configurations are also applicable to instrumentation sensors. The 7-Mc crystal was removed from the modified circuit and replaced with a variable capacitor that covered the range of 7 to 47 pf. This permitted the pulse width of the noncrystal controlled side of the multivibrator to be varied from about a 50 percent duty cycle to a 3:1 duty cycle, with good frequency tolerance. This circuit can also be used for pressure sensing by using a capacitance probe in place of the variable capacitor. Here, small changes in capacitance will produce large changes in symmetry.



CHECKING *a diode quad in a typical redundant circuit*

BASIC RULES FOR Designing

By K. L. HALL
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Melbourne, Florida

EIGHT RULES FOR BETTER RELIABILITY

(1) Study requirements and funds available to accomplish the task. Use a tradeoff analysis to determine what can be sacrificed to gain reliability.

(2) Use the most reliable components possible. Get life history data from the manufacturers for mean time between failures (MTBF) and possible modes of failure.

(3) Determine modes of failure of all components to be used. Most components fail by both opening and shorting, except fixed composition resistors. These fail only by opening.

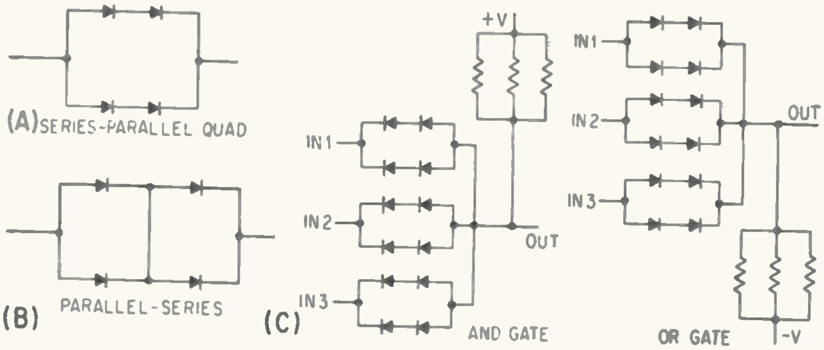
(4) Use actual environmental extremes with reasonable safety factors.

(5) Reduce power supply voltage tolerances through better regulation.

(6) Design logic to eliminate such hazards as long strings of diode gates with no gain stages. Successive worst-case failures in such strings can cause the output to fall outside predetermined states.

(7) Design all circuits so that normal operation will continue after any failure and under all worst case extremes applied simultaneously.

(8) Derate the stress applied (power consumed, voltage applied, etc) to each component as much as possible. A stress of about 30 percent of rated value is desirable. This increases reliability of individual components and prevents overloading after a failure occurs



DIODE QUADS *in two configurations (A) and (B), and logic gates (C) using the series-parallel quad—Fig. 1*

REDUNDANCY in circuit design implies duplicate components or circuits. These duplicate parts may be active at all times, carrying a portion (if in parallel) or all (if in series) of signal flow. Duplicate parts may be on a standby basis to be utilized when a switching device has sensed a failure. In either case, duplicate parts are not superfluous, but are an integral part of the system and are necessary to obtain the required mean-time-before-failure (MTBF) of the complete system.

There are two approaches to redundancy: (1) redundancy of components, and (2) redundancy of circuits (or systems). In the first case, each component in a given circuit is replaced by a redundant configuration that will protect against all modes of expected failure of that type of component. In the second case, circuits (or systems) are in parallel so that failure of one will not effect the output.

DESIGN PRINCIPLES—Good design starts with a set of rules and assumptions and incorporates all known worst-case conditions. For example, if component redundancy is used, a design rule or requirement must be that the circuit will continue to operate normally after one component has failed. Normal operation could continue after two or more failures have occurred, but this is not a requirement.

Most components fail both by opening and shorting. Protection must be provided against all modes of expected failure of each com-

How to apply redundancy techniques to semiconductor switching circuits to increase reliability. These principles can solve many design problems

Reliability into Semiconductor Circuits

ponent. For most components this means either a series-parallel or parallel-series quad. However, only parallel redundancy is used for composition resistors since failure by shorting does not occur.

In low-power equipment, the probability of failure of all components in a redundant configuration is equal, and after one component failure, the stress in the remaining components usually does not change enough to increase the probability of their failure.

COMPONENT REDUNDANCY—Diodes may fail either by shorting or opening. For component redundancy in a logic circuit, the diode may be placed in a quad configuration. If the diodes used are expected to fail more often by shorting than by opening, the series-parallel configuration, Fig. 1A, should be used. The parallel-series quad configuration, Fig. 1B, should be used if more diodes are expected to fail by opening.

The probability of diodes shorting to the probability of diodes opening is about equal, and the probability of success of both configurations is equal. Therefore, the midpoint tie line in a parallel-series configuration is unnecessary. If used, it would only be an extra wire and might degrade reliability. For this reason, the series-parallel diode quad configuration is preferred.

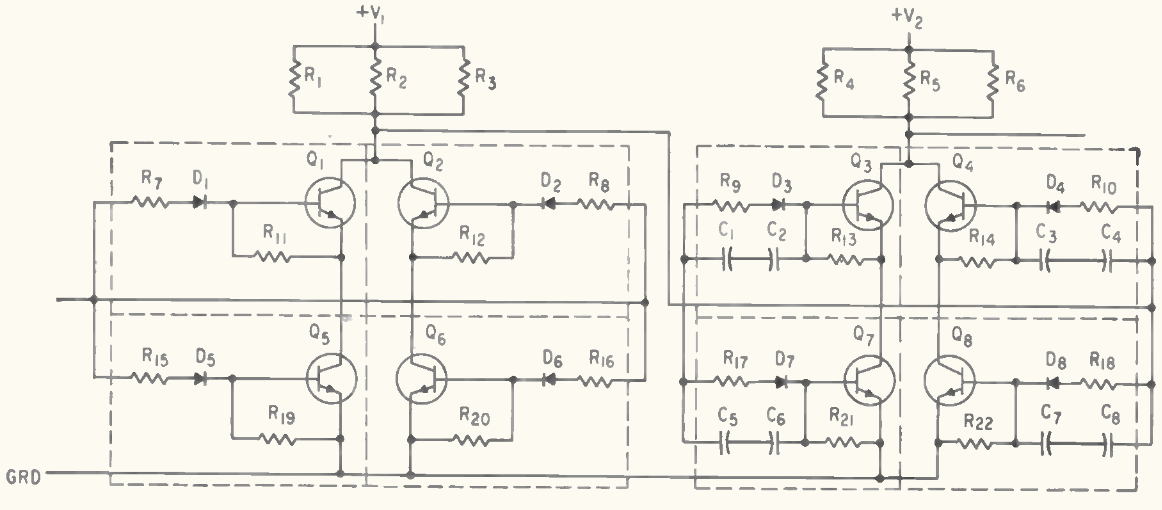
Logic gates using diode quads are shown in Fig. 1C. Resistors are used in parallel groups of three to reduce the overdesign necessary to provide enough drive current to the following stage should one resistor open.

Voltage tolerance on the two output levels must be wider than usual to accommodate the slight change that will be encountered if one diode shorts and changes output voltage by the amount of the forward biased diode voltage.

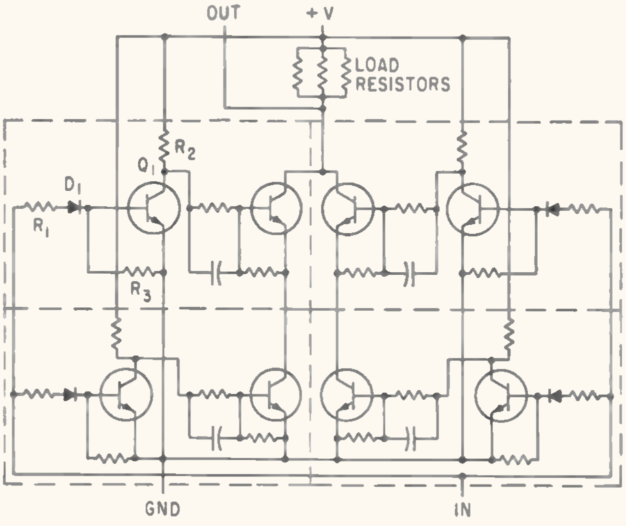
Any one component may fail in any of its expected modes of failure, and several more failures may occur without hampering normal operation. But after one failure has occurred, there is the possibility that an additional component failure will disable the circuit.

INVERTERS — Two redundant transistor inverters forming a redundant buffer, are shown in Fig. 2. The design concepts involved are similar to the diode quad. Since the transistor is a three terminal device, it must be handled slightly different than the diode quad. The bases of the transistors cannot be hooked directly together. Some isolation must be provided.

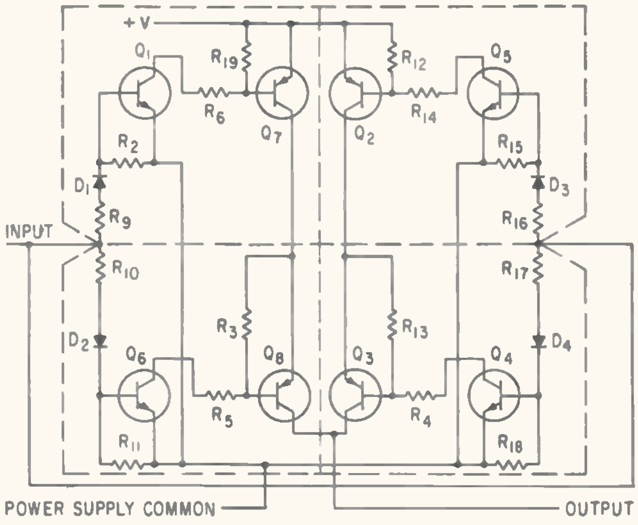
This is done by resistors, R_7, R_8, R_{15}, R_{16}. If the input is driven from a low impedance source, this circuit will perform for all single



REDUNDANT BUFFER *consists of two inverters. Capacitors in the circuit at the right speed-up response time—Fig. 2*



QUAD BUFFER *is similar to Fig. 2 but does the same thing with fewer components—Fig. 3*



POWER SWITCH *application for a noninverting driver —Fig. 4*

failures including a collector-to-base short in an upper transistor. However, if the base-current source is a high impedance, such as a back-biased diode, a collector-to-base short in an upper transistor of the quad could still supply some base current to the remaining transistors. The amount of current would depend on the relative values of the collector circuit resistors and the base circuit resistors. For this reason, diodes are used in the upper base circuits.

Diodes are also placed in the lower legs to more evenly divide available base current and to prevent starving the other transistors out of saturation in the event of a base-to-emitter short in a lower transistor.

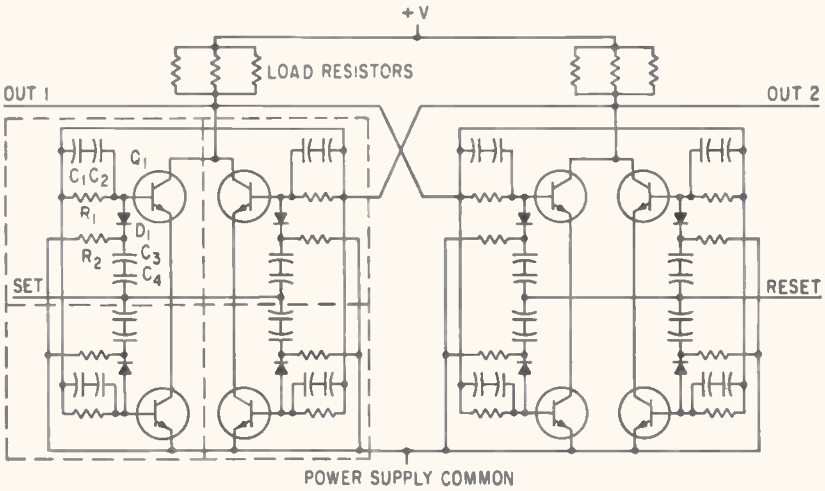
Each transistor used in the quad will have an I_{CBO} leakage current that increases with temperature. A resistor must be placed between the base and emitter of each transistor to carry the maximum expected I_{CBO} and develop a voltage less than the threshold voltage of a silicon transistor (about 0.5 volt). Since the I_{CBO} approximately doubles for every 10 C increase above room temperature (25 C), and assuming that the maximum expected temperature is around 75 C, a multiplication factor of 32 must be used

$$R_{max} = \frac{0.3\ V}{I_{CBO} \times 32}$$

where 0.3 volt is used as it is well below threshold voltage of a transistor at elevated temperatures.

A resistor in the immediate base circuit (R_7 or R_{11}) could open with the result that the leg would be disabled. The quad continues to operate normally, and one failure does not hamper normal operation.

The collector load resistors are a common element and must be handled in a different manner. If only two resistors, R_1 and R_2, were used and should R_1 open, R_2 would still provide drive current to the



FLIP-FLOP *designed with cross coupling to minimize the possibility of a complete failure—Fig. 5* following stage. Assume R_1 and R_2 equal, the drive current to the following stage would be reduced by less than one-half. The transistor quad in Fig. 2 (Q_1, Q_2, Q_5, Q_6) would have to be designed to carry the collector current furnished from the source through R_1 and R_2 in parallel. With R_1 open, this current would be cut in half. This means the quad would carry twice as much collector current as necessary, and since the base drive source is similar to the collector circuit and subject to current reduction by resistor failure, the quad must be able to handle excessive collector current with reduced base current. Furthermore, if R_1 and R_2 are still functioning normally, but reduced base drive is available, one transistor in the quad (Q_2 for instance) could still be allowed to fail by opening or shorting. This means that one side of the quad must now carry the entire (excessive) collector current at reduced base drive current.

To summarize, any one transistor must be able to carry the maximum expected collector current with the minimum expected base current.

Power supply variations must also be considered. Maximum collector current will be encountered at the upper voltage tolerance. Minimum base current will occur at the lower voltage tolerance. If three, or even four, parallel resistors are used in the collector circuit, as shown in Fig. 2, the problem is not as difficult.

Figure 3 is an integrated quad buffer. Each leg of the quad has been expanded to include two transistors. This circuit performs the same function as the circuit of Fig. 2, but with fewer components, and has less propagation delay. The MTBF is slightly less, but it is still more reliable than a conventional circuit.

A shorted or open speed-up capacitor would only disable one leg and not the quad. Therefore, this capacitor need not be made redundant. The integrated quad buffer has two tandem-connected transistor circuits in each leg. Disabling one leg in any manner would not disable the quad.

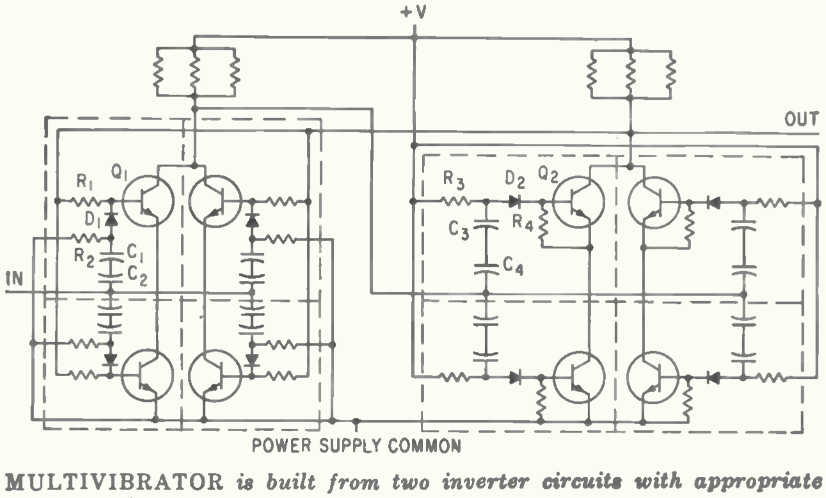
Another possible combination is the *npn-pnp* transistor quad shown in Fig. 4. This circuit can be used as a power switch, thereby offering a significant cut in power consumption. It can also be used as a noninverting driver (buffer) with high current capabilities in the up state.

These inverters and buffers are the main building blocks for all other types of circuits. The extension of these principles is all that is necessary to convert most digital circuits to a redundant design.

FLIP-FLOPS—A redundant flip-flop, Fig. 5, is nothing more than two inverters with appropriate cross coupling that can withstand failures. Capacitors C_3 and C_4 with R_3 form the differentiating input network. Diode D_1 is part of input. C_1 and C_2 are speed up capacitors across R_1. Both sides of the flip-flop are identical and similar components in other legs of the quad perform the same function.

From this beginning, counter stages and shift register stages can be developed. Also, a flip-flop could be developed similar to the integrated quad buffer with two transistors per leg. This could be used if only one side of the flip-flop were desired for an output.

MONOSTABLE MULTIVIBRATORS—The MSMV is similar to the flip-flop circuit in that it can be built from two inverter circuits with appropriate cross coupling. The *RC* network that forms the time constant of the circuit is the first problem. If a capacitor quad were used with resistors in parallel for the timing network, any one component failure would change the time constant. This cannot usually be tolerated. By placing two capacitors in series and using only one resistor, the timing network has been moved into the base circuits of the transistors in the second quad, Fig. 6. Capacitors C_1 and C_2, resistor R_2 and diode D_1 form the differentiating input. Resistor R_1 is



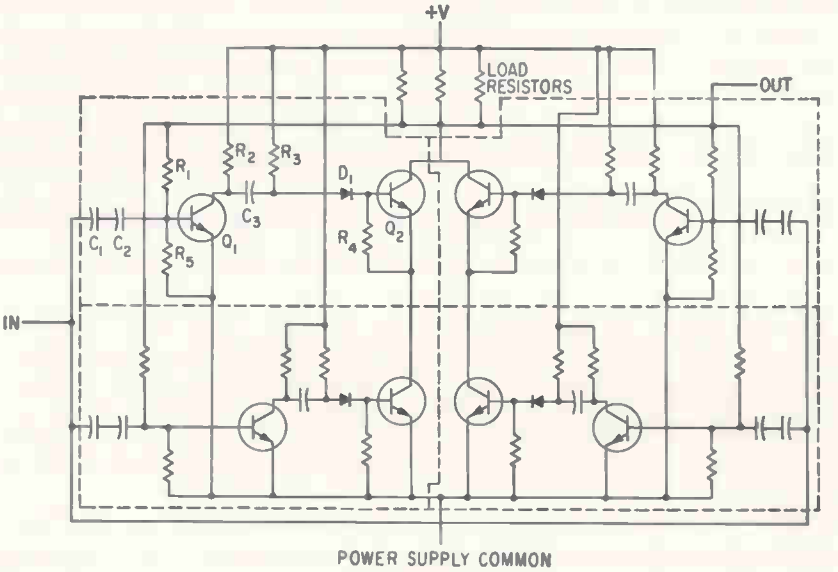
MULTIVIBRATOR *is built from two inverter circuits with appropriate cross coupling—Fig. 6* a feedback resistor. Diode D_2 prevents reverse breakdown of base-emitter junction of Q_2. Capacitors C_3 C_4 and R_2 form the time constant of MSMV.

The second quad (right side) is normally on, but is turned off by coupling action of C_3 and C_4 (and similar capacitors in other legs) when the first quad is turned on. Resistor R_1 (and similar resistors in other legs) are the feedback resistors and hold the first quad on until the second quad again turns on. When the capacitors recharge sufficiently, the second quad again turns on and the operation is complete.

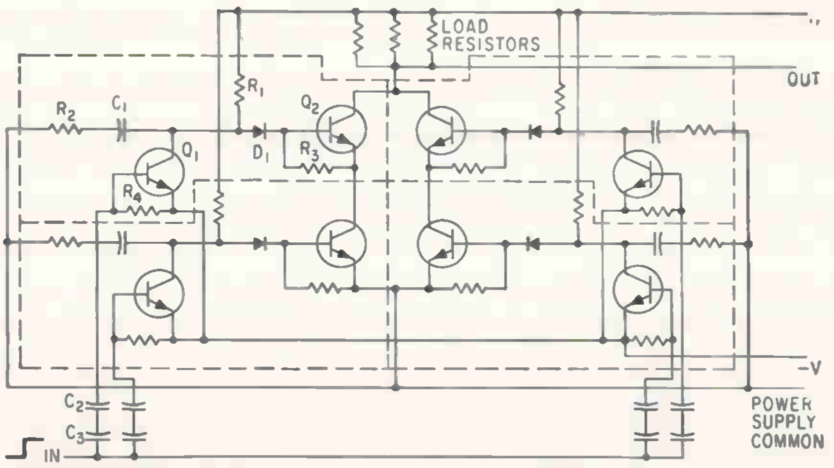
Any failure now will render only one transistor inoperative or make its operation erratic. In this event, the rest of the quad will still govern and normal operation will be continued.

Another possibility for a redundant MSMV, Fig. 7, offers advantages of fewer components and less power consumption than other redundant configurations.

A pulse stretcher (or monostable multivibrator with output pulse wider than the input pulse) is illustrated in Fig. 8. This circuit was designed for a specific application and has the added feature that if the input pulses occur closer than the time constant of the circuit, the output will become positive. Most MSMV circuits cannot be retriggered during the period of operation. This circuit can be retriggered at any time.



REDUNDANT MSMV *uses fewer components than other redundant configurations and uses less power—Fig. 7*



PULSE STRETCHER *may be retriggered at any time during period of operation—Fig. 8*

CIRCUIT REDUNDANCY — Digital circuits are nonlinear, and have two discrete states. By moving these two states slightly farther apart, and widening the tolerances on each state, the techniques of component redundancy can be incorporated into digital circuits.

On the contrary, analog circuits usually do not have two discrete output levels. They may be linear or nonlinear, and will travel through a continuous range of states from one extreme to the other. Since any failure that would cause offset or error in the output is not permissible, analog circuits are not easily adapted to component redundancy.

Only portions of the analog circuit such as bypass capacitors and other noncritical components, can be made redundant. Complete component redundancy is impossible and the improvement obtained in reliability for digital circuits cannot be obtained for analog circuits.

Circuit redundancy is the only approach to these problems. Two circuits may be used in parallel with a failure-sensing device to disable an inoperative circuit and select the operative circuit. If this device is automatic, it is usually complex and must be included in reliability calculations. Sometimes the failure sensing can be by human observation. This places an uncertain factor, the human element, into reliability calculations.

Another method is to place three circuits in parallel and let the majority rule. This is similar to majority logic.

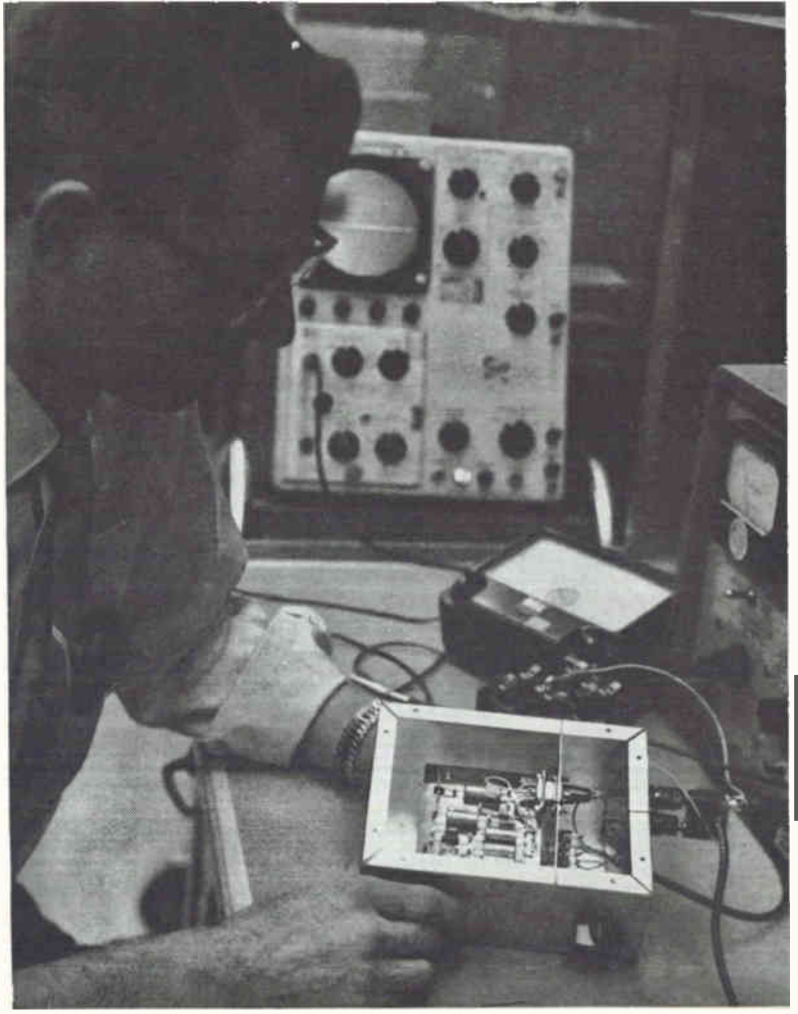
Since individual components are more reliable than the system in which they are used, the use of redundant components provides a system that has a probability of successful operation greater than ordinary systems in a system or circuit redundant configuration.

Design time for systems using circuit redundancy is about the same as that for conventional, nonredundant circuits. The component redundant technique requires more design time because of the many loop equations encountered.

FILLING TRANSISTOR PERFORMANCE GAPS

Despite the profound influence of transistors on circuit design, practical use of these devices has not been without problems. For example, the difficulty of designing transistor amplifiers with high input impedance still makes the vacuum tube the logical choice in many applications. The commercial availability of the field-effect transistor is changing this situation. Here's how its characteristic high input impedance can be used to design a practical low-noise preamplifier suitable for many applications

LOW-NOISE PREAMPLIFIER Uses Field-Effect Transistors



AUTHOR FLEENOR *checks performance of low-noise field-effect transistor preamplifier*

Few parts are needed in multiple-purpose preamplifier design using off-the-shelf field-effect transistors. High input impedance and low noise are combined with gain stability despite temperature change

By E. G. FLEENOR, Senior Electronics Research Engineer
Lockheed Missiles & Space Company, Sunnyvale, California

FIELD-EFFECT transistors have input impedances and optimum source impedances that are typically two orders of magnitude higher than those of ordinary bipolar transistors. These characteristics have been used to design a general-purpose preamplifier that is suitable for use with any low-level, high-impedance source. A commercially available field-effect transistor is used in the circuit, which has an input resistance greater than 100 megohms. Noise figure can be less than 1 db. The preamplifier operates from 12 volts and draws 1.4 ma.

CHARACTERISTICS—The electrical characteristics of the field-effect transistor are similar to those of a vacuum tube, and the same equivalent circuit can be used. The field-effect transistor terminal designations and the analogous tube electrodes are gate for grid, source for cathode and drain for plate. The equivalent circuit is shown in Fig. 1A. Typical values for the 2N2497 field-effect transistor at drain-source voltage V_{DS} of -7 volts and drain current I_D of 0.5 ma are transconductance g_m of 800 micromhos, drain resistance r_d of 100,000 ohms, gate-drain capacitance C_{gd} of 4 pf, drain-source capacitance C_{ds} of 4 pf and gate-source capacitance C_{gs} of 16 pf.

The TI 2N2497 is a silicon *p*-channel field-effect transistor, so polarity of the biasing voltages are opposite to those of an *n*-channel field-effect transistor or a tube. The characteristics, shown in Fig. 1B, are similar to those of a pentode tube.

In the field-effect transistor in Fig. 1C, the bar of *p*-type silicon has had *n*-type impurities introduced into opposite sides creating *p-n* junctions. Ohmic connections for the source and drain are made at opposite ends of the bar, and an ohmic connection for the gate is made to the two *n* regions. If the gate-source and gate-drain junctions are reverse biased, depletion layers are formed between the two *n* regions, which effectively reduces the size of the *p* channel through which majority carriers flow. Thus, source-drain conductance can be modulated by varying gate-source or gate-drain voltage.

The operating range in which the depletion layers are not touching is called the ohmic region and is shown on the curves in Fig. 1B. If gate-drain voltage is increased sufficiently, the two depletion layers touch and pinch off the channel. The constant-current operating range that results is called the pinch-off region. The field-effect transistor is operated in the pinch-off region in linear amplifiers where high transconductance and drain resistance must be maintained.

PREAMPLIFIER—The low-noise field-effect transistor amplifier in Fig. 2A has a voltage gain of 10.5 and an input resistance of 100 megohms. It can be used as a preamplifier for piezoelectric transducers (microphones, hydrophones, accelerometers, pressure cells), capacitor microphones and radiation detectors (thermistor-bolometers, photodiodes, phototubes, and lead-sulfide, cadmium-sulfide and gallium-arsenide detectors).

The input field-effect transistor stage is d-c coupled to a common-emitter transistor stage, and 26 db of feedback is used. The circuit can provide a 3-volt peak-to-peak output into a 5,000-ohm load. Performance can be calculated from the equivalent circuit in Fig. 2B.

Gain can be calculated from the approximation $(R_1 + R_2)/R_1$, which yields a value of 11, compared to the measured gain of 10.5. Precision resistors with low temperature coefficients are used for R_1 and R_2 to stabilize gain. The circuit was tested over a temperature range of −40 to +100 deg C, and gain changed less than 1 percent. This highly stable gain can be partly attributed to the large amount of feedback. In addition, there is a partial cancellation of the negative temperature coefficient of transconductance of the field-effect transistor (−0.6 percent per deg C) by the positive temperature coefficient of beta of the output transistor (+0.5 percent per deg C).

INPUT IMPEDANCE—The equivalent input circuit of the preamplifier is a 100-megohm resistor, R_i, shunted by an 8.3-picofarad capacitor, C_i. The high input resistance is obtained by bootstrapping Q_1 so that the source voltage is fed back through C_2 to the bottom of R_3. Feedback voltage across R_1 also reduces the effect of gate-source capacitance C_{gs} and consequently of C_i.

The value of C_i is determined by gate-drain capacitance C_{gd}, which is increased by the Miller effect, and by gate-source capacitance C_{gs}, which is reduced by the feedback, as shown in Fig. 2B. Thus

$$C_i = C_{gd}\left(1 - \frac{E_d}{E_i}\right) + C_{gs}\left(1 - \frac{E_o}{E_i}\right)$$

The value of R_i is determined by R_3 and the amount of feedback. Gate-source and gate-drain leakage resistances are assumed to be negligible. Thus

$$R_i = R_3/(1 - E_o/E_i) = R_3(1 + R_1 g_m h_{fe}')$$

The value of R_3 was selected to be low enough so that gate leakage current (0.1 μamp at 100 deg C) would not disturb bias at high temperature.

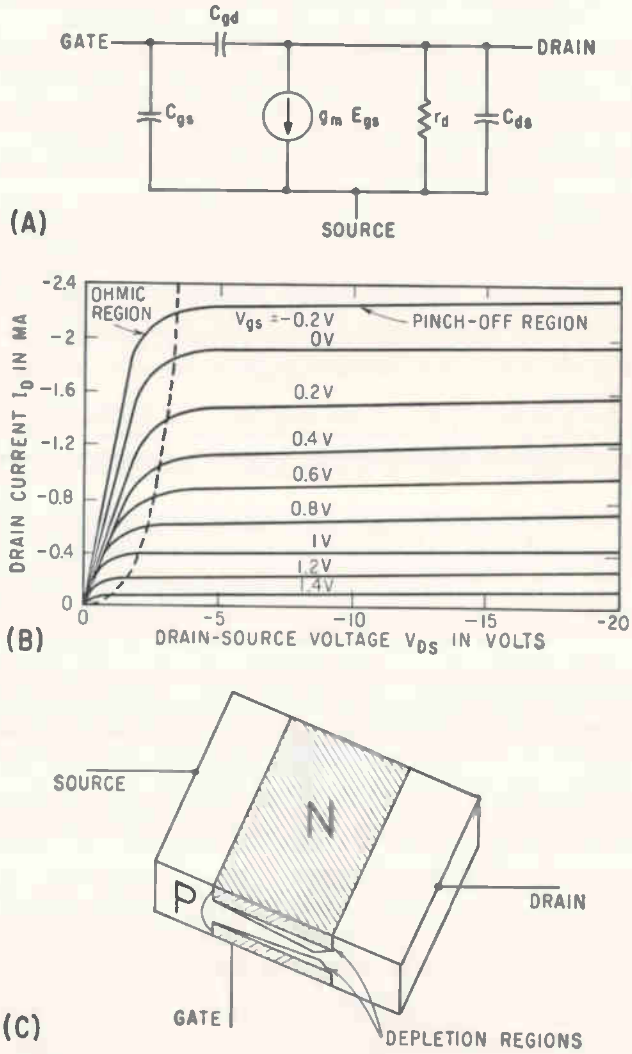
The 3-db frequency response of the preamplifier extends from 0.5 cps to 700 Kc using a 600-ohm source. The lower 3-db frequency is determined by R_4C_4 and the amount of feedback. Thus, the lower 3-db frequency is $f \cong 1/2\pi R_4 C_4 R_1 g_m$. If a resistive source such as a radiation detector is used, the upper 3-db frequency is limited by the R-C circuit formed by external source resistance R_s and C_i of the preamplifier (8.3 pf). For a 1-megohm source, the upper 3-db frequency is 20 Kc. If gain at high frequencies is not needed, it can be reduced to minimize pickup problems by shunting R_2 with capacitor C_6. Thus the upper 3-db frequency is $f \cong 1/2\pi f R_2 C_6$.

Measured output impedance is 250 ohms. The equation is

$$R_o = \left(\frac{1 + R_2/R_1}{h_{fe}'g_m}\right)\left(1 + \frac{R_1R_2}{R_1 + R_2}\,g_m\right)$$

Output impedance can be reduced by a factor of 3 by replacing the 2N910 with the higher beta 2N930.

NOISE FIGURE—The noise figure of the preamplifier is detemined primarily by the noise performance of the field-effect transistor because it has a large power gain and furnishes approximately optimum source impedance to the second stage. Noise figure of a field-effect transistor is limited fundamentally by thermal noise of the conducting channel,[2] but shot noise of the gate current and 1/f noise of the gate and channel currents contribute to the noise.



EQUIVALENT *circuit (A) and characteristics (B) are shown for field-effect transistor (C)—Fig. 1*

At frequencies below 1 Kc and with a high-impedance source, $1/f$ noise of the gate current tends to predominate. The noise figure varies with frequency and source impedance. A test setup for measuring noise figure is shown in Fig. 2B. The following equation can be derived from the definition of noise figure

$$NF = 10 \log \left(\frac{V_{no}^2}{A^2}\right)\left(\frac{1}{4kt\Delta f R_s}\right)\left[(2\pi f R_s C_i)^2 + \left(\frac{R_i + R_s}{R_i}\right)^2\right]$$

where A is voltage gain of preamplifier-amplifier combination, f is center frequency, Δf is bandwidth of wave analyzer, k is Boltzman's constant, t is temperature in deg K and V_{no} is rms noise voltage out. Another method of determining noise figure involves measuring the equivalent short-circuit noise voltage and the open-circuit noise current.[3]

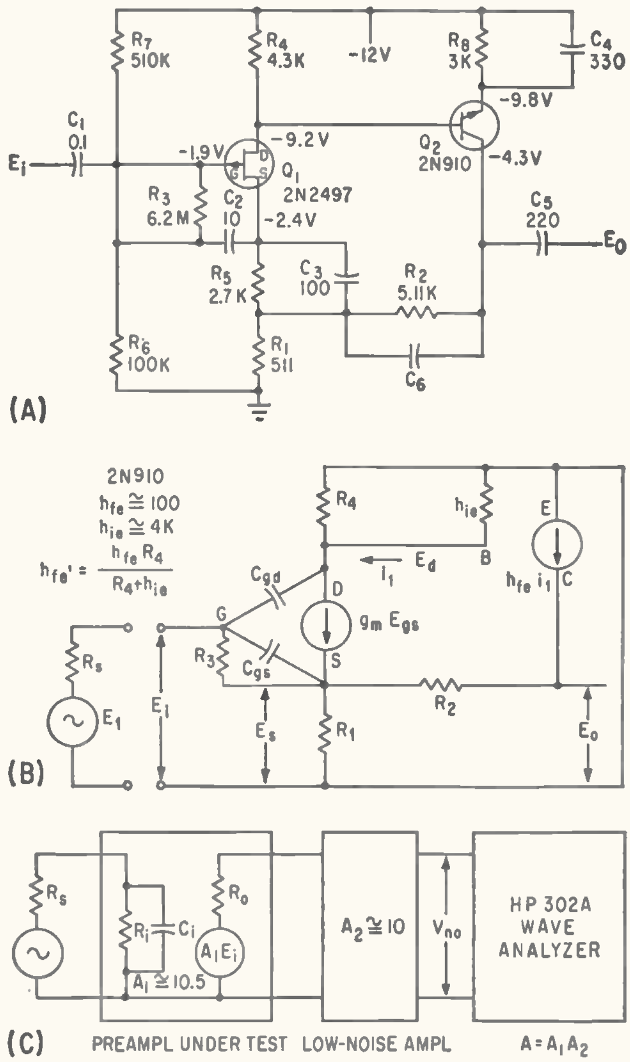
Noise figure is plotted as a function of source impedance and frequency in Fig. 3. In this preamplifier, optimum source impedance is about 0.5 megohm at 1,000 cps, but the preamplifier is useful over an impedance range of 20,000 ohms to 20 megohm. The noise figure is typically less than 3 db referred to 1 megohm at frequencies between 100 cps and 10 Kc. For ultralow noise applications, the 2N2500 field-effect transistor, which has a guaranteed noise figure of 1 db at 1 Kc, can be used by determining the value of R_6 experimentally for the proper bias level.

BIASING—Transistor Q_1 is biased by returning gate resistor R_3 to a fixed bias level determined by the resistance divider formed by R_6 and R_7. Stability of the bias was analyzed, and the results indicate that the temperature coefficient of drain current is reduced from −0.6 percent per deg C to −0.15 percent per deg C by the d-c feedback.

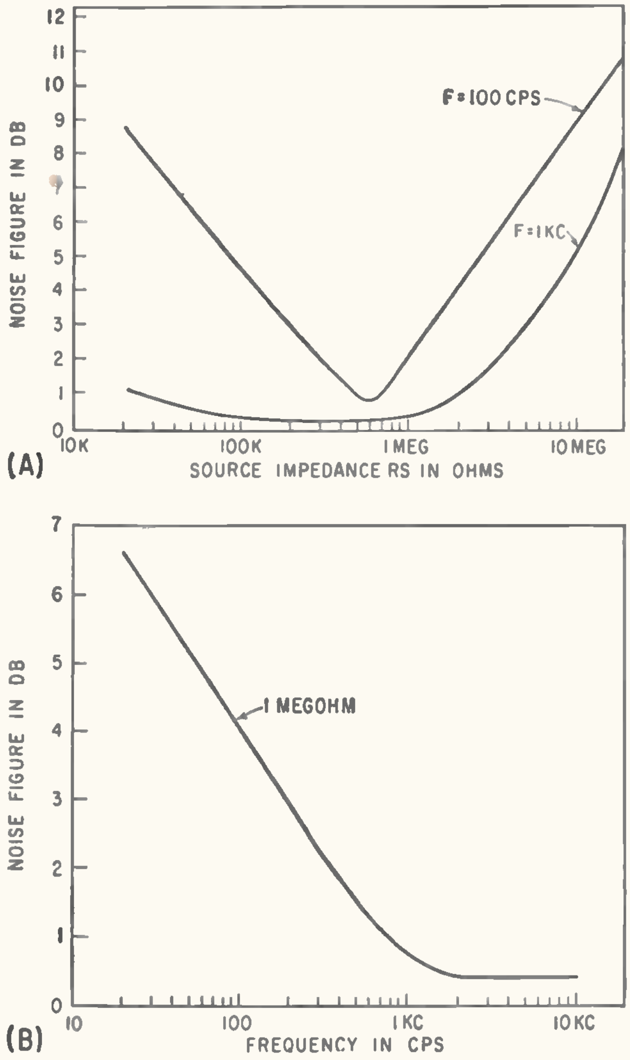
Bias is stable enough so that any 2N2497 having the 3 to 1 range of drain current values can be used without changing the bias resistors (specified drain current of the 2N2497 is between 1 and 3 ma when gate-source voltage is zero and drain-source voltage is −10 volts). The ratio of drain currents for field-effect transistors at the limits is 77.5 percent.

REFERENCES

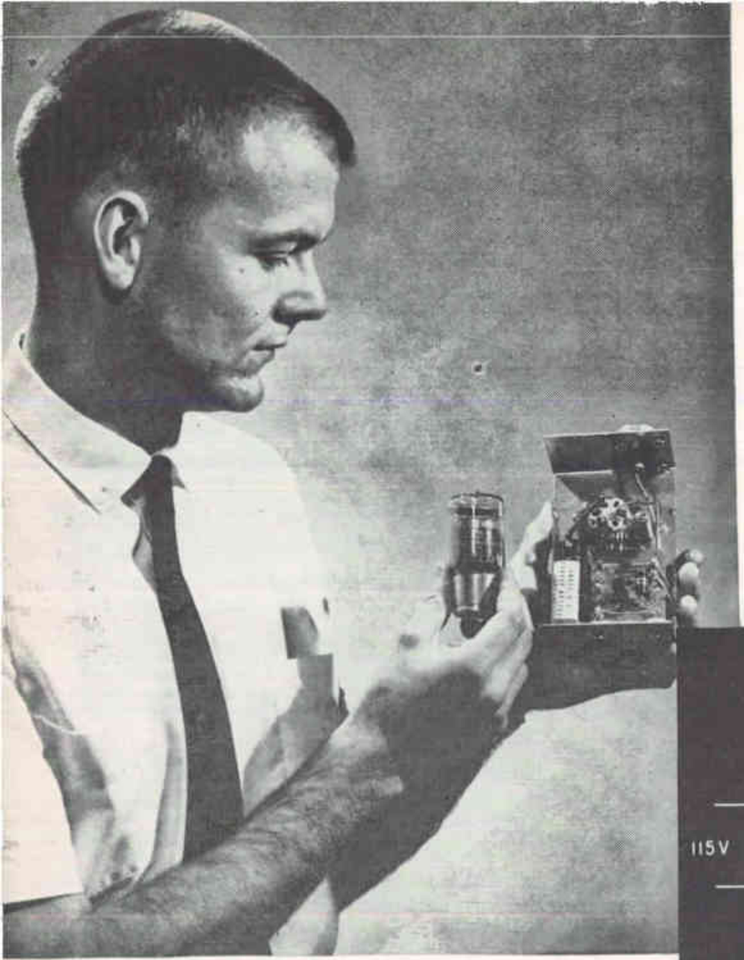
(1) W. Shockley, A Unipolar Field-Effect Transistor, *Proc IRE*, 40, p 1365, November 1952.
(2) A. van der Ziel, Thermal Noise in Field-Effect Transistors, *Proc IRE*, 50, p 1808, August 1962.
(3) A. E. Sanderson and R. G. Fulks, A Simplified Noise Theory and Its Application to the Design of Low-Noise Amplifiers, *IRE Trans on Audio*, p 106, July-August 1961.



LOW-NOISE *preamplifier (A) is shown with equivalent circuit (B) and noise measurement setup (C)—Fig. 2*



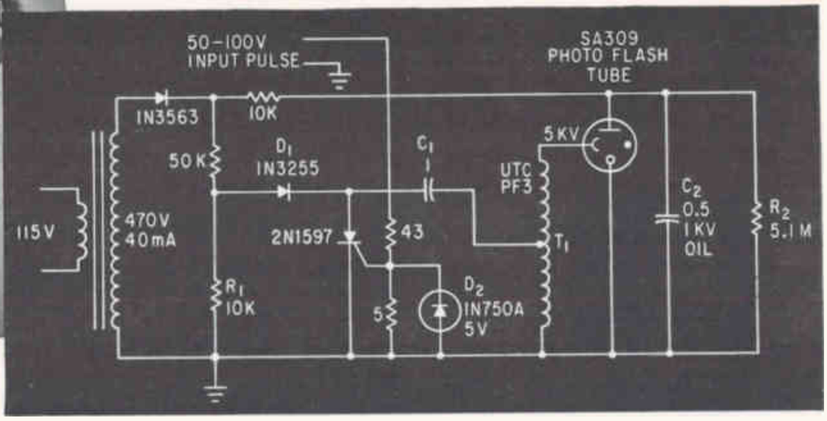
NOISE FIGURE *is plotted as a function of frequency (A) and source impedance (B)—Fig. 3*



AUTHOR *Harris compares photoflash unit with conventional thyratron*

SIMPLIFIED PHOTOFLASH

Developed as part of an experiment with a particle accelerator at the Lawrence Radiation Laboratory, the photoflash control unit described in this article is mounted on a telescope and aimed at a receiver that is ½-million volts above ground



SOLID-STATE *unit is triggered from external pulse generator*

Solid-State Components Shrink Photoflash Control

Physical size of a photoflash unit can be reduced by using an scr and other semiconductors

By EVERETT L. HARRIS Jr.
Lawrence Radiation Laboratory, Berkeley, California

RECENT developments in semiconductor components permit a radical reduction in the physical size of electronic photoflash controls. In addition, filament supplies are not needed and heat generation is greatly reduced when the vacuum tubes are replaced by semiconductor devices.

The scr-controlled photoflash unit uses an scr to replace the conventional thyratron and a 1-Kv piv diode to replace the rectifier tube. A smaller power transformer can be used since the gas-discharge tube requires no filament supply.

OPERATION — Capacitor C_1 charges to approximately 100 v. An external pulser supplies the scr gate with a trigger signal that fires the scr to connect capacitor C_1 across the primary of pulse transformer T_1. The peak voltage at the secondary of T_1 is about 5 Kv, enough to trigger the photoflash tube. Maximum repetition rate is about twenty pulses per second.

Diode D_1 keeps capacitor C_1 from discharging through R_1. Since the external pulser produces a variable voltage, zener diode D_2 is used as a 5-v clamp to protect the scr gate. Resistor R_2 discharges high-voltage oil capacitor C_2 after the unit is turned off.

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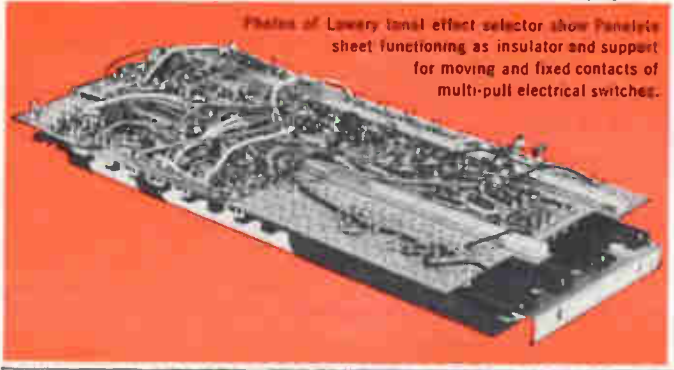

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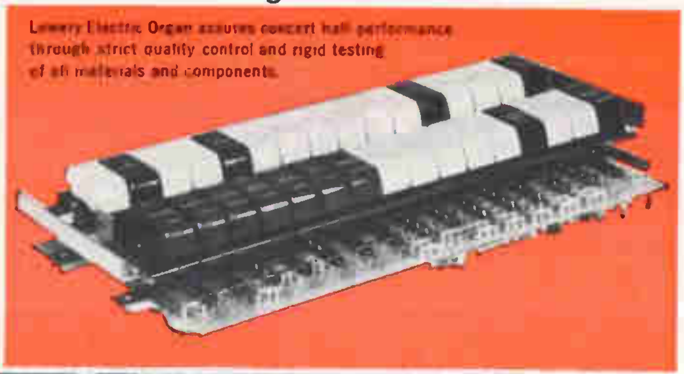

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NEW CHARTS Speed Thin-Film Resistor Design

Graphical method eliminates tedious calculations in finding thin-resistor dimensions for desired resistance and power rating

By HENRY L. COOK
Supervisor, Thin Film Laboratory
Martin Company, Orlando, Florida

GRAPHS and a chart have been developed that eliminate many tedious calculations from thin-film resistor design. This method, now in use at Martin-Orlando, has also improved overall reliability in thin-film operations.

The resistance of a thin-film resistor is determined by the dimensions of a resistive material deposited on a substrate. Many hours may be required to calculate the sizes required to obtain a large number of resistance values. Also, the calculated size is sometimes too small to manufacture, requiring additional calculations to obtain practical dimensions.

Thickness of a thin-film resistor, which is about 200 angstroms, is predetermined. A resistive constant is used in thin-film resistor design, which is the measured resistance of a geometric square (length equals width regardless of their actual dimensions) of a resistive material deposited at constant thickness. The resistive constant is commonly expressed in ohms per square. Since thickness is constant, a desired resistance is obtained by calculating the required length and width.

The ability of a thin-film resistor to dissipate power is governed by the substrate area occupied by the resistor. Power dissipation per unit area is an experimentally determined constant. At the present state of the art, redundant calculations are often required to obtain a desired resistance and power dissipation capability.

The length of a thin-film resistor required to obtain a desired resistance is determined from

$$L = (RP/K_r K_p)^{1/2} \quad (1)$$

where L is length in inches, R is required resistance in ohms, P is required power dissipation in milliwatts, K_r is resistive constant in ohms per square and K_p is power constant in milliwatts per square inch. Length is determined by Eq. 1 so that the resistor will be capable of the required heat dissipation.

Because of the direct relationship between length and width in establishing the resistance of a thin-film resistor, width can be found from

$$W = LK_r/R, \quad (2)$$

where W is width in inches.

When either calculated length or width is too small, additional calculations are required assuming a new length or width.

The table and graphs were constructed from the two equations. Length can be determined for numerous sets of constants from the graph at the top of the figure and from the table, and width can be found from the graph at the bottom of the figure. These graphs and the table are based on resistive constants from 125 to 4,000 ohms per square and power constants

TABLE—RESISTOR LENGTHS FOR GIVEN CONSTANTS

CONSTANTS		LENGTH IN INCHES									
OHMS PER SQUARE	MW PER SQUARE INCH	A	B	C	D	E	F	G	H	J	K
125	32,000	0.01	0.02	0.04	0.08	0.16	0.32	0.64	1.28	....	....
250	16,000	0.005	0.01	0.02	0.04	0.08	0.16	0.32	0.64	1.28	....
500	8,000	0.0025	0.005	0.01	0.02	0.04	0.08	0.16	0.32	0.64	1.28
1,000	4,000	0.00125	0.0025	0.005	0.01	0.02	0.04	0.08	0.16	0.32	0.64
2,000	2,000	....	0.00125	0.0025	0.005	0.01	0.02	0.04	0.08	0.16	0.32
4,000	1,000	....	....	0.00125	0.0025	0.005	0.01	0.02	0.04	0.08	0.16

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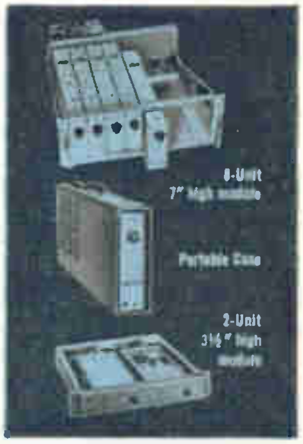
Bandwidth	DC — 10 KC within 3 db	DC — 50 KC within 3 db	DC — 100 cps within 3 db
Linearity	±0.1% of 10 V f.s. at DC	±0.01% of 10 V f.s. at DC	±0.03% of 5 V f.s. at DC
Gain	1000, 500, 200, 100, 50. Smooth gain control covers intermediate ranges	1000, 500, 200, 100, 50, 20, 10. Does not phase invert	1000, 500, 200, 100, 50, 20, 10. (Gain of 10 to 20,000 in 12 fixed steps available on special order)
Overload Recovery	For 20 V, 1 ms to 1% of f.s. output		For ±10 v, 200 ms to within 25 mv of original output
Drift	±2 uv ref. to input. ±0.01% of f.s. at output at constant ambient for 40 hours	±0.02% of f.s. at constant ambient for 40 hours	±2 uv ref. to input. ±0.1 mv. ref. to output for constant ambient for 40 hours
Noise	5 uv rms, DC-10 KC (ref. to input at gain of 1000)	7 uv rms, DC-50 KC (ref. to input)	1 uv p-p, DC-20 cps (ref. to input, at gain of 1000)
Input	Isolated from gnd. and output. Impedance 100 meg. min. at DC in parallel with 0.001 mfd.	Impedance 100 meg. at DC in parallel with 0.001 mfd.	Isolated from gnd. and output. Impedance 500K
Output	Isolated from input and ground. ±10 V at 10 ma. (—4000P has grounded output, ±10 V at 100 ma.)	±10 V at ±100 ma. Sustained short across output will not cause damage to amplifier.	Isolated from input and ground. ±5 V at ±2.5 ma. Part or all of internal 2K in parallel with 25 mfd. may be removed, connected externally.
Common Mode Characteristics	120 db rejection at 60 cps, 160 db rejection at DC (1000 ohms in either input lead). Tolerance ±300 V DC or peak AC.	Amplifier floats with respect to chassis. Isolation impedance is greater than 3000 megohms in parallel with 5 pfd.	130 db rejection at 60 cps, 160 db rejection at DC (1000 ohms in either input lead). Tolerance ±300 V DC or peak AC
Price (F.O.B. Waltham, Mass.)	$825 (860-4000P· $900)	$650 (Including internal power supply)	$425



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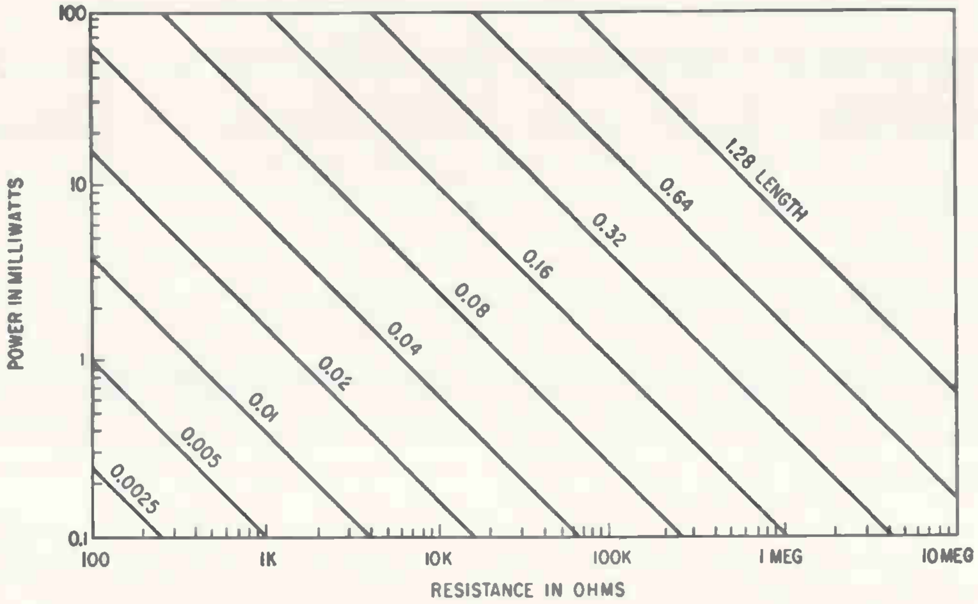
from 1,000 to 32,000 milliwatts per square inch.

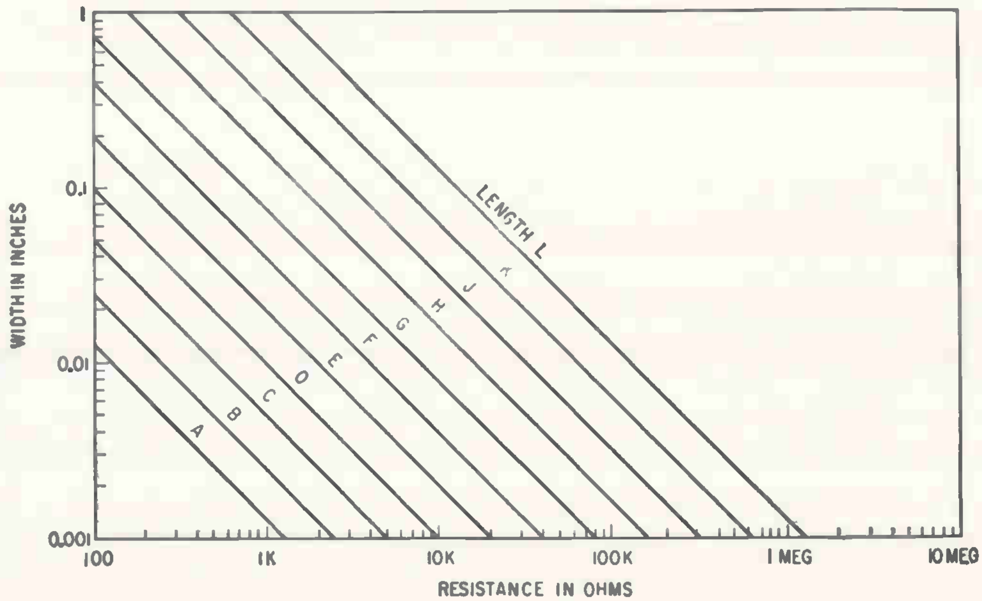
EXAMPLE — Determine the length and width of a 1,000-ohm thin-film resistor that can dissipate 5 milliwatts when the given resistive constant is 500 ohms per square and the given power constant is 8,000 milliwatts per square inch.

Using the graph at the top of the figure, locate the junction of 1,000 ohms and 5 milliwatts. If this point does not fall on a line length, continue upwards to the next line length (0.04 inch), which indicates the required length.

In the table, find the two constants 500 ohms per square and 8,000 milliwatts per square inch. Horizontally along this line, find the line length (0.04). At the top of the column containing the line length, find the corresponding letter (E).

Using the graph at the bottom of the figure, find the intersection of line length E and 1,000 ohms. Moving horizontally from this point, the required width is indicated on the width axis.





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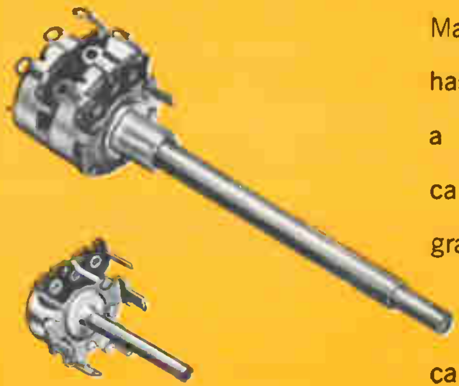

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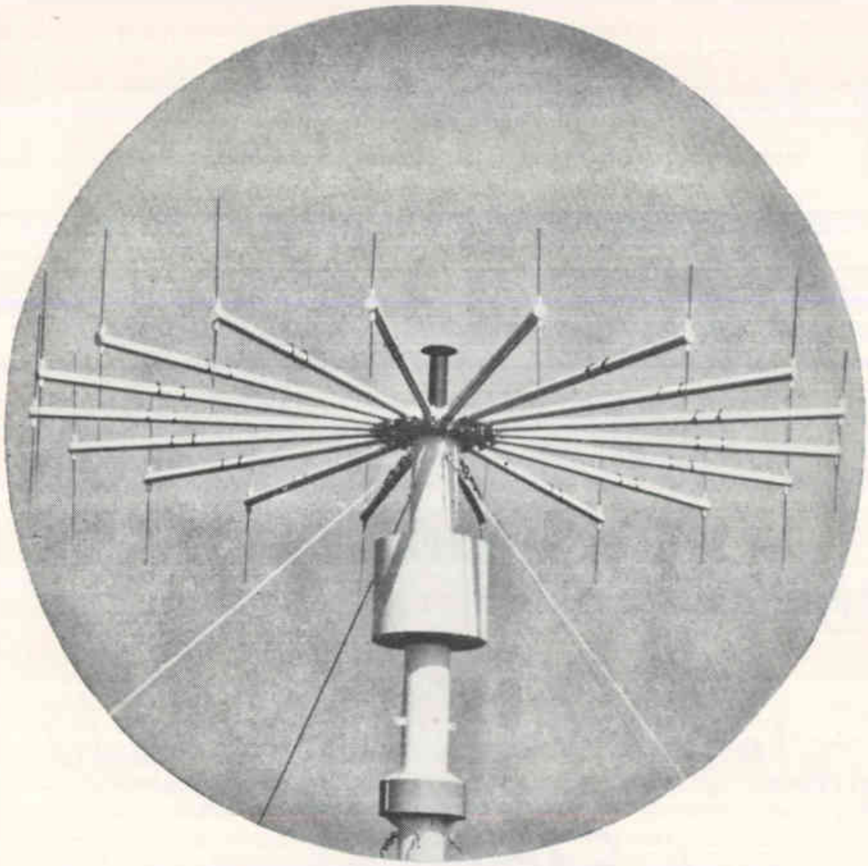

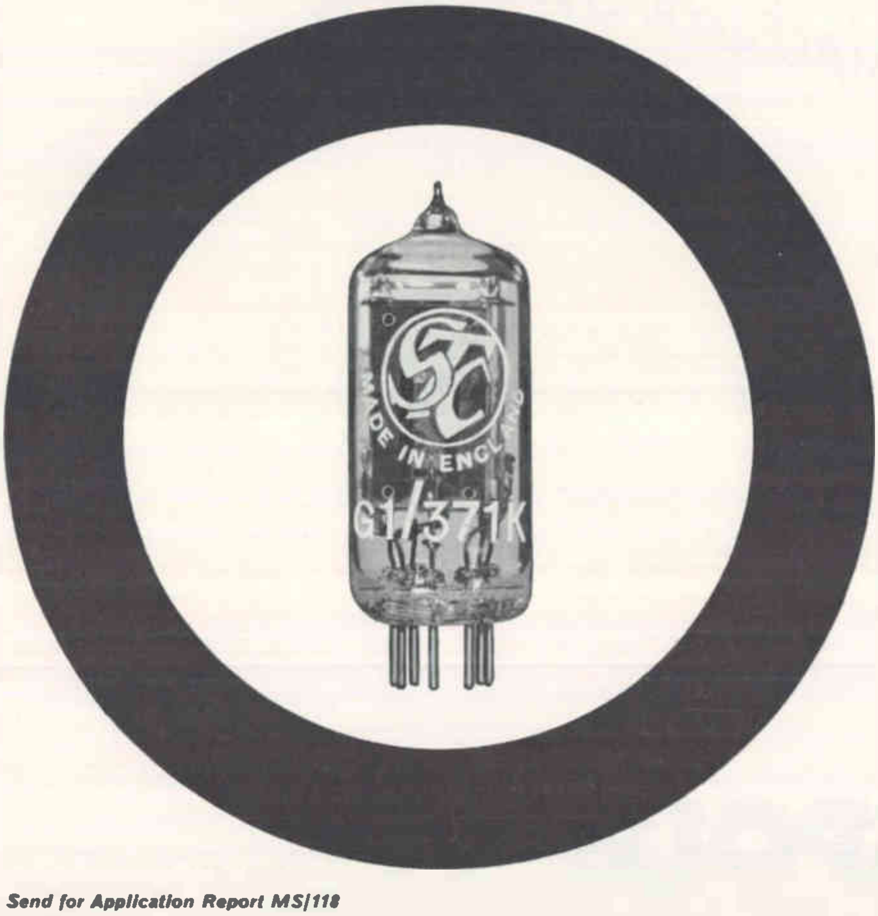

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Anode maintaining voltage	180 V
Cathode current, average	2 to 10 mA
Trigger bias	0 to 165 V
Trigger voltage	
(a) for ionization within 25 μsec	185 V
(b) for ionization within 5 μsec	195 V
Priming gap current	0.2 to 0.5 mA

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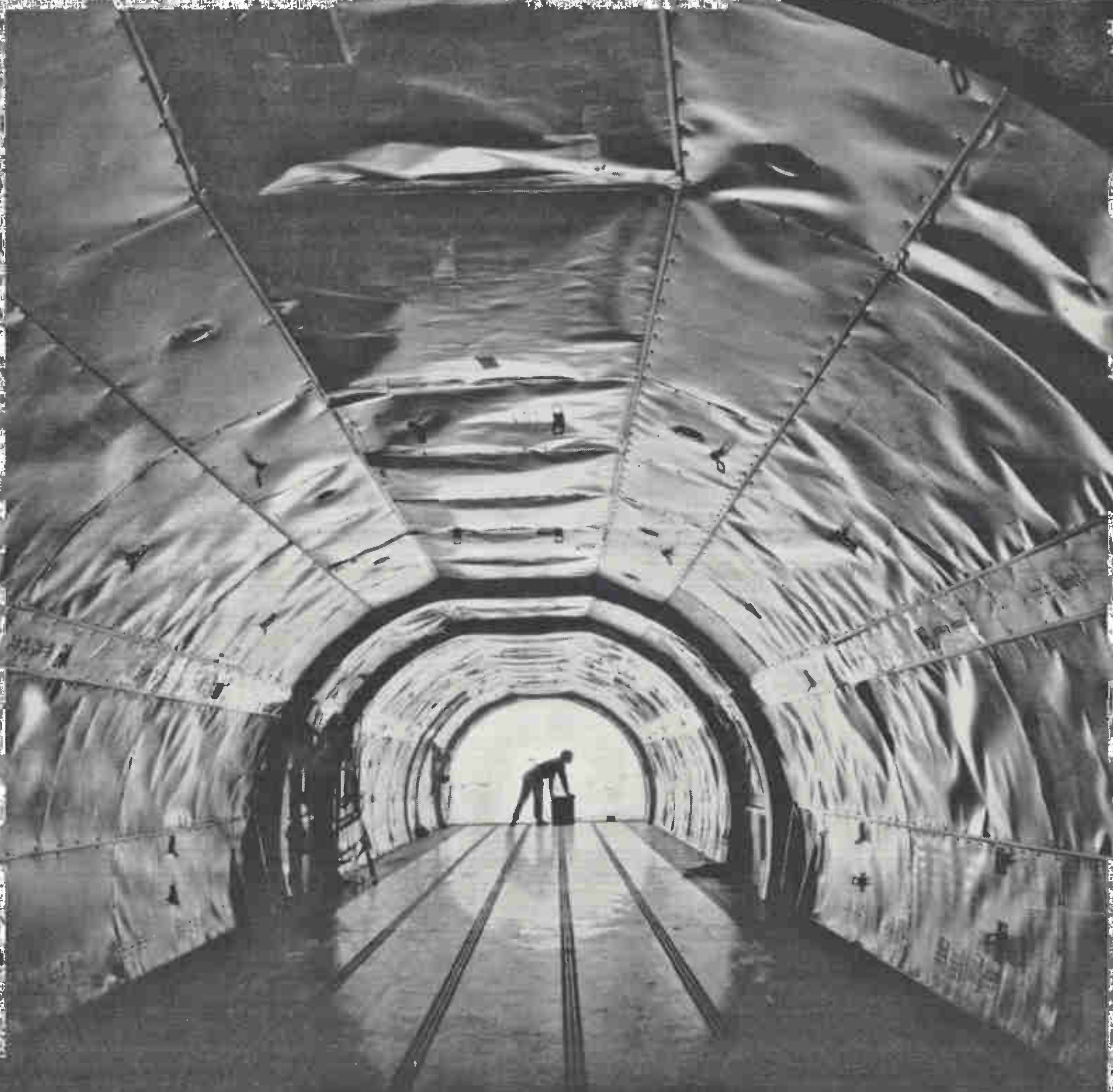

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Total Resistance	1K to 1 Meg.
Resistance Tolerance	±5%
Power Dissipation	2.5 W
Electrical Angle	$3600^{\circ}{}^{+5^{\circ}}_{-0^{\circ}}$
Insulation Resistance (500 VDC)	50 Meg. Minimum
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Equivalent Noise Resistance (Max.)	.1% or 100 Ω
Max. Continuous Working Voltage	500 VDC

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Shock	50 G's (MIL-STD-202 Method 205)
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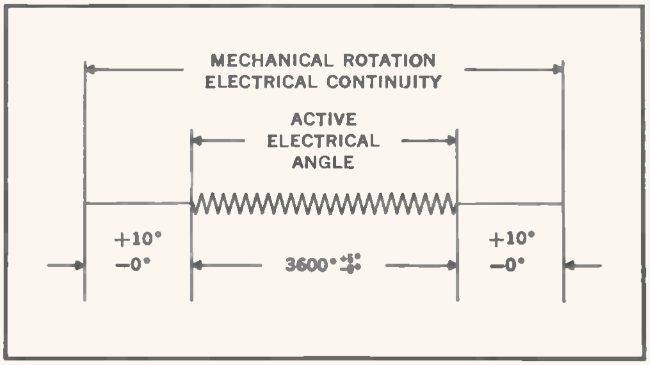

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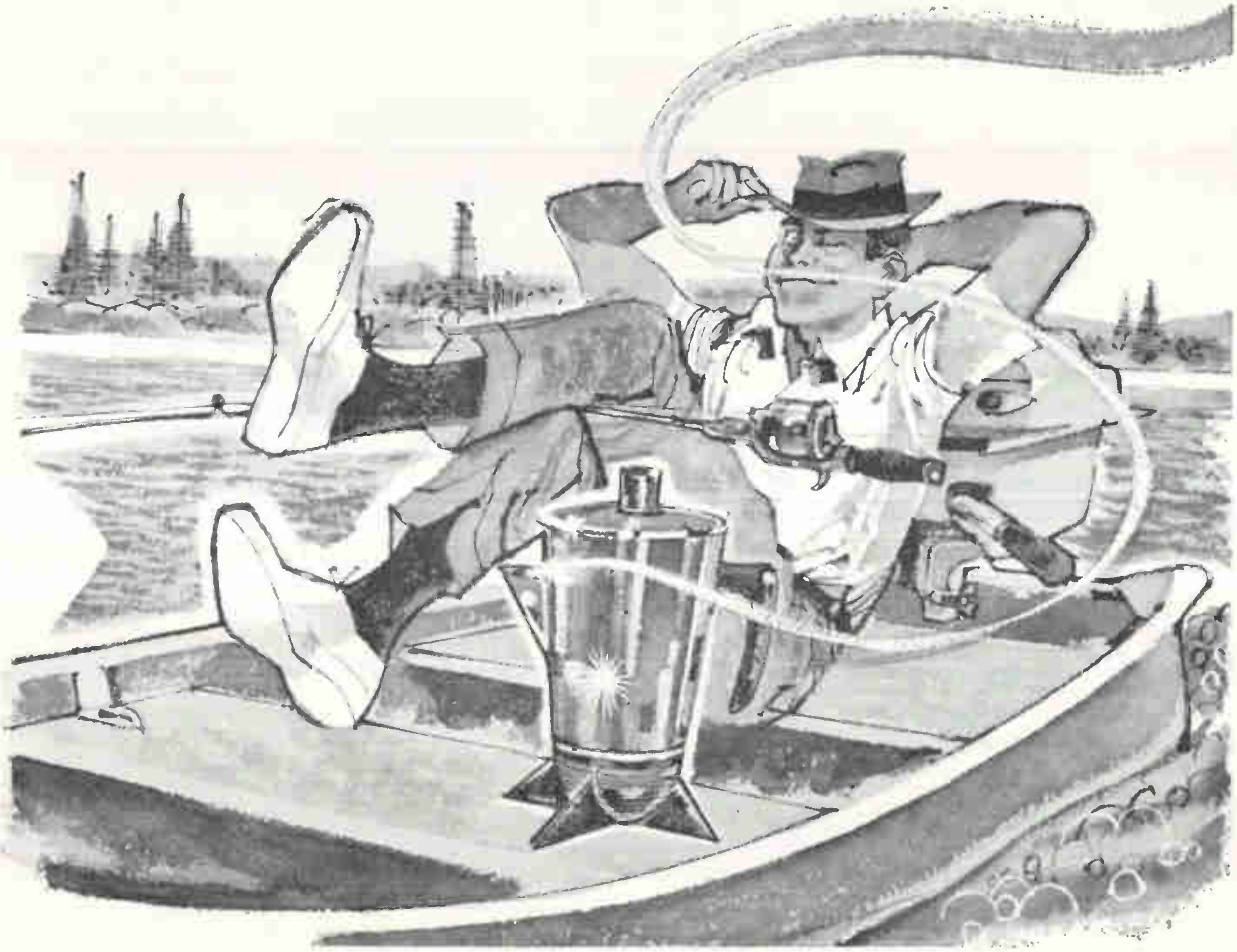

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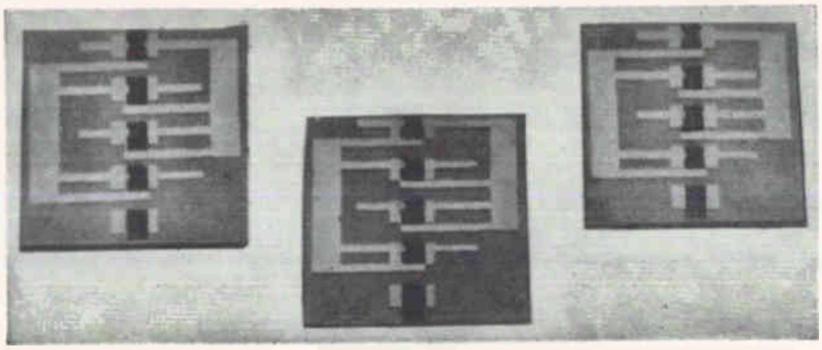


COMPLETELY DEPOSITED *multivibrators using thin-film, insulated gate, field effect devices formed on amorphous glass substrates. At least three semiconductors have been found suitable: cadmium selenide, cadmium sulfide and cadmium telluride*

Vacuum Deposited Circuits Use Field Effect

By CHARLES FELDMAN, HERBERT L. WILSON and WILLIAM A. GUTIERREZ
Melpar Research Laboratories, Falls Church, Va.

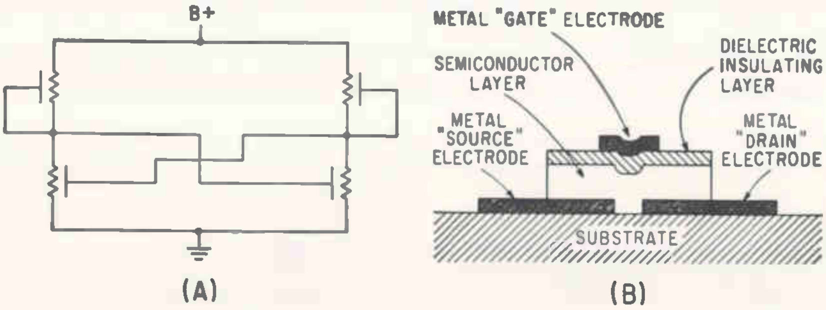
Active microcircuits studied at Melpar have thin-film construction

COMPLETELY DEPOSITED thin-film microcircuits containing both active and passive components are being formed and studied in the research laboratories of Melpar, Inc. The circuits make use of insulated-gate field-effect phenomena for the active elements, as described by Feldman[1], Weimer[2], and previously by Lilienfeld[3], Heil[4] and Shockley[5] and others. The microcircuits are formed on amorphous substrates by a sequence of evaporations in vacuum, and require no intermediate or post-deposition treatment. Oscillators, multivibrators and various digital circuits are currently being studied. Passive circuit components consisting of rhenium film resistors (ELECTRONICS, May 11, 1962, p 69) and silicon dioxide dielectrics are combined with active thin-film devices.

Two types of field-effect modulation are under study. In one type, typefied by germanium films, conductivity modulation is controlled by surface states on the semiconductor (ELECTRONICS, Oct. 12, 1962, p 24). Such units show appreciable current and power gain. The second type of modulation involves voltage dependence of the semiconductor space charge region or majority carrier injection, or both. Devices formed with cadmium selenide, cadmium sulfide and cadmium telluride use this type of modulation. Appreciable voltage gains are achieved, as well as current and power gains.

MULTIVIBRATORS—The photograph shows three experimental multivibrators that were completely vacuum deposited. Each substrate contains five deposited cadmium selenide devices, four of which are used in the circuit. Evaporated gold films form the interconnections according to the schematic of Fig. 1. A cross-section of one of the active devices is shown in Fig. 1B. Devices are formed by subsequent evaporation of metals, source-drain electrodes, a semiconductor layer, a dielectric layer, and a metal gate electrode. Typical film thicknesses are 100 to 500 Å for the metallic electrodes, 200 to 500 Å for the semiconductor layer, and 300 to 1,200 Å for the dielectric layer.

Investigations at Melpar have shown that cadmium selenide and cadmium telluride, in addition to previously reported cadmium sulfide[2], are suitable for use in these devices. Cadmium selenide appears to be the most suitable material for completely deposited active devices. Thus far, the CdSe units have shown better reproducibility, stability, higher electron mobility, while



SCHEMATIC *of the experimental microcircuit, (A); cross-sectional view of a field-effect active device, (B)—Fig. 1*

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But now ITT Surprenant Laboratories have overcome the previous weakness of TFE resins—low abrasion resistance due to poor cold flow properties. The secret: extrusion of a remarkable triple insulation of ultra abrasion-resistant material sandwiched between two layers of pure Teflon.

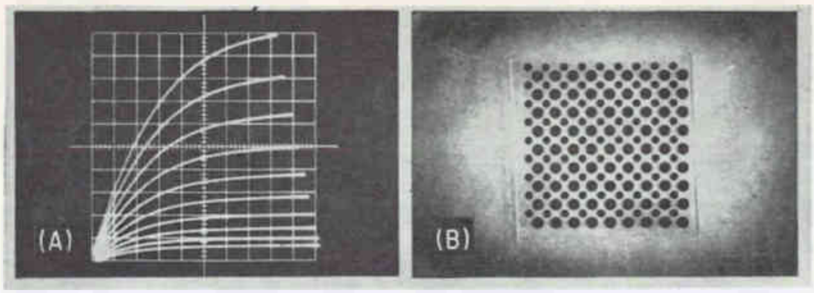
Specify Surprenant Mil Spec MS 17411, MS 17412, MS 18000 and MS 18001 (WEP). Available in all types and sizes, with silver-plated or nickel-plated conductors.

See your ITT Surprenant representative for full details or write for technical information.

Surprenant Mfg. Co., a Subsidiary of International Telephone and Telegraph Corporation, Clinton, Massachusetts.

*Reg. du Pont Trademark **Surprenant Mfg. Co. Trademark

CIRCLE 81 ON READER SERVICE CARD



DEVICE CHARACTERISTIC *of a unit, (A); arrangement of 81 isolated units on a one-inch-square substrate, (B)—Fig. 2*

their sensitivity, transconductance and voltage amplification factors are comparable to CdS devices. Characteristics of a CdSe thin-film transistor are shown in Fig. 2A. SiO_2 is used as the insulating layer.

ARRAYS OF DEVICES—The circuits illustrated represent, of course, only a beginning in the development of sophisticated thin-film circuits. The ability to make large numbers, or arrays, of active devices simply and cheaply is a matter of masking techniques. The arrangement in Fig. 2B, under study at Melpar, contains 81 isolated units on a one-inch substrate; interconnections and passive components may be added for computer and other applications. Further size reductions are possible.

The work is supported by the Bureau of Naval Weapons as part of a general program for development of temperature and radiation resistant circuits.

REFERENCES

(1) C. Feldman, Conference on Navy Lab. Microelectronics Program, Applied Physics Laboratory, The John Hopkins University, June 12-13, 1961, sponsored by Office of Naval Research (OTS No. PB-181314) p 53.
(2) P. K. Weimer, *Proc IRE* 50, p 1462 (1962).
(3) J. Lilienfield, U.S. Pat. 1,745,175 Jan 28, 1930 and U.S. Pat. 1,900,018 Mar 7, 1933.
(4) O. Heil, U.K. Pat. 439,457 Mar 4, 1935.
(5) W. Shockley and G. L. Pearson, *Phys Rev* 74, p 232 (1948).

Cold-Cathode X-Ray Tube For High-Speed Movies

MCMINNVILLE, ORE.—A short step away from stereo x-ray motion pictures, a cine-radiographic system recently developed by Field Emission Corp. takes 16 sequential photos with exposure times as low as 30 nanoseconds and at frame rates up to one million per second. X-ray source is moved electronically to permit stationary photographic film. Present machine mounts tubes in twin banks at angle determined by degree of stereo effect desired, and presents data on film.

Heart of the system is a new cold-cathode x-ray tube which features small size and an impedance of only 70 ohms. Remotely located tubes may be joined to associated electronics by coaxial cable. Applications include studies of ballistic fragmentation, terminal ballistics, hyper-velocity impact, and monitoring and analysis of explosive forming operations. Tubes may be effectively used in radiation effect studies because of their high dose rates of up to 10^8 rads per sec.

Apollo System Checkout For Space Environment

HOUSTON—Garrett-AiResearch Los Angeles has started system development testing of Apollo spacecraft's environmental control system, reports NASA's Manned Spacecraft Center.

Test profile will include simulating prelaunch, ascent, orbital and reentry pressure conditions on an operating system.

Tests will be conducted in new laboratory built specially for the Apollo program. Laboratory is composed of programmed altitude chamber with auxiliary test support instrumentation. Its data acquisition system is described as the most comprehensive ever devised for ECS development.

Over 200 data points of temperature and pressure will be automatically recorded, magnetic tape will then be analyzed by an IBM

Quite a package!

Fluke-manufactured, precision wirewound resistors, aged and matched both for resistance and temperature coefficient, guarantee the long term DC accuracy of the voltmeter to be better than 0.01%. Resistors used in critical portions of the Kelvin-Varley divider have temperature coefficients of less than one part per million per degree Centigrade.

Accuracy of 0.01% DC, 0.1% AC

a uniquely useful measuring instrument

The new Fluke Model 823A differential voltmeter provides the highest accuracy obtainable in a portable instrument. In addition, it provides infinite DC input resistance at null (0-500V), divider terminal linearity of 2-20 ppm, DC polarity switch, recorder output, and no zero controls.

Model 823A is designed to perform under severe environmental conditions. It is guaranteed to withstand the shock and vibration requirements of Mil-T-945A. It is guaranteed to perform within specifications from 0-80% humidity and from 55° to 95°F. It's quite a package.

Ask your Fluke representative for a demonstration, or request complete data from John Fluke Mfg. Company, Inc., P.O. Box 7428, Seattle 33, Wash. Tel. PR 6-1171; TWX 206-879-1864, TLX 852.

FLUKE

Brief Specifications:

MODEL 823A

DC ACCURACY
± 0.01% from 0.5V to 500V
± (0.01% + 10 uv) below 0.5V

AC ACCURACY
± 0.1% from 30 cps to 5 KC
± 0.15% from 20 cps to 10 KC
overall frequency range 5 cps - 100 KC

CALIBRATION
500V internal reference supply calibrated to better than 20 ppm against built-in standard cell

INPUT POWER
115/230V AC ± 10%, 50-400 cps, 80 watts

	CABINET	RACK
SIZE:	13" high x 9¼" wide x 16" deep	7" high x 19" wide x 15½" deep
WT.:	28 pounds	26 pounds
PRICE:	**$1300.00**	**$1320.00**

MODEL 803D

New Model 803D, available in either rack or cabinet configuration, offers many of the features of Model 823A. Accuracy—AC, 0.1%; DC, 0.02%. Price—cabinet, **$1100.00**; rack, **$1120.00**.

CIRCLE 83 ON READER SERVICE CARD

7070 computer. This rapid analysis will permit engineers to correct problem areas on a continuing basis, since a complete test run will be analyzed in less than a day.

Visual monitoring and recording of fluid temperatures, pressures and flows will take place during each run.

Prelaunch condition for the ECS is evaluated by integrating the actual test equipment checkout console into the test loop. A metabolic simulator will inject carbon dioxide, heat and water vapor in measured amounts to simulate one, two or three men in the spacecraft.

Soviet Scientists Probe Ice Thickness

TWO Moscow physicists, V. V. Bogorodskiy and V. N. Rudakov, describe an electromagnetic method for measuring the thickness of floating ice, especially thin ice (up to 3 m thick), from an aircraft. First, the dielectric permeability and the tangent of the angle of electric losses of ice close to sea water were determined. After studying the plane monochromatic and inverse waves, the authors established that the reflection coefficient r of ice is a periodic function of the ratio of ice thickness to wavelength.

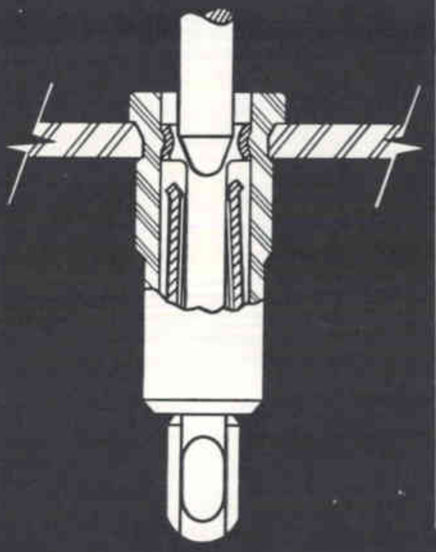
It was found that the absolute error in determination of ice thickness varies inversely with the value of the period, and the relative error

Titan Crew Trainer

SIMULATOR *installed by ACF Electronics at Vandenberg AFB, Calif., is used to train Titan II launch control center crews*

Another Original Sealectro *"PRESS-FIT" TEFLON TERMINAL*

"PRESS-FIT"® GUIDED-ENTRY TEST POINT JACK*



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- GREATER CHASSIS PULL OUT STRENGTH
- HIGHER TORQUE RESISTANCE
- UNIFORM CONTACT RETENTION

"Years ahead" engineering are embodied in this new Sealectro "Press-Fit" SKT-0804 test point jack...and each new feature has been designed to overcome the shortcomings of more conventional construction test jacks. The "formed" beryllium-copper contact provides greater support of the Teflon bushing and at the same time increases substantially the pull-out and torque resistance of the jack from the chassis. Providing guided-entry for an .080" diameter probe, the SKT-0804 maintains uniform retention throughout the contact area. Using a standard S-38 insertion tool, installation into a prepared chassis hole is achieved with simple "Press-Fit" technique. Write today for details and samples to.....

*Patent Pending

"Press-Fit" Teflon Terminals • "Conhex" Subminiature RF Connectors • "Sealectoboard" Program Boards • "Deltime" Magnetostrictive Delay Lines • "Actan" Programming Switches

Sealectro CORPORATION
139 HOYT STREET, MAMARONECK, NEW YORK

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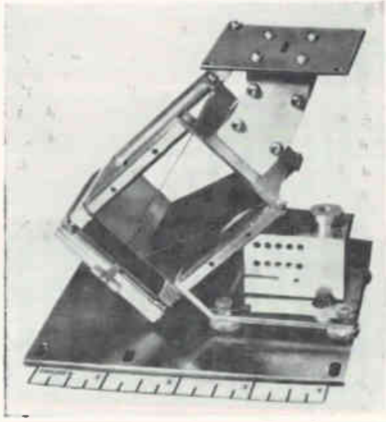
varies inversely with the number of periods. Reflection coefficient *r* was also found to be a function of flight altitude, though this does not hinder the use of the fixed-frequency method of determination. A distorting influence of the snow cover was also discovered.

Ion Beam Generator Gun Has Monoenergetic Beam



MONOENERGETIC ion gun, developed by CBS laboratories, uses surface ionization to emit steady metal-ion beams up to 10 microamperes. Material is inserted in oven well (lower right) and heated, then ionized by hot tungsten ribbon, accelerated through slot in an electrostatic lens, deflected through an electrostatic radical analyzer to separate ions from remaining neutral atoms. Monoenergetic ion beam emerges from slot, top right, can be used for ion bombardment.

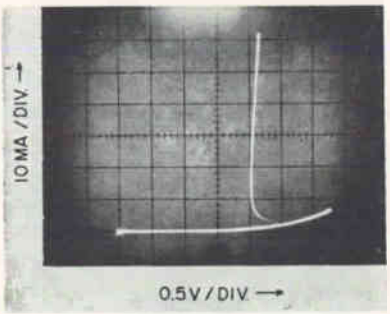
Ion materials are light metals including lithium, sodium, potassium, rubidium and cesium. Ionization efficiencies approach 100 percent for some materials.

Encoder Provides 3-D Display of Heart Beats

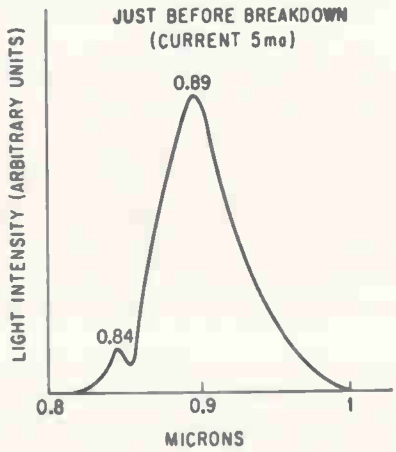
THREE-DIMENSIONAL display of the electrical vectors associated with heart activity is simulated on a two-dimensional crt screen by a vectorcardiograph encoder developed by ITT Federal Laboratories for Lankenau Hospital, Philadelphia. Voltages in the three body axes are represented by loops formed in the crt trace. The third dimension is placed in perspective by size and bright-

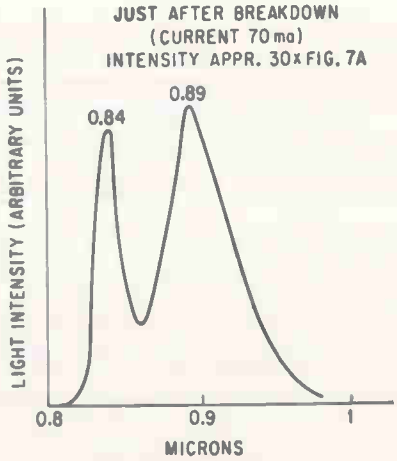
ness coding. ITT says the display is much easier to interpret than two-dimensional projections on conventional vectorcardiographs (ELECTRONICS, p 49, Jan. 20, 1961).

EL Diode Characteristics



TYPICAL current-voltage curve for new electroluminescent gallium arsenide diode (ELECTRONICS, p 7, March 15) is shown in photo, above. Curves, below, of the spectral distribution of light before and after breakdown illustrate the large change in intensity of the 0.84-micron zinc line. Work was described by K. Weiser, R. S. Levitt and W. P. Dumke, of IBM Watson Research Center, at the American Physical Society meeting in St. Louis March 25-28

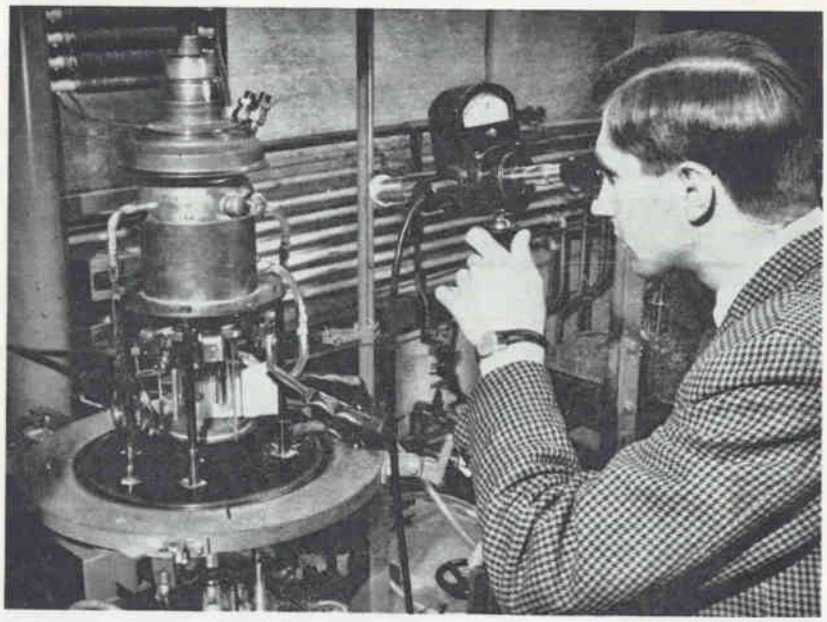




New Thyratron Peaks at 200 Mw

Can handle power for interplanetary radar bounce, and nucleonics

By L. E. ALGAR
J. E. MARSHALL
General Electric, Hirst Research Center, Wembley, England
C. R. RUSSELL
M-O Valve Co.,
Brook Green Works, London

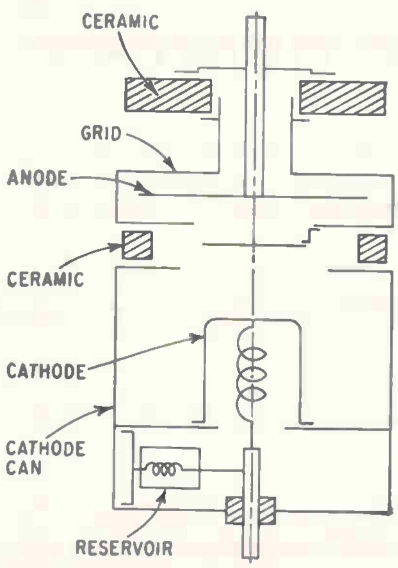


CATHODE *temperature of deuterium thyratron is measured during exhaust stage. Pulse modulator was developed by General Electric Ltd., England on behalf of M-O Valve Company*

TWO HUNDRED megawatts peak and one hundred and fifty kilowatts mean power levels are now commercially available in a deuterium-filled thyratron. Deuterium is a hydrogen isotope having mass number 2. It is one form of heavy hydrogen.

Pulsed from a single trigger circuit, the tetrode requires a pulse of only 10 amps at 1 Kv to switch 10,000 amps at 40 Kv.

Ability to switch such large powers becomes increasingly important for outer space tracking, signal bounces off planets, and resolution of closely-spaced targets. In physics, the charting of new particles require higher energies from new accelerators.



POWER *requirements of thyratron led to metal envelope tube. Reservoir system replenishes gas for long tube life—Fig. 1*

At the present time, large thyratrons are being used in connection with nuclear physics experiments. One such machine is the 50 Mev proton linear accelerator in operation at the Rutherford High Energy Laboratory in Harwell, England.

Maximum parameters at which the thyatron is operated at Harwell are: 30 Kv hold-off voltage, 330 amp peak current, 400 microsecond pulse length, 50 pulses per second and 6.6 amps mean current.

Proton linear accelerator is used 24 hours per day for 10 days of every 14. Reliability of the tube is especially important where the energy level of the accelerator must be well defined.

HEAVY HYDROGEN — In this tube, E2986, the hydrogen is replaced by deuterium.[1] All the advantages of hydrogen are retained. In addition, the tube has less energy loss as a consequence of the reduced mobility of the ions. Further, the ability to use higher anode voltages at a given gas pressure arises from the greater dielectric strength of deuterium.[2]

Consideration of the fundamental requirements in high power thyratrons led to the metal envelope concept, see Fig. 1.

Important differences between ceramic and metal lies in the temperature of the electrodes and of the deuterium gas. The metal envelope configuration makes it possible to take water cooling into the heart of the tube, near the actual grid slots, for maximum effect. Insulator between grid and anode is cooler, enhancing dielectric strength and giving freedom from stray emission effects. Also, the insulator is less likely to become covered with sputtered material.

A hold-off voltage level of 40 Kv was chosen as a compromise. Too low a voltage leads to high cur-

I NEED **50 KW** CW POWER AT **X-BAND** BUT I ALSO NEED **TUBE STABILITY!**

ANY IDEAS ??

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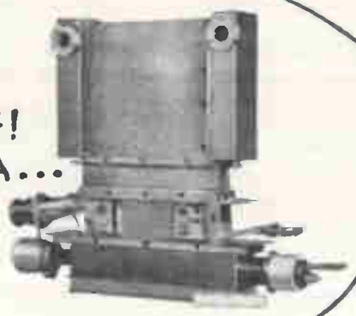


A **WHAT?**

AN **MBK!** IT'S GENERAL ELECTRIC'S **MULTIPLE BEAM KLYSTRON,**

TYPE ZM-6601. THIS NEW TUBE'S conservatively designed individual beams, multiplied in a phase-locked multiple-beam structure, provide high RF power output at low thermal densities. And G.E. is now offering 60 day delivery!

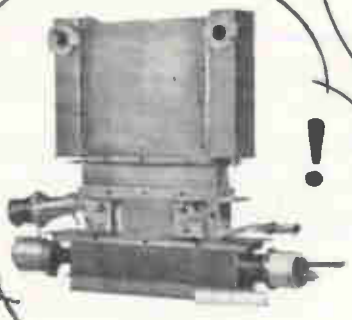
Electrical and thermal stability of the ZM-6601 is typical of tubes operating at one-tenth the power level. The MBK requires only 12.8 KV beam voltage, eliminating extra size and weight encountered in paralleling conventional "high power" klystron tubes. It's unique among factory-built klystrons.

Here are some of its vital statistics . . .

Frequency	8.3–8.5 Gc
Tuning Range	80 mc
Power Output	50 KW CW
Typical Voltage	12.8 KV
Nominal Gain	45 db
Efficiency	35%

Tubes sold in pairs are priced substantially below $1000 per kilowatt. And design is flexible, so ask about other frequency and power capability or pulse service design. Call any G-E Power Tube district sales office for full information.

GET THE PICTURE?



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For audio, video amplifier and field output stages there is no better tube than the Mullard EL86. This 12 Watt output pentode gives advantages of high slope, low impedance and high efficiency. A single EL86 will give an audio output of 5.3 Watts.

CHARACTERISTICS
EL86

g_m	11	mA/V
r_a	26	kΩ
P_a	12	W
E_a	170	V
E_{g1}	−12.5	V
I_a	70	mA

Full details on the Mullard range of tubes for television, stereo and high-fidelity available from:
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81 SPRING STREET, NEW YORK 12, N.Y.
Worth 6-0790

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STABILITY

1-12.4 GC

Introducing a compact electronic instrument to control microwave oscillator frequency

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microwave spectroscopy

You name the application. The Dymec DY-2650A Oscillator Synchronizer will make it easier! Absolute control of frequency is yours when the DY-2650A phase locks your klystron oscillator to a crystal reference, to achieve short-term stability of 1 part in 10^8 per second, 1 part in 10^6 per week. Temperature stability is 1 part in 10^6, 0-50° C. The DY-2650A requires only a small sample of klystron power—less than −10 dbm.

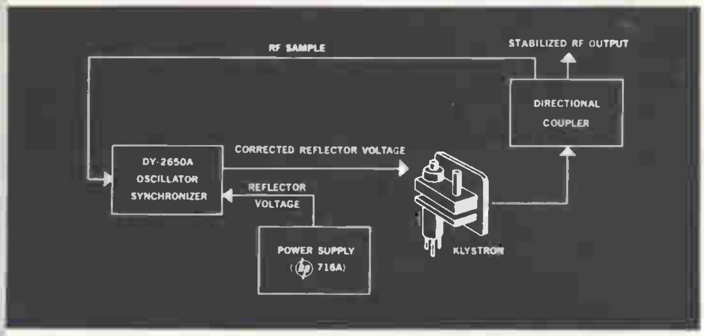
The DY-2650A will synchronize most reflex klystrons, 1 to 12.4 GC, with complete elimination of klystron drift and minimization of all incidental fm caused by klystron noise, power supply ripple and mechanical shock. You can use it for oscillator stabilization, frequency modulation and control, frequency stability monitoring and fm monitoring.

Frequency modulation and control: Use the DY-2650A to apply fm to a klystron oscillator with deviations up to 500 KC at rates to 50 KC.

Manual frequency control: Over 2 MC range of klystron frequency.

Frequency monitoring: Use an electronic counter or frequency meter to monitor the microwave signal for frequency stability.

FM monitoring: Demodulate fm on the test signal, providing an output for monitoring with a VTVM, oscilloscope or other monitoring devices.



The DY-2650A is essentially a crystal-controlled superheterodyne receiver terminating in a phase comparator. An oscillator sample is mixed with harmonics of the rf reference to produce an intermediate frequency of 30 MC, which is compared in phase with the 30 MC reference. For stabilizing a klystron, the resultant phase error voltage is added in series with the klystron reflector power supply voltage.

SPECIFICATIONS

Frequency range: 1 to 12.4 GC
Stability: $1/10^8$ per second, $1/10^6$ per week (over ± 5°C), $1/10^6$ over range 0 to 50°C.
Output circuitry: Suitable for connection to klystron reflector; floating and insulated up to 2000 v dc. A phase lag network provides optimum characteristics for matching klystron sensitivities from 0.05 to 4 MC/volt nominal.
Input power: Less than −10 dbm.
Price: $1,450.00, f.o.b. factory.
Data subject to change without notice.

Describe your requirement today to your Dymec/Hewlett-Packard representative, write Dymec for further information or call Dymec direct. Extension 223 or 224.

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Compact 25 MC Solid State Counter

Features Time Interval Measurement

Northeastern's Model 40-81 meets the demand for a low 5¼" panel height, 8 digit in-line presentation, fully solid state 25MC counter which features Time Interval Measurement in the basic unit as well as frequency, period and ratio. Remote operation and programmability are included features.

Specifications:

Frequency Measurement Range... 0 to 25 MCs

Standard Gates Times........... 1μ sec to 10 sec in decade steps

Period Measurement Range...... (single) 0 to 1MC (multiple) 0 to 300 KC

Time Interval Range............ 1μ sec to 10^9 sec (digit capacity)

Stability..... ±7 parts in 10^9/day (averaged over 7 days)

Temperature.... −20°C to +65°C

Power......................... 115 VAC ±10%, 50-60 Cps.

Dimensions..................... Basic Unit 12" W x 15½ D x 5¼ H
w/rack mount 14" W x 15½ D x 5¼ H
w/plug in 17" W x 15½ D x 5¼ H
w/plug in & rack mount 19" W x 15½ D x 5¼ H

Weight................28 pounds

w/plug-in hardware....33 pounds

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DEPARTMENT 5A, MANCHESTER, NEW HAMPSHIRE

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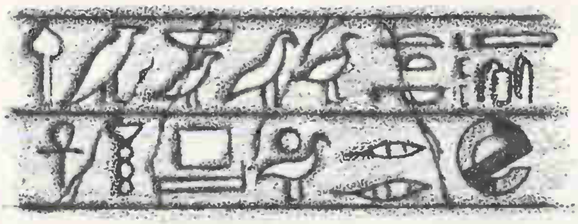

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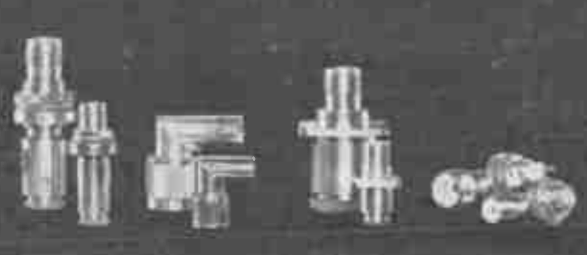
the finest precision coaxial connectors*



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⅞" DIAMETER, +2 MILLION REVOLUTIONS
Like the new, miniaturized (⅞" diameter) 2150 Micropot. Here is a tiny, 10-turn precision potentiometer that delivers over 2 million revolutions with high accuracy and good resolution. Independent linearity holds to ±0.25%.

In fact, the only modest thing about this Micropot is its price (under $10—and much less in production quantities).

GANG IT, HEAT IT TO 105°C
Looking for component versatility? The 2150 ignores heat up to 105°C. You can gang it (2 units). Tap it. Even add rear-shaft extensions, if you want to. Torque and noise are extremely low.

Compare specs and prices. We believe you won't match our 2150 Micropot anywhere for either commercial or military applications.

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Take advantage of the Borg *Quick Reaction Facility*. Get fast delivery of prototypes built exactly to your specifications.

Call your nearby Borg representative or distributor. Or a letter to R. K. Johnson will put the 2150 story on your desk in short order.

2150-2160 SERIES TEN-TURN MICROPOT®

Mechanical rotation	3600° +10° −0°
Electrical rotation	3600° +10° −0°
Resistance range, ohms	100 to 100 K
Resistance tolerance	±3%
Standard linearity	±0.25%
Power rating	3 watts at 40°C
Noise	100Ω equiv. noise resist. max.
Temperature range	−55°C to +105°C
Resolution	from .054% at 100Ω to .0088% at 100K
Torque	Start 0.5 oz/in; Run 0.4 oz/in
Shaft dia.	¼" (2150) and ⅛" (2160)
Weight	1 oz
Life	2,000,000 revolutions

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Can handle power for interplanetary radar bounce, and nucleonics

By L. E. ALGAR
J. E. MARSHALL
General Electric, Hirst Research Center, Wembley, England
C. R. RUSSELL
M-O Valve Co.,
Brook Green Works, London

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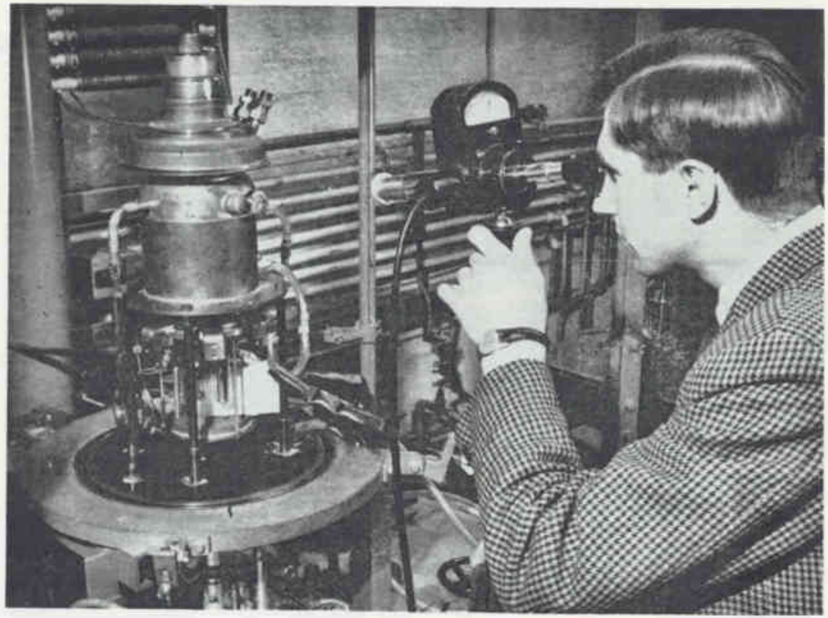

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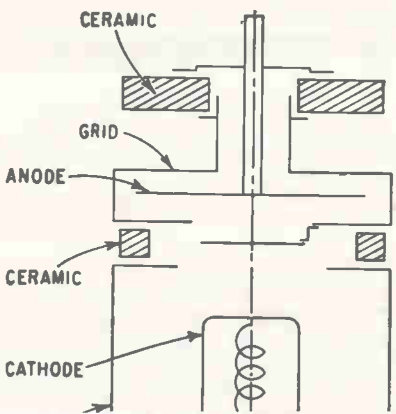

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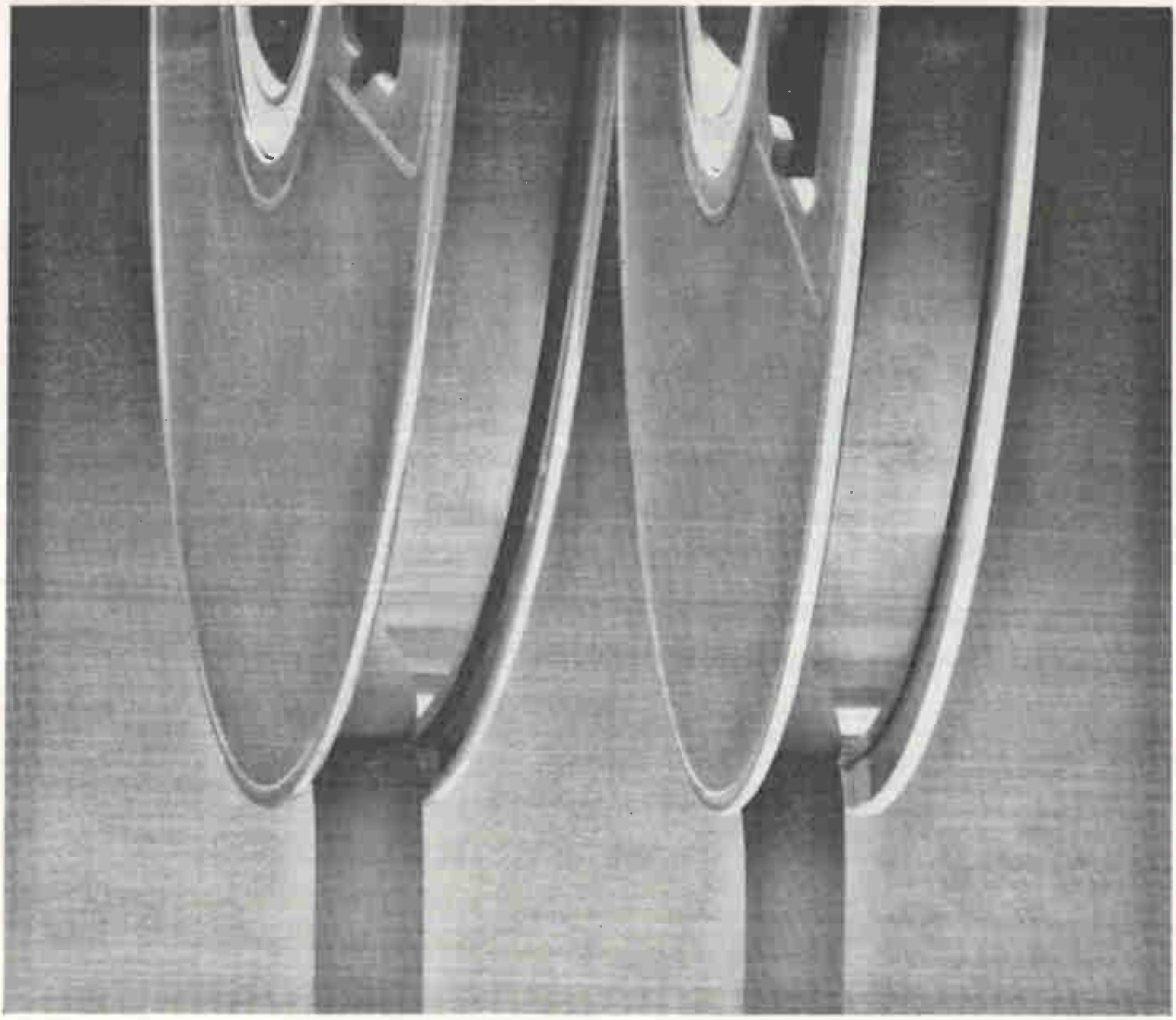
Proton linear accelerator is used

vantages of hydrogen are retained. In addition, the tube has less energy loss as a consequence of the reduced mobility of the ions. Further, the ability to use higher anode voltages at a given gas pressure arises from the greater dielectric strength of deuterium.[3]

Consideration of the fundamental requirements in high power thyratrons led to the metal envelope concept, see Fig. 1.

Important differences between ceramic and metal lies in the temperature of the electrodes and of the deuterium gas. The metal envelope configuration makes it possible to take water cooling into the heart of the tube, near the actual grid slots, for maximum effect. In-



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*Du Pont's registered trademark for its polyester film.

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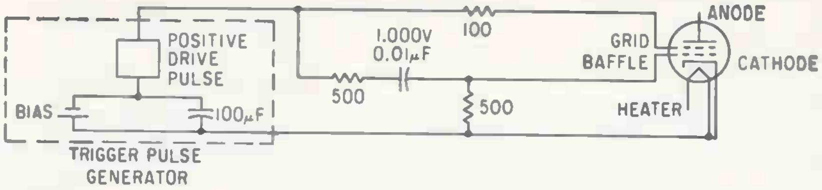

CAPACITOR-*resistor network connects generator to grid and baffle—Fig. 2*

rents and to low delay line impedance. This could lead to trouble from stray inductance. Too high a hold-off voltage leads to too low a gas pressure and failure to support adequate discharge.

Advantage of deuterium stems from gas pressure in the tube.[3] Higher pressure enables the gas to support a higher power discharge. Gas pressure required to support the peak current rating of the tube can be obtained by the use of deuterium. With hydrogen at the same pressure, the operating voltage would be limited to about 25 Kv.

INSULATOR—Voltage breakdown hazard is prevented by inserting an insulator between anode and grid surface. A combination of two concentric cylinders of insulating material, glass, with a gas-filled gap between them was used. The glass cylinders extend to become integral with the envelope.[4]

High mean power of 150 Kw is achieved by preventing grid emission and maintaining a high gas density by cooling. Cooling is taken right to the edge of the grid slots without increasing the impedance of the grid to the discharge.[5]

Efficient grid cooling has led to the tube rating of 40,000 Mw cycles for the product of ½ × peak anode voltage × peak anode current × pulse repetition frequency, that is, a Pb factor of 80 × 10^9. A metal baffle, interposed between grid and cathode, prevents emission from the cathode.

The cathode is maintained at a temperature of 1,050 C by a heater system.[6] Six tungsten coils are arranged in parallel. The total area of primary emitting surface is about 250 sq cm. Heat shield is molybdenum cylinder provided with radial fins. Area acting in an emissive capacity is 750 sq cm. By these two processes, an emitting area of 1,000 sq cm needed for peak currents of 10,000 amps is obtained. Pulse lengths are 5 μs or less. Much longer pulse lengths can be obtained with appropriate reduction in peak current.

The two triggering electrodes, baffle and grid, supplies trigger pulse of minimum amplitude of 1 Kv and leading edge rising at the rate of 2 to 4 Kv per microsecond, see Fig. 2. This ensures that the grid-cathode arc is struck during the rising part of the grid pulse. Variations in the timing of successive pulses are kept to a minimum.

LONG LIFE—A reservoir replenishes lost gas for long tube life.[7] Metallic hydrides of titanium, zirconium or hafnium evolve deuterium gas.

Trigger pulse of 2 to 3 microseconds long is superimposed on a negative d-c bias of 60 to 80 volts. The generator has a maximum pulse source impedance of 100 ohms. A 100 microfarad capacitor, connected across the bias supply, keeps the pulse source impedance within specified value.

The generator is connected to the grid and baffle with a capacitor-resistor network.[8] Grid bias en-

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(1) U. S. Patent No. 2953705, The M-O Valve Co, Ltd. and K. G. Cook.

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(3) Patent No. 798,627, M-O Valve Co Ltd and G. G. Isaacs.

(4) Patent No. 855,998, The M-O Valve Co Ltd and L. E. Algar, K. G. Cook.

(5) Patent Application No. 34220/60, The M-O Valve Co Ltd and L. E. Algar, E. A. Taylor.

(6) Patent Application No. 16527/62, The M-O Valve Co and B. O. Baker, R. J. Wheldon.

(7) Patent No. 729,962, The M-O Valve Co Ltd and A. J. Booth, K. G. Cook.

(8) Patent No. 747,484, The M-O Valve Co Ltd and K. G. Cook.

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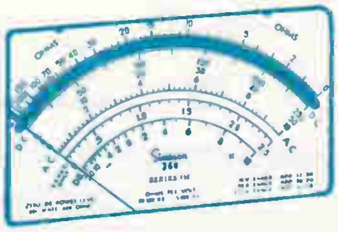

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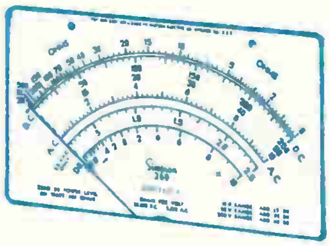

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In the accelerator, used at Harwell pulsed r-f power at a freqency of 202.5 Mc. Peak power of the order of 1 Mw is fed into each of three high Q resonators which are responsible for acceleration successively to 10, 30 and 50 Mev.

Variable Transformers Feature Wider Ratings

MAJOR redesign of a variable transformers was announced last week by General Electric. New line consists of 19 basic single core ratings. There are 11 single phase units rated 120 volts, 2 to 65 amperes, and 8 units rated 240 volts, 3 to 40 amperes.

Automatic Volt-Pac units are designed to provide automatic control of line voltage where incoming line fluctuation cannot be tolerated; or automatic control of variable outputs.

Design features include an exclusive heat sink ring, new current collector, new solid-carbon brush and motor drive. New solid state scr control is utilized to minimize moving parts and provide maintenance-free operation.

Functional Block Trends Pushed by Air Force

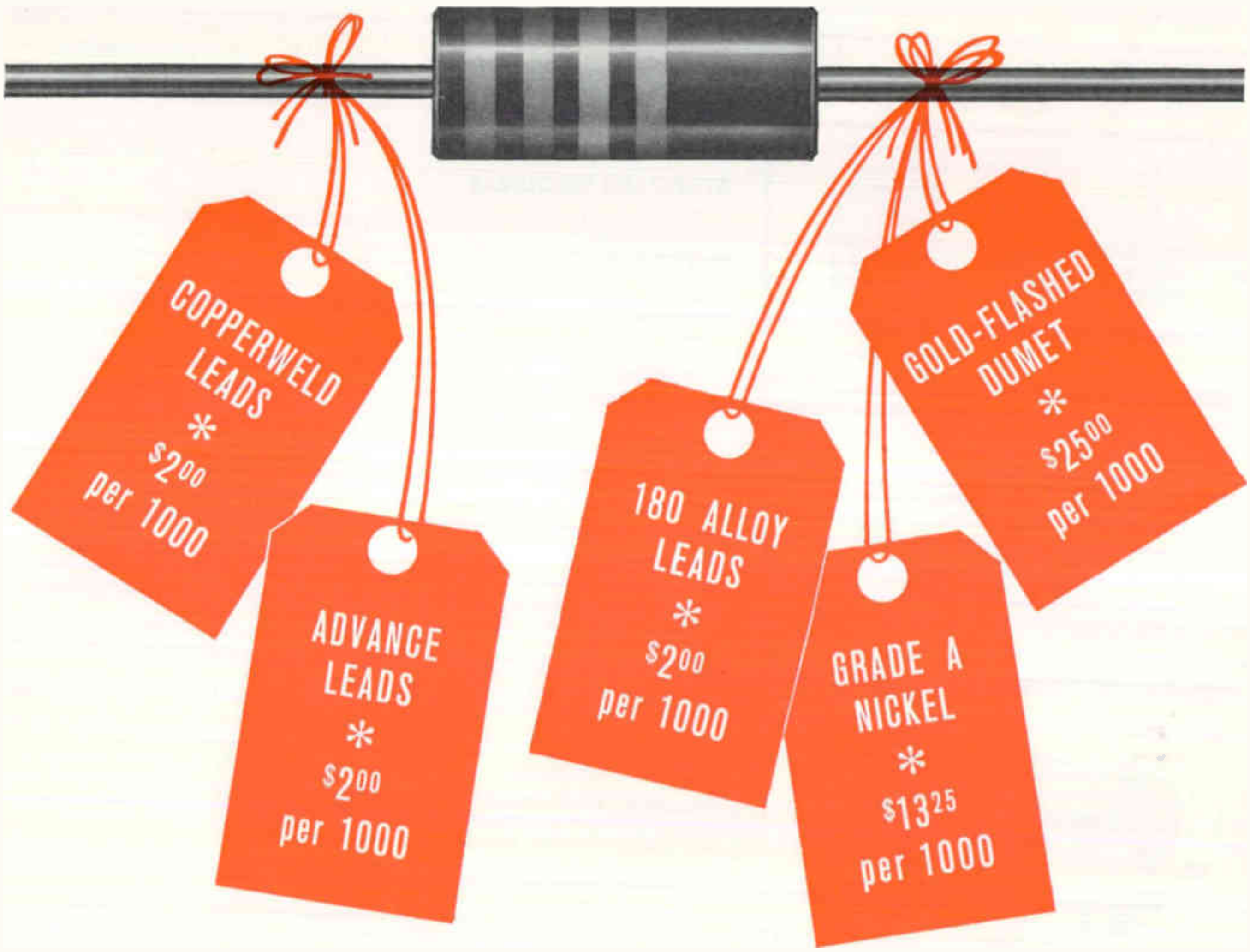
THE MAJORITY of functional electronic blocks, commercially available, are for digital applications. However, there appears to be considerable effort underway to develop solid-state blocks for analog applications, according to United Aircraft.

Presently FEB's are packaged in either hermetic cans, such as the TO-5 and TO-18, or in flat open containers, such as the Texas Instruments package.

Trend strongly encouraged by the Air Force, according to United Aircraft, is latter type packaged with standardized dimensions and geometries.

Prototype modular interconnection packaging system has been built at United Aircraft for a government contract. This is a grooved monolithic ceramic wafer within which functional blocks are to be attached to optimize dissipa-

In FIXED COMPOSITION RESISTORS if it's news, expect it first from IRC



Only IRC Fixed Composition Resistors offer

5 WAYS TO SAVE ON WELDING

HERE'S WHY . . . IRC realizes that no single lead material satisfies all the welding techniques in use today. There is also a wide price differential among different materials. IRC offers 5 types of weldable leads . . . lets you choose the material and price that meets your particular need.

Compare the add-on prices of weldable leads. You will find IRC's to be significantly lower.

IRC's standard leads are alloy-plated copper. Many users weld these leads successfully and save the cost of premium materials.

Write for complete weldable lead pricing and derating information. International Resistance Co., Philadelphia 8, Pa.

**Typical add-on prices are for RC20 size.*

PERFORMANCE ADVANTAGES

IRC Type GBT's also provide

- Superior high frequency characteristics
- Lower operating temperature
- Outstanding load life
- Greater moisture protection
- Ranges to 100,000 megohms
- Stronger terminations
- Better resistance-temperature characteristics

IRC

tion of thermal energy.

Communication between blocks and outside will be provided by a horizontal and vertical interconnection matrix. Hermetic system is directed toward use of uncased functional blocks. However provisions are made for presently available hermetic packaged solid blocks.

Light Dependent Resistor Dissipates 25 Watts

POWER PHOTOCELL with current handling capacity of ½ ampere and power dissipation of 25 watts has been developed by Delco.

Company's LDR-25 is constructed of a thin layer of sintered cadmium sulphide applied to an aluminum oxide substrate. Unit is sealed by film adhesives and a glass cap.

Unit permits variable speed control for fractional horse power motors. The power photocell is intended primarily for medium or high-power switching and control applications where turn-on and turn-off times in the order of tens of milliseconds can be tolerated. Device can operate from 110-v a-c and is conservatively rated at 200 v d-c or peak a-c.

Rating and slow switching speed make photocell particularly suited for control of inductive loads where voltage surges encountered with breaker points or junction devices can be a problem.

When used with standard minia-

Bright Cathode Ray

TUBE *features electrostatic focusing and an aluminized screen. Initial use will be for high-speed military aircraft. Face of tube is 3 inches in diameter. Sylvania tube uses special blend of phosphor in screen*

in the load circuit, with control input of one watt or less. Using miniature neon lamps, it is possible to switch up to 40 watts with less than 500 mw input.

At IEEE show, Mar 25-29, Delco showed how photocell unit can be used in household food mixer. Continuously variable speed control of motor dissipated more than 15 watts in control of 100 w motor.

Electroluminescent Powders in Colors

AVAILABILITY of electroluminescent powders of the zinc sulphide series, in ten colors, has been announced by Cole Commercial Company, Seattle, Washington.

Company compounds powders to specifications, assures average particle size of 10 microns. Minimum half life for most colors is 7,000 hours.

Integrated Wafers

PRACTICAL methods will be devised at Melpar for integrated planar and electrical connections between thin-film circuits, discrete parts, and solid circuits on microwafers. Discrete parts of interest are the dot or chip forms which are suitable for recessing flush with the surface of the wafer.

Vacuum and other deposition techniques will be developed for simultaneously forming interconnection to the hybrid wafers.

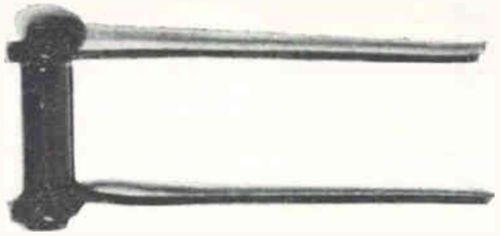
Thin-Film Inductors With Bulk Ferrite

FLAT SPIRAL coils, used in combination with two or more bulk ferrite wafers, have obtained maximum inductance values of 153 μh with a Q value of 20 as measured at 1 Mc.

Final Motorola report on miniature inductors (ELECTRONICS, May 11, 1962, p 72) to Navy indicates limitations of obtaining larger values for both inductance and Q. Substantial increase in inductance would result if ferrite with larger initial permeability could be found. Company recommends further in-

ELECTRONIC PRODUCTS NEWS BY CARBORUNDUM

NEWS



Varistor helps cut picture interference on latest Zenith TV—automatically

A development of the patented "Fringe Lock" circuit incorporated in Zenith TV receivers now automatically cuts annoying picture disturbances, whether made by nearby electrical machines or external influences such as passing automobiles.

Function of the circuit is to cut off the twin pentode 6HS8 (see below) when external noise is introduced. Plates of the pentode are connected respectively to the AGC and Sync circuits. Two of the grids are fed by composite video signals. Automatic bias setting, varying with signal level fluctuations and always safely above the Sync tips, is provided by the voltage-sensitive resistance characteristics of the type BNR-331 Carborundum varistor.

The varistor replaces a potentiometer that required adjustment for maximum noise protection, particularly in fringe areas. The varistor not only provides automatic control and positive, instantaneous cut out, but also costs one-third less than the potentiometer previously used.

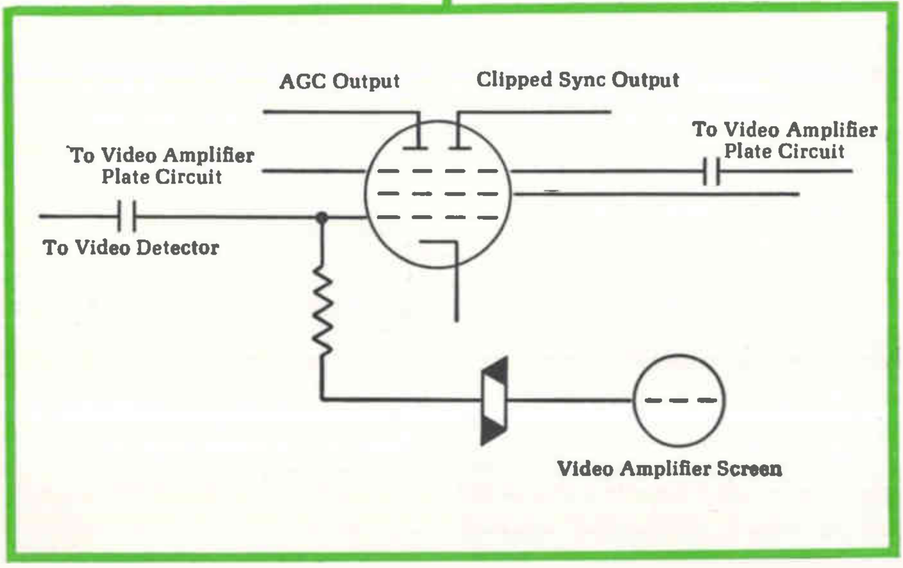
New Technical data on varistors points way to wider applications and production savings

Carborundum offers a new bulletin and technical literature to aid in the selection and application of silicon carbide non-linear, voltage-sensitive resistors.

A variety of body types and sizes is available, with electrical characteristics suitable for applications requiring microamperes at one volt up to kiloamperes at kilovolts. Typical applications are lightning arrestors; contact arc suppression for relay coils and solenoids; protection for silicon rectifiers, capacitors and other electronic components against high peak inverse voltage; and voltage regulation and control.

The bulletin lists standard stock varistors with pertinent design information. Individual technical sheets provide E/I characteristic curves and specifications on over 100 stock varistors.

For your copies, write Dept. EL-4, Electronics Division, Carborundum Company, Niagara Falls, New York. Inquiries regarding application to specific problems are invited.



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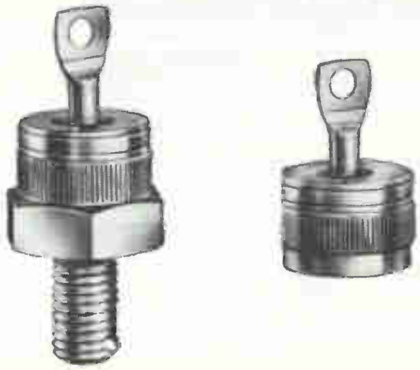

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Stud Mounted	A40F (50V) $0.79 A40B (200V) $1.19	Press Fit	A44F (50V) $0.49 A44B (200V) $0.80

RATINGS AND CHARACTERISTICS (Single Phase Resistive Load)

Stud Mounted A40	Fw'd. Pol.	A40F	A40A	A40B	A40C	A40D	A40E	A40M	
	Rev. Pol.	A41F	A41A	A41B	A41C	A41D	A41E	A41M	
Press Fit A44	Fw'd. Pol.	A44F	A44A	A44B	A44C	A44D	A44E	A44M	
	Rev. Pol.	A45F	A45A	A45B	A45C	A45D	A45E	A45M	
Max. Peak Reverse Voltage		50	100	200	300	400	500	600	volts
Max. Avg. D-C Forward Current at 110°C Stud		← 20 amps →							
at 150°C Stud		← 15 amps →							
Peak One-Cycle Forward Surge Current (60 cps, 25° C T_j)		← 300 amps →							
Operating Junction Temperature Range		← −65°C to +175°C →							
Storage Temperature Range		← −65°C to +175°C →							

NOTE: 1N3208-1N3214 or 1N3208R-1N3214R are available when desired and are identical to A40F-A40M or A41F-A41M respectively, except that hex size will be 1¹⁄₁₆" across the flats on the 1N3208 series.

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INEXPENSIVE *spot tests are rapid, usually nondestructive and sensitive in pointing-out needed manufacturing technique changes. In one instance, a 50-cent spot test correctly identified a contaminant material within 1 minute while a confirmatory 28-dollar test taking 1 week made an incorrect identification*

Spot-Testing Aids Manufacture of High-Reliability Relays

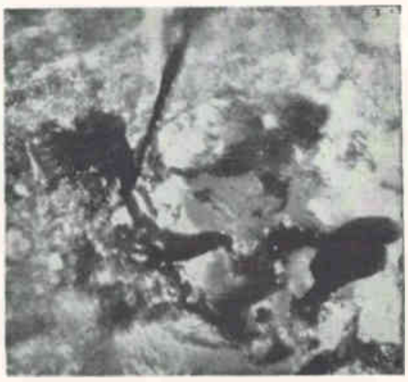
By EARL F. LISH, Filtors, Inc., East Northport, N. Y.

Quick detection of contact contaminants permits timely process adjustments

WHITE - ROOM relay assembly procedures have not eliminated relay contact contamination problems. Despite out-gassing processes, hermetic sealing and precious-metal contacts, failures continue to occur. Obscure and sometimes invisible contaminants of manufacturing origin impede contact conduction. Only through immediate and exacting identification of contaminants can timely adjustments be made in manufacturing processes. Spot tests have been developed that can be performed quickly and easily as against elaborate, time-consuming procedures.

A case-in-point: A white-room relay, supposedly free of particulate contamination, failed. Under 200X magnification it was found that a fiber between contacts was the cause. It appeared to be metallic. But measurement of its melting point, first without, and then with a crystal of p-nitrophenol identified the material as Nylon 6-6 (Zytel 101). This was probably a bit of a flash that fell off Nylon coil bobbin after sealing, indicating that improvement in molding technique was required.

Another white-room relay had high contact resistance after a one-ampere load-life test. Examination under polarized light showed numerous non-metallic inclusions in and around the gold-plated contact area appearing as pin-points of light. These inclusions were traced to a tumblepolish of contacts by vendor.

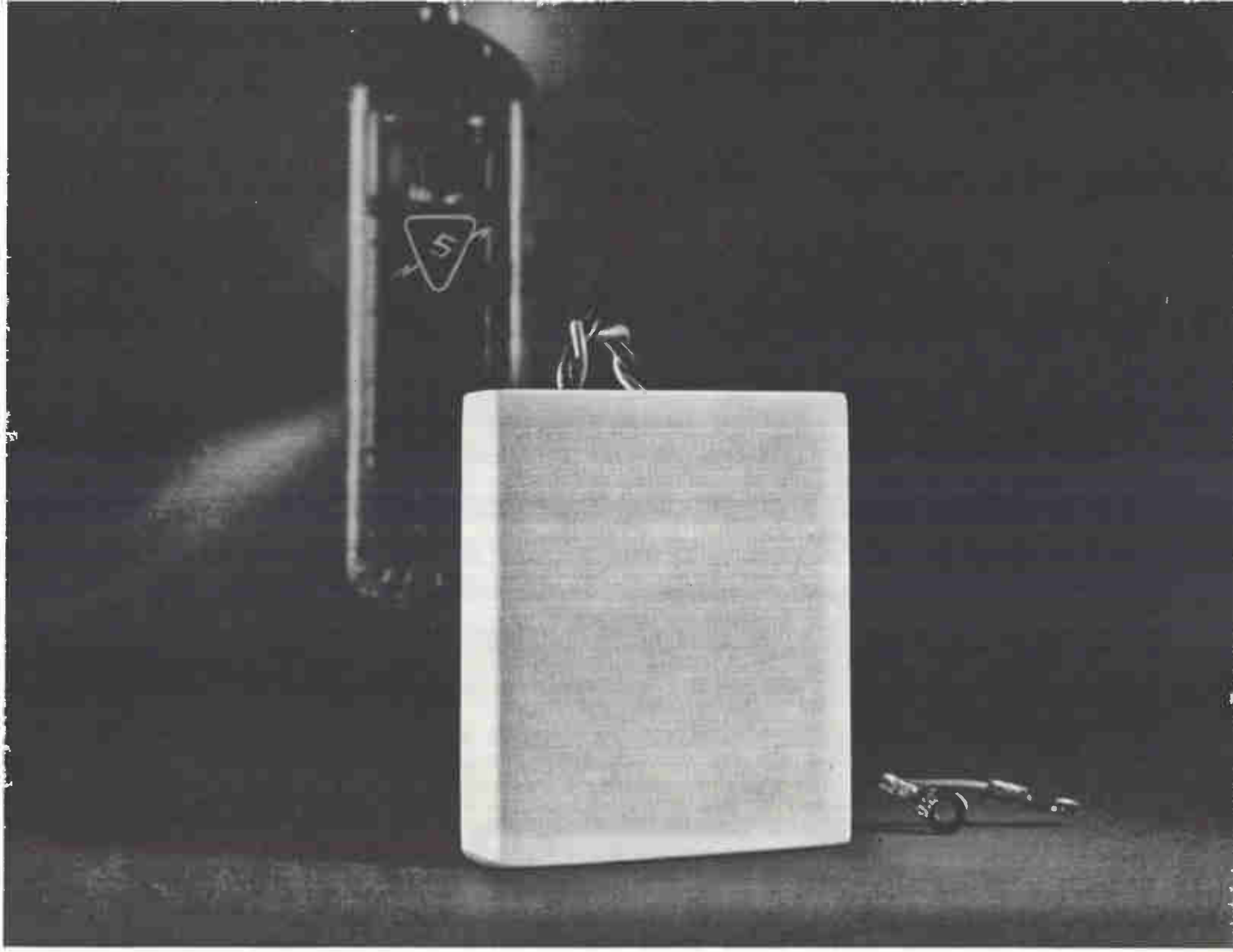


NYLON *coil bobbin flash on relay contact (dark areas) was quickly identified as such, not a metallic fiber as it appeared, thus pinpointing needed improvement in molding process*

SPOT TESTS — Qualitative spot checks are most useful. Such tests are inexpensive, rapid, usually nondestructive and extremely sensitive. A 50-cent spot test identified a contaminant material as nickel-flashed high purity iron within a minute or

WISE EXPENSE

Establishment of a chemistry lab at Filtors for in-process control of precision-relay manufacturing at first appeared extravagant. Its value in ensuing years has been such that it was expanded to permit even better process control. Use is made of exotic techniques mentioned here as well as more common-place ones such as gravimetric and volumeric analysis, pH and conductivity measurements



so. Confirmatory spectrographic analysis costing 28 dollars and taking one week failed to detect nickel as being a surface constituent, erroneously reporting it as being a bulk constituent of less than 0.1 percent.

One important use of spot tests is an immediate check of flux deposits to make sure that not too much is used. With hydrazine flux, almost invisible particles have a greenish glow under ultraviolet light. More exact identification is made with a solution of chloromine-T + fluorescein, which causes the particles to develop a visible red stain. Presence of a certain amount of these particles indicates that something is wrong with hydrazine flux deposit control.

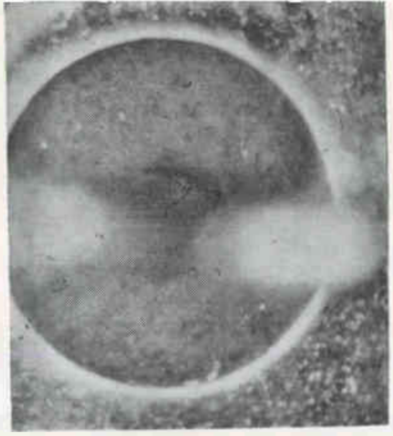
Presence of rosin flux on contacts is also identifiable by a spot test. Quantities too slight (40 micrograms) to fluoresce under ultraviolet light are turned visibly reddish-purple when a drop of acetic anhydride (90-percent) and sulfuric acid (10-percent) mixture is added.

SUBTLE CONTAMINATION — Spot tests are quite useful in detecting and indicating necessary process control of an extremely subtle form of contamination—that due to invisible traces of base metals. Tests at Filtors, Bell Telephone Laboratories, Stanford Research Laboratories and elsewhere have proved that metals such as iron, copper, lead and nickel are transferred to relay contacts during rolling, riveting, plating, welding, gaging, and handling.

Some manufacturers inadvertently leave iron and nickel trace residues on contacts during header assembly welding. Invisible iron particles can be turned visibly blue by fuming contact areas with hydrochloric acid vapors and then adding a drop of potassium ferricyanide. Nickel particles are turned red by neutralizing acid with ammonia fumes before adding a drop of 1-percent dimethylgloxime solution.

Rolled tape contacts may appear clean, but iron and nickel tests often prove these metals are present, showing that more stringent control is required during rolling operation.

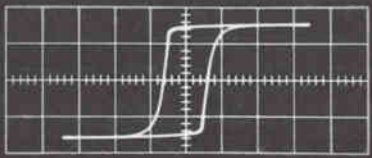
Welding can blow lead from



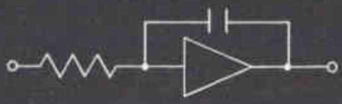
POSITIVE *reaction to spot test disproved vendor's claims of water stains on gold-plated iron headers and indicated nickel contaminant (light areas) due to faulty plating*

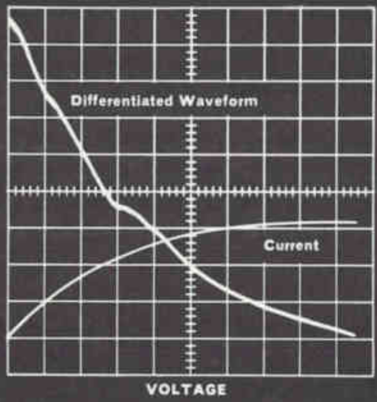
CORNCOB *tumble polish produced insulated areas on contacts that contrasted with metallic areas which remained dark under test*

IRON OXIDE *insulating film on glass reed switch contacts remained light while metallic areas darkened under ferric ferricyanide test*

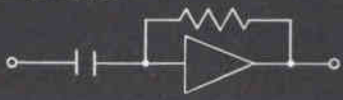


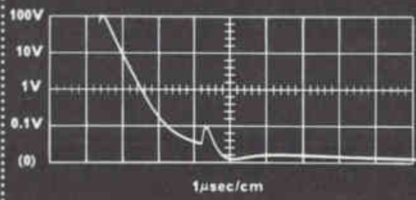
DISPLAY OF INTEGRATED WAVEFORM—transformer secondary voltage integrated and plotted against the transformer primary current—for enabling study of B-H loops of transformer cores.



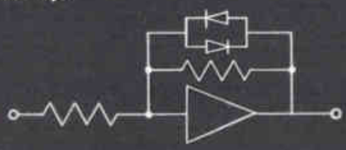


DISPLAY OF DIFFERENTIATED WAVEFORM—tunnel diode in liquid helium—for enabling detection of quantum phenomena at low temperature.

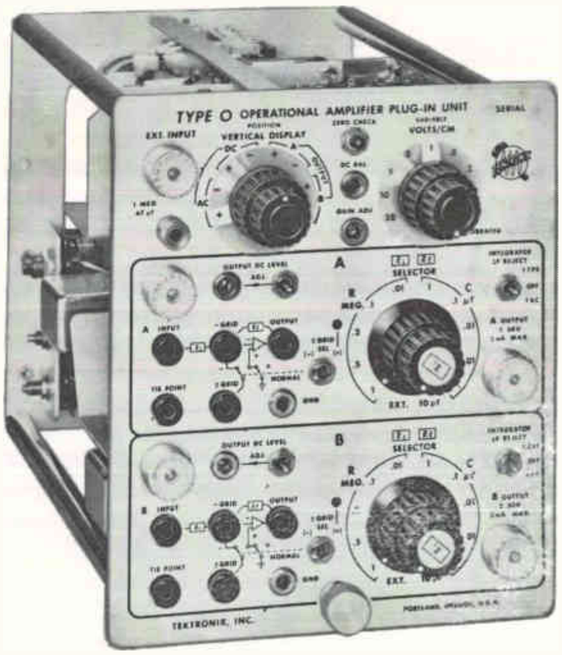




DISPLAY OF LOGARITHMIC RESPONSE—two pulses of widely varying amplitudes—for enabling observation of 100-volt pulse and 0.1-volt pulse in the same viewing area (simplified schematic shown below).



Operational Amplifier Plug-In Unit Permits Oscilloscope Measurements Under Dynamic Conditions



TYPE O UNIT U. S. Sales Price, f.o.b. Beaverton, Oregon $525

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TYPE O UNIT—for Tektronix Oscilloscopes that accept letter-series plug-in units.

Using this new Operational Amplifier Unit in your Tektronix Oscilloscope, you can perform precise operations of integration, differentiation, function generation, linear and non-linear amplification.

You can accomplish many of these operations by simply manipulating the front-panel controls—for the Type O Unit features convenient *selection of precision input and feedback components.*

You can use the Type O Unit as a gated integrator . . . as a high-input-impedance amplifier . . . as a bandpass amplifier . . . as a constant-current-drive amplifier . . . as a peak-memory amplifier . . . as a function generator . . . as a capacitance-measuring device . . . as a low-current measuring device . . . and for many and varied other specialized operations—some performed *with* external circuitry and some *without.*

CHARACTERISTICS

The Type O Unit contains two complete operational amplifiers and one complete vertical preamplifier.

Each operational amplifier features 15 mc open-loop gain-bandwidth product, open-loop dc-gain of 2500, selectable input and feedback impedances, drift rejection for ac integration. The output of one operational amplifier can be applied to the input of the other for combined operations.

The vertical preamplifier can be used independently or to monitor the output of either operational amplifier. In a Tektronix Type 540-Series Oscilloscope, the passband is dc-to-25 mc, the risetime is 14 nsec, and the maximum calibrated sensitivity is 50 mv/cm.

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PLASTIC FILM *from finger cot insulated contact and remained light while metallic areas darkened under test*

solder-coated header pins onto contacts. A spot test using rhodizonic acid will turn lead particles into a visible red stain.

ORGANIC CONTAMINATION — While organic contamination is better known than that due to base metals, common practice of vacuum baking to remove volatile components is ineffectual for bulk removal of rosin—less than 1 percent is removed at 150-degrees C. and 10-microns pressure over a period of 48 hours.

First-rate detection techniques can combat another misconception—that unsintered polytetrafluoroethylene film commonly used as a coil-wrap is oil-free. There is a trace of oil which does not completely vacuum-bake out, as indicated by an iodine fume test; the yellow stain is a positive indication of oil.

An exceptionally useful test for organic contaminants uses a fresh mixture of ferric chloride and potassium ferricyanide solutions; the red ferric ferricyanide that results will leave a blue film on any metallic surface, even platinum. Non-metallics, such as oxides and organic films, will show up on the blue surface as colorless spots since they produce no color change whatsoever.

VENDOR PROCESSES — Relay manufacturers have to contend with insulating films resulting from vendor processes. In one instance, a relay manufacturer's gold-plated

store of reliability . . .

LEACH SUBMINIATURE CRYSTAL CAN RELAYS are ready to do hundreds of critical jobs. Every one meets or beats mil specs for the critical extremes of vibration, shock, high and low temperatures. They perform like grown-up relays but their subminiature sizes are just what missile control, computer, and printed circuits need.

Best of all, they're on the shelf and ready to go.

Half-size at only .4-inches high and weighing a mere .25 ounces, it still meets all standard crystal can specs in low level to 2 amp. switching.

M250 Smallest of the family

It allows increased contact rating for normal life requirements or, if you like, extra long life at 2 amp. rating. It has standard 0.20-inch terminal spacing.

M200 Most versatile

A magnetic latch version of the standard 0.2-inch grid space design, it takes shock to 50 G's . . . vibration, 20 G's to 2000 cps. It switches and carries 2 amp. resistive loads without continuous coil power.

M230 The toughest

It requires a mere 40 milliwatts of power but still stands up against shock and vibration. This is the relay to use where power is limited as in transistorized devices.

M240 Most sensitive

One of the smallest 10 amp. relays available (.885 inches high), it provides greater resistance to shock (to 50 G's) and vibration (20 G's to 2000 cps) than most conventional size 10 amp. relays.

C200 Most powerful

NOT ACTUAL SIZE—So you wouldn't miss them, these Leach relays are pictured almost twice their actual size. For complete specs write Leach Corporation or see your nearest Leach representative.

LEACH

CORPORATION

405 Huntington Drive
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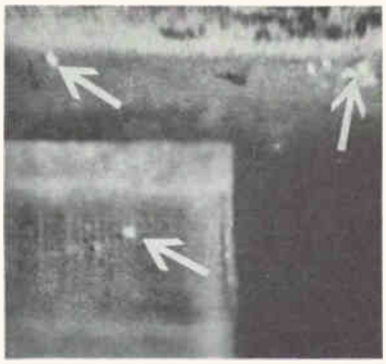


HYDRAZINE FLUX *particles (arrows) normally invisible to eye have green glow under ultraviolet light. When tested with certain solution they turn red under light to give positive identification*

silver rivets appeared to be insulated by a film impervious to solvents and acids. When given the ferric ferricyanide test, only a few small areas turned blue, proving that most of the contact surfaces truly were insulated. An additional test with red chromic acid conclusively proved the film to be organic as the acid changed from red to green and bubbled.

Origin of this film was traced to a vendor who had tumblepolished the plated springs in corncob dust prior to riveting. This tumbling coated the springs with a film of zein, a natural plastic found in corn germ. Rivets then became coated when they rubbed against the springs during subsequent handling. Tumblepolish was eliminated, and so was insulation problem.

Another vendor problem occurred when rhodium plating was used over a nickel undercoat. As all rhodium plating is more or less stressed, and also porous, nickel oxides sometimes rise to the surface, forming an insulating film. A red color with the hydrochloric acid-ammonia-dimethylgloxime test readily proved the presence of nickel oxide. The manufacturing process was modified by slightly etching the nickel surface and by using low pH, Watts-type nickel together with dull, low-stress rhodium.

Defective plating by vendors can be detected by spot tests. A vendor's claim that brown stains containing iron and appearing on some gold-plated iron headers were only water stains, was disproved by a test for nickel. A positive reaction pointed to nickel as culprit, indi-

The Honeywell Visicorder oscillograph

& GUNPOWDER

records forces in circuit breaker bushings

Wham! Forces imposed by the operation of oil-filled circuit breakers—especially during short-circuit interruption—are destructive enough to damage bushings. Engineers at the Ohio Brass Company have devised an ingenious method of simulating this explosive force in order to analyze bushing loads.

On a typical bushing, they mounted a dummy interrupter, in which they exploded gunpowder to propel from the interrupter fist-sized metal projectiles.

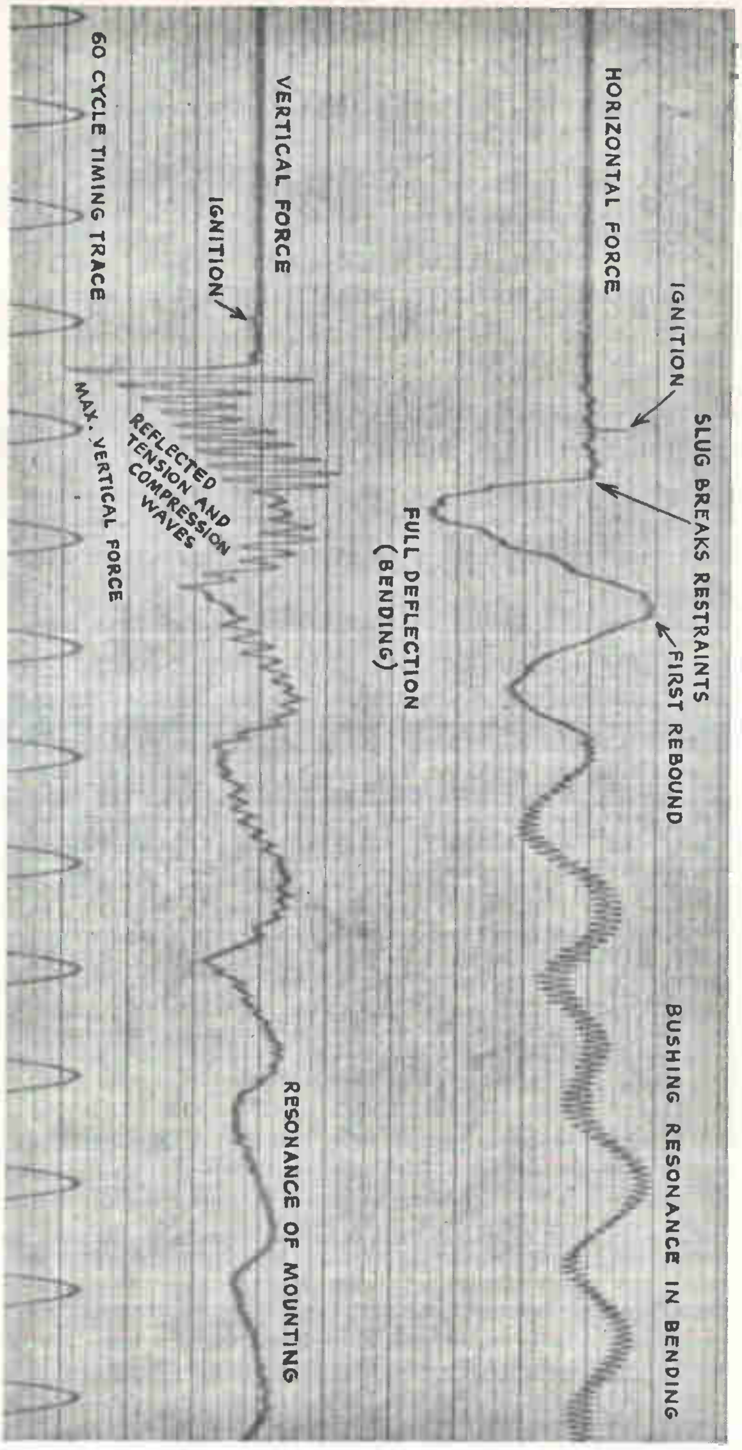
Strain gages, installed on the bushing ground sleeve, were connected to a Honeywell 119 Amplifier.

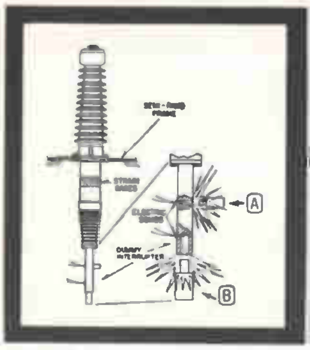
A Honeywell 906 Visicorder oscillograph was chosen to record the test data because of the extremely high speed and transient nature of the signals to be measured.

A typical record of this test, shown at right, was made at a record speed of 50″/second.

These Ohio Brass tests have opened the way to the development of standards for the mechanical performance of bushings (AIEE papers 62-153, 60-107).

This application is only one of thousands where the Visicorder is called upon daily as a basic research, test, and development tool. One of the six different Visicorder models should be a basic instrument in the management of your data acquisition.





Schematic at left diagrams method for duplicating bushing loads during short-circuit interruptions. Projectile (A) produces lateral forces at right angles to bushing axis; projectile (B) produces axial load on bushing terminal. At right, squibs have just detonated charges propelling projectiles from dummy interrupter. Below, Honeywell Model 906 Visicorder Oscillograph records circuit breaker bushing test for Ohio Brass.

For full details on all Visicorder Oscillographs, tape systems, and signal conditioning equipment, write to Honeywell, Denver Division, Denver 10, Colorado, or phone 303-794-4311.

DATA HANDLING SYSTEMS

Honeywell

The Honeywell Model 906 Visicorder Oscillograph—with a Honeywell Model 119 Amplifier—record circuit bushing tests for Ohio Brass.

CIRCLE 113 ON READER SERVICE CARD

cating defective plating since only possible nickel source was between iron header and gold.

Solder Seminar Airs Problems

PRINTED CIRCUIT soldering seminar sponsored by Alpha Metals during IEEE convention highlighted a variety of problems in quality mass-production soldering. Speakers and panel members from various major electronic firms were quite cognizant of legitimate problems of soldering but at same time gave definite approaches to securing reliability.

H. Manko, of Alpha, was first of three speakers who preceded a panel answering questions from audience. He emphasized proper control of process parameters, centering his discussion around optimum use of available fluxes. Water soluble fluxes, he said, are receiving attention where adequate cleaning is feasible and high reliability is desired.

RCA was represented at seminar by L. Pessel. He described tests developed at RCA for determining solderability and stressed roles of solder surface tension and interfacial tension between solder and base metal surfaces.

R. Corish, of IBM, said that it is not enough to inspect solder joints. One key to good quality control, says Corish, is training inspectors in soldering techniques.

The below-listed factors were established by a panel composed of three speakers and following company representatives: W. G. Bader, Bell Labs; G. Cavanaugh (moderator), General Electric; F. C. Disque, Alpha Metals; R. J. Gruendle, IBM; F. A. Hallock, Sperry Gyroscope:

- Alloying of solder and base metal is not required for sound metallurgical bonding. Good electrical joints are formed due to the action of Van der Waal forces (molecular and atomic attractions)
- Contamination of solder pot is generally catastrophic—occurs suddenly due to some basic error in housekeeping
- Dry runs of production soldering should always be done for each different setup
- Soldering of gold-plated materials is universally difficult

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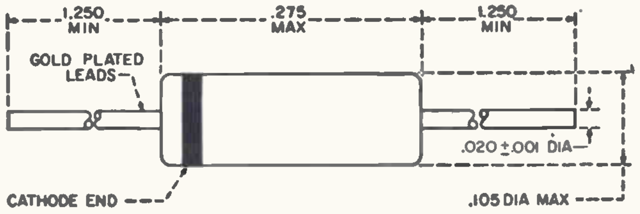
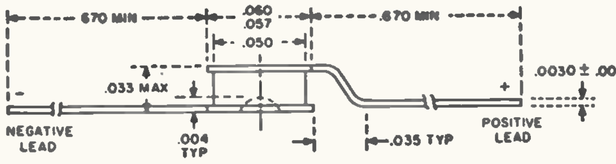


1N4009



1N4043

1N4009, 1N4043 RATINGS AND CHARACTERISTICS

Power — 25°C Ambient
1N4009 Dissipation P_t 250 mw
1N4043 Dissipation P_t 150 mw

	Sym	Min.	Max.	Units
Breakdown Voltage ($I_R = 5$ μa)	B_V	35		volts
Forward Voltage ($I_F = 30$ ma)	V_F		1.0	volts
Reverse Current ($V_R = 25$ V)	I_R		0.100	μamps
($V_R = 25$ V, 150°C)	I_R		100	μamps
Reverse Recovery Time ($V_R = 6$ V, $R_L = 100$ ohms, $I_f = 10$ ma)	t_{rr}		2	nsec.
($I_F = I_R = 10$ ma, Recovery to 1.0 ma)	t_{rr}		4	nsec.
Capacitance ($V_R = 0$ V, Note 1)	C_o		4	pf

NOTE 1: Capacitance as measured on Boonton model 75A capacitance bridge at a signal level of 50 mv and a frequency of 1 mc.

1N3873, 1N3873/HR RATINGS AND CHARACTERISTICS

Power Dissipation (25°C) 250 mw — 25°C Ambient
Power Dissipation (125°C) 100 mw

	Sym	Min.	Max.	Units
Reverse Current, $V_R = -50$ volts	I_R		0.1	μamps
Forward Voltage				
$I_F = 0.01$ ma	V_F	0.32	0.50	volts
$I_F = 20$ ma	V_F	0.70	0.85	volts
$I_F = 150$ ma (Note 1)	V_{F1}	0.95	1.10	volts
$I_F = 200$ ma (Note 1)	V_{F2}	0.99	1.14	volts
Large Signal Incremental Forward Voltage	ΔV_F (V_{F2}-V_{F1})	0.040	0.090	volts
Reverse Recovery Time, ($I_f = 10$ ma, $I_R = 10$ ma, recovery to 1 ma)	t_{rr}		4	nsec
Capacitance, ($V_R = 0$ V, f = 1 mc, Signal level 50 mv)	C_o		4	pf

Note 1
Forward Current, I_F, is peak value of 30 μsec square pulse, 3% duty cycle. Forward voltage, V_F, is measured at 25 ±3 μsec.

Note 2
Reverse Current at 150°C, $V_R = -50$ volts, is 40 μamps maximum.

For the high reliability inherent in the Planar Epitaxial Passivated technology . . . at prices as low as 35¢ in 100-999* quantities . . . specify General Electric Silicon Signal Diodes. The new 1N4009 series, for example, features ultra-high speed switching for general purpose use in military and industrial applications . . . with lower leakage, higher conductance, and switching speeds to 2 nanoseconds. And also at low prices we have the 1N4043 series in a microminiature hermetically sealed package. For **high reliability** applications, try the G-E 1N3873, a very high speed switching diode with electrical specifications identical to or tighter than the Polaris G-321 high reliability diode. The forward voltage of 1N3873 is closely controlled from 10 microamps to 200 ma at both 25°C and 100°C. Diodes processed to the full G-321 specification including 100% burn-in (for 168 hrs.) plus group A, B, C, and D lot acceptance testing are also available on special order. Just check the listing for typical parameters of the low-cost and high reliability types.

For complete details, write Section 16D150, Semiconductor Products Department, General Electric Company, Electronics Park, Syracuse, New York. In Canada: Canadian General Electric, 189 Dufferin Street, Toronto, Ont. Export: International General Electric, 159 Madison Ave., New York 16, New York.

*Manufacturer's suggested resale price

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GENERAL ELECTRIC

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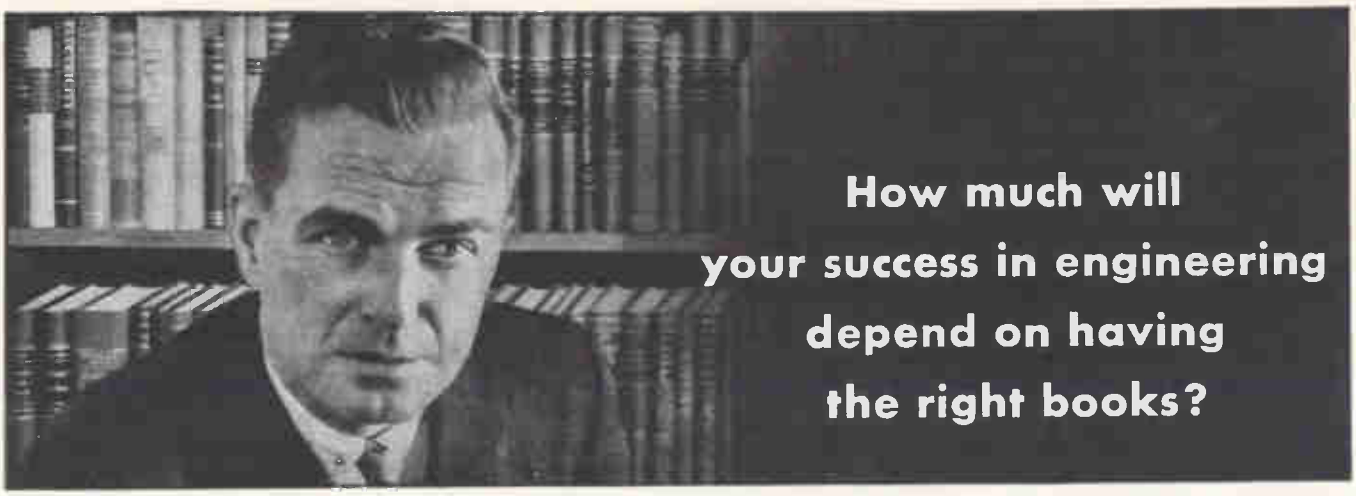

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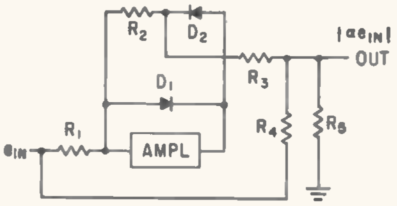
Data Converter Has 60-Db Dynamic Range

A-c to d-c unit also has variable time averaging for statistical studies

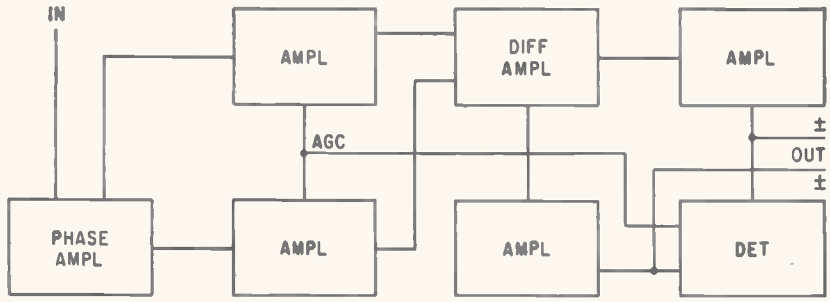


OPERATING with input frequencies from 0 to 25 Kc and with a 60-db dynamic range, the model TP-660 a-c to d-c converter, designed to convert a-c data signals to d-c, is manufactured by Technical Products Company, 6670 Lexington Avenue, Los Angeles 38, California. Operational abilities of this solid-state device are extended by inclusion of a time-averaging circuit. The output then is a time function whose period can be selected from 0.1 to 100 seconds. The absolute value circuit is shown in the sketch. Amplifier gain is very high and controlled by polarity of instantaneous input signal. Positive-going signals produce different gains than negative-going ones. For example, if signal is negative, D_1 is cut off and D_2 conducts. Under this condition, effective gain is established by ratio of R_2/R_1. Voltage at junction of R_2 and D_2 causes current flow through R_3 and R_5. At same time, e_{in} will also cause current flow through R_4 and R_5. Since direction of both currents through R_5 is opposing, difference of the two currents will appear across R_5. The ratio of R_2/R_1 is adjusted so that when signal is negative, current flowing through R_3 and R_5 is twice that flowing through R_4 and R_5. When input becames positive, D_1 conducts while D_2 is cutoff. Effective gain is zero and the only current flowing through R_3 is that derived from e_{in} through R_4. Current through R_5 is in same direction regardless of polarity of e_{in}, and current is directly proportional to absolute value of e_{in}.

CIRCLE 301, READER SERVICE CARD

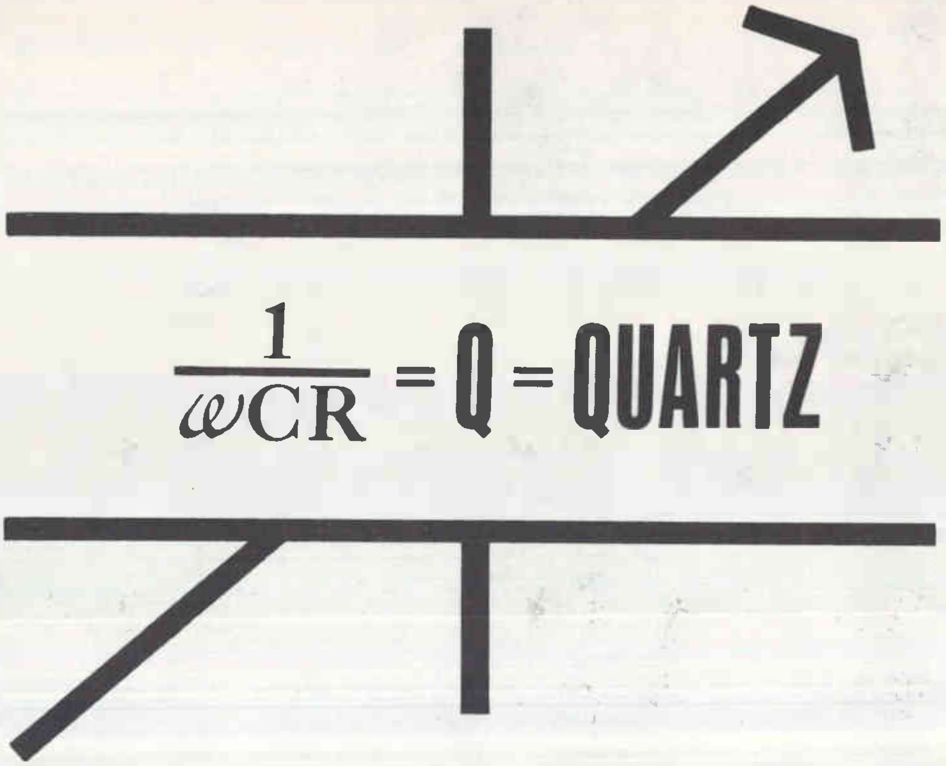
Automatic Gain Control For 40-Db Signal Variation

ANNOUNCED by Winston Research Corp., 11162 LaGrange Avenue, Los Angeles 25, California, the model C automatic gain control unit provides a relatively constant output from tv, facsimile, sinusoidal or pulse-type signals whose input level might vary over a 40 db range. A switch allows selection of either of two inputs; 0.01 to 1.0 v rms and 0.1 to 10 v rms for approximately 1 v peak-to-peak output. Dynamic range compression is 40 db at input to 6 db at output and 26 db at input to 1.5 db at output, attack time is 1 μsec and bandwidth is 10 cps to 10 Mc. System will follow fade rates to 20 cps with 40 db input variation. The device can be used as a compressor when recording receiver video output or receiver i-f before limiting, as might be done in some predetection applications, and it can be used to increase dynamic range capability of magnetic recorders for a-m information. Device operation is shown above. (302)



R-F Switcher Operates Between D-C and 900 Mc

NEW from Blonder-Tongue Labs., Inc., 9 Alling St., Newark 2, New Jersey, the model 4102 is an electronically - actuated, high - speed switch that provides simultaneous display of input and output of a device under test. Usable input frequency response is d-c to 900 Mc, switching rate is 30 cps, impedance is 75 ohms, vswr from 0 to 216 Mc is 1.08 maximum and from 216 to 900 Mc, vswr is 1.15 maximum. Isolation (closed to open contact) from 0 to 216 Mc is 40 db minimum and from 216 to 900 Mc is 27 db mini-



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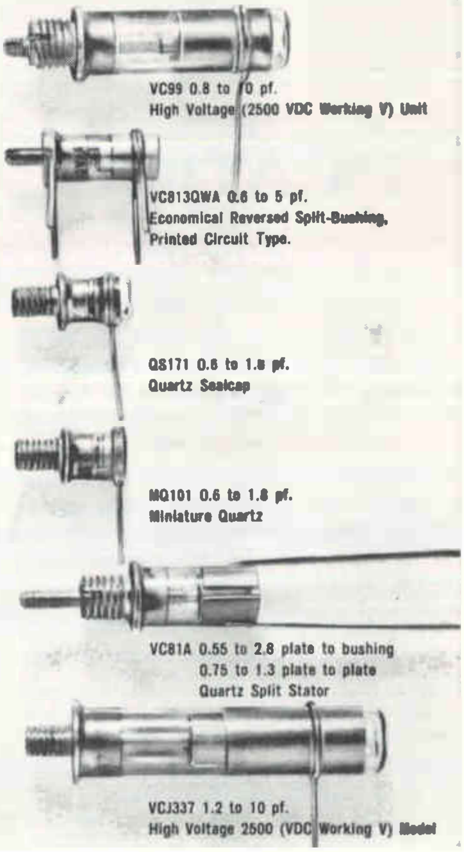

VC99 0.8 to 10 pf.
High Voltage (2500 VDC Working V) Unit

VC813QWA 0.6 to 5 pf.
Economical Reversed Split-Bushing, Printed Circuit Type.

QS171 0.6 to 1.8 pf.
Quartz Sealcap

MQ101 0.6 to 1.8 pf.
Miniature Quartz

VC81A 0.55 to 2.8 plate to bushing
0.75 to 1.3 plate to plate
Quartz Split Stator

VCJ337 1.2 to 10 pf.
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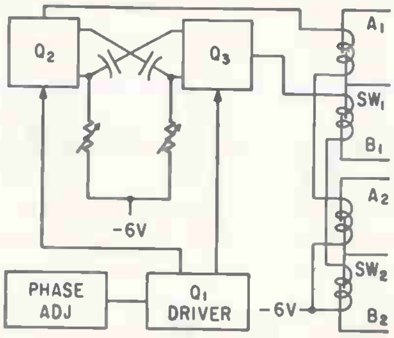
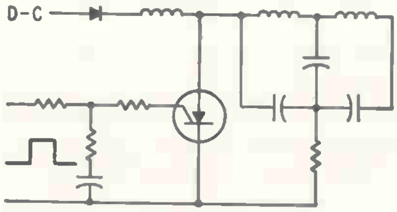
CIRCLE 119 ON READER SERVICE CARD

mum. Full 360-degree phase adjustment is provided. Actual switching is accomplished by a pair of single-pole, double-throw hermetically-sealed reed relays. As shown in the sketch, current flow through Q_2 closes both switches simultaneously in the *A* position. When Q_3 conducts,



direction of current flow through driver coils is reversed and both switches close in the *B* position. Multivibrator frequency is controlled by Q_1 which in turn is driven by a sine wave generated in the power supply. Nominal frequency is 30 cps, but slight variations can be made by bias variation of Q_2 and Q_3.

CIRCLE **303**, READER SERVICE CARD

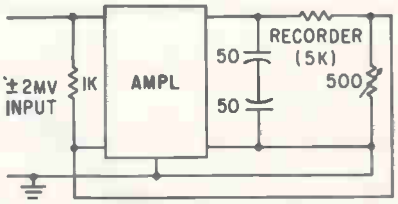


Fast-Switch SCR For Pulse Application

ON THE MARKET from Motorola Semiconductor Products Inc., 5005 East McDowell Rd, Phoenix 8, Arizona, are a series of fast-switching, high-voltage, silicon controlled rectifiers especially designed for radar, proximity fuse, beacon and similar pulse applications. The new devices, types MCR-729-5 through MCR-729-10 are capable of operating with prf's of more than 10,000 pps, at voltages up to 800 v and repetitive pulse currents to 100 amperes. Continuous forward current is 2 amperes, repetitive pulse current with a 10 μsec width is 100 amperes, peak forward voltage is 1 Kv, peak reverse voltage is 50 v, peak gate power is 20 w, and average gate power is 1 w. Peak gate current is 5 amperes and peak gate voltage forward and reverse is 10 v. **(304)**

Solid-State Amplifier Uses Magnetic Techniques

MANUFACTURED by Acromag Inc., 15360 Telegraph Road, Detroit 39, Michigan, the model 190 solid-state magnetic thermocouple amplifier is designed for general purpose, low-level d-c amplification from low-resistance sources. The device does not use choppers, tubes or tran-



sistors. Typical d-c voltage gain with a 5,000-ohm load is 2,750 and with a 25,000-ohm load is 4,000. Linear output (d-c) into a 5,000-ohm load is ±2 v and d-c null stability referred to input is ±5 μv. The device will directly drive panel meters and recorders. The sketch shows operation as a recorder preamplifier. Feedback of 10:1 increases input resistance to approximately 1,000 ohms and stabilizes gain to about 1 percent. **(305)**

Vibrating Capacitor Has Very Low Drift

VIBRATING CAPACITOR is a modulator of the vibrating reed type which varies its capacitance in a sinusoidal manner for the purpose of modulating a d-c signal. When long time stability is required, it becomes the key component in circuits used for measuring currents as low as 10^{-16} amp. It is well suited for high impedance instrumentation such as electrometers and beta-gaging equipment. Drift at constant temperature is 0.1 mv max per 24 hr,

BRUSHLESS D.C. MOTORS Can you use them? Should you?

You may have wondered what to expect from a brushless d.c. motor. In its simplest form a brushless d.c. motor is an a.c. motor with a transistor inverter that changes d.c. to square wave or sine wave a.c., and thus avoids the brushes and commutator. The main advantage of the idea is that the motor will have an extremely long and reliable life because there won't be any brushes to replace or brush dust to reduce bearing life. Side benefits include superior high altitude performance and improved dielectric strength; no brushes mean no arcing, and hence less radio noise. A good brushless d.c. motor may operate continuously for more than 10,000 hours; a conventional d.c. motor under the same conditions will operate for considerably less time before the brushes need changing.

low vs. high price

Brushless d.c. should not be thought of as an automatic solution to all problems. You need more hardware to do the same job when you use the brushless concept and so the price includes performance loss as well as money.

■ From our experience we find that the increased price ranges from \$10 to \$100 per unit, with \$15 a good average. For a given frame size, the brushless d.c. motor is capable of less torque than a permanent magnet motor of the same size, particularly for motors up to 1/10 HP.

■ Another point should be made in all fairness. The semiconductor circuits range from extremely simple, refined and dependable units to complex filtered circuits that are protected against incoming high voltage transients, and outgoing radio noise. The power transistors in the miniature inverter do generate radio noise when they switch, although this noise is easy to filter. However, the more sophisticated the circuit, the higher the price.

motor heat vs. transistor junctions

At Globe we use two basic mounting configurations for the inverter. When used with a motor alone we put the inverter in its own package (3½ cubic inches) separate from the motor to keep temperatures within reason. On axial blowers the best place for the inverter is integral with the motor, a location that permits cooling in the blower's airstream. Motors make a notoriously poor heat sink when they are operating, so you do need caution before you specify an integral inverter.

speed variations

A small potentiometer wired into the winding can be used to change the frequency, and thus to change the speed of the motor. This vernier-type of adjustment may be useful where you need to set the speed to match other components. The potentiometer won't make an infinitely variable drive out of the motor, but a reasonable range may be useful. By using a toroid in the winding, refinements may be made in this technique.

exclusive speed control

Here is another development, different in function, but related in hardware: at Globe we have a unique solid state circuit that not only gives brushless d.c. performance, but holds an exact speed within 0.5% at any variation in the range from 22 to 32 v.d.c. and from −55°C to 75°C. Virtually synchronous performance from d.c. is now possible under variable environments.

A 3" blower may operate more than 10,000 hours on d.c. using an inverter that adds 1⅝" to motor length.

Globe is headquarters

Thus, we have separate inverters, integral inverters, and a black box speed control that works beautifully. All three of these are potted for maximum vibration resistance and environment protection.

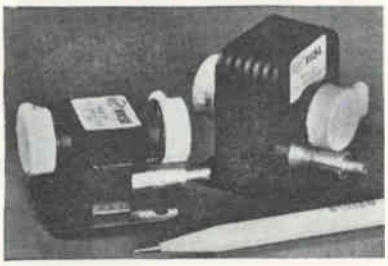
■ Globe is the largest builder of precision miniature motors, and we have spent years refining the brushless d.c. motor from a laboratory development to a practical product. If you are interested in the benefits of brushless d.c. motors, we invite you to talk with us. We have positive, constructive suggestions to give you the quality product you need. Our background can help you to stay in perspective on brushless d.c. motors. Request Bulletin BDC.

Globe Industries, Inc., 1784 Stanley Avenue, Dayton 4, Ohio

GLOBE

noncumulative. Capability is 0.05 mv. Temperature coefficient of drift is 0.03 mv per deg C. Stevens-Arnold Inc., 7 Elkins St., South Boston 27, Mass.

CIRCLE 306, READER SERVICE CARD



Reflex Klystrons For Ku Band

EITEL-MCCULLOUGH, INC., 301 Industrial Way, San Carlos, Calif. Four new Ku reflex klystrons, the X1115A and B, and X1116A and B, are designed to provide stable, efficient operation in severe environments. The A series provide 100 mw, and the B series 30 mw, power outputs. The X1115 tubes operate at 12.2 to 12.7 Gc and the X1116's at 11.7 to 12.2 Gc. All four are gridless gun, low noise types and are intended for microwave relay point-to-point communications, radar and parametric amplifier pump applications. (307)

Printed-Circuit Flux Is Fast-Acting

ALLOYS UNLIMITED SOLDER, 21-01 43rd Ave., Long Island City 1, N. Y., announces a fast-acting printed circuit flux that is easy to apply and leaves substantially reduced deposits after the solvent is volatilized. Called 183-35, it is completely homogeneous, noncorrosive and nonconductive. It meets all military specifications. The flux is available in 1 quart, 1 and 5 gallon glass or plastic containers and 54 gallon drums. (308)

Compact Oscillator Covers 1 to 400 Mc

DIAGNOSTIC INSTRUMENTATION INC., 49 Hampshire St., Cambridge, Mass., offers a high powered oscillator series covering the range of 1-

ANCIENT HISTORY

MINCOM CM-100 1.5 MC RECORDER / REPRODUCER

Only the Mincom CM-100 has a field-proven record of predetection performance. Mincom's leadership in this highly complex telemetry technique stems from the CM-100's long-standing and reliable 1.5-mc response. CM-100's versatility and extreme wideband capability have made it the industry's instrumentation standard: 1, 1.2 or 1.5 mc at 120 ips in analog recording/reproducing, or simultaneous post- and pre-detection recording in FM/FM mod, PCM, PCM/FM, PAM/FM, PACM/FM and other FM-type carrier systems. Superior fixed heads and phase-compensating electronics produce better rise time, correcting for phase shift and overshoot. Write today for specifications.

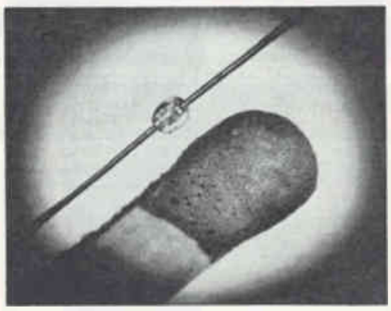
Mincom Division 3M COMPANY

2049 South Barrington Avenue, Los Angeles 25
425 13th Street N.W., Washington 4, D.C.

CIRCLE 123 ON READER SERVICE CARD

400 Mc for use where precise, crystal controlled, fixed frequency sinusoid generation is required. Series is based on the plug-in module concept with a corresponding highly regulated basic power supply. Each of the type 1000 series unit oscillators will generate a conservatively rated 30 w into a 50 ohm load. Sinusoid is free from harmonic content and has extremely low distortion. Development models are available to a range of 1,000 Mc.

CIRCLE 309, READER SERVICE CARD



Thermistors for Dense Packaging

NOW AVAILABLE are Sensistor positive-temperature-coefficient thermistors in a microminiature glass package. Devices measure 0.060 in. long, 0.040 in. in diameter. The MicroSensistor silicon resistor has a large positive temperature coefficient of resistance of 0.7 C, plus a constant rate of change. Guaranteed cyclical repeatability with no hysteresis effect and fast 0.5-to-1.5-sec response time are added advantages. The device is available in resistance values of 10 ohms to 1,000 ohms with a 10 percent tolerance. It is designed for operation in environmental temperatures from −50 C to 200 C. Texas Instruments Inc., 13500 N. Central Expressway, Dallas, Texas. (310)

Television Camera Is Fully Transistorized

TELEVISION camera model V-500 is a fully transistorized unit which incorporates a vidicon tube and offers 500 lines video resolution. It measures 9 in. by 6 in. by 3 in. and weighs 5.7 lb. An automatic light sensor and compensator is built into the circuitry and functions with a variety of standard, telephoto, wide angle, zoom and closeup lenses. Camera is designed for use with any of several matching monitors in the VMW-100 series. Video Systems of America, Inc., 445 Park Ave., New York, N. Y. **(311)**

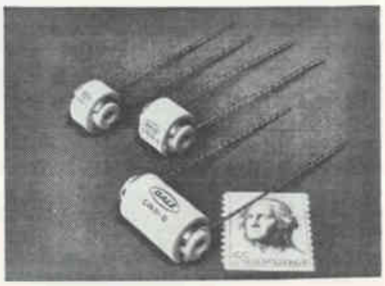
Isolated Power Supply Has Dual Output

ELCOR, INC., 1225 W. Broad St., Falls Church, Va. Model 124-EI Isoply offers an extremely low shunt capacitance of 25 pf and a very high leakage resistance of more than 100,000 megohms at the output. These characteristics are ideally suited for powering an amplifier to be used as a buffer or in the potentiometric mode. Outputs are a positive and negative 18 v d-c plus an unregulated center tapped 6.3 v a-c. This modular unit maintains 0.2 percent line and load regulation. **(312)**

Voltage Comparator Is Modular Unit

BINARY ELECTRONICS, INC., 30-48 Linden Place, Flushing 54, N.Y. Parametric-amplifier input circuitry and solid state logic have been combined to create an ultra high performance and versatile d-c voltage comparator which may be operated in both manual and triggered modes. Unit compares an unknown d-c voltage to one or two externally provided references and forms drift-free decisions of "go", "high" or "low" at a max rate of 10 tests per sec. Circuitry provides a 10,000 megohm differential input resistance virtually eliminating loading errors and a 1-mv operating differential which is unaffected by source impedance effects.

CIRCLE 313, READER SERVICE CARD



Bobbin Resistor Produced in 7 Sizes

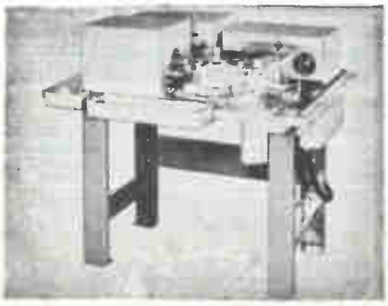
DALE ELECTRONICS, INC., P. O. Box 488, Columbus, Neb. The CWR line of unencapsulated ceramic bobbin resistors are produced in seven sizes ranging from 0.15 w to 1 w. Resistance range is from 1 ohm to 150,000 ohms for the 0.15 w CWR-1 to 1 ohm to 12 megohms for the 1w CWR-7. Tolerances are 0.5 percent and 1 percent. Radial leads of tinned copperweld are standard. Models CWR-1 to CWR-3 are inductively wound; models CWR-4 to CWR-7 have noninductive windings. Operating temperature range is from −55 C to 145 C. (314)

Sequence Timers For Space Use

TWO MINIATURE sequence timers perform switching functions to timing accuracies of up to 1 percent for space and airborne applications. The five- and 10-cam types both are operated by internally contained rfi-filtered and regulated 28 v d-c motors, drawing approximately 70 ma, working through precision worm drives. Units feature a precision method of phasing the switch cams, which are located on a common axis, each operating a spdt microswitch having 7-ampere contacts. Acton Laboratories, Inc., 533 Main St., Acton, Mass. (315)

Diffusion Furnace

MODEL DF4-57 furnace units offering ±0.50 C scr temperature control over a 16-in. flat zone at 1200 C for the diffusion of silicon-integrated circuitry and other semiconductor devices are available. Theco Manufacturing, 242 Commercial St., Sunnyvale 2, Calif. (316)



Voice Coil Winder Is Semiautomatic

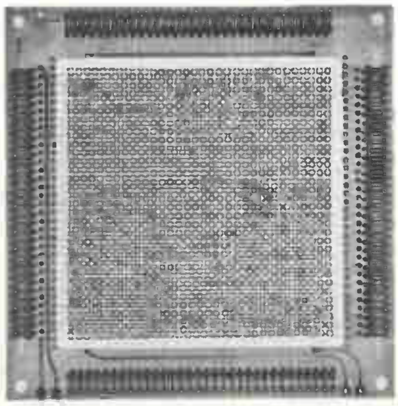
GEO. STEVENS MFG. CO., INC., Pulaski Road at Peterson, Chicago 46, Ill., offers a compact semiautomatic time-saving voice coil winder with which a single inexperienced operator can produce over 800 perfectly sized and finished coils every hour. Model 62-PM winds most 2 and 4 layer voice coils covering over 80 percent of all voice coil winding requirements. Operator never touches wire after original set-up. Automatic operations include applying solvent to wire entering machine, winding to exact turns count, drying coil on sized mandrel, cutting leads to desired length, and ejecting finished coil completely wound, fused, sized and with desired lead lengths to the exact specification required. Price is $6,800. (317)

Transistor Amplifier Tested at 100 Mc

FUNCTIONALLY tested silicon planar-epitaxial transistor amplifier for

Now you can test me quicker, easier, cheaper

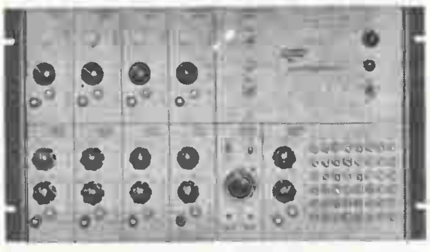
Who says it takes a heavy, expensive tester to check magnetic cores and circuits?



Now you can buy a 35 pound, precise, solid state magnetics tester for only $4,500. It will do everything the big, expensive testers can do. And then some. In fact, when it comes to testing magnetic cores and circuits it's a compact, high performance workhorse. We know. Our 100-Series testers have been used, abused, revised and endorsed by some of the most persnickety, finicky, hypercritical specialists in the business: our own core, and memory production men.

Electronic Memories' 100-Series testers are completely modular; each tester consists of a series of economic, compact high performance pulse generators together with a current calibrator module and a power supply package. Module interchangeability plus an optional program generator module allows complete test program flexibility. And, to reduce costs, you buy only the modules you need for your specific application.

If you're interested in compact, flexible, sensibly priced instruments for testing and evaluating any magnetic core or circuit, you'll want to see our bulletin on the 100-Series Testers. May we send you a copy?



Most flexible tester configuration is shown above. Top modules: 4 univibrators and power supply. Bottom modules: 2 positive drivers, 2 negative drivers, current calibrator and switch activated program generator. Weight: 40 lbs. Price: $6,000. Designation: Model 150.

FERRITE CORES • ARRAYS • TRANSFLUXERS • MEMORY SYSTEMS

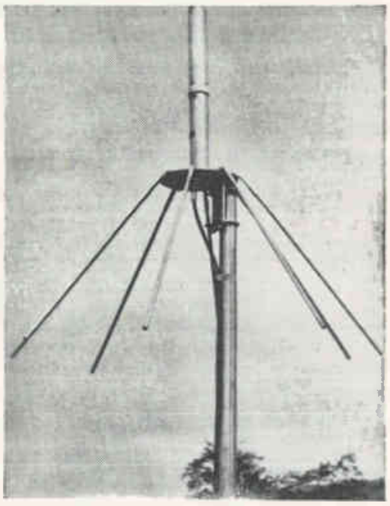
electronic memories inc.

9430 Bellanca Ave., Los Angeles 45, California

CIRCLE 127 ON READER SERVICE CARD

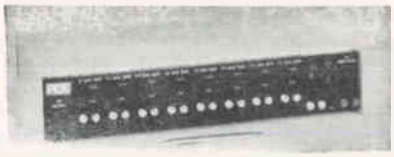
high frequency military and industrial communications circuits is announced. The T-2857 exhibits an 18 db power gain and a 4.5 noise figure typically at 100 Mc. Every transistor is functionally tested to assure users that the units will perform in an amplifier circuit precisely as specified. Philco Corp., Lansdale, Pa.

CIRCLE 318, READER SERVICE CARD



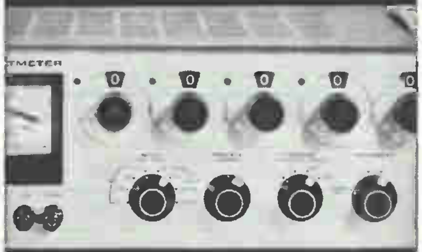
Coax-Stub Antenna For Severe Weather

COAX-STUB ANTENNA, operating in the frequency range from 100 to 174 Mc, is ruggedly designed for use in areas where severe weather conditions exist. Type F-11 is a vertically polarized coaxial stub with 2¼ in. diameter tubular elements. Impedance is 52 ohms, with a vswr under 2.0:1. Diameter across the ground plane rods is 43 in. and the height is 40 in. Connection is with a type N connector. Technical Appliance Corp., Sherburne, N. Y. (319)



F-M Multiplexer in Compact Package

PACIFIC COMMUNICATIONS & ELECTRONICS, INC., 3102 Rolison Road, Redwood City, Calif. Model 501 Datamux provides up to 10 f-m data channels in a 100 Kc frequency band for transmission or recording



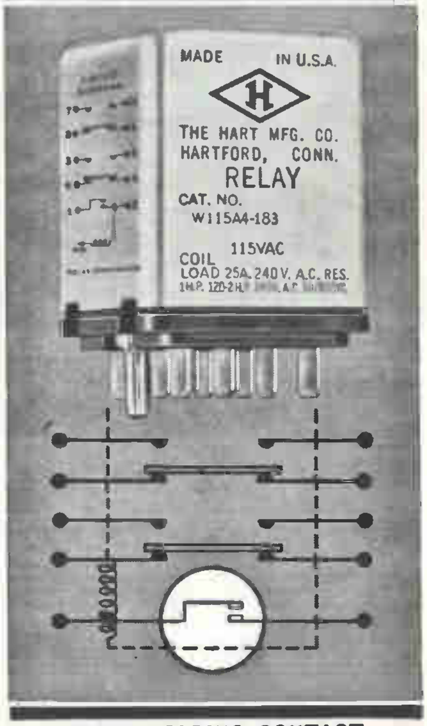
of analog data. Constant bandwidth channels with precise time correlation between channels permits accurate reproduction of data from multiple sources. Transmit and receive units are plug-in mounting 8 units in 3½ in. of rack space with associated power supply. Features include: high input impedance, balanced or unbalanced, 0-5 percent center frequency stability, 1.0 percent linearity and less than 1.5 percent distortion. Interchannel crosstalk is more than 65 db down. **(320)**

Photo Transistor Has High Sensitivity

FAIRCHILD SEMICONDUCTOR, 545 Whisman Road, Mountain View, Calif. Type 2N2452 has a sensitivity radiation system range of 50-200 μa/mw/cm². Its sensitivity illumination system range is 2.6-10.3 μa/ft-can. It is priced at $27 in 1-99 lots, $18.10 in 100-999. **(321)**

Duplexers in the 50 to 1,000 Mc Range

SERIES 9300 solid state duplexers are passive devices for isolating a receiver from a transmitter when a common antenna is employed. On "transmit", insertion loss between transmitter and antenna is typically

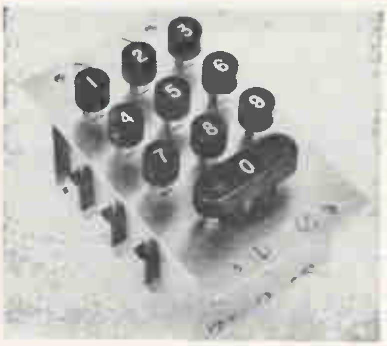


less than 1 db and isolation between transmitter and receiver is typically greater than 30 db. On "receive", insertion loss between antenna and receiver is typically less than 1 db. Bandwidth is typically 5 percent of center frequency. Power handling capacity is 1.5 Kw (peak), 100 w average. RMS Engineering, Inc., 486 Fourteenth St. NW, Atlanta 13, Ga.

CIRCLE 322, READER SERVICE CARD

Power Supplies Are Solid-State Units

DESIGNED for use in major missile, radar, beacon, telemetry and other equipments and systems, the series 600 subminiature solid-state power supplies vary in volume from 1.5 to 3 cu in., match their weight in ounces to volume. All are for 24 to 30 v d-c input, with outputs from 30 to 180 v d-c and current ratings from 175 ma to 10 ma. Regulation is 0.1 percent for all but the 120 ma and 175 ma types which feature 1.0 percent regulation. Ripple is down to 0.03 percent for most units. Advanced Electronics Corp., 2 Commercial St., Hicksville, N.Y. (323)



Keyboard for Input Devices

DONALD P. MOSSMAN, INC., P. O. Box 265, Brewster, N. Y. Series 7100 keyboard is designed to provide a compact assembly for interrogation and input devices in conjunction with data processing equipment.

Buttons are momentary in operation, actuating reliable leaf spring contacts for long life. Standard button spacing is $\frac{3}{4}$ in., however special configurations are available to provide matrices to fit the application. (324)

H-V Power Rectifiers Feature Small Size

ELECTRONIC DEVICES, INC., 50 Webster Ave., New Rochelle, N. Y. Kilowatt selenium cartridges have ratings up to 25,000 v peak inverse and 40 ma forward current in air, 60 ma in oil. Dimensions are 10 in. by $1\frac{1}{8}$ in. square. Three series are available: SA for 20 ma, SB for 30 ma, SC for 40 ma. (325)

Gold-Palladium Based Alloy

AGE HARDENABLE gold-palladium based alloy No. 239 possesses extremely good wear characteristics, electrical stability and spring properties, suiting it for the manufacture of potentiometer sliding contacts featuring high reliability and long, low noise level. Presently available are laminations to beryllium copper, grade C phosphor bronze, 18 percent nickel silver and others of lesser importance in the electrical field. Leach & Garner Co., Attleboro, Mass. (326)

Microminiature Switch Has Durability

TELEX, INC., 3054 Excelsior Blvd., Minneapolis 16, Minn., assures over one-half million positive, trouble-free switching operations for its series TH microminiature switch. Available in both spst and spdt configurations, the switch measures $\frac{3}{32}$ in. by $\frac{1}{8}$ in. by $\frac{1}{2}$ in. Contact rating is 1 amp 30 v d-c, 1 amp 115 v a-c resistive. Contact resistance is 0.120 ohm at terminals. Dielectric strength is 500 v rms at sea level between terminals. Capacitance between contacts is 1 $\mu\mu$f. (327)

Literature of the Week

IR DETECTOR MEASUREMENT Instrumentation Division of Infrared Industries, Inc., Box 989, Santa Barbara, Calif. A 26-page manual spells out circuitry specs and applications of the 33 components that make up the infrared detector measurement console.

CIRCLE 328, READER SERVICE CARD

POWER SUPPLIES Advanced Electronics Corp., 2 Commercial St., Hicksville, L. I., N. Y. Catalog bulletin 209PS covers a series of low power output subminiature solid state d-c to d-c power converters. (329)

DIGITAL VOLTMETER Princeton Applied Research Corp., Box 565, Princeton, N. J., offers bulletin 107 on a small transistorized reed-relay type digital voltmeter. (330)

INSTRUMENTS Kay Electric Co., Maple Ave., Pine Brook, N. J. A 100-page catalog contains data on the various lines of oscillators, audio spectrum analyzers, noise generators, attenuators, etc. (331)

ULTRASONICS Macrosonics Corp., 1001 Roosevelt Ave., Carteret, N. J., has published a brochure describing its capabilities and facilities in the ultrasonic research and development field. (332)

PINHOLE DETECTOR General Electric Co., Waynesboro, Va. Bulletin GEA-7596 describes a transistorized pinhole detector for inspection of fast-moving metal strip. (333)

D-C POWER SUPPLY Kearfott Division, General Precision Aerospace, Little Falls, N. J. Catalog sheet describes the C70 3933001 transistorized regulated d-c power supply. (334)

LOW-NOISE AMPLIFIERS Industrial Instruments Inc., 89 Commerce Road, Cedar Grove, N. J. Catalog sheet No. 26314D describes four low-noise amplifiers. (335)

COORDINATED MANUAL CONTROLS Micro Switch, Freeport, Ill. Catalog 69 describes the new system of manual control and lighted legend display for modern panels. (336)

WELDING TORCH Laramy Products Co., Inc., 220 Beechwood St., Cohasset, Mass. A 6-page catalog describes the Located Heat thermoplastics welding torch and related equipment. (337)

POTENTIOMETERS Computer Instruments Corp., 92 Madison Ave., Hempstead, N. Y. A 20-page catalog covers a complete line of rotary precision film potentiometers. (338)

POWER PACKS Electronic Research Associates, Inc., 67 Factory Place, Cedar Grove, N. J., announces a technical bulletin on a line of low cost 28 v d-c high current power packs. (339)

COOLING EQUIPMENT McLean Engineering Laboratories, P. O. Box 228, Princeton, N. J., has published a 42-page catalog presenting its 1963 line of blowers for cooling electronic enclosures. (340)

METALLIZED MYLAR CAPACITORS Electron Products, division of Marshall Industries, 1960 Walker Ave., Monrovia, Calif. One-page data sheet covers complete specifications for new thin film metallized Mylar capacitors. (341)

GLASS REED RELAYS Wheelock Signals, Inc., 273 Branchport Ave., Long Branch, N. J. Bulletin describes a glass reed relay design which, reportedly, eliminates problems caused by epoxy encapsulation. (342)

MICROWAVE DEVICES International Microwave Corp., 105 River Road, Cos Cob, Conn., has released a file folder and technical bulletins on its solid-state microwave devices. (343)

ELECTROMAGNETIC DELAY LINES ESC Electronics Corp., 534 Bergen Blvd., Palisades Park, N. J., has issued a 4-page catalog describing electromagnetic delay lines, networks and filters. (344)

MULTIPLE TAPE LISTER SYSTEM Anelex Corp., 150 Causeway St., Boston 14, Mass., offers a 4-page brochure on a high speed multiple tape lister system. (345)

SEMICONDUCTOR METALS & ALLOYS Sigmund Cohn Corp., 121 S. Columbus Ave., Mt. Vernon, N. Y., has issued a new, up-dated eight-page brochure on metals and alloys for use in the semiconductor field. (346)

DECADE AMPLIFIER Gulton Industries, Inc., 212 Durham Ave., Metuchen, N. J., has issued bulletin AF2a describing a multi-mode a-c decade amplifier. (347)

SOLID STATE POWER MODULES Technipower, Inc., 18 Marshall St., South Norwalk, Conn., has available its 34-page catalog, No. 634, which reflects its greatly expanded line of solid state power supplies. (348)

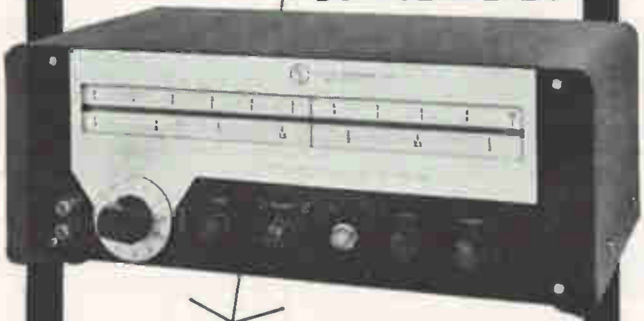
MULTIREED RELAY Thermosen Inc., 375 Fairfield Ave., Stamford, Conn. Technical data TR-1 covers the Multireed relay which combines the advantages of the glass-sealed reed switch with several major advances made by the company. (349)

COAXIAL CABLE Phelps Dodge Electronic Products Corp., 60 Dodge Ave., North Haven, Conn. A 20-page bulletin offers full details on Spirafil coaxial cable. (350)

UHF RECEIVER Communication Electronics, Inc., 4900 Hampden Lane, Bethesda, Md. Bulletin describes type 701 and 702 receivers designed to meet the highest performance requirements for uhf receivers in critical reconnaissance work. (351)

NEW! SELF BALANCING POTENTIOMETRIC

DC VOLTMETER



0.2% ACCURACY
Multi-Range: 11 Selections
0-3 MV to 0-300 Volts

OVER 1000 MEGOHMS INPUT IMPEDANCE
14" Scale
Zener Reference

Universal Case Design providing a quick change from Case to Bench to Rack Enclosures

$625 to $655

Literature Available Upon Request

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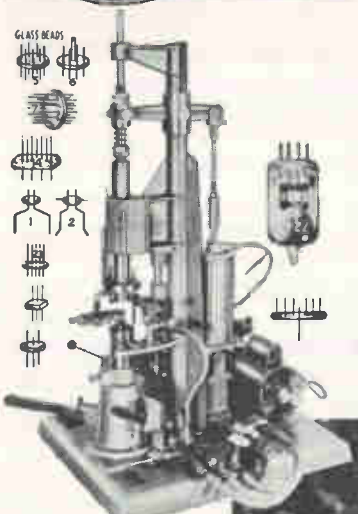
Box 22234G Houston 27, Texas MO 7-7403

CIRCLE 213 ON READER SERVICE CARD

Eisler — A NAME TO REMEMBER IN MACHINERY FOR ELECTRONICS



At left: No. 105-BST1 single position Button Stem and Wafer making machine—Fully automatic. Designed for small production runs on special tube parts or for laboratory use. Produces button stems up to 1¼" diameter. Machine can be supplied with up to 24 positions.

Illustrated below: An Eisler precision Vertical Spot Welder designed exclusively for welding of electronic components. Available in sizes from ½ to 7½ KVA.

Write us today for full particulars!

EISLER ENGINEERING CO., INC.
Charles Eisler Jr., President
751 So. 13th St., Newark 3, N.J.

CIRCLE 214 ON READER SERVICE CARD

For Average or Critical insulation, you need QUALITY-CONTROLLED Synthane laminates

It costs you little or nothing more to have Synthane quality laminated plastics for any application, the same quality you would demand for critical circuits. Synthane quality is built into every Synthane grade—every Synthane sheet, rod, tube or fabricated part—from the time the resins and fillers are received through manufacture and machining of the laminates. Every step is tightly controlled to insure uniform and high quality. You can easily afford Synthane for your normal requirements; use it by all means on your most exacting applications.

SYNTHANE CORPORATION OAKS, PENNA.
GLendale 2-2211 (Area Code 215) TWX 215-666-0589
Synthane-Pacific, 518 W. Garfield Ave., Glendale 4, Calif. TWX 213-240-2104U

Synthane Corporation, 36 River Rd., Oaks, Pa.

Gentlemen:

Please send me complete catalog of Synthane laminated plastics.

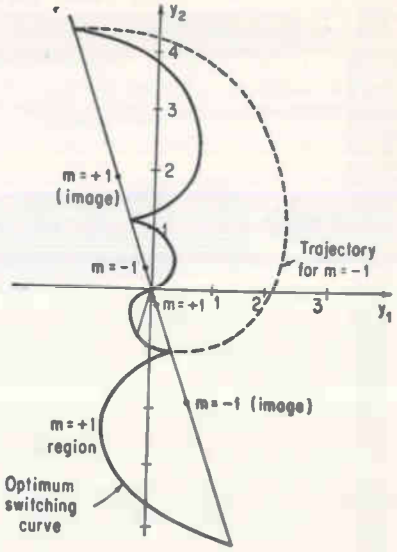
Name____________________

Address____________________

City__________ Zone_____ State_____

CIRCLE 133 ON READER SERVICE CARD

NEW BOOKS



OPTIMUM SWITCHING *boundary for second-order system with complex roots*

Nonlinear Automatic Control

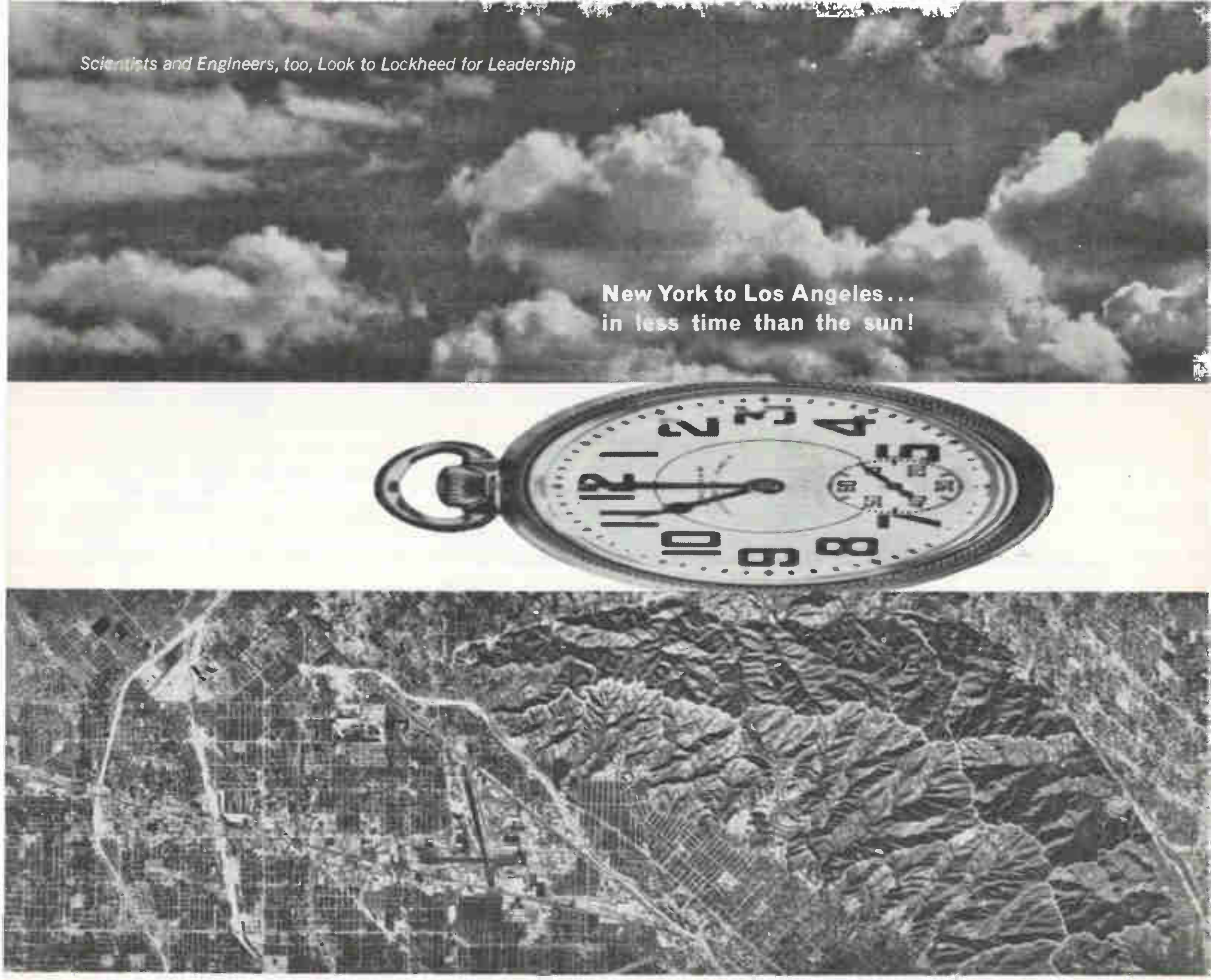
By JOHN E. GIBSON

McGraw-Hill Book Company, Inc., New York, 1963, 585 *p*, $16.50

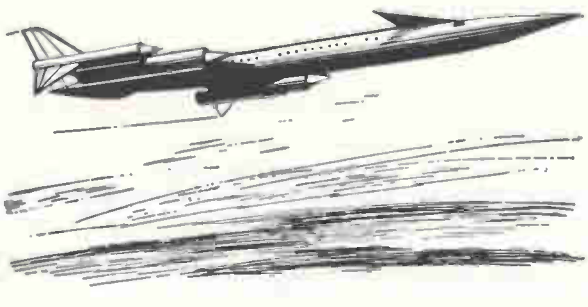
ADMITTING that a general method of synthesis for nonlinear control problems is impossible, the author presents a series of analytic methods that apply to restricted classes of nonlinear problems, and extend the usefulness of known techniques to a wider range of systems.

With this approach, the book starts off as a postgraduate text with a review of linear control theory, and progresses to areas such as adaptive control systems in which there is active research today. In between, the book contains a wealth of material including numerical and statistical methods, time-varying systems, perturbation methods, phase-plane methods, the second method of Liapunov and others. In several instances, Russian techniques and applied-mathematics subjects (subharmonic analysis) are brought together for the first time in English with the control engineer in mind.

In brief, this volume brings to



TIME SQUEEZE



Time: ***NOON***

Place: ***NEW YORK INTERNATIONAL AIRPORT***

A big needle-nosed transport stands poised for take-off in the mid-day sun. Suddenly its jets roar into full-throated life. The plane arrows down the runway and into the air in a sweeping climb-out that takes it to 70,000 feet in less than 20 minutes heading westward toward the distant Pacific.

Time: ***11 AM (Same Day)***

Place: ***LOS ANGELES INTERNATIONAL AIRPORT***

Out of the eastern sky the plane descends in a long glide, its engines muted, its wings still hot from the Mach 3 speed which outpaced the sun for 2,469 miles. Result? Time is squeezed until it runs backward and the plane arrives *before* it departs—less than two hours out of New York.

FANTASTIC? Not at Lockheed California where studies involving flight characteristics and airline operation of the SST have been in process for some time. Projects like these are one reason why the Company appeals to the man who enjoys working in a creative climate that welcomes new ideas and concepts.

SCIENTISTS AND ENGINEERS who are qualified by experience and talent are invited to investigate these immediate openings: Electronic Systems; Flight Test; Aerodynamics; Thermodynamics; Dynamics; Guidance and Control; Operations Research; Astrodynamics; Aerophysics; Theoretical Physics; Astrophysics; Expanding Structures; Spacecraft Radiation Shielding.

Write: Mr. E. W. Des Lauriers, Manager, Professional Placement Staff, Dept. 1504, 2404 N. Hollywood Way, Burbank, California. An equal opportunity employer.

LOCKHEED

CALIFORNIA COMPANY

Spacecraft • Advanced Aircraft • ASW

A DIVISION OF LOCKHEED AIRCRAFT CORPORATION the reader a thorough exposition of up-to-date control theory.

An Introduction to Electronic Analogue Computers

By M. G. HARTLEY

John Wiley & Sons, Inc., New York, 1963, 152 *p*, $4.50.

A volume of the Methuen's Monographs on Physical Subjects, this little book is a thorough introduction to analog computing for research workers and development engineers who may have occasional need for use of such computers. Digital and analog machines are compared in the second chapter; then a detailed discussion follows of the operational amplifier and its applications, and the idealized analog machine.

The second half of the book deals with practical d-c amplifiers, transistor computing amplifiers and auxiliary equipment. Practical examples and circuits are given throughout.

Elements of Network Synthesis

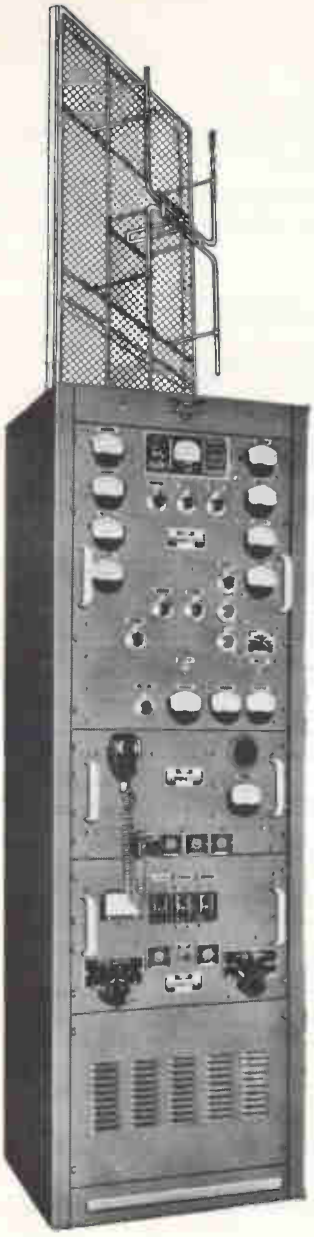
By DOV HAZONY

Reinhold Publishing Corporation, New York, 1963, 352 *p*, $11.50.

THIS text for senior and graduate students represents an attempt to unify as far as possible the variety of techniques used in network synthesis. For instance, the Bott-Duffin, Brune, and cascade synthesis techniques are developed by applying Darlington-type synthesis to extensions of Richard's theorem.

The book makes wide use of nonreciprocal networks (gyrators), in order to achieve further simplification, though reciprocal representations are also covered in all cases.

Basic synthesis functions and mathematical tools are presented first, later, one to n-port networks are covered, and the proof of the existence theorem for an n-port network presented.



AEROCOM PRESENTS VHF AM TRANSMITTERS and RECEIVERS

AEROCOM communications equipment is designed with both performance and reliability in mind, and is produced by experienced personnel using high-quality materials. The following features are found in all three transmitters: Single crystal controlled frequency (plus an additional frequency ½% away from main frequency): stability ± .003% or ± .001% over temperature range of 0° C to + 55° C, any humidity up to 95%; audio system incorporates high level plate modulation, with compression; forced ventilation with air filter is employed. Welded steel cabinets.

Model 10V1-A—1000 Watts output—Successfully being used in Troposcat service for communications with aircraft beyond the optical horizon. Frequency range 118-153 mc. Can be completely remote controlled by using AEROCOM's remote control equipment. All tuning from front panel by means of dials. Power requirements 210-250 V 50/60 cycles, single phase.

Model VH-200—200 Watts output in range 118-132 mc. Excellent for both point-to-point and ground-to-air communications. Press-to-talk and audio input may be remoted using single pair of telephone lines. Power requirements 105-120V 50/60 cycles. Also available for use above 132 mc; output drops gradually to 150 watts at 165 mc.

Model VH-50—50 Watts output. Frequency range 118-153 mc. Outstanding low power transmitter for ground-to-air service. With remote control provisions; main power control with front panel switch. Convection cooling for press-to-talk service—otherwise forced air cooling. Power requirements 115/230 V 50/60 cycles.

Model 85 VHF Receiver. A high performance, low noise, single channel crystal controlled, single conversion VHF receiver. Stability normally ± .001% (with oven crystal ± .0005%) over temperature range 0° C to + 55° C. Sensitivity ½ microvolt or better for 1 watt output with 6 db signal to noise ratio. Standard selectivity bandwidth 30 kc; other widths available. Spurious response down 90 db. Frequency range 118-154 mc. Power requirements either 115 V or 230 V 50/60 cycles. Made for standard rack panel mounting.

As in all AEROCOM products, the quality and workmanship of this VHF equipment is of the highest. All components are conservatively rated. Replacements parts are always available for all AEROCOM equipment.

Complete technical data available on request

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FCC Type Accepted for Aviation Service

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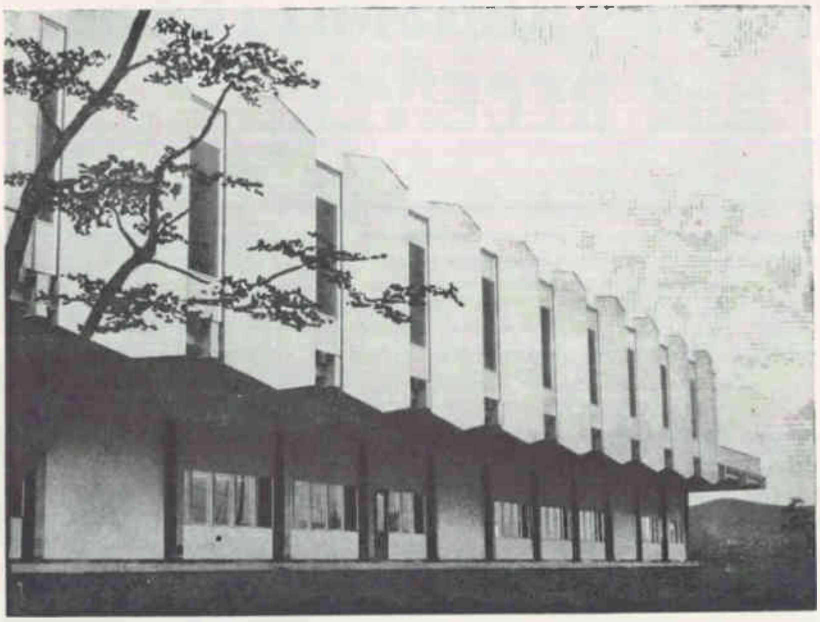
Melabs Moves Manufacturing Activities



MELABS, Palo Alto electronics firm, has moved its manufacturing activities into a new $800,000 supplement to the company's engineering facility. The new building in Stanford Industrial Park more than doubles Melabs' working space.

The two-story building adds 48,600 square feet to the 33,000 square feet in a facility first occupied early in 1960. Built on a 4½-acre site, it can be expanded to essentially double its size for future growth.

The new structure houses assembly and manufacturing testing, metal and machine shops, quality-assurance, printed circuit, plastics, plating and painting facilities, shipping, receiving and stockroom. The older building, containing business and executive offices and engineering laboratories, is connected to the new structure by a covered breezeway.

The plant presents a sharp contrast to the company's quarters when it was founded in 1956—a wine cellar on the property of its president, Lloyd A. Addleman. Operations began with two contracts totaling $15,000, one for an S-band radiometer (for Stanford University) and the other for development of a microwave ferrite switch and driver. Sales in the six-month period ending last January exceeded $3 million, and the firm's staff numbered almost 300.

Since 1956 Melabs has diversified into development and manufacture of microwave systems, equipment and components including receivers, low-noise and parametric amplifiers, filters, mixers, ferrite devices, and diode switches. While substantial commercial sales are made, the firm's major market is federal agencies.

Other corporate officers are Perry H. Vartanian, executive vice president; Wesley P. Ayres, vice president of engineering; and Robert E. Wolfe, vice president of manufacturing.

Hughes Announces Two Appointments

HUGHES AIRCRAFT CO., Culver City, Calif., has appointed two assistant division managers in its space systems division.

Joseph M. Pasternack was named assistant division manager—advanced programs. He also will continue to serve in his current position of manager of the advanced projects laboratories.

Adolph Burstein was named assistant division manager—engineering laboratories. He also will continue as manager of the engineering laboratories.

Loral Subsidiary Elects President

HOWARD B. SALTZMAN has been elected president of Alpha Wire Corp., a subsidiary of Loral Electronics Corp., Bronx, N.Y.

Saltzman, who was executive vice president, succeeds Peter Bercoe, who will remain as a member of the board of directors and a consultant to Alpha.

Alpha, a manufacturer of wire, cable and tubing for the electronics industry, has plants in New York City, Holbrook, L.I., N.Y., and Los Angeles.

Organize New Company In Los Angeles

LP ASSOCIATES, INC., Los Angeles, Calif., has been organized to offer specialized equipment and engineering services in the field of parametric amplifiers, solid state frequency multipliers, ferrite microwave devices, microwave antennas, pulse

there will never be a better time than now

Next to NASA's Manned Spacecraft Center near Houston are Clear Lake City's superb Research and Industrial Parks. These Parks will be second to none for strategic location and stimulating atmosphere. Investigate.

Your facilities will be in good company. In the Research Park, only "think" industries will be permitted. Most will be space-related. The Industrial Park will serve only clean, light manufacturing and service industries. Strict controls will assure architectural harmony. Extensive landscaping. All utilities underground.

Supporting these technical-industrial areas will be a complete community. Homes, shopping center, apartments, community recreation center, country club and motor hotel are already under construction in the first development phase. Soon to follow is the start of a $150 million "downtown" area with high-rise office buildings, major stores, restaurants, and civic center.

Clear Lake City's 15,000 acres reflect long-range planning but short-range fulfillment. Projected population in fifteen years is 180,000.

Isn't it time you looked into an office or plant location next to NASA/Houston? Selections will never be better.

Write: W. Lawrence Prehn, Jr., Resident Manager, Commercial and Industrial Development, Del E. Webb Corporation, 900 Texas National Bank Building, Houston 2, Texas. Your inquiry will be kept in the strictest confidence, of course.

CLEAR LAKE CITY DEL E. WEBB CORPORATION *...Next to NASA/Houston*

A project of Del E. Webb Corporation for Friendswood Development Company, owned by Humble Oil & Refining Company and Del E. Webb Corporation

CIRCLE 139 ON READER SERVICE CARD

modulators and linear accelerator components.

President of the new company is Leonard Pincus (picture on p 138), formerly vice president and director of Quantatron, Inc.

Elect Hansen Vice President

HOWARD INDUSTRIES, INC., announces the election of David F. Hansen as vice president.

Hansen will continue in his capacity as general manager of sales, with headquarters in the Racine, Wisc., office of the company.

Martin-Orlando Appoints Pierson

APPOINTMENT of C. D. Pierson, Jr. as technical director, reliability and maintainability, for Martin Company's Orlando division has been announced. Martin Company is a division of Martin Marietta Corp.

A veteran of 12 years service with Martin, Pierson was previously engineering support manager for the Orlando division.

Birchard Assumes Sony Post

SONY CORPORATION of America, New York, has appointed Bruce Birch-

Are you a

COMPLETELY INFORMED

electronics engineer?

Today you may be working in microwaves. But on what project will you be working tomorrow? You *could* have read **electronics** this past year and kept abreast of, say, microwave technology. *There were 96 individual microwave articles between July, 1961 and June, 1962!*

But suppose tomorrow you work in some area of standard electronic components, in semiconductors, in systems? Would you be up-to-date in these technologies? Did you read the more than 3,000 editorial pages that **electronics'** 28-man editorial staff prepared last year?

electronics is edited to keep you current *wherever* you work in the industry, *whatever* your job function(s). If you do not have your own copy of **electronics**, subscribe today via the Reader Service Card in this issue. Only 7½ cents a copy at the 3 year rate.

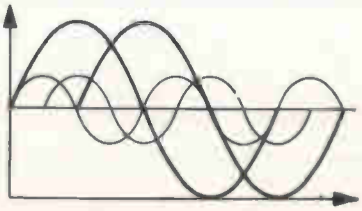
electronics

ACTON LABORATORIES, INC.

PRECISION
DIGITAL PHASE METER
SERIES 330

- Provide direct, four-digit phase angle readings, 0-360° resolution.
- Frequency range, 30 cps to 40 kc.
- Absolute accuracy, ±0.5°.
- Available options include DC or AC/DC voltage measurement, printer output.
- Completely transistorized, except for high impedance input.

Precision Phase/Voltage



Measurement

PRECISION
PHASE/VOLTMETER 360-A

- Measures total, fundamental, quadrature and in-phase voltage components.
- Meter scale provides direct phase angle reading, accurate to ±1° absolute.
- High common mode and harmonic rejection.
- Completely transistorized, except for high impedance input.

SEND FOR COMPLETE DATA

ACTON Laboratories, Inc
533 Main Street
Acton, Massachusetts
A Subsidiary of Bowmar Instrument Corporation

ard as vice president in charge of its newly created Industrial Products division. He will be responsible for the general sales and marketing of all Sony industrial equipment in the United States.

Prior to joining the subsidiary of the Sony Corp., Tokyo, Birchard was manager of the Industrial Products division of Hoffman Electronics Corp., Los Angeles, Calif.

Golub Heads Up New EOS Facility

ELECTRO-OPTICAL SYSTEMS, INC., Pasadena, Calif., has established an electronics fabrication and assembly facility for production line development of soldered, welded, pelletized and integrated circuitry.

Sy Golub has been named to the position of facility manager. He was formerly with United AeroSpace, a division of United Electro-Dynamics, Inc.

DeMornay-Bonardi Promotes Purdy

WILLIAM E. PURDY has advanced to the position of vice president and general manager of DeMornay-Bonardi Corp., Pasadena, Calif. Before joining the organization in 1961, he was associated with Giannini Controls Corporation.

DeMornay-Bonardi designs and manufactures microwave devices and test equipment.

Fisher Advances at Hammarlund

ROBERT W. FISHER has been appointed engineering activities coordinator for Hammarlund Manufacturing Co., a Giannini Scientific Company, with plants in New York City and Mars Hill, N.C.

Fisher joined Hammarlund in 1961 after serving for six years at Allen B. DuMont Laboratories in Clifton, N.J.

Radiometrics Names Vice President

APPOINTMENT of Jordan H. Prince to the post of vice president, Radiometrics division, Polarad Electronics Corp., Long Island City, N.Y., is announced. The Radiometrics division performs research, development, and production of advanced electronic systems for government and industry.

Prince was formerly director of advanced design for Fairchild Stratos-Electronic Systems division, and prior to that director of engineering for Huyck Systems Co.

Automatic Electric Promotes Three

AUTOMATIC ELECTRIC LABORATORIES, Northlake, Ill., recently announced three promotions to the posts of staff supervisors:

Richard P. Sanders, system design; Ronald E. Schauer, electronic techniques and computer design; and Martin R. Winandy, applications engineering. These are newly created positions in the industrial systems laboratory.

PEOPLE IN BRIEF

Michael W. Newell, v-p, named g-m of the Lansdale div. of Philco Corp. **Richard C. Koch** leaves Martin Marietta Co. to return to Regency Electronics, Inc., as v-p, engineering. **R. A. Lambrecht,** formerly with Centralab, appointed chief engineer of Wilrite Products Inc. **David Richardson,** previously with Melabs, named mgr. of research at Mitek Corp. **Philip E. Sellers** moves up from v-p in charge of sales to president of James G. Biddle Co. **Mois Gerson** advances to mgr. of the United AeroSpace div. of United ElectroDynamics, Inc. **Ned J. Marino** promoted to asst. director of mfg. in Lockheed Missile & Space Co.'s Missile Systems div. **Edmund V. Marshall,** ex-Chance Vought Corp., named a v-p at United Aircraft's Hamilton Standard div. **Joseph F. Dolland** elevated to group v-p, sales, for North Electric Co. **Anton Seda,** formerly with Coleman Instrument Co., now chief engineer, equipment design, at Stancor Electronics, Inc. **Bruce L. Mims** leaves Barden Corp. to found Axion Corp. for the development and manufacture of electromechanical components. **Robert J. Lynch,** Col. USAF Ret., has joined General Precision, Inc., as director of command-and-control systems. **George Compton** moves up to head of product engineering, special products, at Fairchild Semiconductor's diode mfg. plant. **Seymour Cohen,** recently with Raytheon, appointed mgr. of quality assurance and applications engineering for the Semiconductor div. of Micro State Electronics Corp. **E. J. Bradley,** previously with Hoffman Electronics, now v-p and g-m of Collins Electronics, Inc. **Robert W. Beckwith,** from General Electric to Gulton Industries, Inc., as mgr., information systems.

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: Classified Advertising Div., ELECTRONICS, Box 12, New York 36, N. Y. (No charge, of course).

COMPANY	SEE PAGE	KEY #
APPLIED PHYSICS LABORATORY The Johns Hopkins University Silver Spring, Maryland	78*	1
ATOMIC PERSONNEL INC. Philadelphia, Penna.	78*	2
COLLINS RADIO CORP. Cedar Rapids, Iowa	104	3
GENERAL DYNAMICS/ELECTRIC BOAT Groton, Conn.	146	4
GENERAL DYNAMICS/ELECTRONICS A Div. of General Dynamics Corp. Rochester, New York	145	5
HONEYWELL St. Petersburg, Fla.	68*	6
LOCKHEED CALIFORNIA CO. A Div. of Lockheed Aircraft Corp. Burbank, California	135	7
LOCKHEED MISSILES & SPACE COMPANY Div. of Lockheed Aircraft Corp. Sunnyvale, California	73*	8
P 1823	78*	9

* These advertisements appeared in the April 5th issue.

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

(Please type or print clearly. Necessary for reproduction.)

Personal Background

NAME ....
HOME ADDRESS ....
CITY ....................ZONE.......STATE.............
HOME TELEPHONE ....

Education

PROFESSIONAL DEGREE(S) ....
MAJOR(S) ....
UNIVERSITY ....
DATE(S) ....

FIELDS OF EXPERIENCE (Please Check) 41263

☐ 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

IMMEDIATE OPENINGS

WITH

GENERAL DYNAMICS / ELECTRONICS

The large number of diversified development contracts now in the house at General Dynamics/Electronics provide immediate assignments for additional professional personnel in the following disciplines:

SYSTEMS ENGINEERING

SENIOR DESIGN ENGINEER. To assist in evaluation of complex electronic reconnaissance systems. Requires experience in 2 or more of the following: digital, RF, pulse, audio, CRT, photorecorders, magnetic recorders, pulse multiplex and frequency multiplex.

SENIOR ENGINEER. With broad knowledge of Aerospace Ground Electronic design. Will analyze aerospace electronic subsystems for test requirements and determine test equipment needs. Experience in Air Force shop or Naval carrier installations desirable, with emphasis on equipment layout, intercabling, work flow analysis, and operational and calibration procedures.

PROJECT ENGINEERS. To supervise design and integration of test equipments and test stations. Should be familiar with all types of testing equipment and techniques in one or more of the following areas: flight control systems, radar, HF-UHF navigation and communication equipment, microwave equipment, antenna systems and electronic countermeasures.

DIGITAL EQUIPMENT DESIGN

SENIOR ENGINEERS. To supervise and do design work on MODEMS, logic and in-put/out-put devices for data communication equipment used in industrial and military systems. Work includes transistor circuit design, logic design, modulation techniques for radio and wire line data transmission, mechanical design of in-put/out-put devices, packaging design and integration of complete communications systems.

CIRCUIT OESIGN ENGINEERS. With experience in the design of transistorized logic circuits, pulse generators and other digitally controlled circuits such as numerical indicators.

MAINTAINABILITY

Long Range Programs in Development/Test/Evaluation/Production of Aerospace Electronic Equipment for:

PRINCIPAL ENGINEER. To establish and operate elite group — experience with all phases of MIL-M-26512; maintenance engineering analysis; principal practices and techniques in the design, maintenance and use of Aerospace Electronic equipment.—Supervisory Position.

SENIOR ENGINEERS. To implement maintainability tasks — experience with design principles, practices and techniques on Aerospace Electronic hardware; analysis, control and demonstration means; familiar with aerospace ground equipment specifications and Government maintenance procedures.

ENGINEERS. To maximize maintainability on Aerospace Electronic Equipment; perform analysis, monitor, audit and review designs; coordinate demonstration testing, simulations; reporting and documentation responsibilities.

RF EQUIPMENT DESIGN

MICROWAVE ENGINEERS. Experienced in the design of signal generators and receivers in the following frequency bands: L, S, C, T, Ku, Ka. Should also know techniques for remote control of frequency and signal amplitude.

ENGINEERS. Experienced in the design of RF and microwave receivers, digital display circuits, data handling and CRT displays including storage tube circuits.

ENGINEERS. Experienced in the design and development of solid state receivers for reconnaissance telemetry, Doppler and communications equipment. Knowledge of tracking filters, phase lock, and synthesizer circuits desirable.

LOW FREQUENCY DESIGNERS. Experienced in the design of audio and sweep signal generators and servo systems test equipment. Senior engineers are also required with experience in the design of LF receivers and transmitters.

HF-UHF ENGINEERS. With experience in design of signal generators, using both transistorized and vacuum tube circuitry. Knowledge of techniques for digital selection of frequency such as frequency synthesis and remote control of signal amplitude is required.

SENIOR ENGINEERS. Experienced in the design and development of single side band receivers and transmitters.

RELIABILITY

Long Range Programs in Aerospace Electronic Equipment. Positions available in staff functional areas and state-of-the-art systems programs for:

PRINCIPAL ENGINEERS. To provide reliability technical group support and program project task support—experience in reliability activities of the following: Analysis, Design Review, Surveillance, Audit, Sub-Contractor Liaison, Apportionment, Allocation and Assessment. Responsible for the application of techniques on Aerospace Electronic programs and generation of methods and procedures. Staff and program positions available.—Supervision.

SENIOR ENGINEERS. To implement reliability engineering and reliability services group tasks. Experience required in Aerospace Electronic equipment reliability activities. Positions available in all reliability areas including: Analysis, Review, Audit, Surveillance, Monitoring, Sub-Contractor Liaison, Statistical Demonstration Testing Studies, etc. Staff and program positions available.

ENGINEERS. To perform reliability tasks of all kinds on Aerospace Electronic equipment.

Please send your resume to Mr. R. W. Holmes, Dept. 22.

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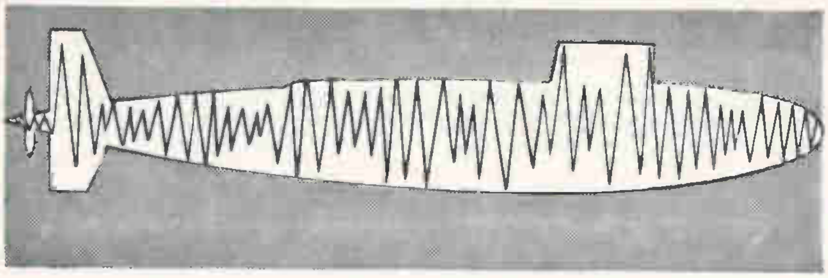
An Equal Opportunity Employer

Look what EE's are doing



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- Design of Special Instrumentation for Measurement of Acoustic & Vibration Data
- Design & Installation of Interior Communication Systems, Navigation Systems, Ship Control Systems, Depth Control Systems, Steering & Diving Devices
- Application and Systems Engineering of Radio, Radar, Sonar & Countermeasures Systems & Components
- Design and Installation of Electric Power Plants & Distribution Systems
- Quality/Reliability Control & Assurance
- Nuclear Power Plant Systems Schematics Review
- Advanced Circuit Design
- Electronic Systems Engineering
- Missile Fire Control, Guidance and Checkout Systems & Equipment
- Installation and Test of Reactor Plant Auxiliary Power Supplies
- Integration of Control and Instrumentation Systems
- Navigation Systems and Equipment
- Procurement
- Vendor Product Application Design
- Electrical Power & Control Systems & Component Design
- Test Development & Instrumentation Design
- Vendor Performance Analysis
- Process Control Engineering & Instrumentation
- Sound, Shock & Vibration Analysis
- Signal Systems Analysis

As a world of technology in miniature—incorporoting missile launching systems, a nuclear propulsion plant, and life support systems—the nuclear submarine is an engineering challenge of the highest order. The Electrical and Electronic Engineer working at Electric Boat has a unique opportunity for professional development, not only in his own specialty but through broad knowledge gained in the unity of all technologies.

Your resumes are invited. Please address Mr. Fred Whitehouse.

GD

GENERAL DYNAMICS
ELECTRIC BOAT
Groton, Connecticut

AN EQUAL OPPORTUNITY EMPLOYER

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(Classified Advertising)

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EQUIPMENT - USED or RESALE

SAVE UP TO 66 2/3%!!!

SOLA REGULATED DC POWER SUPPLIES

Constant voltage within 1%
RMS ripple 1% or less.

Contain Sola Constant Voltage Transformer, semi-conductor rectifier and Hi-Cap filters for mounting on relay racks.

All Primaries, 115, 208, 230 volts, 60 cyc, 1 ph.

No.	Output		
28266	20 volts	4 amps.	$49.50
28270	10 volts	4 amps.	39.50
28271	5 volts	4 amps.	29.50
28267	10 volts	20 amps.	59.50
28237	400 volts	2 amps.	59.50

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MERCURY RELAYS Plunger type

EBERT ELECTRONICS CO. Type EM-7
Coil 230 v AC, 3 Pole, NC $17.50

ADLAKE Type 1101 44Q 512
230 v. 50-60 cyc NO $12.50

Type 1140-50-22
230 v. 50-60 cyc NC $ 9.50

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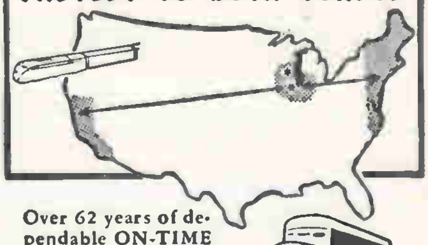
CIRCLE 951 ON READER SERVICE CARD

LIFSCHULTZ
FASTEST TO BOTH COASTS



Over 62 years of dependable ON-TIME Freight Forwarding Service.
We welcome your inquiry.

PROMPT DAILY PICKUP and DELIVERY

LIFSCHULTZ FAST FREIGHT

CIRCLE 952 ON READER SERVICE CARD

CIRCLE 953 ON READER SERVICE CARD

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(Classified Advertising)

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

UNDISPLAYED

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

BOX NUMBERS count as one line additional.

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

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

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ANTENNA PEDESTAL SCR 584-MP 61B

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1D21/SN4	6.00	4J63	150.00	274A	3.50	892R	300.00	5963	1.00
C1K	8.50	4J64	150.00	279A	200.00	913	12.50	5964	.85
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1P25	10.00	4X150D	12.50	QK-288	200.00	1000T	100.00	5993	5.00
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2K56	50.00	6L6GAY	1.25	NL-615	7.50	5670	1.00	6336A	12.75
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3E29	7.50	X-13	150.00	802	7.50	5749	1.00	6877	12.50
3GP1A	12.50	C16J	25.00	803	5.00	5750/6BE6W	2.00	6883	3.50
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3K23	200.00	35TG	3.75	810	18.85	5783	2.25	7521	100.00
3K27	150.00	FP-54	150.00	811	3.00	5784WA	3.35	7580	35.00
3K30	100.00	FG-57	10.00	811A	4.75	5787	2.50	8000	18.85
3KP1	9.75	RK-60/1641	1.50	812A	4.75	5800	7.50	8008	6.00
3RP1	7.50	HY-69	3.00	813	15.00	5803	5.00	8013A	5.00
3WP1	12.50	75TL	15.00	814	4.50	5814A	1.35	8020	6.00
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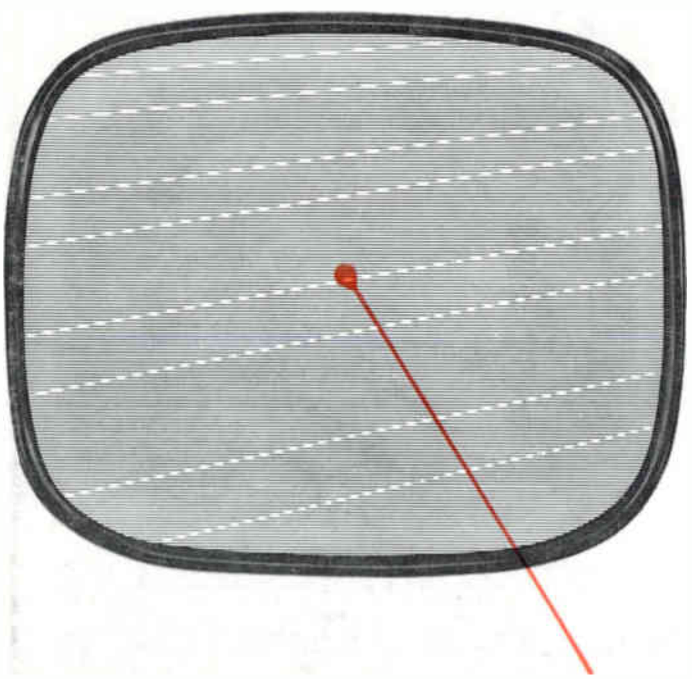

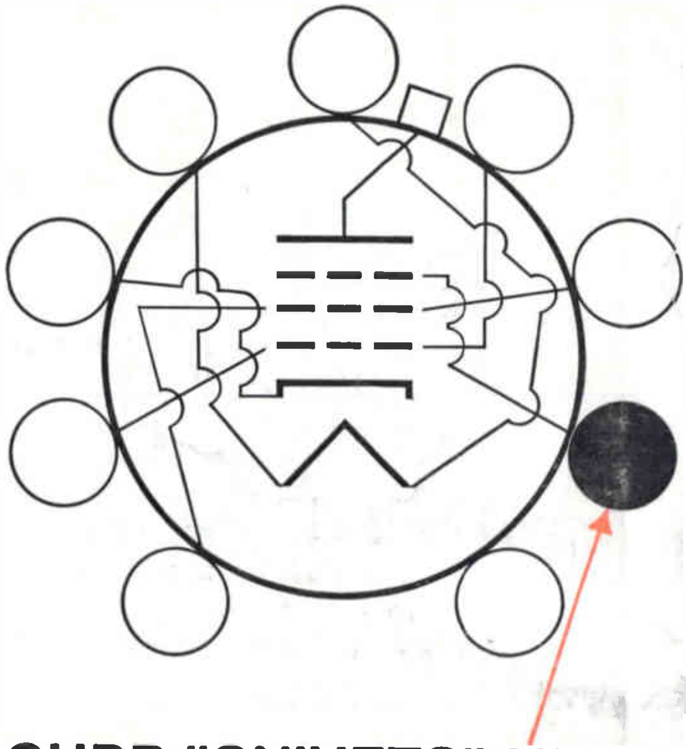

THE PICTURE IS CLEAR! CURB "SNIVETS" HERE

RCA-6JB6 NOVAR for B-&-W TV | RCA-22JG6 NOVAR for low-B+ B-&-W TV | RCA-6JE6 NOVAR for color TV

WITH RCA NOVAR TUBES

New RCA NOVAR Beam Power Tubes Minimize the Picture-Spoiling Effects of TV "Snivets"

New FCC Regulations require that television sets, manufactured after April 30, 1964, and shipped in interstate commerce, shall be capable of adequately receiving all channels allocated by the FCC to the television broadcast service, including UHF channels.

Since "snivets" are most likely to occur in UHF TV receivers, the set designer must, more than ever, be prepared for this problem.

There is a simple solution. The 9-pin construction of RCA NOVAR tubes provides a separate base-pin connection for grid-No. 3. This basing arrangement permits application of positive voltage to grid No. 3 to minimize "snivet"-type interference originating in the horizontal-deflection-amplifier circuit.

Three new families of RCA NOVAR beam power tubes are specifically designed to curb "snivets" in both UHF and VHF TV receivers, color and black-and-white:

RCA-6JB6, -12JB6 and -17JB6 NOVAR tubes for black-and-white TV

RCA-22JG6 NOVAR tubes for low-B+ black-and-white TV receivers

RCA-6JE6 NOVAR tubes for color TV

These new beam power tubes provide the established NOVAR benefits of:

- Large pin circle, long pins, rugged cage structure, integral-based all-glass envelope to assure firm socket seating and very effective heat dissipation.
- Wide pin spacing (0.172") to guard against high-voltage breakdown and interelectrode leakage.
- Low initial cost.
- Plus RCA's highly-efficient "Dark Heater" for cooler heater operation, longer tube life and more stable performance.

Specify applicable RCA NOVAR tubes for your horizontal-deflection-amplifier stages. And for added dependability, there are NOVAR types for TV damper service, audio-output stages and low voltage rectifier use. Ask your RCA Field Representative about them, or write: Commercial Engineering, Section D-19-DE-2, RCA Electron Tube Division, Harrison, N. J.

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